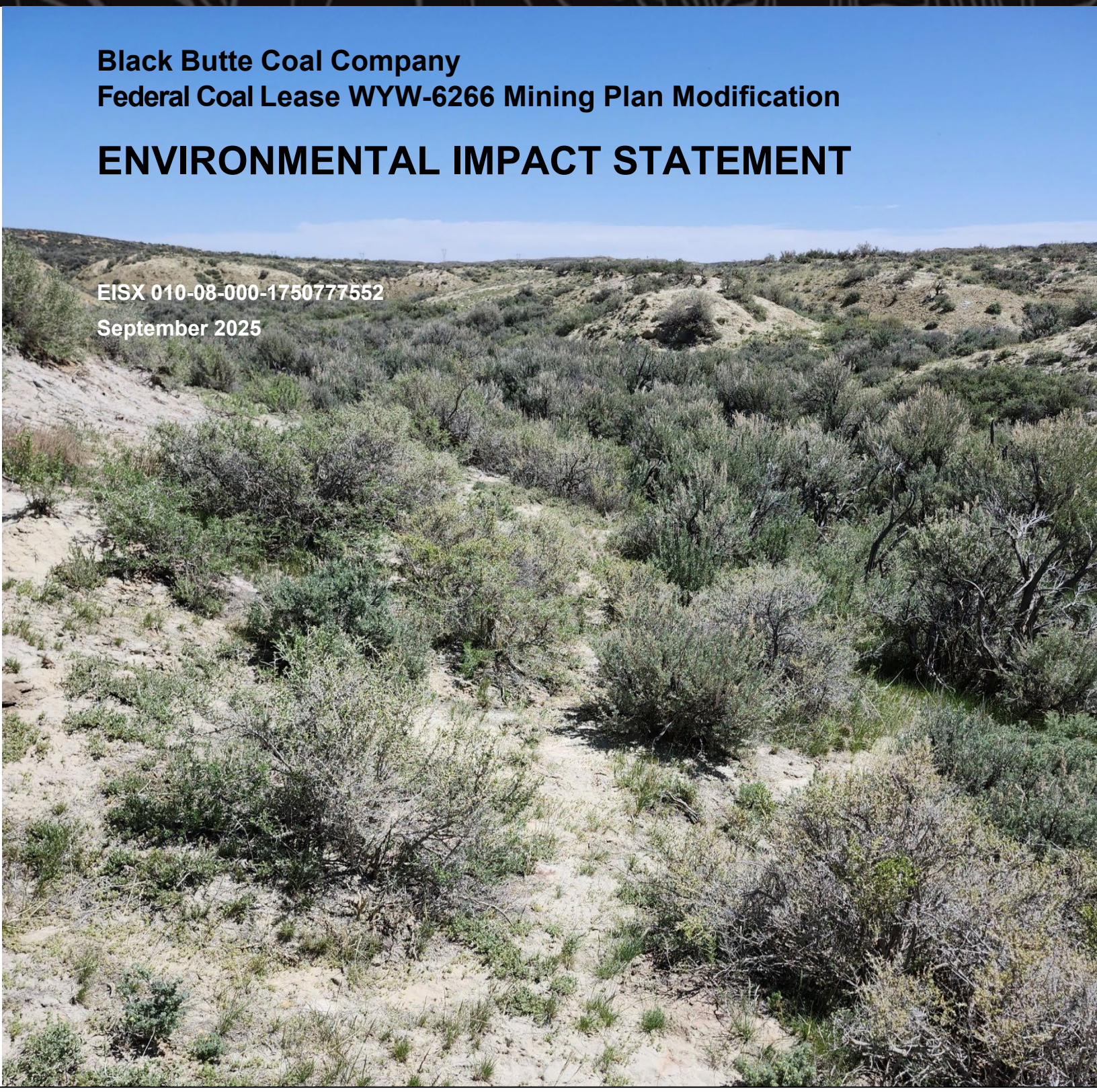
Black Butte Coal Company
Federal Coal Lease WYW-6266 Mining Plan Modification

ENVIRONMENTAL IMPACT STATEMENT



EISX 010-08-000-1750777552

September 2025

Office of Surface Mining Reclamation and Enforcement

The Office of Surface Mining Reclamation and Enforcement's mission is to carry out the requirements of the Surface Mining Control and Reclamation Act of 1977 in cooperation with states and tribes. The agency's primary objectives are to ensure that coal mines are operated in a manner that protects citizens and the environment during mining and assures that the land is restored to beneficial use following mining, and to mitigate the effects of past mining by aggressively pursuing reclamation of abandoned coal mines.

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September 2025

Office of Surface Mining Reclamation and Enforcement

Western Region

Lakewood, Colorado

The Office of Surface Mining Reclamation and Enforcement (OSMRE) has considered the potential environmental impacts of this Proposed Action in compliance with the National Environmental Policy Act of 1969 (NEPA), as amended, and this environmental impact statement represents OSMRE's good-faith effort to prioritize documentation of the most important considerations required by NEPA within the congressionally mandated page and time limits, and the Department of the Interior's August 8, 2025, determination that this project is eligible for alternative arrangements for NEPA compliance to address the National Energy Emergency declared in Executive Order 14156 (January 20, 2025). This prioritization reflects OSMRE's expert judgment, and any considerations addressed briefly or left unaddressed were, in OSMRE's judgment, comparatively not of a substantive nature that meaningfully informs the consideration of potential environmental effects and the resulting decisions on how to proceed.

MARCELO CALLE Digitally signed by MARCELO CALLE
Date: 2025.09.09 16:36:10 -06'00'

Marcelo Calle
Acting Regional Director
Regions 5 & 7-11, OSMRE

Date

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Definition
µg/m^3	micrograms per cubic meter
%	percent
§	section
§§	sections
ANFO	ammonium nitrate fuel oil
AQRV	Air Quality Related Values
ARMPA	Approved Resource Management Plan Amendment
ASLM	Assistant Secretary for Land and Minerals Management
AUMs	animal unit months
BACT	Best Available Control Technologies
BBCC	Black Butte Coal Company
BBCM	Black Butte Coal Mine
BCC	birds of conservation concern
bgs	below ground surface
BLM	Bureau of Land Management
BO	biological opinion
Btu	British thermal unit
CAA	Clean Air Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CH4	methane
CHIA	Cumulative Hydrologic Impact Assessment
CIA	cumulative impact area
CO	carbon monoxide
CO2	carbon dioxide
CO2e	carbon dioxide equivalent
Core Area	Wyoming Greater Sage-grouse Core Population Area
DM	Departmental Manual
DOI	Department of the Interior
dv	deciview
E.	East

Acronym/Abbreviation	Definition
EAD	Economic Analysis Division
EDGAR	Emissions Database for Global Atmospheric Research
E. coli	Escherichia coli
EIA	US Energy Information Administration
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FLPMA	Federal Land Policy Management Act of 1976
GGRB	Greater Green River Basin
GHGs	greenhouse gases
GIS	Geographic Information System
Gt	gigatonnes
Gt/yr	gigatonnes per year
GWP	global warming potential
H2SO4	sulfuric acid
HAPs	Hazardous Air Pollutants
IMPROVE	Interagency Monitoring of Protected Visual Environments
IPaC	Information for Planning and Consultation
IPCC	Intergovernmental Panel on Climate Change
LQD	Land Quality Division
M	million
MACT	Maximum Achievable Control Technology
MATS	Mercury and Air Toxics Standards
MER	Maximum Economic Recovery
mg/L	milligrams per liter
MLA	Mineral Leasing Act of 1920, as amended
mmt	million metric tons
MPDD	mining plan decision document
MSHA	Mine Safety and Health Administration
mt	metric tons
N.	North

Acronym/Abbreviation	Definition
N2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NEI	National Emissions Inventory
NEPA	National Environmental Policy Act of 1969, as amended
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NMHC	Nonmethane hydrocarbon
NO_2	nitrogen dioxide
NOx	nitrogen oxides
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NSR	New Source Review
NSPS	New Source Performance Standards
NWR	National Wildlife Refuge
O3	ozone
OBBB	One Big Beautiful Bill
OHV	off-highway-vehicle
OSMRE	Office of Surface Mining Reclamation and Enforcement
PAP	permit application package
PFYC	Potential Fossil Yield Classification
PHC	Probable Hydrologic Consequences
PHMA	Priority Habitat Management Area
PM	particulate matter
$PM_{2.5}$	particulate matter nominally 2.5 microns or less
PM_{10}	particulate matter nominally 10 microns or less
P.M.	Principal Meridian
ppb	parts per billion
ppm	parts per million
PSD	Prevention of Significant Deterioration
PTE	potential to emit
R.	Range
R2P2	resource recovery and protection plan

Acronym/Abbreviation	Definition
Recovery Program	Recovery Implementation Program for Endangered Fishes in the Upper Colorado River Basin
RFFAs	reasonably foreseeable future actions
RMP	Resource Management Plan
ROD	Record of Decision
ROW	right-of-way
RSFO	Rock Springs Field Office
RSGA	Rock Springs Grazing Association
S.	South
SAR	sodium absorption rate
SCS	Soil Conservation Service
Sec.	Section
short ton	2,000 pounds or 1 ton
SHPO	State Historic Preservation Office
SLAM	State and Local Monitoring Station
SMCRA	Surface Mining Control and Reclamation Act of 1977
SO_2	sulfur dioxide
SPCC	Spill Prevention, Control, and Countermeasure
SPM	Special Purpose Monitor
SWAP	State Wildlife Action Plan
SWCCD	Sweetwater County Conservation District
T.	Township
TDS	total dissolved solids
TEOM	tapered element oscillating microbalance
TMDL	Total Maximum Daily Load
TOC	total organic carbon
U.S.	United States
USACE	United States Army Corps of Engineers
USC	United States Code
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGCRP	US Global Change Research Program
VOCs	volatile organic compounds

Acronym/Abbreviation	Definition
VRI	Visual Resource Inventory
VRM	Visual Resource Management
W.	West
WAAQS	Wyoming Ambient Air Quality Standards
WDAI	Wyoming Department of Administration and Information
WDEQ	Wyoming Department of Environmental Quality
WGFD	Wyoming Game and Fish Department
WLMI	Wyoming Labor Market Information
WMMM	Western Monarch Milkweed Mapper
WQD	Water Quality Division
WRCC	Western Regional Climate Center
WSEO	Wyoming State Engineer's Office
WY	Wyoming
WYDOT	Wyoming Department of Transportation
WYNDD	Wyoming Natural Diversity Database
WYPDES	Wyoming Pollutant Discharge Elimination System

1 INTRODUCTION

Proposed Action Title: Black Butte Coal Company Federal Coal Lease WYW-6266 Mining Plan Modification

Environmental Impact Statement (EIS) Number: EISX 010-08-000-1750777552

Preparing Office: Office of Surface Mining Reclamation and Enforcement (OSMRE)
Western Region
PO Box 25065
1 Denver Federal Center, Bldg. #41
Lakewood, Colorado 80225

Proposed Action Type and Location: To modify the existing Federal mining plan to include tracts of leased Federal coal lands situated within Sections 12 and 24, Township (T.) 19 North (N.), Range (R.) 100 West (W.) (Federal Coal Lease WYW-6266), as shown on **Figure 1-1**.

Applicant: Black Butte Coal Company (BBCC or applicant)
c/o Lighthouse Resources, Inc.
170 South Main Street, Suite 700
Salt Lake City, Utah 84101

Lease/Serial/Case File No.: WYW-6266 (Federal Coal Lease)

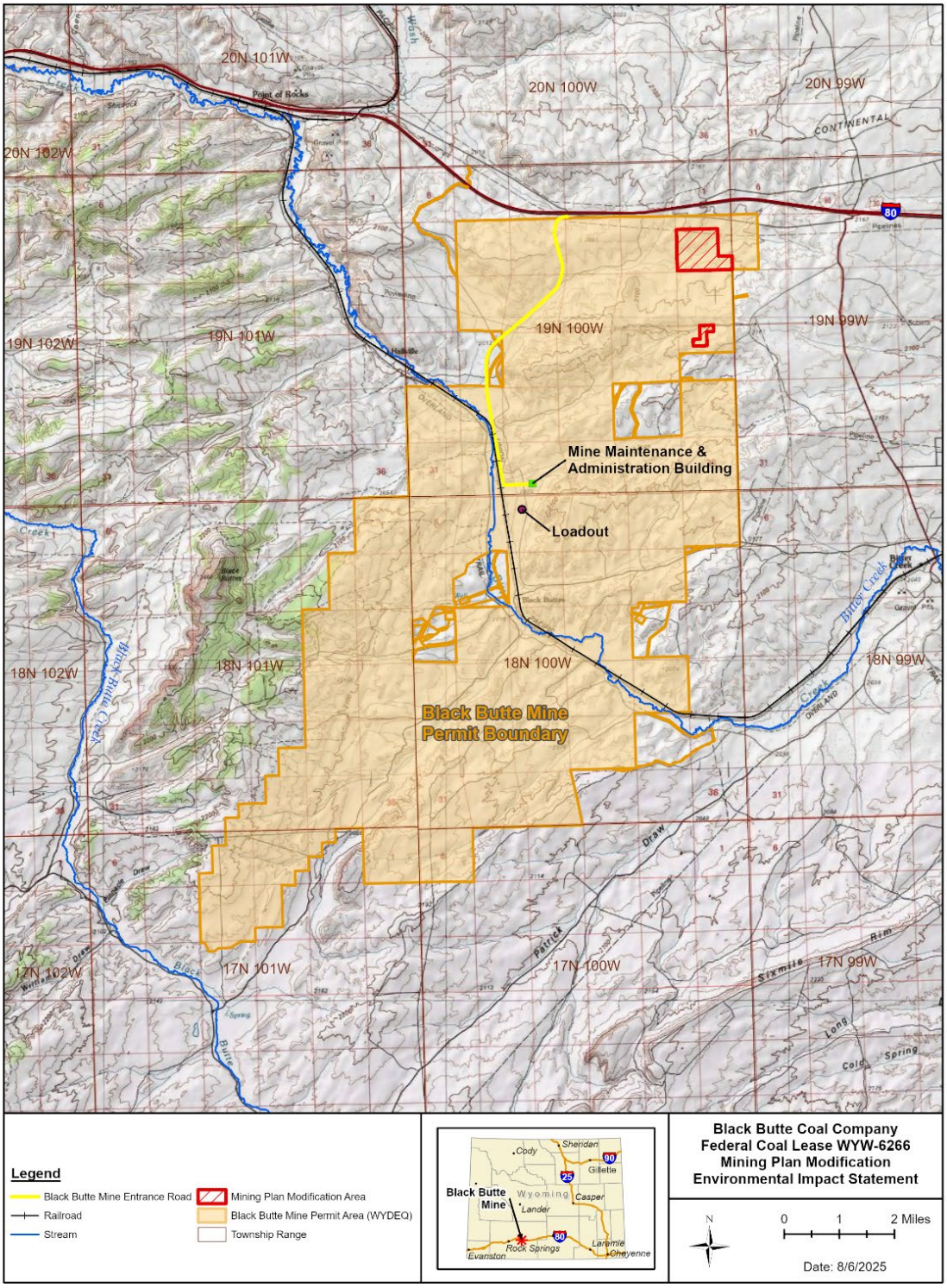
1.1 Background

This EIS was prepared to examine the potential environmental impacts of the Proposed Action and alternative action as described to support informed decision-making by OSMRE and cooperating agencies. This analysis is consistent with the purpose and goals of the National Environmental Policy Act of 1969 (NEPA), as amended; Federal judicial and regulatory interpretations; the Department of the Interior (DOI) Departmental Manual (DM) Part 516 (DOI 2025a); and administration priorities and polices, including the Department's Alternative Arrangements for NEPA Compliance (Apr. 23, 2025) (DOI 2025b).

This EIS has been prepared by OSMRE to disclose and analyze the potential effects on the environment of issuing a modification to the existing Black Butte Coal Mine (BBCM) Federal mining plan for Federal Coal Lease WYW-6266; and inform OSMRE's recommendation of whether to approve, deny, or approve with conditions the Federal mining plan modification to the Assistant Secretary for Land and Minerals Management (ASLM). The Bureau of Land Management (BLM) Rock Springs Field Office (RSFO) administers both the surface and subsurface (coal mineral) estate in Sections 12 and 24, T. 19 N., R. 100 W. Federal Coal Lease WYW-6266 was originally issued to BBCC on April 1, 1976. In 2017, the BLM approved a lease modification to add 450 acres to Federal Coal Lease WYW-6266 (BLM 2017). The Wyoming Department of Environmental Quality (WDEQ) Land Quality Division (LQD) officially approved the permit revision termed "Amendment 3, Change 10 to PT467-T8, TFN 6 3/246" (WDEQ 2021a) related to the development of Pit 15, on January 15, 2021, which expanded the BBCM permit boundary by 963 acres, including the mining of the 450 acres of Federal Coal Lease WYW-6266 not previously approved by the ASLM. Consequently, the

current BBCM permit boundary in its entirety is 43,384 acres. In accordance with the Mineral Leasing Act of 1920 (MLA), the applicant must obtain ASLM approval of the Federal mining plan modification for Federal Coal Lease WYW-6266, as modified, before mining of the Federal coal can occur.

Figure 1-1. Federal Mining Plan Modification Area including Pit 15 and Pit 10 Expansion



Executive Order (EO) 14154, *Unleashing American Energy* (Jan. 20, 2025), and the Presidential Memorandum, *Ending Illegal Discrimination and Restoring Merit-Based Opportunity* (Jan. 21, 2025) (Memorandum), require the DOI to strictly adhere to NEPA, 42 United States Code (USC) §§ 4321-4370. Further, EO 14154 and the Memorandum repealed EOs 12898 (February 11, 1994) and 14096 (Apr. 21, 2023). On April 23, 2025, the Council on Environmental Quality (CEQ) authorized the DOI to use alternative arrangements for projects that respond to the national energy emergency declared in EO 14156, *Declaring a National Energy Emergency* (Jan. 20, 2025), and the DOI subsequently adopted alternative arrangements for qualifying projects to comply with NEPA. *See* "Alternative Arrangements for Compliance with the National Environmental Policy Act amid the National Energy Emergency," April 23, 2025 (DOI 2025b). To expedite the review and approval, if appropriate, of projects related to the identification, leasing, siting, production, transportation, refining, or generation of energy within the United States (U.S.), these measures allow for more concise documents and a compressed timeline. Projects requiring an EIS under DOI's Alternative Arrangements for NEPA Compliance will be published approximately 28 days after publication of the Notice of Intent on a public website. The Alternative Arrangements for NEPA Compliance apply to actions relating to a wide range of energy sources, including coal (DOI 2025b).

On May 12, 2025, BBCC submitted an application to OSMRE to use the alternative arrangements to expedite the NEPA, National Historic Preservation Act (NHPA), and Endangered Species Act (ESA) compliance processes and complete OSMRE's review of the proposed Federal mining plan modification as quickly as possible in light of the national energy emergency. The ASLM approved BBCC's application with respect to NEPA and ESA compliance on August 8, 2025. The request to accelerate the NHPA compliance was not granted because the section 106 analysis was already complete. Although the ASLM also granted BBCC's request to use DOI's Alternative Procedures for Informal Section 7 Consultation, after further analysis, those procedures were not necessary as the project would have no effect on all listed species; thus, no consultation with the United States Fish and Wildlife Services (USFWS) was required.

The Federal mining plan modification area is the boundary of the 450-acre Federal coal lease tract modification area for WYW-6266 previously approved by BLM (BLM 2017). The Federal mining plan modification would allow for an expansion of coal mining into the existing Pit 10 and the development of a new pit (Pit 15). Legal land descriptions and acreages for the Federal mining plan modification area are described in **Table 1-1** for the Pit 10 expansion and Pit 15 areas.

Table 1-1. Federal Coal Lease WYW-6266 Mining Plan Modification Area

Federal Mining Plan Modification Area	Legal Land Description	Acreage	Mineable Coal Resources (tons)
Pit 15	T. 19 N., R. 100 W. 6th P.M., WY Sec. 12 SW¼NE ¼, S½NW¼, SW¼, W½SE¼, and SE¼SE¼	400	8,900,000
Pit 10 Expansion	T. 19 N., R. 100 W. 6th P.M., WY Sec. 24 NW¼NW¼NE¼, E½NE¼NW¼, and N½SE¼NW¼	50	300,000
	Total:	**450**	**9,200,000**
T. = Township, R. = Range, N. = North, E. = East, S. = South, W. = West, P.M. = Principal Meridian, WY = Wyoming			

The BBCM complex, in Sweetwater County in southwest Wyoming, approximately 38 miles east of Rock Springs, is operated by BBCC and consists of a surface mining operation and ongoing reclamation activities (**Figure 1-1** and **Figure 1-2**). The BBCM produces coal from Federal, private, and State lands situated within the historic Union Pacific Railroad checkerboard land grant area.

Figure 1-2. Recent Highwall Mining at Black Butte Coal Mine Pit 10

The BBCM complex has been in production since 1977, providing thermal coal to the Jim Bridger Power Plant and other operators. The annual production of the BBCM from 2020 to 2024 ranged from approximately 2,300,000 to 450,000 tons (BBCC 2024a). BBCC is a 50/50 Joint Venture between KCP and Bitter Creek Coal Company. KCP is a wholly owned subsidiary of Lighthouse Resources, Inc. Lighthouse Resources, Inc. is a private company incorporated under the laws of Delaware. Bitter Creek Coal is a wholly owned subsidiary of Occidental Petroleum Corporation.

BBCC is seeking approval of the Federal mining plan modification to extract Federal coal resources within 450 acres of Federal Coal Lease WYW-6266. The expansion would allow Maximum Economic Recovery (MER) of the Federal coal resources and is a logical progression of the northern portion of the BBCM. The Federal coal resources are needed by the BBCM to maintain mine operations and provide high-quality, low-cost fuel in support of electrical generation at the Jim Bridger Power Plant.

The Federal mining plan modification area consists of 450 acres of the WYW-6266 Federal coal lease tract (as approved by BLM in 2017) (BLM 2017) that extends to the north and south of the current Pit 10 area of the BBCM. Approval of the Federal mining plan modification would facilitate an extension of Pit 10 in its southeast corner of 50 acres and a Pit 15 north of Pit 10 on 400 acres. Each area is within the existing 43,384-acre BBCM permit boundary (WDEQ Permit PT467) (WDEQ 2021a). Approximately 68 acres, or 15 percent of the Federal mining plan modification area, has been previously disturbed by mining activities under a separate existing BLM right-of-way (ROW) agreement. These disturbances include existing access roads, a surface water retention basin, topsoil stripping to accommodate mining of the leased and fee coal, and topsoil and overburden stockpiles. Other previous disturbances within the Federal mining plan modification area include scattered oil and gas exploration, production, and transport (i.e., pipelines); exploration drilling for coal in support of BBCM; and livestock grazing (i.e., cattle and sheep).

The Jim Bridger Power Plant is not considered a connected action because 1) the proposed Federal mining plan modification would not automatically trigger any action at the Jim Bridger Power Plant that would require an EIS, 2) the proposed Federal mining plan modification could proceed without any changes (previous or simultaneous actions) at the Jim Bridger Power Plant, and 3) the proposed Federal mining plan modification is not an interdependent part of a larger action at the Jim Bridger Power Plant and does not depend on the plant for its justification, because the coal could be sold elsewhere due to the coal's market value. Other coal processing plants exist, and transportation infrastructure is available to transport the coal to these other locations.

The proposed Federal mining plan modification would not change production levels at the Jim Bridger Power Plant or require changes to its current regulatory permits. If the proposed Federal mining plan modification is rejected, the Jim Bridger Power Plant would continue to operate by obtaining coal from other sources. These other sources would consist of the surface mine in the Jim Bridger Coal Mine complex and outside third-party suppliers (e.g., other mines within the Powder River Basin). Although the Jim Bridger Power Plant is not considered a connected action, operating and emissions data from the power plant are included in the Air Quality/

Greenhouse Gases section (***Section 3.2***) to provide context and to assist with analysis of the combustion of coal mined from the proposed Federal mining plan modification.

1.2 Purpose and Need for the Proposed Action

The purpose for OSMRE's action is to respond to BBCC's need for a modification to the approved Federal mining plan that is required before Federal coal can be mined from 450 acres of Federal Coal Lease WYW-6266. OSMRE must recommend to the ASLM to approve, disapprove, or approve with conditions BBCC's proposed Federal mining plan modification as required by the MLA and Surface Mining Control and Reclamation Act of 1977 (SMCRA) 30 Code of Federal Regulations (CFR) parts 740 and 746; 30 USC § 207(c). If approved, the Proposed Action would modify the Federal mining plan and authorize BBCC to mine 9.2 million (M) tons of Federal coal on approximately 450 acres from Federal Coal Lease WYW-6266. OSMRE must conduct a thorough analysis of the environmental effects of the proposed Federal mining plan modification to inform its recommendation to the ASLM. The ASLM will consider OSMRE's recommendation when deciding whether the Federal mining plan modification is approved, disapproved, or approved with conditions. OSMRE's recommendation will be based, at a minimum, on the following:

- The permit application package (PAP), including the resource recovery and protection plan (R2P2);
- Information prepared in compliance with NEPA, including this EIS;
- Documentation assuring compliance with the applicable requirements of Federal laws, regulations, and EOs other than NEPA;
- Comments and recommendations or concurrence of other Federal agencies and the public;
- Findings and recommendations of the BLM, who is a cooperating agency, with respect to the R2P2, Federal lease requirements, and the MLA;
- Findings and recommendations of the WDEQ, who is a cooperating agency, with respect to the BBCM permit application and the Wyoming State program; and
- The findings and recommendation of the OSMRE with respect to the additional requirements of 30 CFR Chapter VII, Subchapter D.

BBCC's goal is to mine approximately 9.2 M tons of mineable coal in Pit 10 and Pit 15 for continued operation of the BBCM.

1.3 Decision to be Made

OSMRE must prepare a mining plan decision document containing its recommendation to the ASLM about the proposed Federal mining plan modification associated with the development of Federal Coal Lease WYW-6266, as modified in 2017. The ASLM will evaluate OSMRE's recommendation and decide whether to approve, disapprove, or approve with conditions a Federal mining plan modification for the leased Federal coal.

1.4 Relationships to Statutes, Regulations, or Other Plans

1.4.1 Surface Mining Control and Reclamation Act of 1977

SMCRA, 30 USC §§ 1201-1328, is a "comprehensive statute designed to establish a nationwide program to protect society and the environment from the adverse effects of surface coal mining operations." *Hodel v. Va. Surface Mining and Reclamation Ass'n*, 452 U.S. 264, 268 (1981) (internal quotation marks and citations omitted). SMCRA establishes a program of cooperative federalism, allowing States to enact and administer their own regulatory programs on non-Federal and non-Indian lands, within limits established by minimum Federal standards, and subject to oversight and limited enforcement by DOI. *See* H.R. Rep. No. 95-218, at 57-58 (1977), reprinted in 1977 USC Congressional and Administrative News 593, 595; Hodel, 452 U.S. at 289. Under section 503 of SMCRA, a State may assume primary jurisdiction (or "primacy") over regulation and permitting of surface coal mining operations on non-Federal and non-Indian lands within its borders by submitting a program proposal to the Secretary of the Interior, 30 USC § 1253. A State's primacy under SMCRA does not, however, extend to Federally leased coal or mining that occurs on Indian lands as defined in SMCRA. SMCRA provides that if the State and OSMRE enter into a cooperative agreement, the State program can regulate surface coal mining operations on Federal lands (but not on Indian lands) according to the terms of that agreement. The 30 USC § 1273(c); 30 CFR Part 740; *see also*, *e.g.*, 30 CFR § 750.6(a)(1).

Pursuant to section 503 of SMCRA, the WDEQ developed, and, in November 1980, the Secretary of the Interior approved, a program authorizing WDEQ to regulate surface coal mining operations and surface effects of underground mining on non-Federal lands within the State of Wyoming. In January 1987, pursuant to section 523(c) of SMCRA, WDEQ entered into a State-Federal cooperative agreement with the Secretary of the Interior authorizing WDEQ to regulate surface coal mining operations and surface effects of underground mining on Federal lands within the State of Wyoming. Pursuant to this agreement, Federal coal lease holders in Wyoming must submit PAPs to OSMRE and WDEQ for proposed mining and reclamation operations on Federal lands in Wyoming. The WDEQ reviews the PAP to ensure that it complies with the permitting requirements and that the coal mining operation will meet the performance standards of the approved Wyoming State program.

The WDEQ is the primary enforcement agency ensuring the performance standards and permit requirements for reclamation are met during a mine's operation, and it has primary authority in environmental emergencies. OSMRE retains oversight responsibility to ensure that the standards and requirements are enforced according to Wyoming's State program. The BLM approved the Federal coal lease modification in 2017 to include the requested additional acreage, and the WDEQ approved the permit amendment in 2021. Pursuant to the section 7(c) of the MLA, (30 USC § 207(c)), BBCC needs to obtain approval of the Federal mining plan modification before it can mine the Federal coal.

1.5 BLM Green River Resource Management Plan Conformance

Federal regulations at 43 CFR § 1610.5-3 require coal leasing actions to conform to the approved BLM land use plan. On December 20, 2024, the BLM released the Record of Decision (ROD) for the approval of the Rock Springs Resource Management Plan (RMP); however, amid ongoing controversy over its implementation, the DOI put a hold on the RMP on February 6, 2025 (Heinz 2025). Therefore, the 1997 Green River RMP is the currently approved land use plan and guides land management decisions in the area.

The Green River RMP and ROD, (signed August 8, 1997) as amended by the ROD and Approved RMP Amendments for the Rocky Mountain Region, including the Greater Sage-Grouse Sub-Regions of Lewistown, North Dakota, Northwest Colorado, and Wyoming (signed September 21, 2015) (BLM 1997a and BLM 2015a), allows for coal leasing and development in the affected area, and the BLM determined that the previously approved modifications to Federal Coal Lease WYW-6266 conform to the Green River RMP. The Green River RMP provides land use guidance for coal leasing within the proposed Federal mining plan modification area. The Green River RMP decisions pertaining to this proposal include the following:

- Solid Leasables (Coal), page 13
    - Management Objective: The objective for management of the Federal coal resources in the planning area is to provide for both short- and long-range development of Federal coal, in an orderly and timely manner, consistent with the policies of the Federal coal management program, environmental integrity, national energy needs, and related demands.
    - Management Actions: Federal coal lands within the Coal Occurrence and Development Potential area (about 422,000 acres) are open to further consideration for coal leasing and development (i.e., new competitive leasing, emergency leasing, lease modifications, and exchange proposals under the Federal Coal Management Program) with appropriate and necessary conditions and requirements for protection of other land and resource values and uses.

The lands in the Federal mining plan modification area lie within the Coal Occurrence and Development Potential area (see Green River RMP Map 19, BLM 1997a).

1.6 Roles and Responsibilities

1.6.1 Lead Agency

1.6.1.1 Office of Surface Mining Reclamation and Enforcement

OSMRE is the lead agency for this NEPA analysis. For new mining plans or mining plan modifications on Federal lands, OSMRE must prepare a mining plan decision document (MPDD) in support of its recommendation to the ASLM (30 CFR Chapter VII, Subchapter D). The ASLM reviews the MPDD and decides whether to approve the Federal mining plan or mining plan modification, and, if so, what, if any, conditions may be needed.

1.7 Cooperating Agencies

The BLM, Environmental Protection Agency (EPA), and WDEQ are serving as cooperating agencies for this EIS. Their roles and responsibilities are described in the following subsections.

1.7.1 Bureau of Land Management

The BLM is responsible for the issuance, readjustment, modification, termination, cancellation, and/or approval of transfers of Federal coal leases pursuant to the MLA, as amended. The BLM has the general responsibility to administer the MLA with respect to coal mining, production, and resource recovery and protection operations on Federal coal leases and licenses, and to supervise exploration operations for Federal coal resources. The BLM approved the Federal Coal Lease WYW-6266 modification for Federal coal resources in 2017.

1.7.1.1 Environmental Protection Agency

The EPA sets forth and enforces environmental regulations concerning air and water quality that coal mining operations must comply with, including monitoring and regulating emissions and discharges that could contaminate natural resources.

The EPA reviews all draft EISs prepared by other Federal agencies as required by section 309 of the Clean Air Act (CAA). Section 309 of the CAA also requires that the EPA make these reviews public, and the EPA does this by posting its comment letters on EISs in the EIS database. The EPA's reviews are primarily concerned with identifying and recommending appropriate measures to avoid and mitigate significant environmental impacts associated with a proposed action. The EPA also evaluates the adequacy of the information presented. Lastly, the EPA conducts reviews of final EISs to ensure that the lead agency has taken the EPA's comments into account.

1.7.1.2 Wyoming Department of Environmental Quality

Pursuant to section 523(c) of SMCRA, WDEQ is the primarily regulator of surface coal mining operations on Federal lands within the State of Wyoming. The WDEQ is responsible for reviewing PAPs to ensure that it complies with the permitting requirements and that the coal mining operation will meet the performance standards of the approved Wyoming State program. If it does comply, WDEQ issues the applicant a mine permit to conduct coal mining operations. The WDEQ approved the BBCM permit modification (i.e. Amendment 3, Change 10 to PT467-T8, TFN 6 3/246) related to the development of Pit 15 on January 15, 2021 (WDEQ 2021a). After permit approval, the WDEQ is the primary enforcer of the performance standards and permit requirements for reclamation during a mine's operation and has primary authority in environmental emergencies.

After WDEQ issues the permit, OSMRE will then use the information contained in this NEPA document and other information to make a recommendation to the ASLM to either approve, approve with conditions, or disapprove the Federal mining plan or mining plan modification. The operation cannot start mining the leased Federal coal until it has received the ASLM's approval.

In accordance with Title 35, Chapter 11 of the Wyoming Statutes and Wyoming's Water Quality Rules, the WDEQ Water Quality Division (WQD) is the agency responsible for the protection and restoration of the quality of waters of the State of Wyoming. The WDEQ WQD also implements portions of the Federal Clean Water Act, including development of surface water quality standards, identification of impaired waters, and development of total maximum daily loads for impaired waters under section 303; inventorying water quality under section 305; discharge permitting under section 402; water quality certifications under section 401; and addressing nonpoint sources of pollution under section 319.

1.8 Resource Issues Identified for Detailed Analysis

Instead of amassing needless detail, OSMRE has focused analysis on issues that are truly pertinent to the Proposed Action. As such, OSMRE has narrowed the issues analyzed in detail to only those resource issues that could be affected by the mining of the leased Federal coal pursuant to the Federal mining plan modification approval.

Site-specific resource concerns were identified by OSMRE and cooperating agencies. OSMRE focused on issues determined to be potentially significant as related to the alternatives. Issues have a cause-effect relationship with the alternatives, are within the scope of analysis, and are amenable to scientific analysis. The following resources/issues are analyzed in detail in this EIS:

Air Quality

- What would pollutant emissions from the mining of Federal coal in the Federal mining plan modification area be relative to the Wyoming Ambient Air Quality Standards (WAAQS) and National Ambient Air Quality Standards (NAAQS)?
- How would pollutant emissions from mining of the Federal coal in the Federal mining plan modification area affect sensitive airsheds in the nearby vicinity?

Global Climate/Greenhouse Gases

- What would BBCM's contribution from the mining of Federal coal, including impacts from emissions from employee commuter transportation, in the Federal mining plan modification area be relative to Wyoming, National, and global greenhouse gases (GHGs) emissions?

Vegetation

- Would there be a loss of native vegetation communities and the spread of invasive plant species and noxious weeds due to mining related surface disturbance?

Threatened and Endangered Species

- Monarch Butterfly: Would breeding or non-breeding habitat be lost due to mining related surface disturbance?
- Colorado River Endangered and Threatened Fish Species: Would potential water depletions from the Upper Colorado River Basin affect Colorado River endangered and threatened fish species and their designated critical habitat?

BLM Sensitive Species

- Greater Sage-grouse, Pygmy Rabbit, White-tailed Prairie Dog, and Wyoming Pocket Gopher: Would habitat be lost due to mining related surface disturbance?
- Burrowing Owl, Ferruginous Hawk, Golden Eagle, Mountain Plover, and Sagebrush Obligates: Would mining activity disturb nesting birds and raptors and would habitat be lost due to mining related surface disturbance?

General Fish and Wildlife

- Big Game: Would habitat be lost due to mining related surface disturbance?
- Migratory Birds and Raptors: Would mining activity disturb nesting birds and raptors and would habitat be lost due to mining related surface disturbance?

Geology/Mineral Resources/Energy Production

- How would the geology in the Federal mining plan modification area change due to mining?
- What would be the temporary loss of use of land for oil and gas extraction, processing, and transport?

Hydrologic Conditions

- Would there be a loss of groundwater use for other users?
- Would there be pollutants introduced into groundwater and surface water?
- Would there be a loss of seeps/springs or wetland/riparian habitat?
- Would surface water erosion/head cutting increase?

Social and Economic Resources

- Would there be impacts on the population; housing; community services; local economy (primarily employment and earnings in the mining industry and other sectors of the economy); and local, State, and Federal tax revenues in Sweetwater County due to mining?

On May 29, 2025, the Supreme Court issued a unanimous decision in *Seven County Infrastructure Coalition v. Eagle County*, *Colorado*, 145 S. Ct. 1497 (2025) (*Seven County*), holding that an agency is entitled to "substantial deference" in determining when an EIS has complied with NEPA "[s]o long as the EIS addresses environmental effects from the project at issue . . . ." and that NEPA does not require an agency to evaluate the environmental effects of projects separate in time or place from the agency's proposed action. The court explained, "[t]he effects from a separate project may be factually foreseeable, but that does not mean that those effects are relevant to the agency's decision-making process or that it is reasonable to hold the agency responsible for those effects." 145 S. Ct. 1497, 1516. In conformance with *Seven County*, this EIS only evaluates the effects of coal mining in the Pit 15 and Pit 10 expansion area. OSMRE analyzed other impacts that are separate in time and place from the project at hand, fall

outside OSMRE's regulatory authority, or are carried out by separate third parties except in the case of incremental impacts and in particular in the case of air quality and GHGs.

1.9 Resources Considered but Eliminated from Further Analysis

The interdisciplinary team identified potential issues for resources that may be impacted by the mining of the Federal coal reserves in the Federal mining plan modification area. Scoping for the action alternatives included specialists' professional expertise and site knowledge, and agency specialists' review of data available from regional and site-specific datasets; existing permit documents and reports for the BBCM, other regional survey work, and peer-reviewed literature, and discussions with other Federal and State agencies (e.g., BLM, WDEQ, EPA, USFWS, and Wyoming State Historic Preservation Office [SHPO]). Based on scoping, the resources described in **Table 1-2** were determined to be either not present or present within the Federal mining plan modification area but not affected to a degree that additional analysis is required. If an important issue was identified for a resource, then it is analyzed in full detail in ***Section* 3**.

Some resources were initially considered and analyzed but were eliminated from detailed analysis. Rationale for each resource eliminated from detailed analysis is provided in **Table 1-2**. Furthermore, during the internal scoping process, resources determined not to be present within or adjacent to the Federal mining plan modification area, such as prime or unique farmlands or wild and scenic rivers, would not be impacted by the Proposed Action and were not considered further.

Table 1-2. Resources Considered but Eliminated from Detailed Analysis

Resource	Rationale for Determination to Eliminate from Detailed Analysis
Cultural/Historic Resources	The BLM consulted with Wyoming SHPO for the proposed new Pit 15 and Pit 10 expansion Federal lease modification area, and SHPO concurred with the determination. The BLM approved the new Pit 15 and Pit 10 expansion Federal lease modification area in 2017. OSMRE consulted with the Wyoming SHPO in December 2021 for the proposed Federal mining plan modification as a continuation to BLM's consultation. In a letter dated June 1, 2022, the Wyoming SHPO concurred with the No Historic Properties Affected determination for cultural/historic resources provided that OSMRE requires an archaeological monitor be present for surface stripping activities at one archaeological site that has previously undergone excavations in case previously unobserved feature types are discovered. Wyoming SHPO further agreed that OSMRE will provide expedited direction for any necessary site mitigation related to such a discovery. Resource protection measures discussed in ***Section 2.4***, which would be implemented for the Proposed Action, require that any unanticipated discoveries of archaeological or cultural remains would be reported to the BLM, OSMRE, and WDEQ. No land disturbing activities would take place within 250 feet of such remains until they have been evaluated by a BLM-approved resource specialist, salvaged, if warranted, reviewed by the BLM, OSMRE, and WDEQ and authorization to proceed has been issued by the OSMRE Authorized Officer.

Resource	Rationale for Determination to Eliminate from Detailed Analysis
Floodplains	No impacts on floodplains are anticipated due to reclamation requirements. Channel morphology would be reconstructed per SMCRA requirements to function similar to the current hydrological regime.
Fuels/Fire Management (Pre-suppression)	The proposed Federal mining plan modification area is within the Little Mountain Fire Management Unit. Activities and actions associated with the Proposed Action would have no impact from a hazardous fuels and fire management standpoint. In the event of coal seam fires and anthropogenic caused fires from mining activities and/or operations, proper control measures and established protocols would be followed.
Lands/Access	All of the surface lands within the Federal mining plan modification area are administered by the BLM. The surface ownership adjacent to the Federal mining plan modification area is a checkerboard pattern (i.e., even-numbered sections are Federally administered by the BLM and odd-numbered sections are privately owned). Major land uses at the BBCM have been wildlife habitat and livestock grazing. Wildlife habitat is discussed in ***Section 3.4.1***. Livestock grazing is discussed in the next row of this table. Additional activities include prospecting for gas, oil, coal, uranium, and other minerals. A Federal oil and gas lease exists on the new Pit 15 area in Section 12; however, the leaseholder has not yet initiated oil and gas operations. No active locatable mineral mines or construction aggregate quarries are known in the Federal mining plan modification area. Coal mining is a dominant land use in the area surrounding the Federal mining plan modification area. The BBCM is the only operating mine adjacent to the Federal mining plan modification area. The Federal mining plan modification area has not undergone any farming techniques. This lack of farming activity is corroborated by the Southwestern Wyoming Environmental Statement in which the BLM and Soil Conservation Service (SCS; now the United States Department of Agriculture [USDA] Natural Resources Conservation Service [NRCS]) determined that no prime farmlands exist on the Federal mining plan modification area (BLM 1978). No officially designated vehicle transportation corridors are present within the Federal mining plan modification area with the exception of those supporting the BBCM. Two oil and gas pipelines are present in the northern portion of the Federal mining plan modification area (Section 12). The pipelines are north of the proposed surface disturbance limit. A telecommunication line adjoins the northern boundary of the Federal mining plan modification area outside of the proposed surface disturbance boundary. No other infrastructure is present in the Federal mining plan modification area other than that owned and operated by BBCC. Sweetwater County has no applicable countywide land use plans, and the Federal mining plan modification area has no designated zoning classification. The Sweetwater County Comprehensive Plan (Sweetwater

Resource	Rationale for Determination to Eliminate from Detailed Analysis
	County 2002) provides general land use goals and policies for State and Federal coal leases in the county. In the short term, surface coal mining would restrict public access and disrupt oil and gas development in portions of the Federal mining plan modification area. Once the surface and vegetation in the Federal mining plan modification area are reclaimed and BBCM has received bond release, the land would be returned to BLM management for multiple use, and the land would be available again for oil and gas development and public access. No impacts on existing infrastructure (pipelines or telecommunication lines) are expected based on those features being outside of the proposed surface disturbance area.
Livestock Grazing	The Taylor Grazing Act of 1934, Federal Land Policy Management Act of 1976 (FLPMA), Public Rangelands Improvement Act of 1978, 43 CFR, Subchapter D – Range Management, and the Green River RMP and ROD (BLM 1997a) contain the Federal regulatory framework for grazing on lands administered by the BLM. The BLM-administered rangelands are managed following the Standards for Healthy Rangelands and Guidelines for Livestock Grazing Management (BLM 1997b), which specifies the minimum acceptable health, productivity, and sustainability conditions. Reclamation, including re-vegetation of the BBCM would be required as part of the WDEQ permit amendment for the Federal mining plan modification area. Livestock grazing is a major land use in the region and in the Federal mining plan modification area. The Federal mining plan modification area falls within the Rock Springs Grazing Allotment (13018). The Rock Springs Grazing Allotment consists primarily of lands within the checkerboard land grant, with approximately half being privately owned or leased by the Rock Springs Grazing Association (RSGA). The land ownership within the Rock Springs Grazing Allotment consists of public lands – 956,682 acres, other Federal lands – 98,795 acres, State lands – 20,782 acres, and private lands – 984,803 acres (total acres 2,061,062). No specific grazing breakdown is available solely on the lands encompassed by the Federal mining plan modification area (BBCC 2014a). There are 45 animal unit months (AUMs) within the Federal mining plan modification area. Winter and spring use accounts for the majority of the AUMs, which are predominantly used for sheep grazing by the RSGA. The remaining AUMs are used exclusively by cattle during the winter and spring months (BBCC 2014a). No water features, cattleguards, corrals, or other livestock or range infrastructure are in the Federal mining plan modification area. It is assumed that the entire Federal mining plan modification area would be restricted from livestock grazing when the BBCM starts operating in the area. Approximately 68 acres of the Federal mining plan modification area has been previously disturbed by BBCM mining activities under a separate existing BLM ROW agreement, which impacted forage land available for livestock grazing and resulted in the loss of 7 AUMs in the short term.

Resource	Rationale for Determination to Eliminate from Detailed Analysis
	Implementation of the Proposed Action would impact approximately 257 additional acres of forage land available for livestock grazing and would result in the loss of 26 AUMs in the short term. The remaining forage lands and 12 AUMs would be impacted due to the Federal mining plan modification area being restricted via fence. Allocations of the Rocks Springs Grazing Allotment use would have to be restructured by the BLM to accommodate the loss of forage and access available to grazing permittees. The effects of mining in the Federal mining plan modification area would be most notable to those permittees who use forage production within the Federal mining plan modification area on an annual basis. As portions of the BBCM are reclaimed and made available to graze, the loss of grazing in the Federal mining plan modification area would be reduced. In addition, provided that appropriate reclamation is completed in the Federal mining plan modification area after mining, the allotted AUMs would remain unchanged. See ***Section 3.3*** for the analysis of invasive species and noxious weeds. The entire Federal mining plan modification area would be restricted from livestock grazing; therefore, no livestock and vehicle collisions are anticipated. The impact on livestock grazing in the Federal mining plan modification area would be adverse and substantial in the short term. Long-term impacts would be negligible to minor.
Native American Religious Concerns	Three sacred sites occur within a 0.25-mile of the Federal mining plan modification area. On February 8, 2012, letters were mailed to the following Native American tribes: Northern Arapaho, Eastern Shoshone, Shoshone Bannock, Ute Tribe of the Uintah and Ouray Reservation. Two of these tribes, the Northern Arapaho and the Eastern Shoshone, requested a field visit. On April 16, 2012, the Northern Arapaho and Eastern Shoshone tribes visited four sites, three of which are within a 0.25-mile of the Federal mining plan modification area. Both of these tribes did not identify concerns with the proposed leasing and pit projects, as long as the sites are not disturbed (Stadler 2015). Three sites sacred to Native Americans are within a 0.25-mile buffer of the Federal mining plan modification area. The Proposed Action would not disturb any of the three sites; therefore, there would be no direct effect on any sacred Native American sites. The sites would be visually impacted due to the surface disturbance and other mining activities being visible from each site, degrading the viewshed. However, Native American consultation has determined that the tribes do not oppose the Proposed Action as long as the sites are not directly disturbed and do not see viewshed impacts as degrading the identified sites. Impacts on Native American religious concerns would be negligible. The OSMRE continued consultation and sent letters to the Northern Arapaho, Eastern Shoshone, Shoshone Bannock, and Ute Tribe of the Uintah and Ouray Reservation on January 4, 2022, regarding the potential resolution of adverse effects to one archaeological site that was later determined not eligible, and the tribes provided no responses. The OSMRE

Resource	Rationale for Determination to Eliminate from Detailed Analysis
	sent additional letters to the four tribes on August 12, 2025, regarding the EIS, the NHPA review, and government-to-government consultation.
Paleontological Resources	The BLM has implemented a Potential Fossil Yield Classification (PFYC) system for classifying paleontological resources on public lands. Under the PFYC system, geologic units are classified from Class 1 to Class 5 based on the relative abundance of vertebrate fossils or uncommon invertebrate or plant fossils and their sensitivity to adverse impacts. A higher classification number indicates a higher fossil yield potential and greater sensitivity to adverse impacts. A reconnaissance paleontological survey was conducted for the Federal mining plan modification area at the request of the BLM RSFO, in accordance with BLM policies and guidelines established as a result of the FLMPA, the Paleontological Resources Preservation of the Omnibus Public Lands Act of 2009, and the Instruction Memorandum 2009-011 issued by the BLM. A literature search, records search, and a reconnaissance paleontological field survey were conducted by Stratigraphic rex LLC for the Federal mining plan modification area. The literature search was conducted using the GeoRef database to determine if any previously recorded fossil localities exist in the study area as well as the fossil richness of the formations and rock units involved. Paleontological records that were easily accessible, such as Geographic Information System (GIS)-based locality data, aerial photos, soils maps, and other known paleontological locality information were consulted. The reconnaissance paleontological field survey, a pedestrian survey, was conducted in November and December 2014. Past paleontological surveys have been conducted from 1977 through 1982 for the existing BBCM. Historical fossil localities are known in the region. Based on published geological maps, the Federal mining plan modification area includes sediments associated with the Fort Union Formation (Love and Christianson 1985) and previously disturbed deposits. The Fort Union Formation has a PFYC Class of 3. PFYC Class 3 is described as: Moderate or unknown; Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence; or sedimentary units of unknown fossil potential. Often marine in origin with sporadic known occurrences of vertebrate fossils. Vertebrate fossils and scientifically significant invertebrate or plant fossils known to occur intermittently; predictability known to be low, or Poorly studied and/or poorly documented. Potential yield cannot be assigned without ground reconnaissance. Fossil remains were found during the field survey; however, these remains were of poor quality and had little to no significant scientific value. No

Resource	Rationale for Determination to Eliminate from Detailed Analysis
	significant fossil remains were discovered. The lack of fossil remains could be a normal feature for this formation. The PFYC Class 3 rating makes it a rock unit that is known for fossil remains, but those remains can be inconsistent from one location to the next (Stratigraphic rex LLC 2014). No significant fossil remains were discovered during the reconnaissance paleontological field survey conducted for the Federal mining plan modification area. Mining of the Federal coal resources could create the potential for scientifically significant fossils to be found; however, targeted coal seams are above the stratigraphic units containing the initial dinosaur discoveries at BBCM (personal communication, BLM, G. Smith, September 2015). Resource protection measures discussed in ***Section 2.4***, which would be implemented for the Proposed Action, require that any unanticipated discoveries of paleontological resources would be reported to the BLM, OSMRE, and WDEQ. No land disturbing activities would take place within 250 feet of such resources until they have been evaluated by the BLM, or a BLM-approved resource specialist, salvaged, if warranted, and authorization to proceed has been issued by the BLM Authorized Officer. If such fossils are found, the information gained would have a beneficial impact on the science of paleontology. Scientifically significant fossils that may be inadvertently destroyed would have an adverse impact due to the loss of paleontological information.
Public Safety	Hazards associated with BBCM mining activities have public protection measures implemented as part of the WDEQ mine permit. Active mining areas are signed, bermed, and monitored to ensure public safety and to exclude the public from dangerous areas.
Rangeland Health Standards	Rangeland Health Standards apply to multiple disciplines (i.e., vegetation, hydrology, wetland/riparian, wildlife, air quality, and water quality). Initial surface disturbance would result in areas not meeting standards; however, if successful reclamation occurs, then impacts on rangeland health standards would be minimized.
Recreation	No developed recreation is present in the Federal mining plan modification area. Off-highway-vehicle (OHV) on existing roads does occur. The Proposed Action includes mining near Interstate 80 and surrounding public lands have only limited recreational value.
Roadless	The Federal mining plan modification area does not meet roadless criteria and no designated roadless areas are in the vicinity.
Soils	The BBCM area has a semi-arid climate and is within a frigid soil temperature regime (mean annual air temperature of about 38 degrees Fahrenheit), and a typic-aridic soil moisture regime (mean annual precipitation of about 5 to 10 inches). The average frost-free season is about 60 days.

Resource	Rationale for Determination to Eliminate from Detailed Analysis
	An Order 2 soil survey was conducted for Pit 10 in 1982 and 1983 (BBCC 2008a). An additional 250 acres lying in advance of the active Pit 10 were mapped to an Order 2 intensity in 2002 in preparation for the Pit 10 expansion (Nyenhuis 2002). The best available soils data for the new Pit 15 area are from the Soils of Wyoming, which is a digital statewide soils map at a 1:500,000 scale (Munn and Arneson 1998). The soil map units found on the Federal mining plan modification area consist of: Pit 10 Expansion Area (Nyenhuis 2002): 7.1 acres (2 percent) of Winton Channery Loam 0-45 percent slopes; 24.1 acres (5 percent) of Winston Horsley Rock Outcrop Association, Very Steep; 13.2 acres (3 percent) of Huguston Horsley Haterton Complex, 6-30 percent slopes; and 4.5 acres (1 percent) of Monte Loam, 0-6 percent slopes Pit 15 Area (Munn and Arneson 1998): 237.8 acres (53 percent) of Rock Outcrop & Typic Torriorthents and 161.9 acres (36 percent) of Ustic Haplocambids & Ustic Torriorthents Activities occurring under the Proposed Action would result in approximately 257 additional acres of soil disturbance in the Federal mining plan modification area. Approximately 68 acres of the Federal mining plan modification area have been previously disturbed due to mining activities. Other disturbances have occurred in the Federal mining plan modification area due to oil and gas activities. The approximate total number of undisturbed soil map unit acres within the Federal mining plan modification area that would be impacted by the Proposed Action consists of: Pit 10 Expansion Area (Nyenhuis 2002): 2.6 acres of Winton Channery Loam 0-45 percent slopes; 11.5 acres of Winston Horsley Rock Outcrop Association, Very Steep; 6.8 acres of Huguston Horsley Haterton Complex, 6-30 percent slopes; and 0.2 acres of Monte Loam, 0-6 percent slopes Pit 15 Area (Munn and Arneson 1998): 98.3 acres of Rock Outcrop & Typic Torriorthents and 137.1 acres of Ustic Haplocambids & Ustic Torriorthents Salvaged soils, stockpiled during mining and restored during reclamation, would have different physical, chemical, and biological characteristics than pre-mining soils. Post-mining soil would be more uniform in type, thickness, and texture due to mixing soils during stockpiling and reclamation efforts. While WDEQ permit requirements would reduce

Resource	Rationale for Determination to Eliminate from Detailed Analysis
	erosion potential, impacts on soils from the Proposed Action would increase the potential for wind and water erosion and sedimentation until re-establishment of vegetation. Diversity of vegetation replaced during interim and final reclamation may be reduced due to the alteration of replaced soil physical and chemical components. Average topsoil productivity in the Federal mining plan modification area would generally improve as soil that is not suitable for sustaining vegetation would not be salvaged and used in surface reclamation efforts. Chemistry and nutrient distribution would be more uniform within salvaged soils. However, the diversity of vegetation the salvaged soil would support may be reduced. Special handling procedures for soils containing potentially harmful constituents (e.g., selenium) and the use of erosion control structures are required by State of Wyoming regulations and are considered part of the Proposed Action. The procedures would minimize mobilization of harmful constituents and erosion. As part of the resource protection measures discussed in ***Section 2.4***, BBCC is proposing to minimize soil erosion by using the following measures: Topsoil stockpiles would be planted with an appropriate seed mixture. Seeding of reclaimed areas would occur after topsoil has been applied. Approved sediment control measures would be used when applicable. Surface disturbance would be limited to only those areas required by the operation. Extra caution would be used during wet weather to prevent excessive rutting. Any erosion occurring within the active mine area would be mitigated as necessary.
Visual Resources	The BLM Visual Resource Inventory (VRI) Class III and Visual Resource Management (VRM) Class III exist within the Federal mining plan modification area. Class III management objectives allow a moderate level of change that may attract attention but should not dominate the view of a casual observer. Mining impacts would be temporary and are not expected to be sufficient to change the visual resource class. It would remain Class III following reclamation.
Wastes	Wastes generated during the mining process would be disposed of in accordance with solid and hazardous waste regulations and unsuitable overburden would be placed above the water table and below the vegetation root zone.
Wilderness/Wilderness Study Area/Areas of Wilderness Character	The Federal mining plan modification area fails to meet the minimum standards under FLPMA to qualify as wilderness. In order to qualify as wilderness, it must possess sufficient size, naturalness, and outstanding opportunities for either solitude or primitive and unconfined recreation. The Federal mining plan modification area is within 0.25 mile of Interstate 80, and is adjacent to the existing BBCM, a surface mine that has been operating for over four decades. The presence of these features means that

Resource	Rationale for Determination to Eliminate from Detailed Analysis
	the area does not provide the naturalness or solitude required to qualify as wilderness.
Wild Horses and Burros	The Federal mining plan modification area is within the range of the Salt Wells Creek Herd but is not within a congressionally designated Herd Management Area. Wild horses have the potential to be present in the Federal mining plan modification area; however, impacts on wild horses are considered to be minimal due to the small amount of forage that would be removed in the Federal mining plan modification area relative to the vast range used by the herd in the surrounding area. In addition, the area is not managed specifically for wild horses because it is not a designated Herd Management Area.

2 DESCRIPTION OF ALTERNATIVES

2.1 Introduction

Agencies must evaluate the environmental impacts of a reasonable range of alternatives when analyzing a proposed Federal action. The DOI's NEPA-implementing regulations define reasonable alternatives as those that are "technically and economically feasible, meet the purpose and need for the proposed action, are within the jurisdiction of the bureau, and, where applicable, meet the goals of the applicant" (516 DM 1, Section 6.1(t)). This section describes Alternative I (No Action Alternative) and Alternative II (Proposed Action), which are considered and analyzed in detail in this EIS and provide information on the existing operations at the BBCM and how those operations may change under the alternatives. **Table 2-1** shows the tonnage to be mined, the expected end date of operations (life of mine), and the new surface disturbance anticipated under each alternative.

Action alternatives were developed based on national and OSMRE direction and policy, existing conditions, including surface access agreements, and resource issues as presented in ***Section 1.8***.

Table 2-1. Tonnage, Life of Mine, and New Surface Disturbance by Alternative

Alternative	Mineable Federal Coal Lease WYW-6266 (tons)	Life of Mine	New Surface Disturbance from Mining Federal Coal Lease WYW-6266 (acres)
Alternative I – No Action	0	2033	0
Alternative II – Proposed Action	9,200,000	2035-2039	257

2.2 Alternative I – No Action Alternative

Under the No Action Alternative, OSMRE would not recommend, and the ASLM would not approve, the proposed Federal mining plan modification to allow BBCM to mine Federal coal within 450 acres of Federal Coal Lease WYW-6266. The Federal coal resources contained within the Federal mining plan modification area would not be mined. Due to the relatively small size of the coal reserve, constraints due to a number of faults that isolate coal in the Federal mining plan modification area, oil and gas pipelines on the northern boundary, and its location at the margin of the existing BBCM pits, and economically recoverable depths, it is unlikely that BBCC, or any other coal operator, would be able to economically mine these Federal coal resources later in time once current operations move away from these lands.

The No Action Alternative describes the continuation of operation under the currently approved Federal mining plan and assumes that the additional coal within the tract would not be mined in the foreseeable future. Under the No Action Alternative, BBCC would be limited to recovering the remaining Federal coal reserves associated with existing Federal, State, and private leases. Because the existing Federal mining plan approvals already authorize the mining of some Federal coal, the environmental effects from this Federal coal mining are included in the No Action Alternative.

The BBCC indicated to OSMRE that it is unlikely that another operator would develop the Federal coal within the Federal mining plan modification area due to a number of compounding factors that would make it economically infeasible to invest the time and funds required to mine such a small area. The large overburden stripping ratio of 15:1 to the east of the proposed pit boundaries would preclude the expansion of mining beyond this area due to the high cost of having to move and store a large volume of spoil material. The presence of oil and gas pipelines to the north of the proposed Pit 15 boundary limits northward expansion.

Under the No Action Alternative, the life of mine would be 2032, with Pit 14 being the primary pit mined.

2.3 Alternative II – Proposed Action

Under Alternative II, the Proposed Action, OSMRE would recommend and the ASLM would approve the proposed Federal mining plan modification to modify the existing Federal mining plan to include mining of Federal coal within 450 acres of Federal Coal Lease WYW-6266, (see **Figure 2-1** and **Figure 2-2**) described as follows:

Sixth Principal Meridian, Wyoming

T. 19 N., R. 100 W.

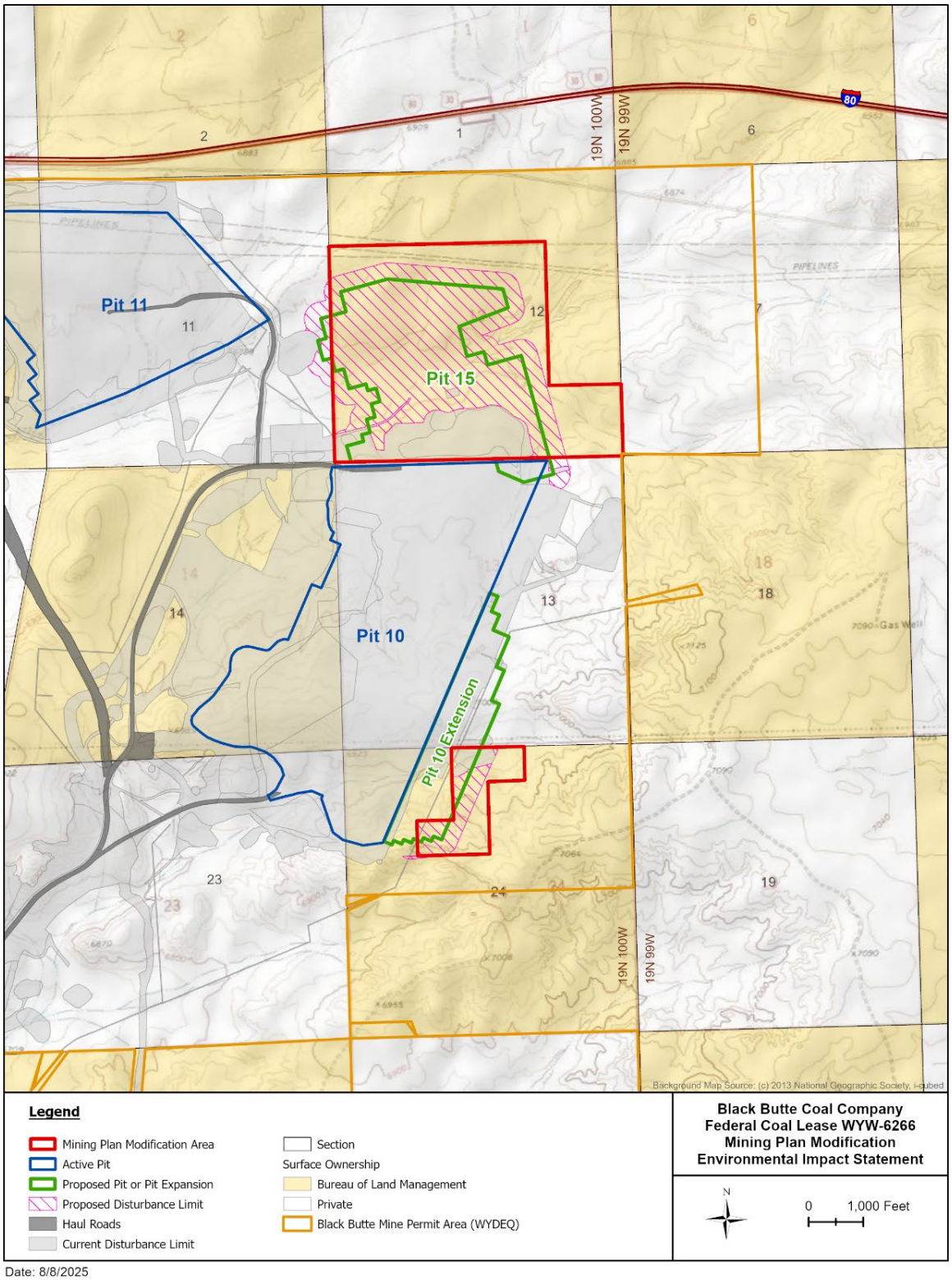
Section (Sec.) 12 SW¼NE ¼, S½NW¼, SW¼, W½SE¼, and SE¼SE¼; Sec. 24 NW¼NW¼NE¼, E½NE¼NW¼, and N½SE¼NW¼

Figure 2-1. Pit 15 Federal Mining Plan Modification Area Looking Toward Existing Pit 10

Mining the Federal coal at this time is feasible for BBCC because its existing infrastructure adjoins the Federal mining plan modification area, facilitating the mining of Federal coal with minimal additional infrastructure development requirements. Approval to mine the approximately 9.2 M tons of in-place mineable Federal coal in the Federal mining plan modification area is anticipated to add approximately 6 to 7 years to the existing life of mine (extending it from 2032 to 2039) but the mining is anticipated to occur over a 10 to 14-year period, depending upon power plant fueling requirements and potential future coal contracts.

The coal would be mined from two seams within the Fort Union Formation. The estimated recoverable reserves within the Federal mining plan modification area are predicated on several factors inclusive of inherent geologic and mining conditions, coal quality, mine economics, marketability, environmental concerns, and safety. The already mined Pit 10 forms the southern boundary of Pit 15. Mining would also occur southeast of Pit 10 within the proposed expansion area.

Figure 2-2. Federal Mining Plan Modification Area and Existing and Proposed Disturbance



Date: 8/8/2025

2.3.1 Surface Coal Mine

Surface coal production at the BBCM began in 1977. The BBCM complex is a dragline/dozer strip operation. Coal extraction at the BBCM is accomplished with front-end-loaders, shovels, or hydraulic excavator loading trucks. If the Proposed Action were approved, the proposed mining in the Federal mining plan modification area would use a dragline/dozer strip/truck shovel surface coal operation, similar to the existing mining methods found in the current Pit 10. Dozers, front-end-loaders, trucks, and/or scrapers would be used to remove topsoil in accordance with all WDEQ regulations in advance of mining operations. Both overburden and coal would require blasting or ripping before removal. Various sediment ponds, clean water diversions, or alternate sediment control structures would be used to provide surface water control within the disturbed areas. Final grading and topsoil distribution would be accomplished primarily with dozers, front-end-loaders, and trucks. **Figure 2-3** shows a dragline at the BBCM.

Figure 2-3. Dragline at the Black Butte Coal Mine

Coal production at the BBCM and destinations for produced coal over the last 5 years are presented in **Table 2-2**.

Table 2-2. Black Butte Coal Mine Coal Production and Destinations 2020-2024

Year	Destination	Tons	Method	One Way Mileage (miles)
2020	Jim Bridger Power Plant	2,221,876	Rail	17.32
2020	Tata Plant west of Green River	33,493	Rail	70.5
2020	PLS Laramie Plant	253	Truck	182
2020 Total		**2,255,622**		
2021	Jim Bridger Power Plant	1,713,900	Rail	17.32
2021	Tata Plant west of Green River	40,062	Rail	70.5
2021	PLS Laramie Plant	145	Truck	182
2021 Total		**1,754,107**		
2022	Jim Bridger Power Plant	1,642,277	Rail	17.32
2022	Valmy Station, NV	381,854	Rail	550
2022	PLS Laramie Plant	205	Truck	182
2022 Total		**2,024,336**		
2023	Jim Bridger Power Plant	1,544,938	Rail	17.32
2023	Valmy Station, NV	60,496	Rail	550
2023	Genesis Alkali	9,835	Rail	71.42
2023 Total		**1,615,269**		
2024	Jim Bridger Power Plant	376,092	Rail	17.32
2024	Valmy Station, NV	68,698	Rail	550
2024	Graymont - Delta, UT	3,693	Truck	350
2024 Total		**448,483**		

The BBCC is not currently producing coal and is instead reclaiming previously mined areas at the BBCM but anticipates going back into coal production in January 2027. The anticipated customer for the produced coal is the Jim Bridger Power Plant. Based on prior contracted coal sales along with discussions on future coal needs at the Jim Bridger Power Plant, BBCC anticipates yearly coal shipments to the Jim Bridger Power Plant would range from 700,000 to 1.3 M tons per year. These tons would be delivered via rail (BBCC 2024b).

The BBCC's current air quality permit allows for the mining of 5 M tons per year. However, based on the existing fleet of equipment currently at the BBCM, the strip ratios of available coal reserves, and the anticipated need for BBCC to blend coal qualities from different coal formations within the BBCM permit area, the top end of anticipated coal production would likely be 1.3 M tons per year (BBCC 2024b). Given anticipated coal pricing levels, a minimum of 500,000 tons per year would need to be produced to continue viable operations at the BBCM (BBCC 2024b). Therefore, the most reasonable assumption for production is that BBCM would

produce a minimum of 500,000 tons per year, but it is likely to produce more than the minimum annually—between 700,000 tons and 1.3 M tons per year.

Mine related surface disturbances have occurred within the Federal mining plan modification area to facilitate removal of coal leased by BBCC at an adjoining tract, as allowed under a separate existing BLM ROW agreement and the currently approved WDEQ mine permit.

Approximately 68 acres or 15 percent of the 450-acre Federal mining plan modification area has been previously disturbed by mining activities. These disturbances include existing access roads, a surface water retention basin, topsoil stripping to accommodate mining of the existing leased and fee coal, and topsoil and overburden stockpiles. As part of the Proposed Action, approximately 257 additional acres of the remaining approximately 382 undisturbed acres within the Federal mining plan modification area would be disturbed during extraction of the leased Federal coal. Coal from the BBCM would be transported by rail to the Jim Bridger Power Plant approximately 13 miles to the northwest (**Figure 2-4**).

Figure 2-4. Rail Load Out Facility at the Black Butte Coal Mine

2.3.2 Reclamation

Reclamation is an ongoing process that is concurrent with mining at the BBCM (**Figure 2-5**). The mine's reclamation plan for Pit 15 and Pit 10 expansion was approved as part of the overall mine permit by WDEQ in 2021. Acreages that are disturbed by mining are typically offset by reclaiming a similar amount each year. The State mine permit includes approximate postmining topography and a general reclamation timeline based on the expected mining sequence, which is updated in annual reports submitted to WDEQ and again for each 5-year term. Reclamation includes grading and contouring, followed by a rest period (approximately 1 year) and then re-application of topsoil, reseeding, and weed control. The seed mix used for re-vegetation would include a certified weed-free diverse seed mix of native grasses, forbs, and shrubs (as defined by existing range sites). A detailed channel restoration plan has been developed for the drainage through the proposed Pit 15.

BBCC would be required to post a reclamation performance bond for all areas physically disturbed by mining operations with the State of Wyoming to ensure that it complies with all of the reclamation requirements of the WDEQ permit and that reclamation requirements are met. Once mining and reclamation operations have been completed, BBCC would follow reclamation bond release procedures specified by WDEQ.

Reclamation bond release would occur after a minimum of a 10-year bond release period (post-completion of permanent reclamation operations) on stable reclaimed land where WDEQ re-vegetation standards have been met. WDEQ would release the full reclamation performance bond after strict reclamation standards have been met and the public has been provided an opportunity to comment.

Figure 2-5. Previously Mined and Reclaimed Slope (in Background) at the Black Butte Coal Mine

Before reseeding, all compacted areas would be scarified by ripping or chiseling to loosen compacted soils. Scarification promotes water infiltration, soil aeration, and root penetration. Scarification would be done when soils are dry to promote shattering of compacted soils. Seedbed preparation would be conducted immediately before seeding to prepare a firm seedbed conducive to proper seed placement and moisture retention, break up surface crusts, and eliminate weeds. It is anticipated that chiseling would be sufficient because it leaves a surface smooth enough to accommodate a tractor-drawn drill seeder but rough enough to catch broadcast seed and trap moisture and runoff.

Reclamation would attempt to re-establish native plant communities. Establishment of native species would support the site's postmining land uses of undeveloped rangeland for livestock grazing and wildlife habitat by stabilizing the soil, providing livestock and wildlife forage, and providing thermal, nesting, and parturition cover for wildlife. Reclamation operations would include a certified weed-free seed mix, equipment, and methods that are appropriate for arid plains conditions and those that have been successfully used for re-vegetation at the BBCM and other mines in the area. Fall and spring seeding would occur to take advantage of available moisture. During final reclamation and bond release, as specified in the BBCM mine permit, BBCC would obtain necessary authorizations from the appropriate regulatory agencies to vacate the reclaimed BBCM permit area. Following full bond release, BBCM would apply to WDEQ for termination of jurisdiction.

2.4 Resource Protection Measures

Beyond the BLM special lease stipulations (**Appendix A**), the resource protection measures discussed previously in ***Section 2.4.10*** are already incorporated into BBCC's permit issued by WDEQ and enforceable under SMCRA.

2.4.1 Air Quality

Dust Suppression

BBCC, pursuant to permits (i.e., Permits to Construct CT-105 and CT-288; Operating Permit OP-55; and Air Quality Permit P0026670), would treat access and haul roads with the application of a chemical dust suppressant to limit air quality impacts by fugitive dust emissions. All conveyor systems are covered to prevent the escape of coal dust. This includes all transfer points at the coal plant and the overland conveyor. In addition, the truck dump at the overland conveyor is equipped with water spray, which operates when the crusher and belts are running. While the overland conveyor would not service the Federal mining plan modification area, dust suppression activities at this area do lower the BBCM's overall emissions. The coal shipped from the BBCM is treated with a water spray as needed to prevent the release of coal dust during the train loading operation.

Reclamation operations are designed so that newly topsoiled areas remain bare for the minimal amount of time possible, as determined by current moisture and topsoil conditions. Seeding and mulching operations would begin as soon as moisture conditions allow, to reduce fugitive dust generation from unprotected areas of topsoil.

Employees are instructed to drive only on properly constructed roads and are restricted from off-road travel. Employees are also instructed on the proper operation of equipment, which would eliminate undue dust emissions (i.e., loading haul trucks with shovels using fully loaded buckets).

The main truck dump is operated to reduce dust emissions. To accomplish this, the hoppers are operated as fully as possible to minimize the free-fall distance of the coal. This involves close coordination between the plant, operator, and the coal pit foreman.

Blasting Emissions

The WDEQ LQD regulates blasting in surface coal mining in Wyoming in accordance with WDEQ LQD Rules and Regulations, Chapter 6. BBCC is currently working with blasting agent manufacturers to reduce nitrogen dioxide (NO_2) emissions by changing the size of the blasts and using different blasting agents, mixtures, and additives. BBCC has moved to using a hybrid explosive by adding substances like microspheres and rice hulls, using different blends of ammonium nitrate fuel oil (ANFO) and slurries and gels, using electronic detonation systems that can vary shot timing, different shot hole patterns, and using plastic liners within the shot holes.

BBCC has developed a very extensive air quality control plan. This air quality control plan can be broken down into a series of programs that are utilized across the BBCM and throughout the

year that are considered Best Available Control Technologies (BACT). BBCC's air quality programs monitor, track, and provide real time data to assist personnel onsite to make informed decisions about how operations are to be conducted to prevent deterioration of air quality, as described in the Wyoming Air Quality Permit Application for the Black Butte Mine Permit Modification (BBCC 2019). Blasting is timed to occur during optimal weather conditions and, based on past monitoring, has not resulted in particulate matter (PM) exceeding what is in the approved air quality permit for the BBCM (Permit Number P0026670) (WDEQ 2020a).

Particulate Emissions and Meteorological Monitoring

BBCC has been monitoring particulate matter with aerodynamic diameter nominally 10 microns or less (PM_{10}) ambient air quality levels around the BBCM throughout the life of operation and would continue to do so. The current ambient air monitoring network consists of five sites that monitor PM_{10} ambient air concentrations. The monitoring is done to determine the effectiveness of dust suppression efforts and to determine BBCM's compliance with air quality regulations.

The meteorological monitoring system at the BBCM consists of a 10-meter instrumented tower and uses a Campbell Scientific CR1000 datalogger to continuously measure wind speed, wind direction, standard deviation of horizontal wind direction, temperature, and precipitation. Hourly aggregate parameters are logged by the system. The meteorological site is located in Section 33, T. 19 N., R. 100 W., at 6,613 feet above mean sea level.

Using 1-hour and 24-hour ambient air PM_{10} concentration data, and opacity monitoring in combination with meteorological data, BBCM has instituted a real-time action plan to address elevated particulate emissions from activities at the BBCM. The actions outlined for implementation include ensuring adequate water trucks are operating, focusing watering on problem areas, recording the location and quantity of watering being performed, and up to shutting down all operations in the area. The actions are documented in BBCM's January 2006 Air Monitoring Action Plan as mandated by the Air Quality Permit P0026670.

2.4.2 Cultural/Historic Resources

Any unanticipated discoveries of archaeological or cultural remains would be reported to the BLM, OSMRE, and WDEQ. No land disturbing activities would take place within 250 feet of such remains until they have been evaluated by BLM-approved resource specialist, salvaged, if warranted, reviewed by the BLM, OSMRE, and WDEQ and authorization to proceed has been issued by the OSMRE Authorized Officer.

2.4.3 Paleontological Resources

Any unanticipated discoveries of paleontological resources would be reported to the BLM, OSMRE, and WDEQ. No land disturbing activities would take place within 250 feet of such resources until they have been evaluated by the BLM, or a BLM-approved resource specialist, salvaged, if warranted, and authorization to proceed has been issued by the BLM Authorized Officer.

2.4.4 Fire Control

Coal fires occur in exposed coal seams, and the mine operation in the Federal mining plan modification area proposes to limit the extent of these fires by removing the burning coal or covering the fire. Coal fires would be extinguished as quickly as possible to limit the loss of coal and to limit environmental impacts. The mine operation in the Federal mining plan modification area would have a water truck and a variety of earthmoving equipment available to use.

2.4.5 Soil Erosion Protection Measures

BBCC proposes minimizing soil erosion by using the following measures:

- Topsoil stockpiles would be planted with an appropriate certified weed-free seed mix.
- Seeding of reclaimed areas would occur after topsoil has been applied.
- Approved sediment control measures would be used when applicable.
- Surface disturbance would be limited to only those areas required by the operation.
- Extra caution would be used during wet weather to prevent excessive rutting.
- Any erosion occurring within the active mine area would be mitigated as necessary.

2.4.6 Water Pollution and Hydrologic Function Protection Measures

BBCC has installed all required groundwater monitoring wells. A plan for monitoring during and after mining has been developed with WDEQ consultation. Unsuitable overburden/interburden would be placed above the final anticipated groundwater recovery elevation and below the vegetation root zone.

Impacts on surface water would be minimized by timely reclamation of disturbed areas and by construction of ditches and berms to divert the flow of water off of disturbed land back into the pits or sediment ponds. Clean water diversions would be constructed around disturbed areas, and water would be routed back into downstream drainages when technically and topographically feasible. Alternate sediment control measures or sediment ponds would also be developed in consultation with the WDEQ. Controlled discharges from sediment ponds would occur if the ponds received inflow from a 10-year 24-hour precipitation event. Discharges from the ponds are required to meet Wyoming Pollutant Discharge Elimination System (WYPDES) permit discharge concentration limits. The existing BBCM permit area is hydrologically isolated, so all surface drainage stays in the area. In addition, sediment erosion control measures such as culverts and rerouting of minor drainages have occurred in the existing BBCM permit area to prevent unnecessary water erosion from occurring.

Reclamation of areas no longer needed for production is ongoing in mined areas, including grading the surface to an acceptable contour and reapplying salvaged soil to an acceptable depth over suitable overburden and reseeding of areas with a native plant seed mix. Additionally, reclamation activities following mining would re-establish existing drainages to similar locations and stream channel profile gradients to minimize the potential for head cutting of the stream

channels. Sedimentation in drainage channels from upland areas would be minimized by topographic moderation, seed bed preparation to encourage infiltration of precipitation, mulching (if necessary), and re-vegetation of upland areas into sustainable landforms. Storm water retention basins receiving water from disturbed areas would be left in place until re-vegetation is complete.

2.4.7 Wildlife Protection Measures

Big Game

The mining operations in the Federal mining plan modification area propose to minimize the impact of mining on big game (pronghorn antelope [*Antilocapra Americana*], mule deer [*Odocoileus hemionus*], and Rocky Mountain elk [*Cervus canadensis*]) by reclaiming the land for a postmining land uses of undeveloped rangeland for livestock grazing and wildlife habitat. The certified weed-free diverse seed mix would consist of native grasses, forbs, and shrubs (as defined by existing range sites), which support the postmining land uses.

During the mining operations in the Federal mining plan modification area, monitoring surveys would be conducted as required by the WDEQ and the Wyoming Game and Fish Department (WGFD). Results of the annual monitoring surveys, existing baseline surveys, and future baseline surveys would be used to further define areas of concern and to identify developing mitigation needs.

Greater Sage-grouse

No greater sage-grouse (*Centrocercus urophasianus*) leks occur within the Federal mining plan modification area. Should any birds be found during additional field surveys or should any new leks become established, appropriate mitigation steps would be taken voluntarily by BBCC. These steps may include any or all of the following techniques: re-establishment of shrubs on reclaimed lands; grading of reclaimed lands to include swales and depressions; and monitoring of greater sage-grouse leks in the area before, during, and after mining. These and other measures are components of the WDEQ permit amendment.

2.4.8 Public Health and Safety

BBCC would conduct all operations within the Federal mining plan modification area in accordance with Mine Safety and Health Administration (MSHA) regulations and procedures. Active areas of Pit 10 and Pit 15 would be bermed or signed to prevent accidental entrance. Blasting areas within the BBCM and blasting schedules would be posted in the area newspapers. All applicable laws concerning the handling and disposal of hazardous wastes would be followed. Spill Prevention, Control, and Countermeasure (SPCC) plans would be updated periodically and kept on file at the BBCM for use in case of spills.

2.4.9 Noise Impacts

The nearest town and inhabited dwellings, Point of Rocks, Wyoming, are approximately 8 miles to the northwest of the Federal mining plan modification area. The prevailing wind direction at the BBCM is from the west (see ***Section 3.2***). This wind direction and the spatial separation

from Point of Rocks would minimize or eliminate impacts from the BBCM related noise to residents of Point of Rocks.

Visitors to the BBCM area may be exposed to occasional blast noise; however, it is very unlikely that the public would be exposed to high-decibel mine noise. Under certain blasting circumstances, Interstate 80 is shut down and patrolled for public safety. It is not anticipated that the proposed operation in the Federal mining plan modification area would require this process as a safety precaution. BBCC employees would be required to wear hearing protection in areas where the noise level may cause hearing damage.

2.4.10 Wetlands

During June 2012, BBCC submitted documentation for a jurisdictional determination request concerning Pit 3, Pit 10, and Pit 11 to the United States Army Corps of Engineers (USACE), Omaha District, Wyoming Regulatory Office. On March 8, 2013, BBCC received a response to the jurisdiction request, which concluded that there are no drainages in these pit areas with evidence of wetlands as defined by the *Corps of Engineers Wetland Delineation Manual*. None of the drainages convey flow sufficient enough to establish physical indicators of an ordinary high-water mark as defined at 33 CFR § 328.3(e). Therefore, the disturbance area for Pit 10 is entirely in upland. Mitigation of disturbance to any identified existing wetlands would be accomplished by creating wetlands in kind.

The proposed Pit 15 area contains an ephemeral drainage that is not considered a jurisdictional Water of the U.S. and is therefore not subject to the Clean Water Act (Tetra Tech, 2025). Following mining, impacted drainages would be reconstructed to a topographical expression and location similar to the former drainage.

2.5 Alternatives Considered but not Analyzed in Detail

NEPA requires that an agency consider a reasonable range of alternatives to the Proposed Action. Reasonable alternatives comprise a reasonable range of alternatives that are technically and economically feasible; meet the purpose and need for the proposed action; are within the jurisdiction of the agency; and, where applicable, meet the goals of the applicant.

OSMRE considered whether to analyze in detail an alternative that would sunset the Federal mining plan modification approval for Federal coal after a certain time period, commonly referred to as a partial mining alternative. When OSMRE has considered this alternative for other mines, the sunset would occur approximately 5 years after the Federal mining plan modification approval because, among other things, a 5-year timeframe is consistent with the permit approval and 5-year permit term period under SMCRA. OSMRE did not analyze this alternative here because sunsetting the Federal mining plan modification approval after 5 years would significantly disrupt the operation, impacting the economics and operations in a manner that would not meet the purpose and need for the Proposed Action and would frustrate the goals of the applicant (516 DM 1, Section 6.1(t)). The Proposed Action would likely extend mining at the BBCM for approximately 7 years but will actually be mined over the next 10-14 years because BBCC intends to blend coal from various sources within the permit area to meet the specifications of its coal contracts. Limiting BBCM's authorization to mine coal from the

Federal mining plan modification area to 5 years would likely impact mining throughout the larger permit area, as the mine would have to account for a limitation in the supply of coal needed for blending to meet specific contract requirements. As such, a 5-year term would not be technically or economically feasible as it would likely impact the viability of mining activities both within and outside of the Federal mining plan modification area. In addition, reconsideration of this matter in such a short timeframe would be an inefficient use of agency resources and is contrary to the national energy emergency outlined in EO 14516.

No other alternatives were suggested or identified that met the purpose and need of this Federal action and accomplished the goals of the applicant.

3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

This section describes the existing environment of the area that would be affected by the No Action Alternative (Alternative I) and the Proposed Action (Alternative II) and discloses the potential effects of implementing these alternatives. Past and present actions are discussed in the Affected Environment and the reasonably foreseeable future actions (RFFAs) are discussed in the Environmental Consequences under Incremental Impacts, regardless of which agency (Federal or non-Federal) or person undertakes such actions. Short-term effects are defined as effects that last through mining and reclamation activities. Long-term effects are defined as effects that last beyond mining and reclamation activities.

As mining activity from other portions of the BBCM would occur under both the Proposed Action and the No Action Alternative, the No Action Alternative is presented under each resource discussed for reference to display the difference between continuation of existing permitted mining activity under the No Action Alternative and continuation of existing permitted mining activity that includes the proposed Federal mining plan modification area that would occur under the Proposed Action.

The issues identified in ***Section 1.8*** and associated potential impacts are discussed for the No Action Alternative (Alternative I) and the Proposed Action (Alternative II).

3.1 Past, Present, and Reasonably Foreseeable Future Actions

3.1.1 Past and Present Actions

Approximately 68 acres or 15 percent of the Federal mining plan modification area has been previously disturbed by coal mining activities under a separate existing BLM ROW agreement. These disturbances include existing access roads, a surface water retention basin, topsoil stripping to accommodate mining of the existing leased and fee coal, and topsoil and overburden stockpiles. Other previous disturbances within the Federal mining plan modification area include scattered oil and gas exploration, production, and transport (i.e., pipelines); exploration drilling for coal in support of BBCM; and livestock grazing (i.e., cattle and sheep). The Federal mining plan modification area is adjacent to an interstate highway transportation corridor and numerous subsurface oil and gas pipelines. Past and present actions occurring nearby but outside the Federal mining plan modification area include other oil and gas activities and livestock grazing. These past and present actions contribute to the Affected Environment. The discussion of past, present, and RFFAs in this chapter considers the impacts of other activities and processes in the area as reasonably foreseeable environmental trends and planned actions to provide context for the comparison between the Proposed Action and the No Action Alternative.

3.1.2 Reasonably Foreseeable Future Actions

The RFFAs are decisions, funding, or formal proposals that are either existing or are probable within the next 14 years (based on maximum life of mine of 2039 under the Proposed Action). The RFFAs identified as occurring within the overall impact assessment area include future oil and gas exploration, production, and transport (i.e., pipelines); exploration drilling for coal in support of BBCM; livestock grazing (i.e., cattle and sheep); and potentially future coal leases

and sales. These RFFAs would contribute to the incremental impacts of the Proposed Action in the Environmental Consequences.

Notably, President Trump recently signed into law, Public Law No. 119-21, commonly referred to as the One Big Beautiful Bill (OBBB), which directs the Secretary of the Interior to make available for lease at least 4 M acres of known recoverable coal resources, which may impact recovery of Federal coal in and around the BBCM area, but the location of any future Federal coal leases as a result of the OBBB are unknown at this time and too speculative to analyze in this EIS. The Wyoming BLM State Office has not received any lease application proposals from either the Jim Bridger Coal Mine or BBCM since passage of the law. At this time, neither of the coal mines in the area have indicated that they will be leasing additional coal in the near future. However, BLM is preparing for additional sales in 2025 elsewhere in the State that are the direct result of the OBBB and there is some possibility that the Jim Bridger Coal Mine or BBCM may seek new leases in the future.

3.1.3 Analysis Assumptions and Guidelines

The relationship between the short-term use of the environment versus the long-term productivity as it relates to the extraction of coal, and resource use sustainability, are intertwined with effects. The mining of 9.2 M tons of in-place mineable Federal coal from the Federal mining plan modification area would be a short-term use of the environment that would benefit the short-term productivity of the BBCM. WDEQ permitting and Secretary of the Interior approval of the Federal mining plan modification would be required before mining could occur. The mining plan and reclamation plan are designed to protect the long-term productivity of resources after the cessation of mining.

Mining would alter many natural resources in the short term; however, the required topsoil salvaging and replacement, topographic recontouring, and re-vegetation would promote the following long-term resource effects:

- Soil productivity re-establishment;
- Native vegetation re-establishment;
- Wildlife re-habitation;
- Livestock grazing use;
- Groundwater resource recovery; and
- Surface water and watershed function stabilization.

The function of these resources and resource uses would return to a condition approximating pre-mining conditions. To provide a clear context of the relationship between short-term use of the environment and long-term productivity, further discussions of these relationships are presented in pertinent resource impact analysis subsections within this section.

Unless otherwise specified, “short-term” is the period starting with the development of the Federal mining plan modification area, mining of Federal coal, and ending with surface reclamation and vegetation seeding, and is anticipated to last approximately 10 to 14 years from

the initiation of mining. “Long- term” is defined as those effects that would occur or remain after surface reclamation has been performed and includes the monitoring and bond release period and beyond. Long-term effects could potentially last, as in the case of groundwater table recovery 60 to 240 years; however, most resource impacts are anticipated to be much shorter in duration.

Effects are quantified where possible, primarily by GIS applications. In the absence of quantitative data, resource specialists use their best professional judgment. The effects are sometimes described using a range of the intensity in qualitative terms. All mining and reclamation operations would comply with SMCRA, Wyoming statutes, and the BLM special lease stipulations. These regulations are designed to ensure that surface coal mining impacts are mitigated. This impact assessment considers all standing measures required by Federal and State regulatory authorities as part of the Proposed Action and No Action Alternative. This impact assessment assumes that the resource protection measures described in ***Section 2.4*** would be successfully implemented.

3.2 Air Quality/Greenhouse Gases

Air Quality

The impact assessment area for alternatives impact analyses for air quality includes the Federal mining plan modification area. Incremental impact analyses for air quality assess a larger regional airshed. The issues identified for impact analysis for air quality are pollutant emissions from the mining of coal in the Federal mining plan modification area relative to the WAAQS, NAAQS, and their impact on the regional airshed.

The past and present actions within the alternatives impact analysis area (i.e., Federal mining plan modification area) for air quality are scattered oil and gas exploration, production, and transport (i.e., pipelines); exploration drilling for coal in support of BBCM; livestock grazing (i.e., cattle and sheep); and BBCM coal mining activities under a separate existing BLM ROW agreement.

The RFFAs within the incremental impact analysis area (i.e., Federal mining plan modification area) for air quality are scattered oil and gas exploration, production, and transport (i.e., pipelines); exploration drilling for coal in support of BBCM; livestock grazing (i.e., cattle and sheep); BBCM coal mining activities under a separate existing BLM ROW agreement; and potential new coal leases facilitated by the OBBB.

Global GHG Emissions

The impact analysis area for alternatives impact analyses for GHGs is the State of Wyoming. The impact analysis area for incremental impact analysis for GHGs is global. The issues identified for impact analysis for GHGs are the BBCM’s contribution from the mining of coal in the Federal mining plan modification area and the combustion of that coal relative to Wyoming, national, and global GHG emissions and qualitative impacts resulting from those emissions.

The past and present actions within the alternatives impact analysis area (i.e., the State of Wyoming) for GHGs are fossil fuel combustion from the electrical power industry, industrial sector, transportation sector, and commercial sector.

The RFFAs within the incremental impact analysis area (i.e., global) for GHGs are fossil fuel combustion from the electrical power industry, industrial sector, transportation sector, and commercial sector.

3.2.1 Affected Environment

3.2.1.1 Criteria Pollutants and Air Quality Standards

The Clean Air Act (CAA) requires the Environmental Protection Agency (EPA) to set NAAQS[1] for six air contaminants, known as criteria pollutants, which can be harmful to public health and the environment (EPA 2025a). These criteria pollutants are particulate matter 10 micrometers (μm) or less (PM_{10}), particulate matter 2.5 μm or less ($PM_{2.5}$), nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), ozone (O_3), and lead (Pb). O_3 is not emitted directly but is formed secondarily through atmospheric photochemical reactions. Nitrogen oxides (NO_x) and volatile organic compounds (VOCs) are not criteria air pollutants but contribute to the formation of ground level O_3. In addition to the NAAQS, the WDEQ Air Quality Division (AQD) has statewide WAAQS (WDEQ 2024a).

The NAAQS include both primary and secondary standards. Primary standards provide public health protection, including protecting the health of sensitive populations such as asthmatics, children, and the elderly. Secondary standards provide environmental and public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings (EPA 2025a).

The NAAQS have been developed for short-term periods of 24 hours or less as well as long-term annual averages. The units of measure for the standards are parts per million (ppm) by volume, parts per billion (ppb) by volume, or micrograms per cubic meter ($\mu g/m^3$) of air. The current primary and secondary NAAQS and WAAQS are presented in **Table 3-1.**

[1] Title 40 CFR Part 50

Table 3-1. National and State of Wyoming Ambient Air Quality Standards

Pollutant	Averaging Time	NAAQS (Primary Standard)			NAAQS (Secondary Standard)			WAAQS (Primary Standard)		
		(ppm)	(ppb)	($\mu g/m^3$)	(ppm)	(ppb)	($\mu g/m^3$)	(ppm)	(ppb)	($\mu g/m^3$)
CO	1-hour	35	---	---	None			35	---	---
	8-hour	9	---	---	None			9	---	---
Pb	Rolling 3-month average	---	---	0.15	---	---	0.15	---	---	0.15
NO_2	1-hour	---	100	---	None			---	100	---
	Annual (Arithmetic Mean)	---	53	---	---	53	---	---	53	---
O_3	8-hour	0.070	---	---	0.070	---	---	0.070	--	---
$PM_{2.5}$	Annual (Arithmetic Mean)	---	---	9.0	---	---	15.0	---	---	9.0
	24-hour	---	---	35	---	---	35	---	---	35
PM_{10}	24-hour	---	---	150	---	---	150	---	---	150
	Annual (Arithmetic Mean)	None						---	---	50
SO_2	1-hour	---	75	---				---	75	---
	Annual (Arithmetic Mean)	None			---	10	---	0.5	---	---

Source: EPA 2025a and WDEQ 2024a

Under the CAA, the EPA must designate areas as either meeting or not meeting NAAQS (EPA 2024a). If the air quality in a geographic area meets or is cleaner than the NAAQS, it is called an attainment area (designated attainment/unclassifiable); areas that do not meet the NAAQS are called nonattainment areas. In some cases, EPA is unable to determine an area's status after evaluating the available information and those areas are designated unclassifiable (EPA 2024b).

On October 1, 2015, the EPA strengthened the NAAQS for ground-level O_3 to 70 ppb from the previous 2008 standard of 75 ppb. Currently, all of Wyoming's counties are meeting the O_3 NAAQS of 70 ppb and have been designated as attainment/unclassifiable by the EPA. In July 2012, the EPA designated all of Sublette County and portions of Lincoln and Sweetwater counties as an O_3 nonattainment area, collectively known as the Upper Green River Basin Ozone Nonattainment Designation Area. Monitored O_3 in the Upper Green River Basin Ozone Nonattainment Designation Area was in attainment for the 2008 O_3 NAAQS (75 ppb) by the attainment date of July 2015. The Upper Green River Basin Ozone Nonattainment Designation Area remains classified as a nonattainment area. The WDEQ is assessing a request to the EPA to redesignate the Upper Green River Basin Ozone Nonattainment Designation Area as attainment based on the 2008 O_3 NAAQS (WDEQ 2025a). The Upper Green River Basin Ozone Nonattainment Designation Area is the only nonattainment designated area in Wyoming. All other counties in Wyoming are meeting all NAAQS and have been designated as attainment/unclassifiable by the EPA.

3.2.1.2 Ambient Air Quality Monitoring

The CAA also requires states to develop a general plan to attain and maintain the NAAQS in all areas of the country and a specific plan to attain the NAAQS for each designated nonattainment area. These plans, known as State Implementation Plans (SIPs), are developed by State and local air quality management agencies and submitted to EPA for approval (EPA 2024a). Once the EPA approves all or part of a SIP, those control measures are enforceable in Federal court. EPA's approved SIP for the State of Wyoming is codified in 40 CFR §52.2620. The EPA has delegated responsibility for many provisions of the CAA to the State of Wyoming, including demonstrating compliance with NAAQS. The WDEQ is responsible for monitoring the levels of criteria pollutants to demonstrate compliance with NAAQS in the State of Wyoming. In order to maintain the ambient air quality in accordance with the NAAQS for the seven criteria pollutants, the WDEQ AQD operates and maintains a network of ambient air quality monitors, AQD's State and Local Air Monitoring Stations (SLAMS), Special Purpose Monitors, and mobile monitoring locations.

The nearest SLAMS monitor is in Rock Springs, approximately 30 miles (48 kilometers) west of BBCM as shown in **Figure 3-1**. The location of the Wamsutter and James Town monitoring stations are also shown in **Figure 3-1**. The locations of all of the WDEQ monitors are shown in **Figure 3-2**. Ambient air quality concentrations for criteria pollutants from the monitoring stations in Sweetwater County for the three most recent years are shown in **Table 3-2** which also shows that Sweetwater County is currently in compliance with the NAAQS.

Table 3-2. Monitored Values for WDEQ Air Monitoring Stations Located in Sweetwater County

Pollutant	Averaging Time	Monitoring Station	2022	2023	2024	3 Year Average	% of NAAQS
NO_2	1-hour (98^{th} percentile of 1-hour daily maximum concentrations averaged over 3 years)	Moxa Arch	13 ppb	13 ppb	15 ppb	14 ppb	14%
		Wamsutter	30 ppb	31 ppb	33 ppb	31 ppb	31%
	Annual (Mean)	Moxa Arch	1.39 ppb	1.55 ppb	1.22 ppb	1.39 ppb	3%
		Wamsutter	3.01 ppb	2.7 ppb	2.3 ppb	2.7 ppb	5%
O_3	8-hour (annual 4^{th} highest daily maximum 8-hour concentration averaged over 3 years)	Moxa Arch	0.061 ppm	0.076 ppm	0.072 ppm	0.070 ppm	100%
		Wamsutter	0.061 ppm	0.067 ppm	0.070 ppm	0.066 ppm	94%
SO_2	1-hour (annual 99^{th} percentile of 1-hour daily maximum concentrations averaged over 3 years)	Moxa Arch	8 ppb	7 ppb	6 ppb	7 ppb	9%
	Annual (Mean averaged over 3 years)	Moxa Arch	0.16 ppb	0.44 ppb	0.67 ppb	0.42 ppb	4%
PM_{10}	24-hour (Not to be exceeded more than once per year on average over 3 years.)	Moxa Arch	43 $\mu g/m^3$	47 $\mu g/m^3$	37 $\mu g/m^3$	42 $\mu g/m^3$	28%
		Wamsutter	51 $\mu g/m^3$	49 $\mu g/m^3$	76 $\mu g/m^3$	59 $\mu g/m^3$	39%
$PM_{2.5}$	24-hours (98^{th} percentile averaged over 3 years)	Rock Springs	10 $\mu g/m^3$	11 $\mu g/m^3$	12 $\mu g/m^3$	11 $\mu g/m^3$	31%
	Annual (Mean averaged over 3 years)		4.3 $\mu g/m^3$	3.7 $\mu g/m^3$	3.2 $\mu g/m^3$	3.7 $\mu g/m^3$	41%

Source: EPA 2025b

Figure 3-1. Location of Near-field PM_{10} Ambient Air Quality Monitors

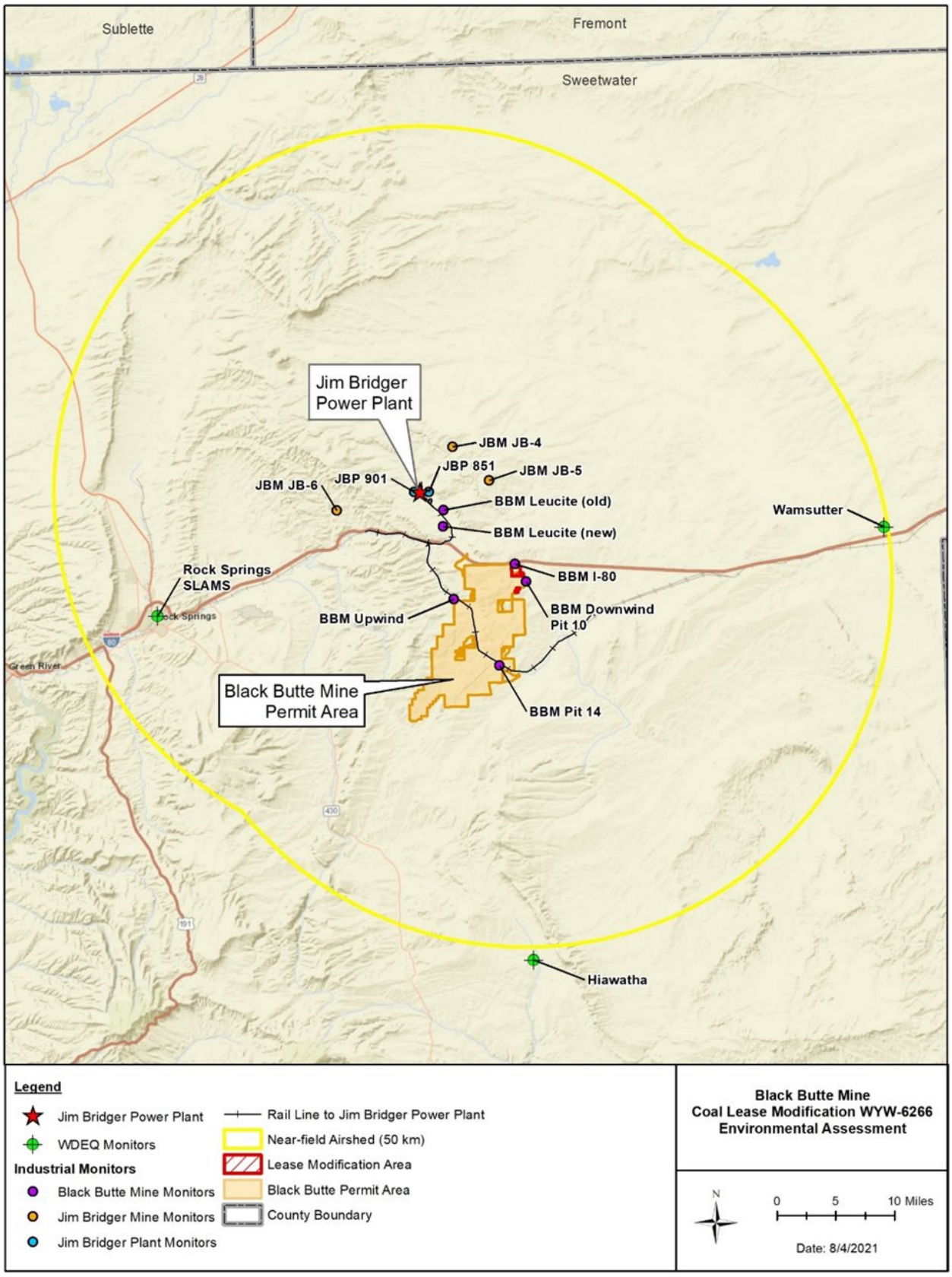
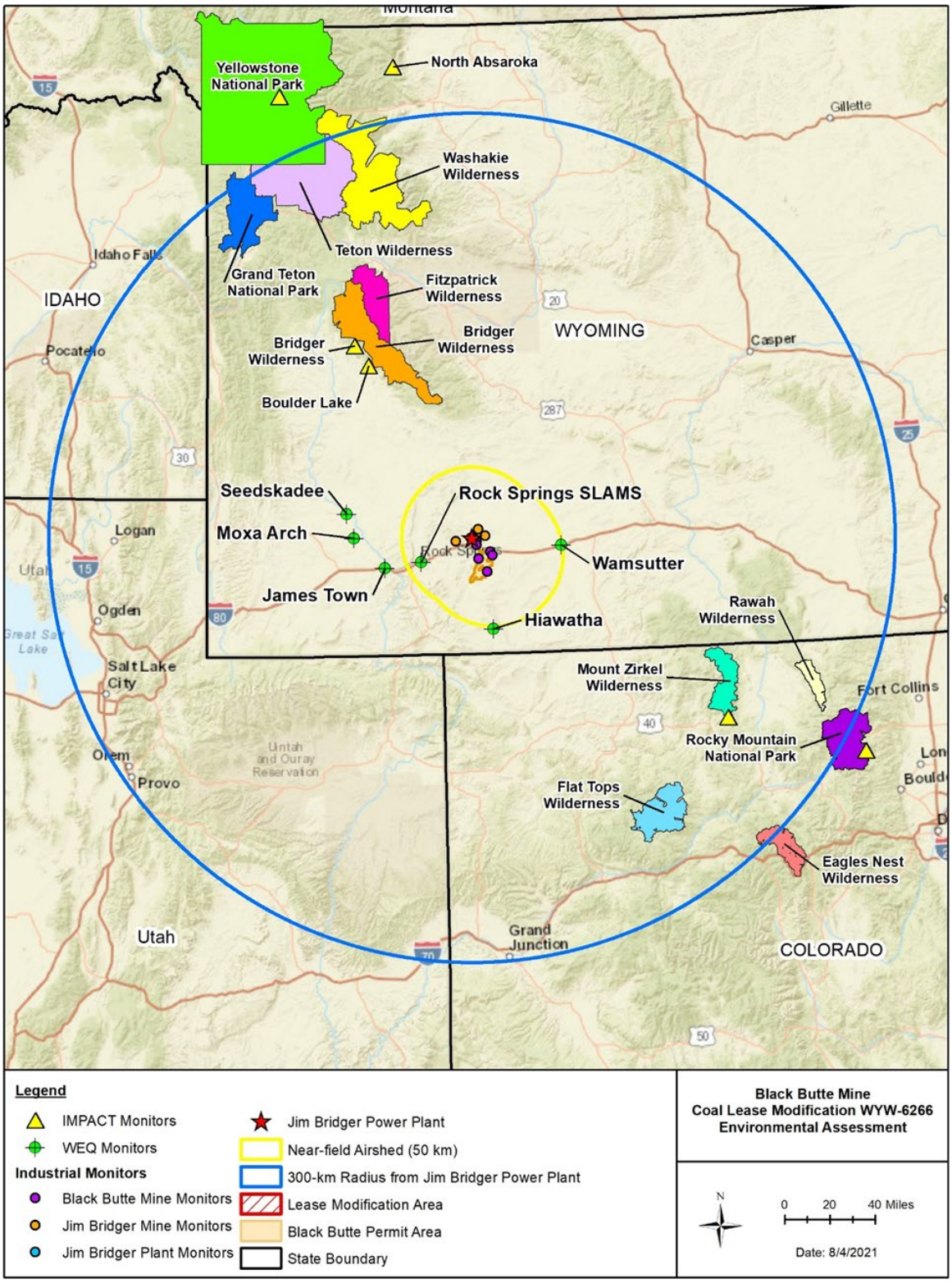


Figure 3-2. Locations of Ambient Air Quality Monitoring Stations



BBCC operates an extensive ambient air monitoring network, measuring PM_{10} concentrations at the BBCM as required by BBCC's air quality permit. Bridger Coal Company operates a PM_{10} monitoring network at the neighboring Bridger Mine and PacifiCorp also monitors PM_{10} concentrations at the nearby Jim Bridger Power Plant as required by the air quality permits for these sites. The locations of these industrial air monitors can be seen in **Figure 3-1**.

Particulate concentration summaries for the BBCM and Jim Bridger Power Plant and Jim Bridger Coal Mine are presented in **Table 3-3** and **Table 3-4**, respectively, for the last 3 years (2022 through 2024). The 24-hour NAAQS for PM_{10} is 150 µg/m^3, which is not to be exceeded more than once per year on average over 3 years; therefore, one exceedance is allowed per year on average. The 24-hour concentration of each day is used to calculate the annual arithmetic mean to determine compliance with the Annual PM_{10} WAAQS of 50 µg/m^3.

Table 3-3. Black Butte Coal Company Monitored PM_{10} Concentrations (2022-2024)

WAAQS PM_{10} Standards = 50 µg/m^3 Annual, 150 µg/m^3 24-Hour				
Year	**Site**	**Annual Average**	**24-Hour 1st High**	**24-Hour 2nd High**
2022	I-80	14.4	102.8	95.7
	Upwind	13.5	87.7	54.0
	Pit 10	16.8	268.6	149.3
	Pit 14	13.0	103.7	53.1
	Pit 15	13.5	62.4	48.8
2023	I-80	11.8	362.1	64.7
	Upwind	11.1	42.3	39.3
	Pit 10	14.9	136.9	99.7
	Pit 14	11.0	45.8	45.3
	Pit 15	12.2	102.9	58.0
2024	I-80	12.3	117.7	62.8
	Upwind	11.7	58.3	54.1
	Pit 10	13.3	189.7	90.5
	Pit 14	13.6	103.8	90.3
	Pit 15	12.7	73.3	56.7

Source: IML Air Science 2023a; Pace Analytical Services 2024a, and 2025a

Table 3-4. Jim Bridger Power Plant and Jim Bridger Coal Mine Monitored PM_{10} Concentrations (2022-2024)

WAAQS PM_{10} Standards = 50 µg/m^3 Annual, 150 µg/m^3 24-Hour				
Year	**Site**	**Annual Average**	**24-Hour 1st High**	**24-Hour 2nd High**
2022	851 (downwind)	25.4	126.0	62.0
	901 (Upwind)	13.3	164.6	28.0
	JB4	14.6	84.7	67.1
	JB5	21.3	148.8	126.1
	JB6	13.7	121.8	81.1
2023	851 (downwind)	19.5	113.7	67.5
	901 (Upwind)	11.4	28.3	25.3
	JB4	10.0	104.8	46.3
	JB5	12.9	148.7	84.2
	JB6	11.4	72.9	59.9
2024	851 (downwind)	23.7	149.6	144.6
	901 (Upwind)	13.2	53.4	45.2
	JB4	11.6	62.3	45.0
	JB5	15.5	100.1	59.9
	JB6	16.9	104.0	73.0

Source: Trinity Consultants 2023, 2024, and 2025; IML Air Science 2023b; and Pace Analytical 2024b, and 2025b

Major stationary sources for criteria air pollutants are sources that emit or have the potential to emit 100 tons per year (tpy) or more of any air pollutant.

3.2.1.3 Prevention of Significant Deterioration and Airshed Classification

The Prevention of Significant Deterioration (PSD) applies to new major sources or major modifications to existing sources located in attainment or unclassifiable areas. For PSD applicability, there are two thresholds that define a major source for a federally regulated new source review (NSR) pollutant as follows:

- For source categories listed in 40 CFR §52.21(b)(1)(i)(a), sources are major if they have a potential to emit (PTE) 100 tpy or more of a regulated pollutant; and
- All other sources that are not listed are major if they have a PTE of 250 tpy or more of a regulated pollutant.

Under PSD regulations, air sheds are assigned a priority class (I, II, or III) which describes how much degradation to the existing air quality is allowed to occur within the area. Class I areas are areas of special national or regional natural, scenic, recreational, or historic value, and essentially allow minimal degradation in air quality (e.g., National Parks and Wilderness Areas). Class II

areas allow for reasonable economic growth and associated emissions. Class III areas allow for substantial economic growth and associated emissions.

There are no Class I or Class II sensitive areas within 10 miles of the Federal mining plan modification area. The closest Class I areas, shown in **Figure 3-2**, include the Bridger Wilderness on the Bridger-Teton National Forest, which is approximately 70 miles to the northwest, and the Mount Zirkel Wilderness on the Medicine Bow-Routt National Forest, which is approximately 103 miles to the southeast, of the Federal mining plan modification area. Nearby Class II areas include Seedskadee National Wildlife Refuge (NWR), which is 56 miles to the northwest; Pathfinder NWR, which is 97 miles to the northeast; Browns Park NWR, which is 56 miles to the southeast; Dinosaur National Monument, which is 61 miles to the south; and Flaming Gorge National Recreation Area, which is 40 miles to the southwest of the Federal mining plan modification area.

3.2.1.4 Visibility

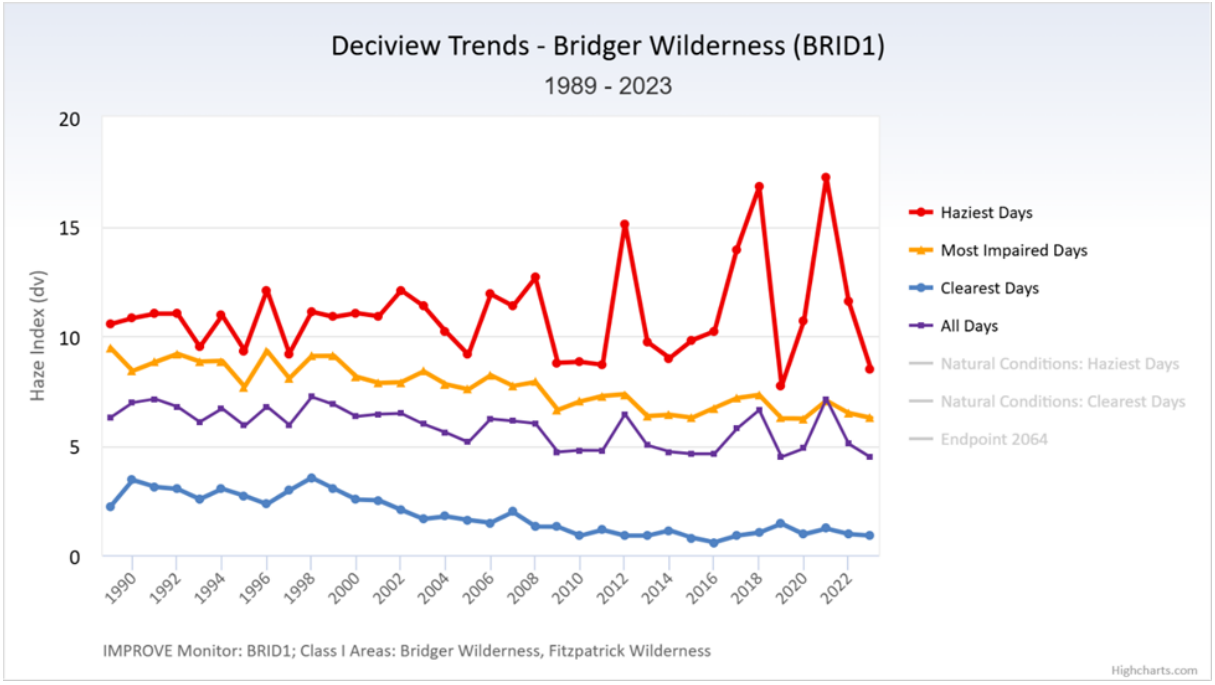
The visibility in Class I areas, as an Air Quality Related Value (AQRV), must be monitored based on the Regional Haze Rule (CAA 169A and 169B, 40 CFR part 51, subpart P). Visibility impairment refers to the reduction in clarity of landscapes and scenic vistas from a distance resulting from human air pollution. The Regional Haze Rule requires states to coordinate with Federal agencies and other interested parties to develop a SIP to reduce the pollution that causes visibility impairment and meet the national goal of no anthropogenic visibility impairment by 2064. Visibility reduction is caused by aerosols or small particles in the atmosphere which scatter and absorb light, thus, impacting visibility. Substances in the atmosphere associated with visibility impairment are ammonium sulfate aerosols, ammonium nitrate aerosols, organic carbon, and elemental carbon. Emissions of NO_x, SO_2, VOCs, and fine particulates ($PM_{2.5}$) may be contributors to the concentrations of these substances as precursors. Visibility impairment, or haze index, is measured in deciviews (dv), which is a measure of light extinction such that uniform dv changes in the haze index correspond to uniform incremental changes in visual perception. The dv scale is zero for pristine conditions and increases as visibility degrades. Average visual range in many Class I areas in the west is 60 to 90 miles (100 to 150 kilometers), equivalent to 13.6 to 9.6 dv (64 Federal Register 35714).

The primary anthropogenic sources of visibility impairment in Wyoming Class I areas include electric utility steam generating units, energy production and processing sources, aggregate and mineral processing and manufacturing sources, chemical manufacturing sources, and fugitive dust sources (WDEQ 2020b).

The purpose of the Interagency Monitoring of Protected Visual Environments (IMPROVE) network is to establish current visibility and aerosol conditions and characterize broad regional trends and visibility conditions using monitoring data collected at or near Class I areas across the United States. The active IMPROVE monitoring locations within 186 miles (300 kilometers) of the Jim Bridger Power Plant are shown in **Figure 3-2** and the visibility trends for the three closest Class I area monitors are shown in **Figure 3-3** through **Figure 3-5**. Visibility conditions, within the context of the Regional Haze Rule, are described in terms of the haze index on the 20% worst visibility days (haziest days) and 20% best visibility days (clearest days). All of the active IMPROVE monitoring site locations show a trend of decreased haze index (increased

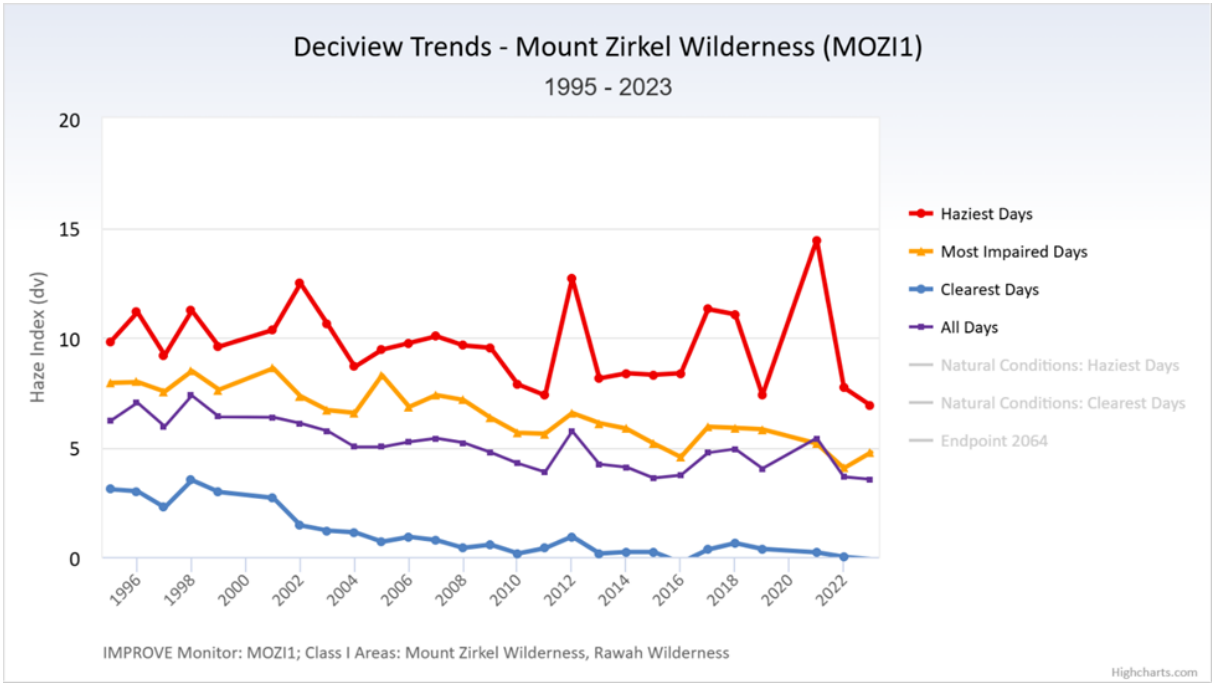
visibility) on most impaired days, clearest days, and all days. The Mount Zirkel Wilderness Area IMPROVE monitoring site also shows a significant trend of decreased haze index (increased visibility) on haziest days.

Figure 3-3. Bridger Wilderness Visibility Trends



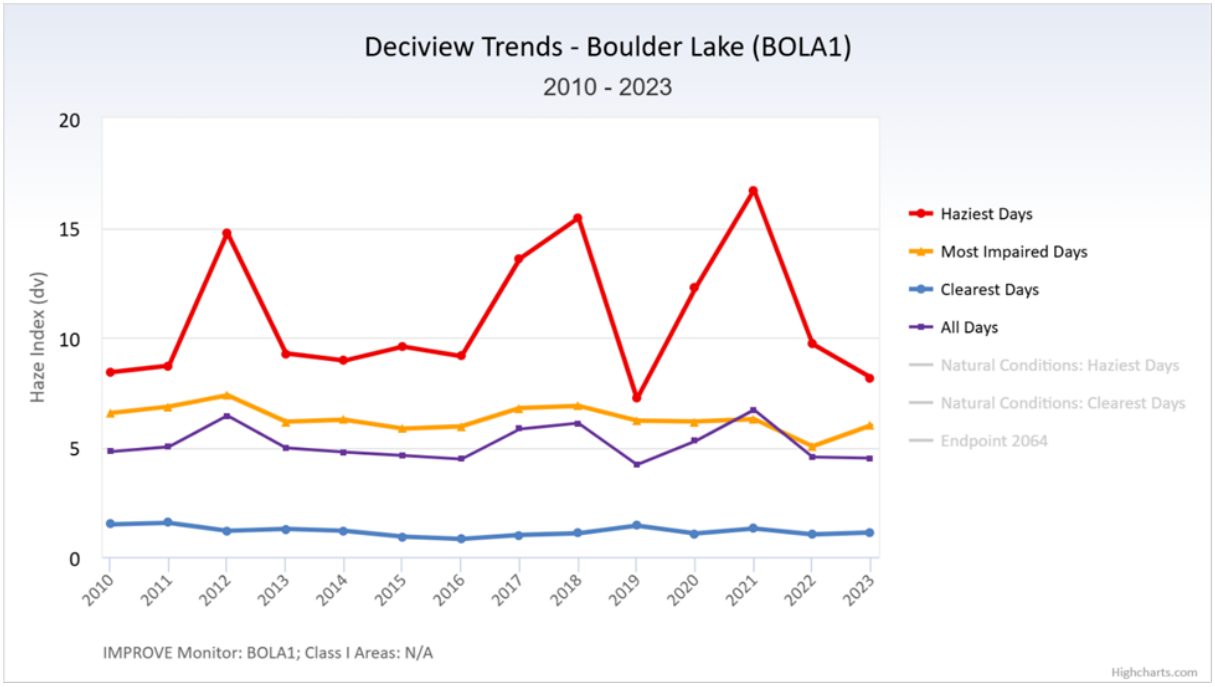
Reference: (FED 2025)

Figure 3-4. Mount Zirkel Wilderness Visibility Trends



Reference: (FED 2025)

Figure 3-5. Boulder Lake Visibility Trends



Reference: (FED 2025)

3.2.1.5 National Emission Standards for Hazardous Air Pollutants

Hazardous Air Pollutants (HAPs), also known as toxic air pollutants or air toxics, are those pollutants that are known or suspected of causing cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects (EPA 2024c). Under Section 112 of the CAA, known as the National Emission Standards for Hazardous Air Pollutants (NESHAPs), the EPA is required to regulate emissions of HAPs. The original list included 189 pollutants, which EPA has modified through rulemaking and currently includes 188 HAPs, including pollutants such as asbestos, benzene, chlorine, and mercury compounds. Most air toxins are generated from mobile or stationary anthropogenic sources (originating from human activity). The Wyoming Air Quality Standards and Regulations (WAQSR) incorporate the EPA regulations at 40 CFR Part 63 by reference under Section 3 of Chapter 5 of Wyoming's air quality regulations (Wyoming Administrative Code 020.0002.5 § 3).

Major stationary sources for HAPs are sources that emit 10 tpy of any single listed HAP or 25 tpy of all HAPs combined. Major HAPs sources are subject to a case-by-case determination of maximum achievable control technology pursuant to 40 CFR §63.42(c), which are specific to the industrial source category. Area sources are defined as smaller facilities that release less than 10 tpy of any listed HAP and less than 25 tpy of total HAPs (40 CFR § 63.2). The BBCM emits less than 10 tpy of any listed HAP and less than 25 tpy of all HAPs combined and is not subject to maximum achievable control technology standards.

A number of inorganic hazardous air pollutants are found in trace quantities in coal, including arsenic, beryllium, cadmium, chromium, copper, mercury, manganese, nickel, lead, thorium, and

uranium (EPA 1995); therefore, the particulate matter (PM) released during the mining, transport, processing, and combustion of coal also contains trace amounts of these HAPs. Additionally, during the coal mining process, the broken coal releases gases such as hydrogen sulfide (Li et al. 2023). HAPs are also generated from the tailpipe exhaust diesel and gasoline powered equipment used to mine and transport coal.

Due to the potential for emitted mercury to undergo chemical conversion to methyl mercury and bio-accumulate in aquatic organisms and fish, the EPA has promulgated standards for emission technologies to remove mercury from power plant emissions, thereby reducing the deposition of mercury in the environment.

In 2011, EPA issued the Mercury and Air Toxics Standards (MATS) regulation to reduce emissions of toxic air pollutants from coal- and oil-fired power plants. The compliance date for MATS was in 2015, and power plants have taken steps such as installing controls or updating operations to meet these standards, which protect public health (EPA 2025c).

From 2014 to 2023 releases of mercury to air in the United States decreased by 63%; this decrease was driven by a reduction in mercury air emissions from electric utilities. This large decrease is attributed to a shift from coal to other fuel sources (e.g., natural gas) and by the installation of pollution control technologies coal-fired power plants (EPA 2025d). In 2023, the primary metals sector, which includes iron and steel manufacturers, accounted for 41% of the air emissions of mercury while the electric utilities sector accounted for 21% of mercury emissions (EPA 2025d).

Historically, the majority of the coal mined from the BBCM has been combusted at the Jim Bridger Power Plant. The Jim Bridger Power Plant is a major source for HAPs and is subject to the maximum achievable control technology standards for coal and oil-fired electric utility steam generating units (40 CFR Part 63 Subpart UUUUU and Wyoming Administrative Code 020.0002.5 § 3).

In 2014 the Jim Bridger Power Plant was issued Air Quality Permit wv-15754 (WDEQ 2014) to install mercury controls which included flue gas desulfurization re-emission additive control, calcium bromide fuel additive control, and activated carbon injection control on the coal-fired boilers. In 2018, the Jim Bridger Power Plant was issued Air Quality Permit Waiver P0023982 (WDEQ 2018a) authorizing an additional mercury fuel additive control product, potassium iodide, for the coal-fired boilers (Units 1 through 4). In 2021, Jim Bridger Power Plant Units 1 and 2 were converted to natural gas fired boilers. The MATS limit mercury emissions from coal fired electric utility steam boilers to 1.2 pounds (lbs) per trillion British thermal unit (TBtu). The Jim Bridger Power Plant Units 3 and 4 are equipped with continuous emissions monitoring systems (CEMS) for mercury and the most continuous emissions report for mercury is summarized in **Table 3-5**, which shows both coal-fired boilers meet the MATS.

Table 3-5. Summary of Jim Bridger Power Plant Mercury Continuous Emissions Monitoring Reports (lbs/TBtu)

Coal Fired Boiler	2024 Quarter 3	2024 Quarter 4	2025 Quarter 1	2025 Quarter 2
Unit 3	Pass	0.865	0.848	0.618
Unit 4	Pass	0.883	0.873	0.462

Source: Specific values not provided in 2024 Quarter 3 report (Rocky Mountain Power 2024), Rocky Mountain Power 2025a, 2025b, and 2025c.

3.2.1.6 Greenhouse Gasses

Gases that trap heat in the atmosphere are termed GHGs. Anthropogenic GHGs are commonly emitted air pollutants that include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases. The most abundant GHG is CO_2, and more than two-thirds of man-made CO_2 emissions in the United States come primarily from the transportation and electricity production sectors. CH_4 from human activities accounts for approximately 10% of total United States GHG emissions and results from primarily agriculture and natural gas and petroleum systems. N_2O emissions from agriculture, fuel combustion, and industrial sources account for approximately 7% of the total United States GHG emissions. Fluorinated gases are powerful GHGs that are emitted from a variety of industrial processes and are often used as substitutes for O_3-depleting substances (i.e., chlorofluorocarbons, hydrochlorofluorocarbons, and halons), but they are not typically associated with OSMRE-authorized activities and, as such, will not be discussed further in this analysis (BLM 2024).

Of the primary GHGs, CO_2 is the most widely occurring. It is a major component of natural carbon cycling in the terrestrial biosphere including photosynthesis (CO_2 uptake by plants) and respiration (CO_2 release by plants, animals, and microorganisms), decomposition, and ocean releases. CO_2 is emitted from human activities including the combustion of fossil fuels (i.e., oil, natural gas, and coal), solid waste, deforestation and wood products, and also as a result of other chemical reactions such as steam reforming for the production of hydrogen and calcination for the production of cement clinker. CO_2 emissions accounted for 79.7% of the total United States GHG emissions in 2022 (EPA 2024d).

CH_4 emissions accounted for 11.1% of United States GHG emissions in 2022 (EPA 2024d). CH_4 is emitted during the production and transport of coal, natural gas, and oil. CH_4 is also produced biologically under anerobic conditions in ruminant animals, wetlands, landfills, and wastewater treatment facilities. In addition, fertilizer use, agriculture, and changes in land use (e.g., from forest to grazing) are major sources of CH_4 in the atmosphere. In 2022, N_2O emissions accounted for 6.1% of the total United States GHG emissions (EPA 2024d).

GHGs are considered air pollutants and are regulated under the CAA (42 USC §§ 7401 *et seq*.). In 2009, the EPA published a rule for the mandatory reporting of GHGs (40 CFR Part 98, Subpart C), which is referred to as the Greenhouse Gas Reporting Program (GHGRP). This rule establishes mandatory GHG reporting requirements for owners and operators of certain facilities that directly emit GHGs as well as for certain indirect emitters, or suppliers. For suppliers, the GHGs reported are the quantity that would be emitted from combustion or use of the products supplied. The rule provides a basis for future EPA policy decisions and regulatory initiatives

regarding GHGs. Facilities are generally required to submit annual reports under 40 CFR Part 98 if annual emissions exceed 25,000 metric tons of carbon dioxide equivalent (CO_2e) per year.

Federal regulations require that GHG emissions related to coal be quantified and reported under 40 CFR Part 98. Coal-fired electric power plants are required to continuously monitor CO_2 emissions under 40 CFR Part 98, Subpart D, and submit quarterly emissions reports to EPA under 40 CFR 75. The EPA has established emissions control requirements in the New Source Performance Standards (NSPS) at 40 CFR Part 60 that apply to coal, oil, and natural gas production facilities. Subpart TTTT sets Standards of Performance for Greenhouse Gas Emissions for Electric Generating Units.

According to the latest data from the Emissions Database for Global Atmospheric Research (EDGAR), global GHG emissions in 2023 reached 53.0 gigaton (Gt) CO_2e (without Land Use, Land Use Change, and Forestry) which represents the highest level recorded and an increase of 1.9% or 994 metric ton (Mt) CO_2e compared to the levels in 2022 (EDGAR 2024). Historical global GHG emissions by sector are summarized in **Table 3-6**.

Nationally, the largest percentage of GHG emissions in 2022, 28%, were from the transportation sector and 25% were from the electrical power sector. Nationally, total gross GHG emissions decreased by 3% from 1990 to 2022, down from a high of 15.2% above 1990 levels in 2007. Nationally, gross emissions increased from 2021 to 2022 by 0.2% (14.4 million metric tons [MMTs] CO_2e). Net emissions (including sinks) were 5,489 MMT CO_2e in 2022. Overall, net emissions increased by 1.3% from 2021 to 2022 and decreased by 16.7% from 2005 levels (EPA 2024). Between 2021 and 2022, the increase in total greenhouse gas emissions was driven largely by an increase in CO_2 emissions from fossil fuel combustion across most end-use sectors due in part to increased energy use from the continued rebound of economic activity after the height of the COVID-19 pandemic (EPA 2024d). Historical national GHG emissions by sector are summarized in **Table 3-6**.

In 2022, Wyoming's GHG emissions accounted for approximately 1.3% of gross United States GHG emissions and emissions have increased by 4.9% since 1990. At the State level, the largest percentage of GHG emissions in 2022 were from the electrical power sector (43%), followed by the industrial sector (35%) as shown in **Table 3-6**.

The effects of GHG emissions and global climate change are fundamentally cumulative phenomena; therefore, it is not possible to track the effects of GHG emissions from a proposed action to climate change effects in a localized manner to be able to determine significance one way or the other.

Table 3-6. Recent Trends in Global, National, State, and County GHG Emissions (in MMT CO_2e)

Sector	1990	2005	2018	2019	2020	2021	2022
Global[a]							
Electric Power	7,686.35	11,077.66	14,348.00	14,222.07	13,723.76	14,798.53	14,837.78
Industry	5,974.38	8,097.42	10,825.38	11,003.20	11,026.77	11,342.14	11,170.65
Transportation	4,706.04	6,630.90	8,409.63	8,420.51	7,217.05	7,767.30	8,081.81
Agriculture	5,395.43	5,617.91	6,257.91	6,290.85	6,395.21	6,423.23	6,463.94
Fuel Exploitation	3,965.93	4,784.58	5,588.57	5,771.55	5,424.88	5,602.75	5,738.87
Buildings	3,725.27	3,642.75	3,786.27	3,727.55	3,668.16	3,722.72	3,731.23
Waste	1,272.83	1,445.67	1,810.87	1,842.61	1,871.72	1,911.58	1,944.19
Gross Total	32,726.23	41,296.88	51,026.63	51,278.35	49,327.54	51,568.25	51,968.47
National[b]							
Electric Power	1,880.18	2,457.45	1,799.18	1,650.75	1,482.17	1,584.45	1,577.49
Industry	1,723.32	1,587.26	1,541.87	1,531.80	1,435.91	1,455.80	1,452.54
Transportation	1,521.42	1,965.92	1,871.61	1,874.55	1,625.28	1,805.47	1,801.52
Agriculture	595.95	634.30	683.53	661.04	640.05	645.88	633.96
Commercial	447.01	418.86	453.48	462.63	436.92	443.66	463.66
Residential	345.60	371.19	376.82	384.21	358.04	369.61	391.30
United States Territories	23.45	59.66	26.26	25.15	23.44	23.93	22.73
Gross Total	6,536.91	7,494.64	6,752.75	6,590.13	6,001.81	6,328.79	6,343.21
Wyoming[b]							
Electric Power	40.50	44.66	41.47	37.16	35.97	34.78	36.24
Industry	24.31	37.31	33.44	31.24	31.33	31.03	29.37
Agriculture	7.71	8.06	8.91	9.41	8.46	8.72	8.56
Transportation	5.29	7.96	7.53	7.43	6.99	7.30	6.92
Commercial	1.10	1.15	1.31	1.34	1.24	1.28	1.45
Residential	0.85	0.85	1.05	1.13	1.03	1.05	1.10
Gross Total	79.45	99.98	93.70	87.69	85.02	84.16	83.64

Source: [a](EDGAR 2024),[b] (EPA 2023a)

3.2.1.7 Emissions from Mining

Criteria pollutants evaluated as part of the Proposed Action are PM_{10}, $PM_{2.5}$, and SO_2. Non-criteria air pollutants evaluated include VOC and NO_X, which contribute to the formation of ground level O_3. The major types of emissions that come from surface coal mining activities are in the form of fugitive dust (PM_{10} and $PM_{2.5}$) and tailpipe emissions (PM_{10}, $PM_{2.5}$, NO_X, CO, SO_2, VOC, HAPs, CO_2, CH_4, and N_2O) from large mining equipment. Activities such as blasting, loading and hauling overburden and coal, and the large areas of disturbed land all produce fugitive dust. Stationary and point sources are associated with coal crushing, storage, and handling facilities. In general, PM_{10} is the major pollutant from coal mine point sources. Overburden blasting is also sometimes responsible for producing NO_X from the incomplete combustion of explosives used in the blasting process. The United States Energy Information Administration (EIA) tracks data on United States coal production, number of mines, productive capacity, recoverable reserves, employment, productivity, consumption, stocks, prices, annual United States domestic coal distribution data (excluding waste coal and imports) by coal-origin State, coal-destination State, mode of transportation, and consuming sector as well as a report summarizing foreign coal distribution by coal-producing State. Coal mined in Wyoming accounted for 41% of United States coal production in the past 5 years, on average, as shown in **Table 3-7**. The BBCM has accounted for less than 1% of the coal produced in Wyoming and 51% of the coal produced in Sweetwater County (EIA 2025).

Table 3-7. Historic Coal Production at United States, State, County, and Project Level (tons) and Percentage of Black Butte Coal

Location	2019	2020	2021	2022	2023	Average
United States	706,309,263	535,434,354	577,431,278	594,155,282	577,954,017	598,256,839
Wyoming	276,911,907	218,555,844	238,772,511	244,730,451	237,261,496	243,246,442
Wyoming % of United States	39%	41%	41%	41%	41%	41%
Sweetwater County	4,634,339	3,671,084	2,985,223	4,408,578	4,323,943	4,004,633
Black Butte Mine[a]	2,307,947	2,216,235	1,771,411	2,035,630	1,601,806	1,986,606
Black Butte % of Wyoming	0.8%	1.0%	0.7%	0.8%	0.7%	0.8%
Black Butte % of Analysis Area	50%	60%	59%	46%	37%	51%

[a]Includes coal mined at Leucite Hills
Source: (EIA 2025)

In 2019, BBCC submitted an application (BBCC 2019) to modify the ambient air boundary for the BBCM and the mining progression. This application included an assessment of the potential air quality impacts of the revised Federal mining plan modification area. BBCC enlisted IML Air Science to develop a project emissions inventory and to model the potential impacts of these emissions on ambient air quality. Based on the mining plan, IML Air Science estimated the

maximum potential emissions by year from 2019 through 2026 and determined that year 2025 would have the highest emissions and mining activities would come closest to the ambient air boundary in 2026. The maximum potential emissions from both years are summarized in **Table 3-8**, which is significantly higher than the historic mining levels shown in **Table 3-7**.

Table 3-8. Maximum Potential Emissions from 2019 Black Butte Mine Air Quality Permit Application (tpy)

Year	Tons of Coal Mined	PM_{10}	$PM_{2.5}$	NO_x	CO	SO_2	VOC	HAPs	CO_2
2025	4,962,442	1,784	256	1,010	1,404	106	158	1.7	75,227
2026	4,995,863	1,631	233	865	1,934	92	135	1.5	65,016

Source: Wyoming Air Quality Permit Application for the Black Butte Mine Permit Modification (BBCC 2019) Tables A-1, A-3, A-7, and A-10.

IML Air Science used AERMOD (an air quality modeling program) to model the PM_{10}, $PM_{2.5}$, and NO_X emissions in **Table 3-8** to predict potential air quality impacts of the revised Federal mining plan modification area. The IML Air Science modeling results for each year (2025 and 2026) using the meteorological year with the highest emissions are shown in **Table 3-9**. The modeling results show that the emissions from the BBCM (maximum modeled concentrations) would not exceed the NAAQS/WAAQS for the modeled pollutants; however, the modeled emissions may contribute to an exceedance of the $PM_{2.5}$ annual NAAQS/WAAQS downwind of the mine. When the modeling was performed in 2019 the $PM_{2.5}$ annual NAAQS/WAAQS limit was 12 $\mu g/m^3$ but was lowered to 9 $\mu g/m^3$ in 2024 following changes to EPA's PM NAAQS to better protect the public from the dangerous and costly health effects of fine particle pollution (EPA 2025e).

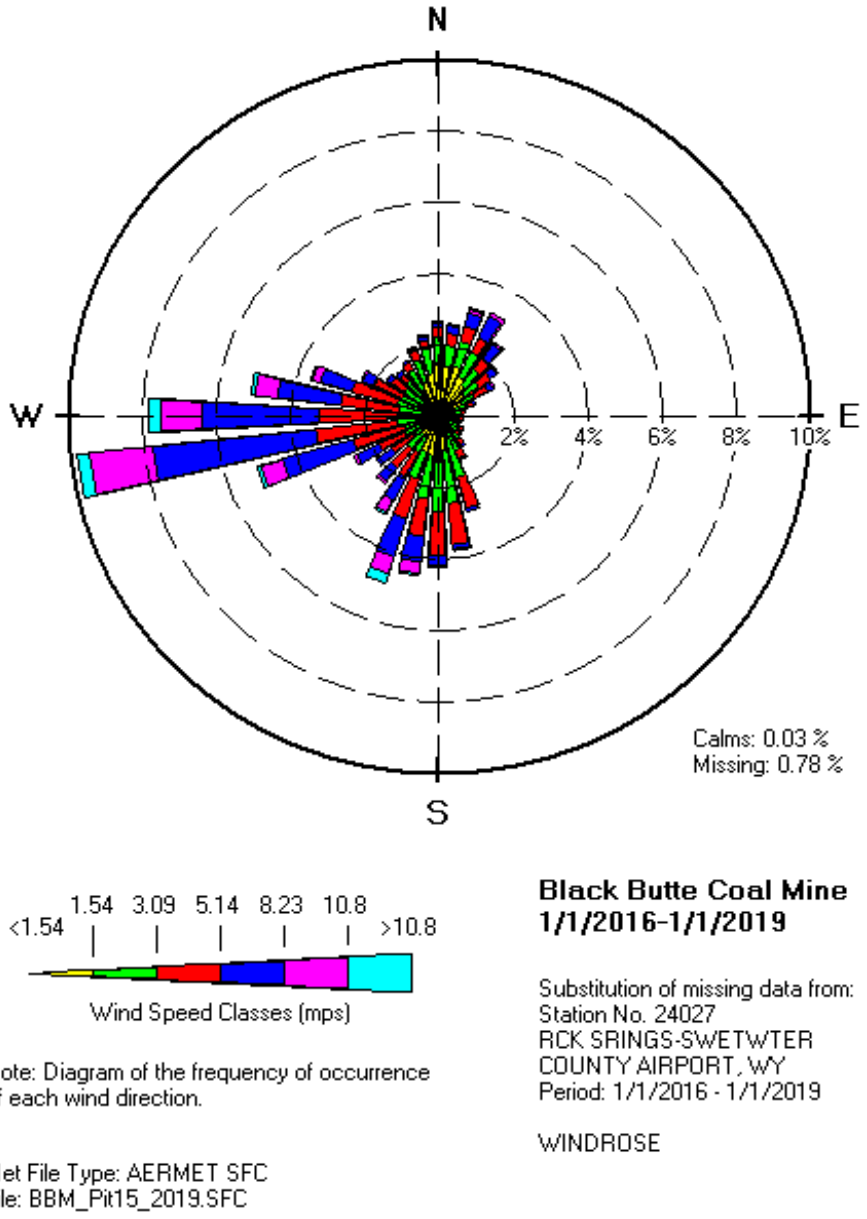
Table 3-9. Modeling Results from 2019 Black Butte Mine Air Quality Permit Application

Pollutant	Year	Averaging Time	Maximum Modeled Concentration ($\mu g/m^3$)[1]	Background Concentration ($\mu g/m^3$)[1]	Total Concentration ($\mu g/m^3$)	NAAQS/ WAAQS ($\mu g/m^3$)
PM_{10}	2025	Annual Mean	36.27	13	49.27	50
	2026		28.59		41.59	
$PM_{2.5}$	2025		6.12	5.3	11.42	9
	2026		5.98		11.28	
NO_2	2025		1.0	6.3	7.3	53
	2026		1.0		7.3	

Source: Wyoming Air Quality Permit Application for the Black Butte Mine Permit Modification (BBCC 2019) Tables 6-12 through 6-17 BBCC Sources only.

A wind rose, a diagram used by meteorologists to provide an illustration of how wind speed and direction are typically distributed at a particular location, for BBCM's on site meteorological station is provided as **Figure 3-6**. It shows that the majority of the wind comes from the west and west-southwest direction and that the downwind direction would be east and east-southeast.

Figure 3-6. Black Butte Coal Mine Wind Rose



As part of BBCM's existing Air Quality Permit (P0026670), the facility is required to implement measures to reduce air quality impacts. Based on this, BBCC has developed an extensive air quality control plan included in the permit appendices. This air quality control plan can be broken down into a series of programs that are utilized across the BBCM site and throughout the year that are considered BACT. BBCC air quality programs monitor, track, and provide real time data to assist personnel onsite to make informed decisions about how operations are to be

conducted to prevent deterioration of air quality. Air dust levels are periodically monitored throughout the day with set actions taken when levels exceed certain values. For instance, if a PM_{10} 110 µg/m^3 24-hour average is identified, then the following three actions that must be completed, recorded, and provided to the environmental coordinator:

1. Production superintendent will notify the mine manager.

2. Shut down drill and blasting in the area.

3. Record actions taken.

BBCM air quality permit MD-7424 (WDEQ 2009) requires the operation of an ambient air monitoring network near the perimeter of the mine. The operation of the particulate and meteorological monitoring network at the BBCM follows the Black Butte Coal Quality Assurance Project Plan (QAPP) (IML Air Science 2021). Quality control is largely implemented through the QAPP and the Standard Operating Procedures (SOPs). Each instrument in the various monitoring programs has unique requirements, statutory standards, and support equipment that must be in place in order for the instrumentation to be operated according to the guidelines, rules, and policies that must be followed. The meteorological monitoring systems consist of a 10-meter instrumented tower and utilize a Campbell Scientific CR1000 datalogger to continuously measure wind speed, direction, standard deviation of horizontal wind direction, temperature, and precipitation. Hourly aggregate parameters are logged by the meteorological monitoring systems.

Nitrogen Oxides (NO_X)

Overburden blasting sometimes produces NO_X. NO_X is one of several products resulting from the incomplete combustion of explosives used in the blasting process. BBCC is currently working with blasting agent manufacturers to reduce NO_X emissions by changing the size of the blasts and using different blasting agents, mixtures, and additives.

Sulfur Dioxide (SO_2)

SO_2 forms during combustion from trace levels of sulfur in coal or diesel fuel and can convert to ammonium sulfate and sulfuric acid (H_2SO_4), which can cause visibility impairment and acid deposition. Although generally not considered a significant direct result of surface coal mining, sulfur compound emissions from coal combustion have been identified as a potential concern at coal-fired power plants.

BBCM Annual Emissions

As explained above, there are two types of emission sources under Title V of the CAA, major and area (minor) sources. BBCM is not considered a major emission source under WAQSR Chapter 6, Section 3 because the majority of the emissions are fugitive emissions and fugitive emissions from a stationary source are not considered in determining whether it is a major stationary source. Minor emission sources within the State of Wyoming are required to report their emissions to the WDEQ every 3 years (triennially) in accordance with 40 CFR Part 51, Subpart A. The annual emission for the BBCM for the last four triennial emissions inventory

reports are shown in **Table 3-10**. It should be noted that CO, NO_X, and SO_2 emissions were not calculated for coal or overburden blasting in 2014; these emissions were calculated based on emission factors used for 2017, 2020, and 2023 emission inventories. Additionally, the emissions reported in **Table 3-10** do not include tailpipe emissions from mining equipment.

Table 3-10. 2023 Emissions Inventory for the BBCM (in tpy)

Emissions	2014	2017	2020	2023
Tons of Coal Mined	4,062,370	2,594,209	2,216,229	2,341,031
CO	260.52	282.42	282.42	266.17
NO_X	66.10	71.66	71.66	67.50
PM_{10}	787.17	790.84	611.17	692.60
$PM_{2.5}$	94.46	94.86	73.29	83.24
SO_2	7.78	5.31	5.31	4.68
VOC	Unavailable	Unavailable	Unavailable	Unavailable

Source: WDEQ 2018b, 2019, 2021a, 2024b.

3.2.1.8 Emissions from Employee Commuting

EPA regulations apply to virtually every vehicle, engine, and gallon of transportation fuel sold in the United States. The CAA requires that all engines and vehicles be covered by a certificate of conformity before they can enter into commerce. A certificate of conformity demonstrates that the respective engine or vehicle conforms to all of the applicable emission requirements. The certificate represents engines and vehicles covered by a specific engine family or, in the case of light-duty vehicles, a specific test group for each manufacturer. All of EPA's emission regulations specify test procedures to measure engine or vehicle emission levels. EPA uses the test results to determine compliance with the applicable emission standards (EPA 2025f). Nearly all cars on the road today are held to either the current Tier 3 standards or the previous Tier 2 standards. The oldest cars on the road (model years 2003 or older) are held to Tier 1 standards (EPA 2025g). Sweetwater County data from the last National Emissions Inventory (NEI) in 2020 for gasoline powered passenger cars and trucks is shown in **Table 3-11** below.

Table 3-11. Emissions from Passenger Cars/Trucks in Sweetwater County from 2020 NEI (tpy)

Pollutant	Passenger Cars	Passenger Trucks	Passenger Cars and Trucks Total
CO	1,337.96	3,236.16	4,574.12
NO_X	98.56	325.57	424.14
PM_{10}	6.89	15.66	22.54
$PM_{2.5}$	2.23	5.64	7.87
SO_2	0.60	1.55	2.15
VOC	67.78	147.27	215.05

Pollutant	Passenger Cars	Passenger Trucks	Passenger Cars and Trucks Total
HAPs	19.06	41.35	60.40

Source: EPA 2023b

It is estimated that BBCM employees carpool and commute from Rock Springs an average one-way distance of 38.25 miles per shift. The mine operates seven days per week with two shifts per day. It is estimated that 21 employee vehicles commute per shift and that 76% of the vehicles are passenger cars with the remaining 24% being light duty passenger trucks. The CO, NO_X, PM_{10}, $PM_{2.5}$, VOC, and HAP emissions from BBCM employee commuting were estimated using emission factors derived from EPA's Motor Vehicle Emissions Simulator (MOVES 5.0) for Passenger Cars and Trucks for Sweetwater County, Wyoming and are shown in **Table 3-12**. GHG emissions were calculated using emission factors from EPA's Emission Factors for GHG Inventories (EPA 2025h)

Table 3-12. Estimated Historical Emissions from Black Butte Coal Mine Employee Commuting

Pollutant (tpy)	Passenger Cars	Passenger Trucks	Passenger Cars and Trucks Total
CO (tpy)	3.37	1.06	4.42
NOx (tpy)	0.12	0.06	0.19
PM_{10} (tpy)	0.002	0.001	0.003
$PM_{2.5}$ (tpy)	0.002	0.001	0.003
SO_2 (tpy)	0.002	0.001	0.003
VOC (tpy)	0.10	0.04	0.14
HAPs (tpy)	0.06	0.02	0.08
CO – Metric tpy	258.18	108.16	366.35
CH_4 – Metric tpy	0.005	0.003	0.008
N_2O – Metric tpy	0.005	0.002	0.007
CO2e (GWPs from IPCC 6^{th} AR) – Metric tpy	259.60	108.91	368.51

3.2.1.9 Emissions from Coal Transport

EPA has adopted emission standards for all types of nonroad engines, equipment, and vehicles, which include NO_x, PM, hydrocarbon, and CO emission standards for locomotives (40 CFR Part 1033). To demonstrate compliance with these standards, manufacturers are required to perform certification testing to obtain a certificate of conformity and submit compliance reports to the EPA.

GHGs are also produced from transporting coal to the end user once it is mined. As with criteria air pollutants, manufacturers of locomotives are required to perform emissions testing and

submit compliance reports to the EPA, which includes GHGs under EPA's Mandatory GHG Reporting Rule (40 CFR Part 1033).

As discussed in **Section 3.2.1**, coal has been transported via rail and truck to multiple locations in the past 5 years, with the majority being shipped to the Jim Bridger Power Plant via rail. However, for the Proposed Action it is assumed that all coal from the BBCM would be transported via rail exclusively to the Jim Bridger Power Plant, which has a one-way rail distance of approximately 17 miles (27 kilometers). Coal is transported five days a week (Monday-Friday) with one train running per day. Each train has 74 cars, two engines, and transports 7,455 tons of coal (BBCC 2022).

3.2.1.10 Emissions from Coal Combustion

As stated in **Section 2.3.1**, the anticipated customer for the produced coal is the Jim Bridger Power Plant. The Jim Bridger Power Plant burns 8 to 9 M tons of coal annually and is regulated as a major source under the CAA, which is administered by the WDEQ. The Jim Bridger Power Plant operates under Title V Operating Permit No. P0022223, issued by the WDEQ (WDEQ 2020c), which contains requirements for ambient air monitoring, recordkeeping, and annual reporting. The Jim Bridger Power Plant is considered a stationary source with the majority of emissions being emitted through the Jim Bridger Power Plant's four stacks and a lower fraction occurring as fugitive and other emissions. The Jim Bridger Power Plant is equipped with electrostatic precipitators to control particulate emissions and wet scrubbers to control SO_2 emissions. Ninety percent of SO_2 emissions from the Jim Bridger Power Plant were eliminated with the installation of the wet scrubbers. The Jim Bridger Power Plant installed selective catalytic reduction systems to remove NO_X from the plant's emissions per authorization in Permit MD-13260 (WDEQ 2013). Prior to the installation of the selective catalytic reduction systems, WDEQ Permit No. MD-12186 for the Jim Bridger Power Plant (WDEQ 2011) states the boilers had a 0.26 lb NO_X/million metric (MM) Btu, 30-day rolling average rolled daily limit. The Jim Bridger Power Plant January 2020 Title V Permit No. P0022223 includes the NO_X limit decrease due to installation of the selective catalytic reduction systems as 0.07 lb NO_X/MMBtu, 30-day rolling average. With the implementation of the selective catalytic reduction system, an overall reduction of approximately 70% in NO_X emissions is possible. **Table 3-13** presents the 2024 annual emission inventory for the Jim Bridger Power Plant. It should be noted that emissions from the combustion of BBCM coal accounts for only a portion of the emissions as shown in **Table 3-13.** Mercury is not specifically included in this table because it is considered a regulated HAP and is included under that category. Additionally, power plants are required to have controls in place to remove and limit most of the mercury that is generated as discussed in **Section 3.2.1.5**.

Table 3-13. 2024 Annual Emissions Inventory for the Jim Bridger Power Plant

Emissions	Reported Cumulative Tons	Estimated Tons from the Burning of BBCM Coal[1]
CO	2,926.96	1,200.1
NO_x	2,997.84	1,229.1
PM_{10}	599.019	245.6

Emissions	Reported Cumulative Tons	Estimated Tons from the Burning of BBCM Coal[1]
SO_2	3,984.09	1,633.5
VOCs	176.301	72.3
HAPs	53.469	21.9

[1]Calculated as a direct correlation between the percentage of coal consumed at the Jim Bridger Power Plant supplied by BBCM annually (41%) and the resultant indirect emissions.
Source: WDEQ 2024c

3.2.2 Environmental Consequences

3.2.2.1 Alternatives Impacts

Alternative I – No Action Alternative

Under the No Action Alternative, the Proposed Action would not be implemented and no additional impacts on air quality or additional emissions of GHGs other than those already authorized would occur. If the Proposed Action is not implemented, the life of the BBCM would be 6 to 7 years shorter and a corresponding shortening of the future emission time frame would occur. During the interim, air quality impacts would not be expected to change from current conditions.

Alternative II – Proposed Action

Under the Proposed Action, operations at the mine are not anticipated to substantially change. Emissions of air pollutants at the BBCM remain limited by a production rate condition established in its air quality permit, which was recently re-issued with the same limit to meet the Wyoming Air Quality Standards and Regulations requirement for an air quality permit modification whenever the corresponding permit boundary is changed. Therefore, the mining of the Black Butte Federal Coal Lease WYW-6266 is still subject to all conditions in the current air quality permit. The Proposed Action would not authorize a change in already permitted actions or in production levels, meaning that there would be no increase in annual emissions from implementation of the Proposed Action. At the anticipated annual rate of approximately 1.9 million tons of coal mined per year for the entire mine, the 9.2 million tons of Federal coal to be mined from Pits 10 and 15 (WYW-6266) would add 6 to 7 years of operations with emissions similar to the historic emissions shown in **Table 3-10**. However, the mining of the Federal coal would take place in smaller tonnages over 14 years as shown in **Table 3-14**, along with non-Federal coal mined contemporaneously from other portions of the mine to reach the annual mining rate of 1.9 million tons.

Table 3-14. Mining Plan for Federal Coal in Pits 10/15 (WYW-6266)

Year	Tons of Coal Mined	Percent WYW-6266 Extractable Coal	Percent of Projected Black Butte Annual Coal Mined
2026	398,165	4%	21%
2027	531,816	6%	28%
2028	568,990	6%	30%
2029	581,870	6%	31%
2030	730,037	8%	38%
2031	718,000	8%	38%
2032	690,000	7%	36%
2033	717,042	8%	38%
2034	705,680	8%	37%
2035	410,000	4%	22%
2036	410,000	4%	22%
2037	410,000	4%	22%
2038	1,402,000	15%	74%
2039	970,000	10%	51%
Source: (BBCC 2025)			

Mobile (tailpipe), fugitive, and blasting emissions associated with the mining of Federal coal in WY-6266 are each discussed in this section and estimated emissions are summarized in **Table 3-15**, **Table 3-16**, and **Table 3-17,** respectively. The total estimated emissions for mining activities associated with the Proposed Action are shown in **Table 3-18**. Actual emissions from BBCM are used in the analysis to provide meaningful comparisons to emissions from other sources.

Table 3-15. Estimated Tailpipe Emissions from Proposed Action Federal Coal (CAPs/HAPs tpy, GHGs metric tpy)

Year	PM_{10}[1,2]	$PM_{2.5}$[1,2]	CO[1]	NO_X[1]	SO_2[3]	VOC[1,4]	HAPs[5]	CO_2[6]	CH_4[6]	N_2O[6]	CO_2e[7]
2026	0.88	0.88	18.38	15.21	0.01	2.13	0.64	1,245	0.16	0.13	1,285
2027	1.05	1.05	22.12	18.16	0.02	2.55	0.77	1,497	0.20	0.16	1,545
2028	1.16	1.16	24.37	20.24	0.02	2.84	0.86	1,678	0.22	0.17	1,732
2029	1.65	1.65	34.40	29.47	0.03	4.14	1.23	2,417	0.30	0.24	2,492
2030	1.78	1.78	37.12	31.70	0.03	4.45	1.34	2,635	0.34	0.27	2,718
2031	1.91	1.91	39.60	34.04	0.03	4.78	1.43	2,819	0.35	0.28	2,907
2032	1.98	1.98	41.14	35.51	0.03	4.99	1.49	2,928	0.36	0.29	3,019
2033	1.98	1.98	41.14	35.51	0.03	4.99	1.49	2,928	0.36	0.29	3,019
2034	1.99	1.99	41.29	35.63	0.03	5.01	1.49	2,937	0.36	0.29	3,028

Year	PM_{10}[1,2]	$PM_{2.5}$[1,2]	CO[1]	NO_X[1]	SO_2[3]	VOC[1,4]	HAPs[5]	CO_2[6]	CH_4[6]	N_2O[6]	CO_2e[7]
2035	1.99	1.99	41.29	35.63	0.03	5.01	1.49	2,937	0.36	0.29	3,028
2036	1.99	1.99	41.29	35.63	0.03	5.01	1.49	2,937	0.36	0.29	3,028
2037	1.99	1.99	41.29	35.63	0.03	5.01	1.49	2,937	0.36	0.29	3,028
2038	1.80	1.80	37.40	32.01	0.03	4.51	1.28	2,539	0.30	0.25	2,616
2039	1.37	1.37	29.48	23.68	0.02	3.36	0.92	1,812	0.21	0.18	1,867
Total	23.52	23.52	490.31	418.04	0.39	58.78	17.41	34,244	4.26	3.45	35,313

1 Nonroad Compression-Ignition Engines: Exhaust Emissions Standards (EPA 2016a) were used as emission factors for Tier 1 and Tier 2 equipment and AP-42 emission factors (EPA 2022d) from Tables 3.3-1 and 3.4-1 were used for Tier 0 equipment.

2 Conservatively assumes $PM=PM_{10}=PM_{2.5}$

3 SO_2 emissions assumes the use of ultra low sulfur diesel with a sulfur content of 15 ppm and gasoline with a sulfur content of 30 ppm

4 Assumes all NMHC is VOC.

5 HAP emission factors from AP-42 (EPA 2022d) Tables 3.3-1 and 3.4-1.

6 Emissions from EPAs Emission Factors for Greenhouse Gas Inventories (EPA 2025). Emission factors for the liberation of methane from mined coal taken from Table A-115 (EPA 2020b)

7 CO2 equivalency calculated using GWPs from IPCC 6th Assessment Report

Tailpipe emissions from equipment used to mine the Federal coal under the Proposed Action were estimated using projected operating hours (BBCC 2025) and the emission factors for that engine. Nonroad Compression-Ignition Engines: Exhaust Emissions Standards (EPA 2016) were used as emission factors for NO_x, CO, VOC, and PM for Tier 1 and Tier 2 equipment. VOC calculations assume 100% of nonmethane hydrocarbon (NMHC) standard is VOC emissions. Emission factors for SO_2 were calculated assuming the use of ultra-low sulfur diesel with a sulfur content of 15 ppm and gasoline sulfur content of 30 ppm. Emission factors for NO_x, CO, PM, and total organic carbon (TOC) for Tier 0 equipment and HAPs for all equipment were taken from EPA's *AP-42, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources* (EPA 1995b). These amounts are reported in **Table 3-15**.

Fugitive dust emissions are generated from mine and vehicle activities related to coal extraction, stockpiling, reclamation, and vehicle traffic. BBCM would continue its historical practice of semi-annual treatment of primary haul roads and the facilities area. Magnesium chloride is applied more frequently than twice per year if road conditions indicate a need. BBCC's Road Dust Control Program provides standard practices, application rates and frequencies, etc. The 2018 Road Dust Control Program report provides these details, along with maps showing the locations of dust suppression activities (BBCC 2019b). Additionally, a Fugitive Dust Action Plan was developed that provides for temporary alteration or curtailment of mining activities during periods of high ambient particulate concentrations. The Fugitive Dust Action Plan was submitted as Appendix C of the Wyoming Air Quality Permit Application for the Black Butte Mine Permit Modification (BBCC 2019a). Fugitive dust emissions were estimated using projected operating hours, material (coal and overburden) tonnage from the Life of Mine (LOM) Plan Tons Mined by Year (BBCC 2025), and WDEQ emission factors (WDEQ 2018c). **Table 3-16** shows the anticipated fugitive dust emissions related to mining Federal coal in WY-6266.

Table 3-16. Estimated Fugitive Dust Emissions from Proposed Action Federal Coal (CAPs/HAPs tpy, GHGs metric tpy)

Year	PM_{10}[1]	$PM_{2.5}$[2]	CH[3]	CO_2e[4]
2026	5.80	228.70	228.70	6,175
2027	7.13	305.46	305.46	8,248
2028	9.06	326.82	326.82	8,824
2029	10.21	334.21	334.21	9,024
2030	12.92	419.32	419.32	11,322
2031	13.67	412.41	412.41	11,135
2032	13.82	396.32	396.32	10,701
2033	14.21	411.85	411.85	11,120
2034	14.51	405.33	405.33	10,944
2035	13.78	235.50	235.50	6,358
2036	13.91	235.50	235.50	6,358
2037	13.95	235.50	235.50	6,358
2038	15.68	805.28	805.28	21,743
2039	13.28	557.15	557.15	15,043
Total	171.93	5,309	5,309	143,352

Source: Emission factors and/or formulas from (WDEQ 2018g; WDEQ 2019a)

1 PM_{10}/PM Ratio = 30% (WDEQ 2018c)

2 $PM_{2.5}/PM_{10}$ Ratio = 12% (WDEQ 2019)

3 Emission factors for the liberation of methane from mined coal taken from Table A-98 (EPA 2024d)

4 CO_2 equivalency calculated using GWP for non-fossil fuel combustion from IPCC 6th Assessment Report

Emissions from coal and overburden blasting were estimated using data provided by BBCC (BBCC 2025) and emission factors from EPA's AP-42 (EPA 1995b). The annual and total blasting emissions are shown in **Table 3-17**.

Table 3-17. Estimated Blasting Emissions from Proposed Action Federal Coal (tons)

Year	CO[1]	NO_X[1]	SO_2[1]
2026	36.19	9.18	1.08
2027	38.70	9.82	1.16
2028	58.69	14.89	1.75
2029	68.41	17.36	2.04
2030	90.12	22.87	2.69
2031	102.23	25.94	3.05
2032	107.56	27.29	3.21
2033	110.38	28.01	3.29
2034	113.89	28.90	3.40

Year	CO[1]	NO_X[1]	SO_2[1]
2035	113.89	28.90	3.40
2036	113.89	28.90	3.40
2037	113.89	28.90	3.40
2038	113.89	28.90	3.40
2039	113.89	28.90	3.40
Total	1,295.62	328.74	38.68

1 Emission factors from AP-42 (EPA 1995b) Table 13.3-1

Table 3-18. Total Estimated Mining Emissions from Proposed Action Federal Coal (tons)

Year	PM_{10}	$PM_{2.5}$	CO	NO_X	SO_2	VOC	HAPs	CO_2	CH_4	N_2O	CO_2e
2026	49.20	6.68	54.57	24.39	1.10	2.13	0.64	1,245	228.86	0.13	7,459
2027	60.44	8.18	60.82	27.98	1.17	2.55	0.77	1,497	305.67	0.16	9,793
2028	76.66	10.22	83.06	35.13	1.77	2.84	0.86	1,678	327.04	0.17	10,556
2029	86.76	11.87	102.80	46.83	2.07	4.14	1.23	2,417	334.51	0.24	11,516
2030	109.41	14.70	127.24	54.57	2.72	4.45	1.34	2,635	419.66	0.27	14,040
2031	115.86	15.58	141.83	59.98	3.08	4.78	1.43	2,819	412.76	0.28	14,042
2032	117.17	15.80	148.70	62.80	3.24	4.99	1.49	2,928	396.68	0.29	13,720
2033	120.38	16.19	151.52	63.51	3.33	4.99	1.49	2,928	412.22	0.29	14,139
2034	122.91	16.50	155.18	64.53	3.43	5.01	1.49	2,937	405.69	0.29	13,972
2035	116.86	15.77	155.18	64.53	3.43	5.01	1.49	2,937	235.86	0.29	9,386
2036	117.91	15.90	155.18	64.53	3.43	5.01	1.49	2,937	235.86	0.29	9,386
2037	118.21	15.93	155.18	64.53	3.43	5.01	1.49	2,937	235.86	0.29	9,386
2038	132.46	17.48	151.30	60.90	3.43	4.51	1.28	2,539	805.58	0.25	24,358
2039	112.03	14.65	143.37	52.58	3.42	3.36	0.92	1,812	557.36	0.18	16,911
Total	1,456.24	195.45	1,785.93	746.78	39.07	58.78	17.41	34,244	5,313.61	3.45	178,665

As discussed in ***Section 3.2.1.7***, AERMOD was used in 2019 to model the maximum potential near-field impacts of the revised mine plan as part of the Wyoming Air Quality Permit Application for the Black Butte Mine Permit Modification (BBCC 2019a). The on-site $PM_{10,}$ $PM_{2.5}$, and NO_2 emissions shown in **Table 3-8** were modeled for two separate years, the year with the highest projected emissions calculated in the air permit application (2025) and the year coal mining and haulage activities are projected to come closest to the Black Butte Mine Permit Area Boundary shown in **Figure 2-2** (2026). **Table 3-14** shows the projected tons of coal mined and emissions for the Proposed Action for the year with the highest estimated emissions (2038) is significantly less than the emissions modeled (see **Table 3-8**). Additionally, the 3 year average background concentration of $PM_{2.5}$ of 3.7 $\mu g/m^3$ (see **Table 3-2**) is lower than the modeled background concentration of 5.3 $\mu g/m^3$ (see **Table 3-9**). Since the modeled emissions are lower than the emissions from the proposed action, the impacts are anticipated to be less than the

maximum modeled concentrations shown in **Table 3-9**. Therefore, mining emissions from the Proposed Action are not likely to exceed the NAAQS or WAAQS.

As discussed in ***Section 3.2.1.3***, BBCC has implemented an air monitoring action plan to address fugitive dust and periodic exceedances of particulate emissions. If exceedances continue to occur, the WDEQ would require that more stringent control measures be implemented at the BBCM to prevent future occurrences. WDEQ has the authority to implement fines or other penalties for air quality violations.

Following the mining of coal and reclamation in the Federal mining plan modification area, emissions of air pollutants from this area would cease. The impacts on air quality from the Proposed Action would be adverse and vary between minor and moderate in intensity depending on climatic conditions (wind events) at the Federal mining plan modification area. However, the duration of the impacts would be short term.

Because the number of employee cars per shift, shift schedules, and average commuting distance do not vary by year, the emissions from employee commuting for the Proposed Action would be the same as the estimated historic emissions shown in **Table 3-12** for an additional 6 to 7 years.

As discussed in ***Section 3.2.1***, coal from the BBCM is expected to be transported via rail exclusively to the Jim Bridger Power Plant where it will be combusted. Criteria air pollutant emissions from locomotives used to transport Federal coal in the Proposed Action (shown in **Table 3-19**) were estimated using tons of coal mined annually, the distance traveled via rail (17.32 from **Table 2-2**), an approximate national average of 400 ton-miles per gallon (EPA 2009), and weighted emission factors in grams per gallon from the 2020 NEI which were calculated for the US Class I locomotive fleet based on the percentage of line-haul locomotives certified at each regulated Tier-level (ERG 2022). HAPS were calculated using the EPAs HAP Augmentation Profile Assignment Factors from 2017 (EPA 2017). GHG emissions were calculated using emission factors from EPAs Emission Factors for Greenhouse Gas Inventories (EPA 2025h).

Locomotive emissions from hauling the mined and processed coal are currently occurring in the impact assessment area and would continue at similar levels under the Proposed Action. New emission standards for new and reconstructed locomotives may decrease current locomotive emissions as the locomotive engines reach their expected lifespan of 10 years. In March 2008, the EPA finalized a three-part program that dramatically reduces emissions based on year of manufacture from diesel locomotives of all types. The rule (40 CFR 1033) cuts both line-haul and switch locomotive PM emissions from these engines by almost 90 percent and NOx emissions by as much as 80 percent when comparing Tier 0 standards to Tier 4 standards. Therefore, it is reasonable to conclude that rail emissions from the transport of coal to the Jim Bridger Power Plant would decrease in the future if newer manufacture year locomotives were utilized.

Table 3-19. Total Estimated Coal Transport Emissions from Proposed Action Federal Coal (CAPs/HAPs tpy and GHG metric tpy of CO2e)

Year	PM_{10}	$PM_{2.5}$	CO	NO_X	SO_2	VOC	HAPs	CO_2	CH_4	N_2O	CO_2e
2026	0.06	0.06	2.29	0.51	0.00	0.09	0.04	176.03	0.41	1.22	177.66
2027	0.08	0.07	3.06	0.68	0.00	0.12	0.05	235.11	0.55	1.63	237.30
2028	0.08	0.08	3.27	0.72	0.00	0.13	0.06	251.55	0.59	1.75	253.88
2029	0.08	0.08	3.35	0.74	0.00	0.13	0.06	257.24	0.60	1.79	259.63
2030	0.11	0.10	4.20	0.93	0.00	0.17	0.07	322.74	0.75	2.24	325.74
2031	0.10	0.10	4.13	0.91	0.00	0.17	0.07	317.42	0.74	2.21	320.37
2032	0.10	0.10	3.97	0.88	0.00	0.16	0.07	305.04	0.71	2.12	307.88
2033	0.10	0.10	4.12	0.91	0.00	0.17	0.07	317.00	0.74	2.20	319.94
2034	0.10	0.10	4.06	0.90	0.00	0.16	0.07	311.98	0.73	2.17	314.87
2035	0.06	0.06	2.36	0.52	0.00	0.09	0.04	181.26	0.42	1.26	182.94
2036	0.06	0.06	2.36	0.52	0.00	0.09	0.04	181.26	0.42	1.26	182.94
2037	0.06	0.06	2.36	0.52	0.00	0.09	0.04	181.26	0.42	1.26	182.94
2038	0.20	0.20	8.06	1.78	0.01	0.32	0.14	619.81	1.45	4.31	625.57
2039	0.14	0.14	5.58	1.23	0.00	0.22	0.10	428.83	1.00	2.98	432.81
Total	1.34	1.30	53.16	11.75	0.04	2.14	0.95	4,086.53	9.54	28.41	4,124.48

Combustion of the mined and processed coal would produce the majority of the air pollutants emitted from implementation of the Proposed Action Alternative. BBCC's coal sales contracts are exclusively with the Jim Bridger Power Plant and are expected to remain so during the mining of the Federal coal within the mining plan modification area (BBCC 2024b). The amount and rate of BBCC coal combusted at the Jim Bridger Power Plant is expected to remain similar to the current levels (see **Table 2-2**) during the mining of the Federal mining plan modification area.

The AQD Operating Permit limits the amount of coal that can be combusted at the Jim Bridger Power Plant to a maximum 9.5 million TPY and the plant has combusted 6.3 million tons of coal per year on average over the past five years. The BBCM predicted annual coal production of 1.9 million TPY would account for only a portion of the coal combusted at the Bridger Plant and the Federal coal associated with the Proposed Action would account for an even smaller annual portion. The amount of BBCM Federal coal associated with the proposed action that would be processed and combusted at the Bridger Power Plant and the estimated portion of emissions (including mercury) are shown in **Table 3-20.**

Table 3-20. Total Estimated Emissions from Proposed Action Federal Coal Processed and Combusted at the Jim Bridger Power Plant (CAPs/HAPs tpy and GHG metric tpy of CO2e)

Year	PM_{10}	$PM_{2.5}$	CO	NO_X	SO_2	VOC	HAPs	CO_2	CH_4	N_2O	CO_2e
2026	262.26	172.36	1,553.97	1,561.35	4,192.29	86.06	14.39	925,920.92	109.19	15.88	933,510.54
2027	350.29	230.22	2,075.59	2,085.44	5,599.50	114.95	19.22	1,236,722.37	145.84	21.21	1,246,859.57
2028	374.77	246.31	2,220.68	2,231.22	5,990.90	122.98	20.56	1,323,169.40	156.03	22.70	1,334,015.19
2029	383.26	251.89	2,270.94	2,281.72	6,126.52	125.76	21.02	1,353,121.46	159.57	23.21	1,364,212.76
2030	480.85	316.03	2,849.22	2,862.74	7,686.57	157.79	26.38	1,697,679.43	200.20	29.12	1,711,595.02
2031	472.92	310.82	2,802.24	2,815.54	7,559.83	155.19	25.94	1,669,687.75	196.90	28.64	1,683,373.89
2032	454.48	298.70	2,692.96	2,705.74	7,265.02	149.14	24.93	1,604,574.58	189.22	27.52	1,617,727.00
2033	472.29	310.40	2,798.50	2,811.78	7,549.75	154.98	25.91	1,667,459.95	196.63	28.60	1,681,127.83
2034	464.81	305.48	2,754.15	2,767.23	7,430.12	152.52	25.50	1,641,037.95	193.52	28.15	1,654,489.26
2035	270.05	177.49	1,600.16	1,607.76	4,316.90	88.62	14.81	953,442.86	112.43	16.35	961,258.07
2036	270.05	177.49	1,600.16	1,607.76	4,316.90	88.62	14.81	953,442.86	112.43	16.35	961,258.07
2037	270.05	177.49	1,600.16	1,607.76	4,316.90	88.62	14.81	953,442.86	112.43	16.35	961,258.07
2038	923.45	606.92	5,471.78	5,497.75	14,761.68	303.03	50.66	3,260,309.50	384.47	55.92	3,287,033.69
2039	638.90	419.91	3,785.75	3,803.72	10,213.14	209.65	35.05	2,255,706.29	266.00	38.69	2,274,195.92
Total	6,088.42	4,001.49	36,076.27	36,247.52	97,326.01	1,997.89	333.99	21,495,718.19	2,534.87	368.71	21,671,914.87

Emissions related to combustion were calculated for railcar unloading, one reclaim tunnel conveyor, one secondary crusher and associated dust extractor, and one of the two coal combustion units. The Bridger Power Plant NO_x air permit limit for the Unit 3 and 4 Boilers is 420 lbs/hr. Emissions from coal combustion were calculated based on actual 2024 emissions from the Unit 3 Boiler. GHG emissions were calculated using EPAs Emission Factors for Greenhouse Gas Inventories (EPA 2025h) and CO_2e emissions were calculated using GWPs from IPCCs 6th assessment report (IPCC 2023).

3.2.2.2 Incremental Impacts

Alternative I – No Action Alternative

Under the No Action Alternative, the Federal coal would not be mined and there would be no increase in the effects in the incremental impact assessment area other than those that would occur as a result of RFFAs.

Under the No Action Alternative, the Proposed Action would not be implemented and there would be no increase in the effects in the incremental impact assessment area.

Alternative II – Proposed Action

The RFFAs identified as occurring within the overall impact assessment area include future oil and gas exploration, production, and transport (i.e., pipelines); exploration drilling for coal in support of BBCM; livestock grazing (i.e. cattle and sheep); and potential future coal leasing facilitated by the OBBB. The contribution to air quality impacts from mining of the Federal mining plan modification area would be a minor component in comparison to the combined emissions from the other sources in the area. **Table 3-21** presents available 2023 annual and triennial emissions data from BBCM compared to the two largest non-BBCM pollutant emission sources in the impact assessment area. This data was gathered from the WY Air Quality Division's IMPACT database for air emission inventory details. The 2023 BBCM emissions (from Emissions Inventory ID EI0029897) (WDEQ 2024b) are less than 10 percent of the combined Jim Bridger Coal Mine (EI0039369) (WDEQ 2024c) and Jim Bridger Power Plant (EI0026692) (WDEQ 2024c) emissions. During mining of the Federal mining plan modification area, it is anticipated that the BBCM emissions would amount to approximately 9 percent of the combined Jim Bridger Coal Mine and Jim Bridger Power Plant emissions.

Table 3-21. 2023 Triennial Mine and 2024 Annual Power Plant Emissions Inventory (tons)

Emissions	2023 BBCM (tons) EI0029897	2023 Jim Bridger Coal Mine (tons) EI0039369	2024 Jim Bridger Power Plant (tons) EI0043199
Carbon Monoxide (CO)	266.17	10.91	2,926.96
Nitrogen Oxides (NO_X)	67.50	139.06	2,997.84
Particulate Matter 10 microns or less (PM_{10})	692.61	688.52	599.019
Particulate Matter 2.5 microns or less ($PM_{2.5}$)	83.24	94.37	285.299

Emissions	2023 BBCM (tons) EI0029897	2023 Jim Bridger Coal Mine (tons) EI0039369	2024 Jim Bridger Power Plant (tons) EI0043199
Sulfur Dioxide (SO_2)	4.68	0.10	3,984.09
Volatile Organic Compounds (VOCs)	0	0.41	176.301
Total	1,114.20	933.38	10,969.51

Sources: WDEQ 2024a, 2024b, and 2024c

Incremental impacts from implementation of the Proposed Action Alternative would be similar to current conditions respective to public health protection, including protecting the health of sensitive populations such as asthmatics, children, and the elderly. The extremely rural setting of the incremental impact assessment area in the prevailing wind direction makes these impacts negligible. Visibility impacts are expected to improve with the implementation of locomotive and Jim Bridger Power Plant emission control measures. However, PM or fugitive dust is expected to continue to have a minor impact during high wind events. Negligible incremental impacts on animals, crops, vegetation, and buildings are anticipated.

Based on the BBCC permit application modeling done in 2019, emissions from the Proposed Action combined with the background concentrations from nearby sources may exceed the NAAQS or WAAQS limits for annual PM2.5. As identified in **Table 3-1**, the WAAQS are the same as the NAAQS except it also has a standard for PM10 annual averaging period. However, the emissions inventory for on-site mining activities associated with the Proposed Action shows emissions significantly less than the modeled emissions, indicating that the 2019 modeling may overestimate PM2.5 emissions.

3.3 Vegetation (Including Forestry and Rangeland) and Invasive Species/Noxious Weeds

The impact assessment area for alternatives and incremental impacts analyses for vegetation (including forestry and rangeland) and invasive species/noxious weeds is the Federal mining plan modification area. The issues identified for impact analysis for vegetation (including forestry and rangeland) and invasive species/noxious weeds are loss of native vegetation communities and the spread of invasive plant species and noxious weeds due to mining related surface disturbance.

The past and present actions within the alternatives impact assessment area (i.e., Federal mining plan modification area) for vegetation (including forestry and rangeland) and invasive species/noxious weeds are scattered oil and gas exploration, production, and transport (i.e., pipelines); exploration drilling for coal in support of BBCM; livestock grazing (i.e., cattle and sheep); and BBCM coal mining activities under a separate existing BLM ROW agreement.

The RFFAs within the incremental impact assessment area (i.e., Federal mining plan modification area) for vegetation (including forestry and rangeland) and invasive species/noxious weeds are scattered oil and gas exploration, production, and transport (i.e., pipelines); exploration drilling for coal in support of BBCM; livestock grazing (i.e., cattle and sheep);

BBCM coal mining activities under a separate existing BLM ROW agreement; and potential future coal leases facilitated by the OBBB.

3.3.1 Affected Environment

A list of threatened and endangered species to consider in this EIS was obtained from the USFWS (USFWS 2025, **Appendix B**). All threatened and endangered species (and proposed threatened and endangered species) on the project species list obtained through the USFWS Information for Planning and Consultation (IPaC) planning tool are evaluated in this EIS. The Ute ladies'-tresses (*Spiranthes diluvialis*) is a threatened plant species that is the only plant included on the project species list (USFWS 2025). Habitat for Ute ladies'-tresses is found along floodplains of larger rivers and smaller rivers and streams that are fed by groundwater, where it grows in wet meadows, gravel bars, oxbows, seeps, springs, and fens. There are only 10 locations where it occurs in Wyoming, and all are from eastern Wyoming (WYNDD 2025a). There are no known occurrences in Sweetwater County despite surveys in the area (Beauvais et al. 2017). In addition, there are no perennial or ground fed water sources, and, therefore, no suitable habitat for this species in the impact assessment area. Vegetation types in the impact assessment area consist of upland shrublands and ephemeral drainages. Based on known geographic range and the absence of suitable habitat, Ute ladies'-tresses are not expected to occur in the impact assessment area.

There is no suitable habitat for any of the BLM sensitive plant species in the impact assessment area, and, therefore, they are not considered further. A pre-mining vegetation survey must be performed to verify the absence of ESA-listed and BLM sensitive plant species, in accordance with BLM lease stipulations (**Appendix A**).

3.3.1.1 Vegetation Range Sites

A range site and condition class inventory of the BBCM was conducted by the SCS, now known as the NRCS in 1975. Range site complexes were mapped rather than range sites alone due to the size of the area to be mapped and the heterogeneous nature of the range sites in relation to one another. Identification and mapping of SCS range site complexes was accomplished using on-site inspection of soil and vegetation combinations to construct a 1 inch – 2,000 feet scale range site complex map for BBCM. Range site complexes were identified in relation to SCS soil mapping units.

Three range site complexes comprise the Federal mining plan modification area. The majority (65 percent) of the Federal mining plan modification area is mapped as the Shallow Sandy 50 percent-Shale 50 percent complex, which encompassed 289 acres. Twenty-eight percent (128 acres) is mapped as Saline Upland, and the remaining 7 percent (31 acres) is mapped as Sandy 64 percent-Shallow Sandy 36 percent complex. **Table 3-22** describes the range sites that comprise these complexes. These correlate with big sagebrush shrubland and salt desert scrub vegetation communities. **Figure 3-7** and **Figure 3-8** photos of the vegetation within Pit 15 and Pit 10, respectively.

Since this range site map was completed, disturbed areas have been created within the Federal mining plan modification area from current mining activities and existing ROWs for pipelines

and oil and gas activities. These areas that have been impacted by human activities are generally devoid of vegetation and topsoil.

Table 3-22. Vegetation Range Sites

Vegetation Range Site	Description
Shale	Generally located in scattered locations on steep outcrop faces or small knolls on the dip slope. Soils are characterized by very shallow clays lying over shale. Plant growth is sparse. The few plant species that occupy the range site generally exhibit a low growth form. Major plants growing include Gardner saltbush (*Atriplex gardneri*), bud sagebrush (*Picrothamnus desertorum*), big sagebrush (*Artemisia tridentata*), squirreltail (*Elymus elymoides*), and molly (*Kochia americana*).
Saline Upland	Located in the low-lying areas and drainages. Soils are generally heavy saline clays. Two distinct vegetation cover types occur. Greasewood (*Sarcobatus vermiculatus*) is a major component of the vegetation near flow lines, generally 10 to 30 meters on either side of the flow line. Greasewood becomes sparser as one moves away from the flow line until Gardner saltbrush becomes the major plant species. Major plants growing include Gardner saltbrush, greasewood, Sandberg bluegrass (*Poa sandbergii*), big sagebrush, squirreltail, and Indian ricegrass (*Achnatherum hymenoides*).
Shallow Sandy	Generally located on the gently sloping dip slopes. Extends from sparsely vegetated areas near the top of rock outcrops to fairly heavy sagebrush areas where it merges with the sandy range site. Sagebrush in most shallow sandy areas is generally less than 50 centimeters in height. Soils are coarse, sandy loams usually found on southwest-facing slopes. Major plant species occurring include big sagebrush, thickspike wheatgrass (*Agropyron dasystachyum*), shadscale (*Atriplex confertifolla*), Indian ricegrass, Hood's phlox (*Phlox hoodii*), and green rabbitbrush (*Chrysothamnus viscidiflorus*).
Sandy	Generally small in size and located on the lee side of draws or knolls, giving this range site a patchy distribution. Soils of the sandy range site are characterized by deep, coarse textured, loamy sands. Sagebrush is often over 50 centimeters in height. Major plant species include big sagebrush, thickspike wheatgrass, squirreltail, and spiny hopsage (*Grayia spinosa*).

Source: BBCC 2014a.

Figure 3-7. Vegetation in the Pit 15 Federal Mining Plan Modification Area is Dominated by Big Sagebrush and Spiny Hopsage.

Figure 3-8. Vegetation in the Pit 10 Federal Mining Plan Modification Area includes Big Sagebrush and Grasses.

3.3.1.2 Invasive Species/Noxious Weeds

Invasive species and noxious weeds are plant species that are highly competitive, highly aggressive, and spread easily. In the broadest sense, a weed is any plant growing where it is not wanted. Weeds can be native or non-native, invasive or non-invasive, and noxious or non-noxious. Although many noxious weeds are invasive, invasive plant species are not necessarily the same as noxious weeds. Invasive plant species include not only noxious weeds, but other plants that are not native to the U.S. or the area where they are growing. The BLM considers plants invasive if they have been introduced into an environment where they did not evolve. Some invasive plant species can produce significant changes to vegetation, composition, structure, or ecosystem function. A noxious weed is "any plant designated by a federal, state or county government as injurious to public health, agriculture, recreation, wildlife or property" and is commonly defined as "a plant that grows out of place and is competitive, persistent, and pernicious" (BLM 2010).

The Federal Noxious Weed Management Act (as amended by Section 15, Management of Undesirable Plants on Federal Lands, 1990) authorizes cooperation among Federal and State agencies in the control of weeds. Per the Wyoming Weed and Pest Control Act of 1973, plants that are designated as noxious weeds throughout the State of Wyoming are identified on the list of State Designated Weeds (Wyoming Weed and Pest Council 2025), and the BLM recognizes this list. Some additional species are declared noxious at the county-level (Wyoming Weed and Pest Council 2017).

The BLM policy relating to the management and coordination of noxious weeds and invasive plant species activities is set forth in the BLM Manual 9015 – Integrated Weed Management (BLM 1992). The primary focus of the BLM is providing adequate capability to detect and treat smaller weed infestations in high-risk areas before they have a chance to spread. Noxious weed control is based on a program of prevention, early detection, and rapid response.

According to the BLM RSFO Botanist (Glennon 2014), some scattered noxious weeds are known to occur in the Federal mining plan modification area including black henbane (*Hyoscyamus niger*), and thistles, which are State-designated noxious weeds, and foxtail barley (*Hordeum jubatum*), which is a declared noxious weed in Sweetwater County. Other invasive plant species that are present include halogeton and cheatgrass (*Bromus tectorum*).

3.3.2 Environmental Consequences

Threatened and Endangered Plant Species

There would be no effect to Ute ladies'-tresses from either the No Action Alternative or Proposed Action because the species does not occur in the impact assessment area. No critical habitat for the Ute ladies'-tresses would be affected because none has been designated for this species.

3.3.2.1 Vegetation Range Sites – Alternatives Impacts

Alternative I – No Action Alternative

Under the No Action Alternative, the Proposed Action would not be implemented and no additional impacts on vegetation (including forestry and rangeland) other than those already authorized would occur.

Alternative II – Proposed Action

The Proposed Action would result in the impact and short-term (approximately 10 years) removal of approximately 257 additional acres of vegetative cover within the Federal mining plan modification area. Approximately 68 acres of the Federal mining plan modification area have been previously disturbed. The total surface disturbance would be approximately 325 acres or 72 percent of the Federal mining plan modification area. **Table 3-23** identifies the approximate total number of undisturbed range site acres that would be impacted by the Proposed Action.

Table 3-23. Acres of Mine Development on Undisturbed Range Sites Found within the Federal Mining Plan Modification Area

Range Site	Approximate Acres of Impact
Shallow Sandy 50 percent-Shale 50 percent Complex	153
Saline Upland	86
Sandy 64 percent-Shallow Sandy 36 percent	18
Total:	**257**

Impacts from surface disturbance would leave approximately 325 acres of vegetation communities unavailable for use as wildlife habitat and livestock forage during the life-of-operations (i.e., 10 to 14 years). Interim reclamation (conducted during operations associated with the Proposed Action on all disturbances) would occur gradually over the short-term, and vegetation production could become established within approximately 3 to 5 years following reclamation of disturbed sites. Some disturbed areas could become available for use by wildlife during the life-of-operations. Following the life-of-operations, impacts associated with the Proposed Action would cease, and remaining areas of disturbance would be reclaimed.

In addition to the disturbance of a total of approximately 325 acres (approximately 68 acres previously disturbed) of vegetation, impacts could occur anywhere within the remaining 125 acres of the Federal mining plan modification area and could include removal or modification of vegetation or modification to existing range sites (e.g., changes in plant make-up, distribution, and density) through invasive weed establishment or changes in land use (e.g., grazing and wildlife use). While some areas may re-establish vegetation more quickly, a large component of the existing disturbance area is sagebrush steppe, which, due to local climatic conditions, can be difficult to re-establish and will likely require a longer period of time to fully re-establish.

BBCC has developed a site-specific post-mining detailed reclamation plan in coordination with the WDEQ, BLM RSFO, and the WGFD for the Proposed Action. The reclamation plan includes detailed specifications for reclamation activities such as grading, contouring, re-application of topsoil, reseeding, and weed control. The seed mix used for re-vegetation includes a certified weed-free diverse mix of native grasses, forbs, and shrubs (as defined by existing range sites).

Before release of the reclamation bond (a minimum of 10 years following closure of the pits), establishment of a diverse, productive, and permanent vegetative community would be required. To achieve this, reclamation has been designed to facilitate the return of current, and/or anticipated postmining land uses of undeveloped rangeland for livestock grazing and wildlife habitat. Reclamation would produce range sites of equal or greater productivity than those found within the Federal mining plan modification area prior to mining development. Species diversity would initially be lower on reclaimed lands, with the shrub component of each range site requiring the longest amount of time to re-establish.

With careful seedbed preparation and timely seeding, as required by WDEQ, reclaimed lands could eventually support vegetation cover and production rates similar to pre-mining conditions. Species diversity would be emphasized with a certified weed-free diverse seed mix, and special planning practices for shrubs, particularly sagebrush, would encourage re-growth of this important ecosystem component.

3.3.2.2 Vegetation Range Sites – Incremental Impacts

Alternative I – No Action Alternative

Under the No Action Alternative, the Proposed Action would not be implemented and there would be no increase in the effects in the incremental impact assessment area other than those that would result from RFFAs in the incremental impact assessment area.

Alternative II – Proposed Action

Impacts in the incremental impact assessment area would be dominated by mining activities. However, RFFAs would impact vegetation in the incremental impact assessment area. These impacts range from negligible to substantial in intensity. Many of these impacts would be temporary and vegetation would eventually return to pre-mine conditions after reclamation of the impacted area. The majority of the incremental impact assessment area would be revegetated following reclamation; however, the types of vegetation present may differ from pre-disturbance conditions and range conditions within the incremental impact assessment area are expected to support pre-mining uses following reclamation of short-term land uses.

3.3.2.3 Invasive Species/Noxious Weeds – Alternatives Impacts

Alternative I – No Action Alternative

Under the No Action Alternative, the Proposed Action would not be implemented. Impacts caused by the threat of invasive species and noxious weeds would continue to follow existing trends, which would generally include the implementation of precautionary measures when there

is potential to establish and spread invasive species and noxious weeds from a contaminated area to a non-contaminated area.

Alternative II – Proposed Action

Surface disturbance would increase the potential for the spread of invasive species and noxious weeds that are currently found within the Federal mining plan modification area (e.g., black henbane, halogeton, thistles, cheatgrass, and foxtail barley). Disturbance would also have the potential to introduce new invasive species and noxious weeds from outside the Federal mining plan modification area. Such introductions could result in infestation and consequent alteration of species distribution within a given range site. Alteration could include destruction of otherwise unaffected acres of existing range sites and could complicate reclamation.

Per the Green River RMP and ROD (BLM 1997a), noxious weed infestations would be controlled by livestock management or environmentally acceptable mechanical, chemical, or biological means. Additionally, grazing systems and wildlife management would be designed to maintain or improve plant diversity and restore disturbed or altered habitat with the purpose of attaining desired native plant communities. BBCC has developed a site-specific post-mining detailed reclamation plan in coordination with the WDEQ, BLM RSFO, and the WGFD for the Proposed Action. The plan includes detailed specifications for reclamation activities such as grading, contouring, re-application of topsoil, reseeding, and weed control. The seed mix used for re-vegetation includes a certified weed-free diverse mix of native grasses, forbs, and shrubs (as defined by existing range sites). The re-establishment of a self-perpetuating native plant community would limit opportunities for the establishment of invasive species and noxious weeds.

Because there are only some scattered invasive plant species and noxious weeds in the area and the mining and reclamation plans would include control measures to prevent the spread of invasive plant species and noxious weeds, impacts from annual grass introduction or the establishment of other invasive plant species and noxious weeds would be minimized.

3.3.2.4 Invasive Species/Noxious Weeds – Incremental Impacts

Alternative I – No Action Alternative

Under the No Action Alternative, the Proposed Action would not be implemented and there would be no increase in the effects in the incremental impact assessment area other than those that would result from RFFAs in the incremental impact assessment area.

Alternative II – Proposed Action

Surface disturbance from the Proposed Action in the incremental impact assessment area would total approximately 325 acres (approximately 68 acres previously disturbed) or 72 percent of the Federal mining plan modification area. Because the incremental impact assessment area for invasive plant species and noxious weeds is limited to the Federal mining plan modification area, any incremental impacts from invasive plant species and noxious weeds associated with the Proposed Action would be the same as the impacts described above in the alternatives impacts

(***Section 3.3.2.3***) except greater in area due to the presence of RFFAs outside of areas identified for ground disturbing activities associated with the Proposed Action.

3.4 Fish and Wildlife

3.4.1 Affected Environment

The impact assessment area used to evaluate potential effects on fish and wildlife species (except for greater sage-grouse and big game) is the Federal mining plan modification area plus a 1-mile buffer for both impacts from the alternatives and incremental impacts. This area was selected to account for expected effects to habitat within the Federal mining plan modification area as well as noise and visual disturbance that would extend outside the area. The analysis for greater sage-grouse uses a larger 4-mile buffer as the impact assessment area (see ***Section 3.4.1.2***) and the big game analysis uses a 4-mile buffer as the impact assessment area for incremental impacts (see ***Section 3.4.1.3***). The issues identified for fish and wildlife vary by species and are therefore described individually below under the appropriate subsection.

Wildlife surveys are conducted annually within 1 mile of the BBCM complex as part of the wildlife monitoring plan included in the current mine permit. These surveys include prey abundance surveys (lagomorph/ground squirrels), point-count surveys for migratory birds, and monitoring of big game mortalities, raptor nests, and greater sage-grouse leks (Fox River Resources 2024). Additional wildlife surveys were conducted in 2012 under the BBCC Exploration Drill Hole Program, which encompassed the Federal mining plan modification area (Intermountain Resources 2013). Results from these surveys provide information on species occurrences in or near the Federal mining plan modification area. Species that may occur or be affected by the proposed activities are discussed below.

Wildlife habitat types in Wyoming have been classified and described in the Wyoming State Wildlife Action Plan (SWAP) (WGFD 2017). The Wyoming SWAP key habitat types present in the Federal mining plan modification area include Cliff and Rock Outcrop, Desert Shrubland, and Sagebrush Shrubland. There are no wetlands or perennial streams within the Federal mining plan modification area.

3.4.1.1 Threatened and Endangered Wildlife Species

A list of threatened and endangered species to consider in this EIS was obtained from the USFWS (USFWS 2025, **Appendix B**). All threatened and endangered species (and proposed threatened and endangered species) on the project species list obtained through the USFWS IPaC planning tool are evaluated in this EIS in compliance with the ESA.

Threatened and endangered wildlife species issues identified for impact analysis are:

- Potential effects of mining-related water depletions from the Upper Colorado River Basin on the four Colorado River fish species and their critical habitat.
- Potential loss of monarch butterfly (*Danaus plexippus*) non-breeding habitat in the Federal mining plan modification area.

Yellow-billed Cuckoo

The yellow-billed cuckoo (*Coccyzus americanus*) is listed as a threatened species. It inhabits deciduous riparian forest and woodland habitat. The vegetation in the impact assessment area consists of sagebrush and desert shrublands, there are no forested riparian areas. Yellow-billed cuckoos do not occur in the impact assessment area due to the lack of suitable habitat. There is no designated critical habitat for yellow-billed cuckoo in the impact assessment area.

Colorado River Fish Species

The humpback chub (*Gila cypha*) is a threatened fish species and bonytail chub (*Gila elegans*), Colorado pikeminnow (*Ptychocheilus lucius*), and razorback sucker (*Xyrauchen texanus*) are endangered fish species, all of which are endemic to the Colorado River system. The closest occupied habitat and designated critical habitat is in the Green River, beginning at the confluence with the Yampa River in Colorado, approximately 210 miles downstream of BBCM. Although these species do not occur in the impact assessment areas, surface water in the Federal mining plan modification area flows into Bitter Creek, which flows into the Green River, and eventually the Colorado River. Water depletions from any hydrologic system that is tributary to the Colorado River may affect the four Colorado River fish. The USFWS tracks water depletions in the Colorado River basin along with natural variation in the river flows, to understand the effect of the aggregate of depletions on the four Colorado River fish, as reported in annual Recovery Implementation Program for Endangered Fishes in the Upper Colorado River Basin (Recovery Program) reports. Therefore, this EIS analyzes potential impacts from mining-related water depletions or water otherwise contained from entering Bitter Creek.

Monarch Butterfly

The monarch butterfly is a proposed threatened species. Monarchs are broadly distributed in North America, where they are found in open habitats, such as grasslands, pastures/fields, roadsides, wetlands, streamsides, and suburban areas. Breeding habitat is tied to where milkweed (*Asclepias* spp.) occurs because larvae feed only on the leaves of these plants. Adults require an abundance and diversity of nectar plants, particularly during migration. Monarchs migrate to wintering grounds in coastal California and central Mexico (Xerces 2018). Monarch migration is mostly concentrated in river valleys and irrigated agricultural areas (Dingle et al. 2005; McIntyre et al. 2024). Threats to monarch butterfly include loss and degradation of breeding, migratory, and overwintering habitat due to past conversion of grasslands/shrublands to agriculture and widespread use of herbicides and pesticides, logging/thinning at overwintering sites in Mexico, urban development, senescence, incompatible management at California overwintering sites, and drought (USFWS 2024a). Critical habitat has been proposed at wintering sites in California, but none is present in the impact assessment area.

There are no known monarch or milkweed occurrence records in the impact assessment area based on queries of the Western Monarch Milkweed Mapper (WMMM) database (WMMM 2025) and the Wyoming Natural Diversity Database (WYNDD 2025b). The closest known monarch occurrence record in WMMM is approximately 12 miles to the west of the Federal mining plan modification area, which was from 1978 (WMMM 2025). The closest known monarch occurrence record in WYNDD is approximately 30 miles to the northeast of the Federal

mining plan modification area, which was collected in 2022. Showy milkweed (*A. speciosa*) and pallid milkweed (*A. cryptoceras*) are the most common milkweed species in Sweetwater County (UWBI 2025). Showy milkweed grows along streams, roadsides, and other disturbed sites, and pallid milkweed grows in desert hills in southwest Wyoming. Based on the plant species list from the baseline vegetation surveys, no milkweeds were documented in the Federal mining plan modification area. Therefore, it is unlikely that monarch breeding habitat is present in the impact assessment area. Other potential nectar foraging resources are present, including flowering shrubs such as rabbitbrush and some perennial forbs, providing non-breeding/migration habitat in the impact assessment area.

Suckley's Cuckoo Bumble Bee

Suckley's cuckoo bumble bee (*Bombus suckleyi*) is listed as a proposed endangered species. It has not been observed in the contiguous U.S. since 2016 (USFWS 2024b) and in Wyoming since 2012 (WYNDD 2025c). Suckley's cuckoo bumble bee historically occurred primarily in the western U.S. and Canada where it was documented in grasslands, shrub-steppe, montane to subalpine mesic meadows, conifer forest, agricultural fields, and urban areas (USFWS 2024b). From historic records, its habitat in Wyoming appears to be in forested mountainous areas, and all records are from northwestern Wyoming (WYNDD 2025c). Its primary host species, the western bumble bee (*Bombus occidentalis*) has also not been observed in sagebrush steppe communities, only in urban and mountainous areas (Tronstad et al. 2024). There are no known records of occurrence for the Suckley's cuckoo bumble bee or western bumble bees in the impact assessment area (WYNDD 2025c; 2025d). Suckley's cuckoo bumble bee may have been extirpated from Wyoming (Tronstad et al. 2024). Suckley's cuckoo bumble bee is not expected to occur in the impacts assessment area given its known range in Wyoming and the habitat conditions.

3.4.1.2 BLM Wyoming Sensitive Species

The issues identified for BLM sensitive species impact analysis are habitat loss and noise/ disturbance from mining activities.

Species are listed as BLM sensitive if there is evidence of a downward trend in population numbers, such that viability or a distinct population segment of the species is at risk across all or a significant portion of its range. A species may also be listed if it has a restricted geographic range or requires specialized or unique habitat that occurs on BLM-administered land, and there is evidence that these areas are threatened such that the species' viability may be at risk. The BLM Wyoming sensitive species listed for the RSFO that are considered in this analysis include pygmy rabbit (*Brachylagus idahoensis*), white-tailed prairie dog (*Cynomys leucurus*), Wyoming pocket gopher (*Thomomys clusius*), burrowing owl (*Athene cunicularia*), ferruginous hawk (*Buteo regalis*), golden eagle (*Aquila chrysaetos*), mountain plover (*Charadrius montanus*), and sagebrush obligates, which include Brewer's sparrow (*Spizella breweri*), sage sparrow (*Amphispiza belli*), sage thrasher (*Oreoscoptes montanus*), and loggerhead shrike (*Lanius ludovicianus*), and greater sage-grouse.

Pygmy Rabbit

The pygmy rabbit occurs only in the southwestern part of Wyoming, where it inhabits dense, tall stands of big sagebrush, usually along drainages within sagebrush-grasslands. Pygmy rabbits are dependent on sagebrush, which comprises up to 99 percent of their winter diet. Soft, deep soil is a key habitat feature since pygmy rabbits excavate their own burrows. Abundance and population trends in Wyoming are unknown, but the species appears to be declining range-wide (Keinath and McGee 2004; WGFD 2017).

Pygmy rabbits have been documented at the BBCM during previous annual lagomorph surveys (2009, 2011, 2013, 2014, and 2015), but they do not appear to be abundant (Fox River Resources 2024). During the 2012 exploration drill hole survey, pygmy rabbits were not observed, but suspected burrows and pellets were observed 5 miles to the west and 10 miles to the northwest and southwest of the Federal mining plan modification area (Intermountain Resources 2013).

White-tailed Prairie Dog

The white-tailed prairie dog is found in western and central Wyoming, where it inhabits desert shrublands, sagebrush-steppe, and grasslands (Orabona et al. 2012). Due to their colonial nature, white-tailed prairie dogs show high fidelity for their habitat once selected (Keinath 2004). They are highly susceptible to sylvatic plague, which can result in 90 percent mortality rate in infected colonies. White-tailed prairied dogs have low rates of dispersal, making it difficult for them to recolonize areas once extirpated (WGFD 2017). They are still widespread in Wyoming but are found in smaller, more fragmented colonies compared to their historic distribution, such that a moderate population decline has occurred statewide. Although current population trends appear to be stable, the species can experience at times drastic, localized declines attributed to disease, large-scale control efforts, and habitat modification (WGFD 2017).

White-tailed prairie dogs are relatively common around BBCM. During the 2012 exploration drill hole survey, an active white-tailed prairie dog town was within the proposed Pit 15 Federal mining plan modification area. The prairie dogs were generally found on sites with heavier soils dominated by Gardner saltbush (*Atriplex gardneri*) and other subshrubs (Intermountain Resources 2013).

Wyoming Pocket Gopher

The Wyoming pocket gopher is found only in south-central Wyoming where it is a year-round resident. This species inhabits upland dry ridge tops and shallow or gravelly loose soils within greasewood (*Sarcobatus* sp.) communities. It typically occurs on sites with 50 to 80 percent bare ground where shrubs are absent (WGFD 2017). Population status is unknown, but this species is considered rare with a very restricted geographic range (Beauvais and Dark-Smiley 2005).

Surveys were conducted for this species during the 2012 exploration drill hole survey. No pocket gophers were observed in the Federal mining plan modification area; however, two suspected pocket gopher mounds were found in habitat to the southwest and northwest of the Federal mining plan modification area (Intermountain Resources 2013). The closest was approximately 1.5 miles north of the Federal mining plan modification area, north of

Interstate 80. There is habitat for this species within the Federal mining plan modification area where greasewood communities are present.

Burrowing Owl

The burrowing owl is found in arid and semiarid environments, where it uses a variety of sites in well-drained, level to gently sloping areas that are characterized by sparse vegetation and bare ground. This species prefers open prairie, grassland, desert, and shrub-steppe habitats, but may also inhabit agricultural areas. It is dependent on mammals, particularly prairie dogs and ground squirrels that dig burrows, which the owl uses for nesting, roosting, and escape. It is considered an uncommon summer resident in Wyoming (WGFD 2017).

Within 1 mile of the BBCM, nine burrowing owl nests are currently still intact and monitored, with 1 or 2 typically being active in any one breeding season (Fox River Resources 2024). In 2024, two nests were active (adults present) and one of the nests produced two fledglings. Based on past nest history and monitoring at BBCM, burrowing owl nests have never been found within the Federal mining plan modification area, although several white-tailed prairie dog towns are present and foraging habitat is present.

Ferruginous Hawk

Ferruginous hawks breed throughout most of Wyoming, and winter in the southern portions of the State (Bechard and Schmutz 1995, Travsky and Beauvais 2005). Breeding occurs in arid grasslands, shrub-steppe, and desert shrublands where terrain is flat or rolling. Elevated nest sites are preferred, such as boulders, low cliffs, ridge crests, buttes, pinnacles, lone trees, and artificial nest platforms. This hawk requires areas with abundant prairie dog, jackrabbit, and/or ground squirrel populations (Travsky and Beauvais 2005). The North American population appears to be declining, but the species is relatively secure in Wyoming (Travsky and Beauvais 2005).

There are 19 intact ferruginous hawk nests within 1 mile of the Federal mining plan modification area. Of these nests, one (FH342) has been active and one (FH402) has been tended in the past 5 years (2020 to 2024) (Fox River Resources 2024). FH342 is on a power pole approximately 0.5 mile to the southwest of the Pit 10 portion of the Federal mining plan modification area. FH342 has fledged young in 4 of the past 5 years (2020 to 2023). In 2024, FH342 was used by great horned owls and red-tailed hawks and not ferruginous hawks. FH402 is 0.8 mile to the south of the Pit 10 portion of the Federal mining plan modification area on a cliff/rock outcrop. FH402 was tended in 3 of the past 5 years (including in 2024) but never produced young. Foraging habitat is present throughout the impact assessment area, except where mining disturbance is present.

Golden Eagle

The golden eagle is listed as a bird of conservation concern (BCC, USFWS 2025, **Appendix B**). The golden eagle is found year-round in western and southern Wyoming in grassland and shrub-steppe habitat (DeLong 2004). It typically nests on cliffs but may also use large trees or artificial platforms. Golden eagles tend to return to the same territory each year and frequently reuse nests. It preys primarily on prairie dogs, jackrabbits, and ground squirrels, and prey abundance

affects reproduction (DeLong 2004). This species is a common year-round resident to Wyoming (Orabona et al. 2012) though populations across the western U.S. are declining (Kochert and Steenhof 2002).

There currently are no intact golden eagle nests within 1 mile of the Federal mining plan modification area. Historically there were two nests on Pit 10 high walls, but both were destroyed by natural causes in 2011 (Fox River Resources 2024). Golden eagles regularly nest in other portions of the BBCM permit area and may use the impact assessment area for foraging.

Mountain Plover

The mountain plover inhabits arid shortgrass prairies and other areas with low, open vegetation, such as desert shrublands. This species is adapted to sparsely vegetated and bare ground areas associated with various disturbances (e.g., fire, heavy grazing, or prairie dog colonies) (Nicholoff 2003). The core breeding area in Wyoming is concentrated in the central portion of the State, but it has been detected in every county (Smith and Keinath 2004). Approximately 25 percent of the entire North American population breeds in Wyoming (Smith and Keinath 2004). The current population trend in Wyoming is unknown, but the species is threatened by habitat loss and human disturbance (WGFD 2017).

Surveys were conducted for this species during the 2012 exploration drill hole survey, but no mountain plovers were observed in the Federal mining plan modification area. Furthermore, mountain plovers have not been recorded during any other past wildlife baseline or annual monitoring surveys completed within the BBCM permit area. However, the species is known to occur several miles to the east of the BBCM (WYNDD 2025e), and potential habitat is present in the Federal mining plan modification area, including white-tailed prairie dog towns, Gardner saltbush communities, and other subshrub plant communities (Intermountain Resources 2013).

Sagebrush Obligates

Brewer's sparrow, sage sparrow, and sage thrasher are considered sagebrush obligates because they are restricted to sagebrush ecosystems and cannot survive in large expanses that lack sagebrush shrubs (WGFD 2017). The loggerhead shrike is also highly associated with sagebrush, but may also use open pinyon-juniper, grasslands, and other shrub-steppe communities where perch sites are available. These species commonly breed throughout most of Wyoming wherever sagebrush is present (WGFD 2017, Orabona et al. 2012). All four species have stable populations in Wyoming, but habitat loss is a major threat, and range-wide populations have shown declines (Keinath and Schneider 2005, WGFD 2017).

During the 2012 exploration drill hole survey, all of these species were observed in suitable habitats throughout the Federal mining plan modification area. The Brewer's sparrow, sage sparrow, and sage thrasher were common, occurring primarily in habitats dominated by Wyoming big sagebrush (*Artemisia tridentata wyomingensis*). The loggerhead shrike was less common but was still observed throughout the Federal mining plan modification area. The loggerhead shrike was found most frequently in habitats that were dominated by tall shrubs such as greasewood and basin big sagebrush (*A.t. tridentata*), but they were also observed in mixed shrub and Wyoming big sagebrush habitats (Intermountain Resources 2013). The 2024 annual

wildlife surveys recorded Brewer's sparrow and sage thrasher at established point count stations in the BBCM permit area.

Greater Sage-Grouse

The impact assessment area for evaluating impacts of the alternatives and incremental impacts on greater sage-grouse is a 4-mile buffer around the Federal mining plan modification area, which is consistent with requirements in BLM's 2015 Approved Resource Management Plan Amendment (ARMPA) for Greater Sage-Grouse (BLM 2015b) and the Wyoming Governor's EO 2019-3 (State of Wyoming 2019). The greater sage-grouse issue identified for impact analysis is mining-related habitat loss and noise/disturbance.

Greater sage-grouse is a sagebrush-obligate species and requires sagebrush to meet most of its breeding, nesting, and foraging needs throughout the year. While greater sage-grouse use other types of vegetation communities adjacent to sagebrush patches, it cannot survive in large expanses that lack any sagebrush component. Sagebrush shrubs are used for forage and for nesting, brood-rearing, and fall/winter cover. Greater sage-grouse congregate on leks from March through April, when the males display breeding plumage to attract hens for mating. Approximately two-thirds of hens nest within 3 miles of the lek where they were bred and the remainder usually nest within 15 miles of the lek where they were bred. Nesting and early brood-rearing occur from late spring to mid-July (WGFD 2003).

The Federal mining plan modification area is not within a Wyoming Greater Sage-grouse Core Population Area (Core Area)/BLM Priority Habitat Management Area (PHMA) as identified by the Governor's EO 2019-3 (State of Wyoming 2019) and the BLM (BLM 2015b). There are no Core Areas/PHMAs within the impact assessment area (i.e., a 4-mile buffer around the Federal mining plan modification area). The closest Core Area/PHMA is approximately 5 miles to the north. The proposed Federal mining plan modification area is within general habitat for the greater sage-grouse as mapped by WGFD (2015). There are no greater sage-grouse leks within 4 miles of the Federal mining plan modification area (Fox River Resources 2024). Within the impact assessment area, past and present disturbances are primarily from the BBCM, in addition to transportation infrastructure (e.g., Interstate 80, local paved and gravel roads, rail line), utility corridors, oil and gas production and exploration, livestock grazing, and fencing.

3.4.1.3 General Fish and Wildlife

The Federal mining plan modification area provides habitat for a variety of birds, mammals, and reptiles that are associated with sagebrush and desert shrubland communities. There are no aquatic or mesic habitat types in the Federal mining plan modification area to support breeding; therefore, amphibians are unlikely to be present.

Big Game

The impact assessment area for evaluating the impacts of the alternatives on big game species is the Federal mining plan modification area and an associated 1-mile buffer. The impact assessment area for incremental impacts on big game is a 4-mile buffer. WGFD designates big game herd units for management purposes and tracking population trends. The pronghorn antelope in the assessment areas are part of the Bitter Creek Herd Unit for pronghorn, which

encompasses 1,836,420 acres. The mule deer are part of the South Rock Springs Herd Unit (1,475,090 acres) and the Rocky Mountain elk are part of the Petition Herd Unit (1,836,540 acres). The issue identified for big game impact analysis is habitat loss due to mining related surface disturbance.

The primary big game species that use the BBCM area are mule deer and pronghorn antelope, but Rocky Mountain elk are now found in the area almost year-round, with herds up to 100 elk observed (Fox River Resources 2024). During the 2024 annual wildlife surveys, elk appeared to be more abundant than mule deer in the BBCM area, where they frequented reclaimed mine lands (Fox River Resources 2024). WGFD classifies the entire Federal mining plan modification area as winter/year-long range for both pronghorn antelope and mule deer (WGFD 2021a, 2021b). This means that a resident population occupies the area year-round, but, during the winter months, additional animals enter the area from nearby seasonal ranges. The entire Federal mining plan modification area is classified as undetermined for elk, which means that the area is expected to or does support a population, but no seasonal range type has been formally designated (WGFD 2021c). All the big game ranges are classified as general use; none are classified as crucial range. There are no big game migration routes or parturition areas in the Federal mining plan modification area.

The number of pronghorn in the Bitter Creek Herd (Unit 414) met the WGFD population objective from 2018 to 2022. However, the severe winter of 2022-2023 resulted in a 60 percent decrease in the population. Competition with the high number of feral horses in the area continues to be an issue (WGFD 2024). The mule deer South Rock Springs Herd (Unit 424) was below WGFD population objective from 2018 to 2022. There are no trends or population numbers available for the Elk Petition Herd (Unit 430).

Raptors and Other Migratory Birds

The impact assessment area for evaluating the impacts of the alternatives on raptors and other migratory birds is the Federal mining plan modification area and an associated 1-mile buffer. The impact assessment area for incremental impact analyses for raptors and other migratory birds is the Federal mining plan modification area and an associated 1-mile buffer. The issue identified for impact analysis is disturbance to nesting birds and raptors due to mining activity and habitat loss due to mining related surface disturbance.

Analysis of migratory birds is focused on the Coal Mine List of 40 Migratory Bird Species of Management Concern in Wyoming (USFWS 2002). This list is based on the Wyoming Bird Conservation Plan (Nicholoff 2003), which ranks species in order of conservation priority. **Table 3-24** lists Priority Level 1 and Level 2 species that have suitable habitat in the Federal mining plan modification area. Several of these species are ESA-listed species or BLM sensitive species, which were discussed in detail in Sections 3.4.1.1 and 3.4.1.2, respectively.

Raptor species that are classified as BLM sensitive (i.e., burrowing owl, ferruginous hawk, and golden eagle) were previously discussed in Section 3.4.1.2. Other raptors that occur in the Federal mining plan modification area include red-tailed hawk (*Buteo jamaicensis*), prairie falcon (*Falco mexicanus*), great horned owl (*Bubo virginianus*), and northern harrier (*Circus cyaneus*). Potential nesting substrates in the impact assessment area include rock outcrops/cliffs,

utility poles, mining equipment, and mine high walls. There is an intact red-tailed hawk nest (RH190) on a highwall in the southwestern portion of Pit 10 (Fox River Resources 2024). It was active from 2020 to 2023 but inactive in 2023 and 2024. Great horned owls have historically nested on the high wall of Pit 10, but the nest site was removed by mining operations in 2012. In addition, there is a nest (FH342/RH121/GH59) on a power pole south of Pit 10 that is used alternatively by red-tailed hawk, great horned owl, and ferruginous hawk, depending on the year. The impact assessment area provides foraging habitats for all these raptor species.

Avian species are monitored annually at the BBCM through point-count surveys focused on Priority Level 1 and Level 2 species, and raptor nest surveys (Intermountain Resources 2014) and more recently USFWS BCC (USFWS 2021; Fox River Resources 2024). The USFWS IPaC project list only identified one BCC, golden eagle, as potentially occurring in the Federal mining plan modification area (see Section 3.4.1.2 for additional information on golden eagle). Priority species that were observed at the BBCM during the 2024 annual survey or incidentally during other previous wildlife surveys at BBCM are indicated in **Table 3-24**. Other non-priority birds observed during the surveys included Brewer's blackbird (*Euphagus cyanocephalus*), common raven (*Corvus corax*), horned lark (*Eremophila alpestris*), mourning dove (*Zenaida macroura*), rock wren (*Salpinctes obsoletus*), and Say's phoebe (*Sayornis saya*) (Intermountain Resources 2014; Fox River Resources 2024).

Table 3-24. Priority Bird Species with Suitable Habitat in the Federal Mining Plan Modification Area

Conservation Priority	Species Name	Primary Habitat Type(s)	Observed at BBCM
Level I (Conservation Action)[1]	**Brewer's Sparrow** *Spizella breweri*	Shrub-steppe, Mountain-foothills Shrub	**Yes**
	Burrowing Owl *Athene cunicularia*	Shortgrass Prairie	**Yes**
	Ferruginous Hawk *Buteo regalis*	Shrub-steppe, Shortgrass Prairie	**Yes**
	Greater Sage-grouse *Centrocercus urophasianus*	Shrub-steppe	**Yes**
	McCown's Longspur *Rhynchophanes mccownii*	Shortgrass Prairie, Shrub-steppe	No
	Mountain Plover *Charadrius montanus*	Shortgrass Prairie, Shrub-steppe	No
	Sage Sparrow *Amphispiza belli*	Shrub-steppe, Mountain-foothills Shrub	**Yes**
Level II (Monitoring)[2]	Black-chinned Hummingbird *Archilochus alexandri*	Plains/Basin Riparian, Shrub-steppe	No
	Grasshopper Sparrow *Ammodramus savannarum*	Shortgrass Prairie, Shrub-steppe	No
	Lark Bunting *Calamospiza melanocorys*	Shortgrass Prairie, Shrub-steppe	No

Conservation Priority	Species Name	Primary Habitat Type(s)	Observed at BBCM
	Lark Sparrow *Chondestes grammacus*	Shrub-steppe	**Yes**
	Loggerhead Shrike *Lanius ludovicianus*	Shrub-steppe	**Yes**
	Sage Thrasher *Oreoscoptes montanus*	Shrub-steppe	**Yes**
	Vesper Sparrow *Pooecetes gramineus*	Shrub-steppe	**Yes**

[1]Level I – Species clearly needs conservation action. Declining population and/or habitat loss may be significant.

[2]Level II – The action and focus for the species is monitoring; declining populations and habitat loss are not yet significant.

Source: Nicholoff 2003.

3.4.1.4 Past and Present Projects Affecting Fish and Wildlife

Past and present projects within the impact assessment area that are contributing to the current affected environment for fish and wildlife include BBCM mining activities (existing access roads, a surface water retention basin, topsoil stripping to accommodate mining of the existing leased and fee coal, and topsoil and overburden stockpiles); oil and gas exploration, production, and transport (i.e., pipelines); exploration drilling for coal to support BBCM; and livestock grazing. The past and present projects have disturbed and removed habitat in the impact assessment areas, though some has been reclaimed. Interstate 80 is also within the impact assessment areas. Approximately 13,521 acres of wildlife habitat have been disturbed by BBCC mining related activities within the BBCM permit boundary (Fox River Resources 2024). Currently about 6,907 acres of these disturbed lands have been reclaimed to mixed upland shrubland and upland grassland. About 6,614 acres are still disturbed and un-reclaimed because of ongoing mining activities.

3.4.2 Environmental Consequences

3.4.2.1 Threatened and Endangered Species – Alternatives Impacts

Alternative I – No Action Alternative

Under the No Action Alternative, the Proposed Action would not be implemented, and no Federal coal would be mined in the Federal mining plan modification area. No additional impacts on threatened, endangered, or proposed species from habitat removal or water depletions would occur other than those already authorized at the BBCM.

Alternative II – Proposed Action

Yellow-billed Cuckoo

Yellow-billed cuckoo does not occur in the impact assessment area and there is no suitable riparian habitat present that would support this species. No designated critical habitat is present. Therefore, the Proposed Action would have **no effect** on yellow-billed cuckoo or its critical habitat because none is present.

Colorado River Fish Species

BBCM is a total containment mine where surface water controls and containment structures intercept and divert stormwater to minimize runoff entering disturbed areas and to prevent discharge of surface runoff from disturbed areas. Impounded storm water at BBCM typically evaporates, infiltrates, or is used for dust control on haul roads and therefore is not discharged. See hydrology analysis (***Section 3.6.1.3***) for further details. The retained water is considered a temporary water depletion because it is no longer entering Bitter Creek (which is a tributary of the Green River where the fish occur downstream). As pits at BBCM are fully mined and then closed and reclamation is complete, the diversions and containment structures are removed, returning the water to the original drainage basin.

In 1984, OSMRE engaged in formal ESA section 7 consultation with USFWS for continued operation and a proposed Federal mining plan modification for the BBCM. The USFWS issued an interim biological opinion (BO) in 1984 contingent on the outcome of the Flaming Gorge Dam BO. The interim BO addressed the effects of BBCM's consumptive water use on Colorado pikeminnow and humpback chub and their critical habitats. A final BO (USFWS 1988) for the BBCM was issued in 1988 for water depletions of up to 72 acre-feet per year. In 2003, consultation was re-initiated to cover an increase in consumptive water use at BBCM in the amount of 160 acre-feet/year (USFWS 2003). In 2003 BBCC paid a fee to the Recovery Program to offset the effects of 160 acre-feet of annual depletions on the Colorado River endangered fish, as described in the Reasonable and Prudent Measures section of the 1988 BO (USFWS 1988). The fee offsets effects from depletions because the money is used to acquire water and other recovery activities for the fish to ensure sufficient instream flow (USFWS 1988; USFWS 2003).

At maximum development, the BBCM will have disturbed 14,000 acres, which is a 4 percent total reduction in the watershed area contributing runoff to Bitter Creek. The potential loss of runoff due to the control structures was also estimated in a year-by-year life of mine study and compared to the estimated flow in Bitter Creek of 4,000 acre-feet per year. In any given year of mining, the maximum percent of temporary flow reduction in Bitter Creek would be approximately 4 percent, which equates to 160 acre-feet per year (see **Appendix D**). The Proposed Action, entailing 257 acres of new surface disturbance in proposed Pit 15 and the Pit 10 Expansion area, would result in annual water depletions from Bitter Creek of between 3.7 to 7.5 acre-feet per year. Current surface disturbance area at BBCM plus the 257 acres of new surface disturbance, would total approximately 12,500 acres. Since the disturbed areas where runoff is diverted and contained would remain less than 14,000 acres (maximum development scenario), or 4 percent of the Bitter Creek watershed, the total annual water depletions at BBCM would continue to remain under the amount of 160 acre-feet per year on average (see

Section 3.6.2 and **Appendix D** for further details). The depletions resulting from the Proposed Action are therefore covered by the 2003 consultation and BBCM's fee payment and are not considered a new depletion. The Proposed Action would have **no effect** on humpback chub, bonytail chub, Colorado pikeminnow, and razorback sucker or their designated critical habitat because the effects of ongoing water depletions have already been mitigated through the fee payment.

Monarch Butterfly

The Proposed Action would remove 257 acres of foraging and migration habitat in the Federal mining plan modification area in addition to the 68 acres that have previously been disturbed. No breeding habitat is present; therefore, none would be affected. Reclamation following mining would restore topography and topsoil, and the disturbed areas would be reseeded per BLM requirements. Over time, nectar plants, such as rabbitbrush are expected to return to the area. The amount of foraging/migration habitat that would be removed is negligible compared to what is available in the species' range across North America, and no breeding habitat would be impacted. For these reasons, the Proposed Action is **not likely to jeopardize** the continued existence of the monarch butterfly.

Suckley's Cuckoo Bumble Bee

Suckley's cuckoo bumble bee is unlikely to occur in the impact assessment area. Therefore, the Proposed Action would have **no effect** on Suckley's cuckoo bumble bee. No critical habitat has been designated for this species.

3.4.2.2 Threatened and Endangered Species – Incremental Impacts

Alternative I – No Action Alternative

Under the No Action Alternative, the Proposed Action would not be implemented, and the federal coal would not be mined. There would be no habitat loss or water depletions other than what is currently authorized; therefore, there would be no incremental impacts on threatened, endangered, and proposed species.

Alternative II – Proposed Action

Colorado River Fish Species

In conjunction with the Proposed Action, RFFAs that deplete water from the Upper Colorado River Basin may incrementally affect the four Colorado River fish species. Total annual depletions at BBCM would continue to remain within the 160 acre-feet/year limit previously covered under the 2003 ESA section 7 consultation for the BBCM (USFWS 2003). The fee paid at that time by BBCC offsets the effects from ongoing annual water depletions at BBCM. Therefore, no new water depletions would occur that have not previously been analyzed and mitigated through prior section 7 consultation, and no new incremental impacts would occur.

Monarch Butterfly

The Proposed Action would not contribute incremental impacts on breeding habitat because none is present in the impact assessment area. In conjunction with the Proposed Action, RFFAs that remove flowering plants may incrementally affect monarch foraging and migration habitat within the impact assessment area (i.e., Federal mining plan modification area plus 1-mile buffer). Reclamation of mined areas would minimize the incremental impacts. The area of foraging and migration habitat that would be incrementally impacted is negligible relative to the species large geographic range, and is not likely to have population level effects, particularly since no breeding habitat would be impacted.

3.4.2.3 BLM Wyoming Sensitive Species – Alternatives Impacts

Alternative I – No Action Alternative

Under the No Action Alternative, the Proposed Action would not be implemented and no additional impacts on BLM Wyoming sensitive species other than those already authorized at the BBCM would occur.

Alternative II – Proposed Action

Pygmy Rabbit, White-tailed Prairie Dog, and Wyoming Pocket Gopher

The Proposed Action would remove vegetation, disturb soils, and alter topography in approximately 257 acres of habitat for pygmy rabbit, white-tailed prairie dogs, and Wyoming pocket gopher, which is 4 percent of the 6,360-acre impact assessment area (i.e., Federal mining plan modification area plus 1-mile buffer). Other potential impacts include mortality of individuals, restriction of movement (caused by fences, pits, or other infrastructure), and disturbance from noise and mining activity that may cause individuals to avoid otherwise suitable habitat in the impact assessment area. White-tailed prairie dogs inhabiting the colonies in the Federal mining plan modification area would be displaced to other adjacent habitats. Reclamation following completion of mining activities would minimize adverse effects from removal of vegetation cover and foraging resources. Topsoil would be salvaged and then returned during reclamation. The structure and composition of the soils at deeper depths where burrows are created would likely change but should be suitable for these species over time.

Burrowing Owl, Ferruginous Hawk, Golden Eagle, Mountain Plover, and Sagebrush Obligates

The Proposed Action would result in removal of 257 acres of habitat for sensitive bird species, which would reduce foraging resources/prey and cover in 4 percent of the 6,360-acre impact assessment area (i.e., Federal mining plan modification area plus 1-mile buffer). Reclamation following completion of mining activities would minimize adverse effects from the temporary habitat removal. Reclamation would be ongoing as mining proceeds, and some vegetation could become established within approximately 3 to 5 years following reclamation. Consequently, some disturbed areas could become available for use by these species in the short term. However, the re-establishment of sagebrush shrubs can take 20 to 30 years; therefore, sagebrush obligates would be unable to fully use this area until habitat reclamation is complete.

Other impacts could include temporary displacement from the area; interference with breeding activities and nest abandonment because of construction or operations noise, vibration, and other human activity; increased predation of eggs or young as a result of land use changes; and/or decrease in prey populations. Avian species are less likely to incur direct mortality compared to species that cannot fly, but vehicle/equipment collisions are possible.

No golden eagle nests would be affected by the Proposed Action because none are known to exist within the impact assessment area. There are 19 intact ferruginous hawk nests and 9 known burrowing owl nest burrows within the impact assessment area. None of these nests would be destroyed by the Proposed Action because none are within the proposed disturbance area. Individuals using these nests may be displaced during blasting and initial ground clearance if the Proposed Action is implemented. These individuals could move to one of the many alternative nest sites available in the vicinity. Ferruginous hawks and other raptors at BBCM have a history of successfully nesting adjacent to active mine pits, including on artificial nest platforms and pit high walls (Fox River Resources 2024). Raptors using the BBCM area appear to be capable of habituating to baseline noise levels associated with dragline and other day-to-day pit operations. Resource protection measures, including those discussed in ***Section 2.4***, would ensure the protection of active raptor nests and reduce the likelihood of affecting nesting sagebrush obligates during the breeding season. These include annual monitoring of raptor nests and the productivity of occupied nests, monitoring prey populations, instituting spatial buffers as needed during the nesting season, nest clearance surveys prior to ground clearing during the breeding season, or other mitigation measures determined in coordination with the USFWS.

Greater Sage-Grouse

Mining activities under the Proposed Action would result in removal of approximately 257 acres of general sage-grouse habitat which would reduce forage and cover in 0.5 percent of the impact assessment area (i.e., 4-mile buffer around the Federal mining plan modification area). This is in addition to the 68 acres that have previously been disturbed in the Federal mining plan modification area. In the larger impact assessment area, past and present mining has impacted approximately 6,950 acres (roughly estimated from aerial imagery) or 15 percent of the 46,988-acre impact assessment area, some of which has been reclaimed. Other disturbances such as roads, utility corridors, and oil and gas development/exploration have also impacted sage-grouse general habitat in the impact assessment area. The Proposed Action would have no impact on Core Areas/PHMAs. Reclamation of the disturbed habitat would occur according to the BBCM mine permit and BBCM reclamation plan approved by WDEQ and OSMRE, and resource protection measures, including those described in ***Section 2.4***, would be implemented. However, re-establishment of sagebrush at a level adequate for greater sage-grouse use may require 20 to 30 years. Mining-related disturbance would also increase opportunities for invasive plant species and noxious weeds to establish, which could reduce habitat quality for greater sage-grouse. This impact would be minimized via the weed control portion of the BBCM reclamation plan.

Greater sage-grouse may also be disturbed by noise and ground shock from blasting and other mining activities. This could temporarily displace individual greater sage-grouse that are in the impact assessment area but is not expected to interfere with survival, breeding, or have population-level effects since there are no leks within 4 miles of the Federal mining plan modification area, and the impact assessment area is not within a Core Area/PHMA. The

Proposed Action would be consistent with the Wyoming EO 2019-3 (State of Wyoming 2019) and BLM's 2015 ARMPA for Greater Sage-Grouse (BLM 2015b). No surface occupancy or seasonal use/human activity stipulations from the EO or ARMPA would apply because the leks are distant and no Core Areas/PHMAs are present. Should any new leks be found during future field surveys, appropriate mitigation steps would be taken according to the resource protection measures in ***Section 2.4***.

3.4.2.4 BLM Wyoming Sensitive Species – Incremental Impacts

Alternative I – No Action Alternative

Under the No Action Alternative, the Proposed Action would not be implemented and therefore no mining would occur. The Proposed Action would not contribute to incremental habitat and disturbance impacts resulting from RFFAs in the incremental impact assessment areas.

Alternative II – Proposed Action

Pygmy Rabbit, White-tailed Prairie Dog, Wyoming Pocket Gopher, Burrowing Owl, Ferruginous Hawk, Golden Eagle, Mountain Plover, and Sagebrush Obligates

RFFAs in the incremental impact assessment area (i.e., Federal mining plan modification area and an associated 1-mile buffer) include continued expansion and reclamation of the BBCM and associated mining exploration activities; oil and gas exploration and production; livestock grazing; transportation corridors (vehicle and rail); utility corridors; and possible additional coal leasing facilitated by the OBBB. Implementation of the Proposed Action would result in removal of approximately 257 additional acres of habitat for BLM sensitive species which equates to 4 percent of the incremental impact assessment area. The Proposed Action and RFFAs within the incremental impact assessment area would continue to disturb and incrementally remove habitat for these species. Incremental impacts on these species would be minimized with successful implementation of the BBCM reclamation plan and raptor and other avian protection measures.

Greater Sage-Grouse

RFFAs in the incremental impact assessment area (i.e., Federal mining plan modification area and an associated 4-mile buffer [46,988 acres]) include continued expansion and reclamation of the BBCM and associated mining exploration activities; oil and gas exploration and production; livestock grazing; transportation corridors (vehicle and rail) and a network of other gravel/dirt roads; and utility corridors.

The RFFAs within the incremental impact assessment area could incrementally alter and/or remove greater sage-grouse habitat. Implementation of the Proposed Action would contribute to the removal of approximately 257 additional acres of general sage-grouse habitat, which equates to 0.5 percent of the incremental impact assessment area. Incremental impacts on general sage-grouse habitat would be minimized through implementation of the BBCM reclamation plan. There are no Core Areas/PHMAs or leks within the incremental impact assessment area. Therefore, there would be no impact on Core Areas/PHMAs or leks or interference with breeding activities. Incremental impacts on greater sage-grouse are expected to be minimal given no Core Areas/PHMAs would be affected, only 0.5 percent of the incremental

impact assessment area would be impacted, and because reclamation would restore sagebrush habitat over the long term.

3.4.2.5 General Fish and Wildlife – Alternatives Impacts

Alternative I – No Action Alternative

Under the No Action Alternative, the Proposed Action would not be implemented and no additional impacts on big game (i.e., mule deer, pronghorn antelope, and Rocky Mountain elk), raptors, or other migratory birds would occur other than those already authorized at the BBCM.

Alternative II – Proposed Action

Big Game

Impacts on pronghorn antelope, mule deer, and Rocky Mountain elk would include temporary loss of forage and cover, mortality from animal-vehicle collisions, and displacement from otherwise suitable habitat due to noise and mining activity in the impact assessment area (i.e., Federal mining plan modification area and an associated 1-mile buffer). Other potential impacts could include habitat alteration as a result of invasive plant species and noxious weed establishment. Temporary impacts from surface disturbance would leave approximately 257 acres of pronghorn antelope and mule deer winter/year-long range as well as general habitat for Rocky Mountain elk unavailable for use in the long-term, affecting 4 percent of the 6,360-acre impact assessment area. The amount of habitat that would be affected is small relative to the large areas used by big game, and no crucial habitat would be impacted. Once reclamation is initiated, vegetation production could become established within approximately 3 to 5 years such that some areas could become available for big game use in the short term. Elk are known to use reclaimed areas of the BBCM (Fox River Resources 2024).

According to the resource protection measures discussed in ***Section 2.4***, impacts on big game would be minimized by reclaiming the land using a certified weed-free diverse seed mix, which would consist of native grasses, forbs, and shrubs (as defined by existing range sites), to support the post-mine land use as range for livestock and wildlife. Big game monitoring surveys would also be completed as required by the WDEQ and the WGFD. Results of annual monitoring surveys, existing baseline surveys, and future baseline surveys would be used to further define areas of concern and to identify developing mitigation needs. Given that the Federal mining plan modification area does not provide crucial habitat or parturition areas, that a reclamation and monitoring plan would be implemented, and that these species are wide-ranging and could move to other nearby habitat, impacts on big game would be minimal.

Raptors and Other Migratory Birds

The Proposed Action would result in removal of 257 acres of habitat for raptors and other migratory birds, which would reduce foraging resources/prey and cover in 4 percent of the 6,360-acre impact assessment area (i.e., Federal mining plan modification area plus 1-mile buffer). Reclamation following completion of mining activities would minimize adverse effects from the temporary habitat removal. Reclamation would be ongoing as mining proceeds, and some vegetation could become established within approximately 3 to 5 years following reclamation.

Consequently, some disturbed areas could become available for use by these species in the short term. However, the re-establishment of shrubs can take 20 to 30 years. None of the raptor nests known to occur in the impact assessment area would be destroyed because they are not within the proposed pit boundaries where disturbance would occur.

Other impacts on birds could include habitat fragmentation, temporary displacement, mortality from vehicle/equipment collisions, interference with breeding or nest abandonment as a result of construction or operations noise and activity, increased predation of eggs or young, and alteration of habitat due to invasion of invasive plant species and noxious weeds. Resource protection measures, including those discussed in ***Section 2.4***, would ensure the protection of active raptor nests and reduce the likelihood of other migratory birds during the breeding season. These include annual monitoring of raptor nests and the productivity of occupied nests, monitoring prey populations, instituting spatial buffers as needed during the nesting season, nest clearance surveys prior to ground clearing during the breeding season, or other mitigation measures determined in coordination with the USFWS.

3.4.2.6 General Fish and Wildlife – Incremental Impacts

Alternative I – No Action Alternative

Under the No Action Alternative, the Proposed Action would not be implemented and, therefore, no mining would occur. The Proposed Action would not contribute to incremental habitat and disturbance impacts resulting from RFFAs in the incremental impact assessment area.

Alternative II – Proposed Action

Big Game

RFFAs in the incremental impact assessment area (i.e., Federal mining plan modification area and an associated 4-mile buffer [46,988 acres]) include continued expansion and reclamation of the BBCM and associated mining exploration activities; oil and gas exploration and production; livestock grazing; transportation corridors (vehicle and rail) and a network of other gravel/dirt roads; utility corridors; and possible additional coal leasing facilitated by the OBBB.

The RFFAs within the incremental impact assessment area could incrementally alter and/or remove big game habitat. Implementation of the Proposed Action would contribute to the removal of approximately 257 additional acres of pronghorn antelope and mule deer winter/year-long range as well as general habitat for Rocky Mountain elk, which equates to 0.5 percent of the incremental impact assessment area. Incremental impacts on big game habitat would be minimized through implementation of the BBCM reclamation plan and reseeding to restore post mining land use that would provide big game range. There would be no impact on crucial range or parturition areas because none are present in the incremental impact assessment area. Incremental impacts on big game are expected to be minimal.

Raptors and Other Migratory Birds

Implementation of the Proposed Action would result in removal of approximately 257 acres of habitat for raptors and other migratory birds, which equates to 4 percent of the incremental impact assessment area (i.e., Federal mining plan modification area plus 1-mile buffer). The Proposed Action and RFFAs within the incremental impact assessment area would continue to disturb and incrementally remove habitat for these species. Incremental impacts on these species would be minimized with successful implementation of the BBCM reclamation plan and raptor and other avian protection measures.

3.5 Geology/Mineral Resources/Energy Production

The impact assessment area for alternatives and incremental impacts analyses for geology/mineral resources/energy production is the Federal mining plan modification area. The issues identified for impact analysis for geology/mineral resources/energy production are the current use of the coal resource versus future use, modification of the geology in the mined area, and the temporary loss of use of land for oil and gas extraction, processing, and transport.

The past and present actions within the alternatives impact assessment area (i.e., Federal mining plan modification area) for geology/mineral resources/energy production are scattered oil and gas exploration, production, and transport (i.e., pipelines); exploration drilling for coal in support of BBCM; livestock grazing (i.e., cattle and sheep); and BBCM coal mining activities under a separate existing BLM ROW agreement.

The RFFAs within the incremental impact assessment area (i.e., Federal mining plan modification area) for geology/mineral resources/energy production are scattered oil and gas exploration, production, and transport (i.e., pipelines); exploration drilling for coal in support of BBCM; livestock grazing (i.e., cattle and sheep); BBCM coal mining activities under a separate existing BLM ROW agreement; and possible additional coal leasing facilitated by the OBBB.

3.5.1 Affected Environment

The Federal mining plan modification area is on the dissected arid upland on the east flank of the Rock Springs Uplift. The Rock Springs Uplift is a large anticline dome with exposures of Cretaceous and Tertiary aged rocks. The major axis of the dome trends north-south and is approximately 90 miles long and the minor axis trends east-west and is approximately 50 miles long (Love and Christiansen 1985). The topography of the Federal mining plan modification area and adjoining areas is characterized by a series of north-south trending hogback ridges having steep western faces and gentle dipping (3 to 10 degree) slopes to the east. The ridges are generally composed of the more resistant sandstones, while soft, and easily erodible shales form strike valleys between them.

Total relief in the Federal mining plan modification area is approximately 350 feet. Elevations vary from approximately 6,650 feet in the lowland drainage basins to 7,000 feet on the eastern extent of the Pit 10 portion of the Federal mining plan modification area.

3.5.1.1 Stratigraphy

Sedimentary rocks in the Rock Springs Uplift range in age from middle Cambrian to Tertiary. The formations exposed at the surface are late Cretaceous and younger in age and have a composite thickness of 12,000 to 14,000 feet. The oldest exposed formation is the late Cretaceous Baxter shale. The formations, ascending through the Cretaceous, consist of the Blair, Rock Springs, Ericson, Almond, Lewis, Fox Hills, and Lance formations. The Paleocene Fort Union Formation unconformably rests on the Lance Formation, while the Eocene Wasatch Formation unconformably overlies the Fort Union Formation (Love and Christiansen 1985).

The Wasatch grades into the Green River Formation which is overlain by the Uinta, Bridger, and Washakie formations, respectively. The Oligocene Bishop conglomerate unconformably overlies these.

These sequences reflect a depositional change in environment from the marine Baxter shale to the terrestrial Wasatch and Green River formations. The period from the late Cretaceous through the Tertiary was one of slow marine regression of the Epeiric Sea marked by periods of transgression.

3.5.1.2 Coal Occurrence

People have mined coal all over the State of Wyoming for more than 100 years. Coal is the second largest resource produced in the State and is mined using both surface and underground mining methods. In 2019, the State was responsible for producing more than 270 M tons of coal (BLM 2025).

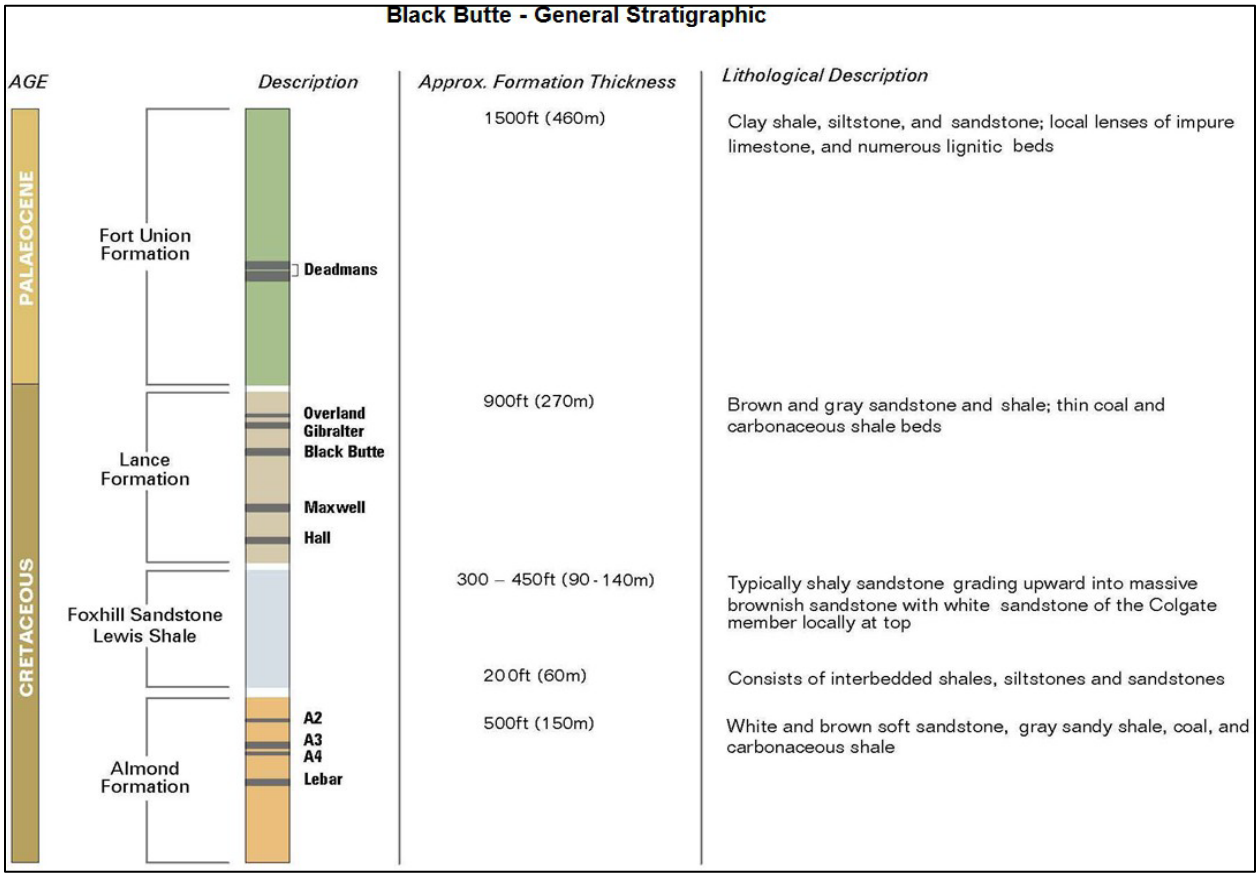
Coal beds of the Rock Springs Uplift occur within the Rock Springs, Almond, Lance, Fort Union, and Wasatch formations. The beds generally weather shallow drab-gray slopes and valleys between hogback ridges of resistant sandstone. The soft coal weathers several feet below the surface and is usually covered by a veneer of soil and vegetation. In isolated areas, the outcrops have been burned by spontaneous combustion, lightning strikes, or wildfires, resulting in reddish-orange clinker beds. Minerals associated with the weathering of the coal beds include selenite, limonite, and some calcite.

Coal beds at the BBCM occur within the Almond, Lance, and Fort Union formations. There are from 7 to 18 coal beds in the BBCM area. The BBCM general stratigraphy can be seen in **Figure 3-9**. The coal beds range in average thickness from 1 to 31 feet.

The Federal mining plan modification area is in the Fort Union Formation. The Fort Union Formation outcrops as a series of drab-brown and drab-gray northeast trending ridges and valleys. The Fort Union Formation has a thickness of less than 800 feet and is composed of gray shale and interbedded gray siltstone, gray very fine-grained sandstone, gray and brown carbonaceous shales, and coal. The coal bearing units are mostly present in the lower half of the Fort Union Formation (BBCC 2008b).

The drill hole logs, coal analysis, and detailed local geology for the Federal mining plan modification area have been previously submitted to the BLM under a separate (confidential) data transmittal package.

Figure 3-9. Black Butte Coal Mine General Stratigraphy



Source: BBCC 2014a.

3.5.1.3 Other Mineral Occurrences

Prospecting for gas, oil, coal, and possibly uranium and other minerals has occurred in the Federal mining plan modification area. There are oil and gas leases in both sections 12 and 24, T. 19 N., R. 100 W. The oil and gas leases are part of the Arch Almond B unit held by the unit WYW-094516B, dated 1959. All of the wells in Section 12 have been plugged. There are two oil wells in Section 24 in the northwestern quarter section. They are both outside of the Federal mining plan modification area.

A water rights search of the Federal mining plan modification area and a 2-mile buffer surrounding it through the Wyoming State Engineer's Office (WSEO) indicated that coal bed CH_4 wells were extracting water to facilitate gas production from a depth greater than 2,000 feet below ground surface (bgs) south of the Federal mining plan modification area (WSEO 2015). This depth is below the Fort Union Formation. The southern tract of the Federal mining plan modification area (Pit 10) is not covered by any oil and gas leases; however, an oil and gas pipeline are on a portion of the Federal mining plan modification area in an area proposed for disturbance. No other mineral extraction activities are known to exist in the Federal mining plan modification area.

3.5.2 Environmental Consequences

3.5.2.1 Alternatives Impacts

Alternative I – No Action Alternative

Under the No Action Alternative, the Proposed Action would not be implemented and no additional impacts on geology/mineral resources/energy production other than those already authorized would occur in the impact assessment area (i.e., Federal mining plan modification area). Coal resources would be available for future extraction; however, the size and isolated nature of the coal make it unlikely this would happen under current economic conditions. Therefore, the coal would most likely be bypassed. This would result in the loss of the use of the coal resource and Federal revenues from the sale of the coal.

Alternative II – Proposed Action

The mining operation would remove the coal and return non-coal rock back into Pit 10 and Pit 15. The surficial geology would be disturbed on approximately 257 additional acres. Approximately 68 acres (15 percent) of the Federal mining plan modification area has been previously disturbed by mining activities under a separate existing BLM ROW agreement. The total surface disturbance would be approximately 325 acres or 72 percent of the Federal mining plan modification area. The geology of the mined-out pits would be permanently altered. The replaced interburden and overburden material would be similar to pre-mining lithologies; however, the physical characteristics, including the permeability and stratigraphy of the subsurface materials, would be altered through the placement of a mixture of rock types and sizes back into the mined-out pits. Rock types containing elevated mineral concentrations considered unsuitable for placement in close proximity to groundwater and surface water resources would be segregated for appropriate placement in the backfilled pits. The impact on geology would be moderate and long-term.

The mining of the coal as proposed, to be performed by BBCC with active operations adjacent to the coal tract, represents the only opportunity to economically extract the coal under current and reasonably foreseeable future economic conditions. The mining of the coal would allow the continuation of mining activities at the BBCM but would remove the opportunity to mine it in the future. Mining of the approximately 9.2 M tons of in-place mineable coal in the Federal mining plan modification area is anticipated to add approximately 6 to 7 years of reserves to the existing operation. Due to blending with other coal, the mining of the Federal mining plan modification area is anticipated to occur over a 10-to-14-year period, depending upon power plant fueling requirements and potential future coal contracts. Once BBCM's coal reserves in the Federal mining plan modification area are mined, they would no longer be available for future use. The impact on the potential future use of the coal resource would be negligible to minor and long-term.

There are no known conflicts between oil and gas development and mining on the Federal mining plan modification area. Oil and gas development can still occur adjacent to the mining operation. There would be a short-term impact on access to a portion of the oil and gas leases in

Section 12, T. 19 N., R. 100 W. Based on current oil and gas extraction activity in the adjoining area, this impact would be minor.

3.5.2.2 Incremental Impacts

Alternative I – No Action Alternative

Under the No Action Alternative, the Proposed Action would not be implemented and there would be no increase in the effects in the incremental impact assessment area other than those that would result from RFFAs.

Alternative II – Proposed Action

Under the Proposed Action, mining of the approximately 9.2 M tons of in-place mineable coal in the Federal mining plan modification area is anticipated to add approximately 6 to 7 years of reserves to the existing operation. The mining of the Federal mining plan modification area is anticipated to occur over a 10-to-14-year period, depending upon power plant fueling requirements and potential future coal contracts. Once BBCM's coal reserves in the Federal mining plan modification area are mined, they would no longer be available for future use. The Proposed Action and potential new leases facilitated by the OBBB could result in additional impacts on coal reserves within the incremental impact assessment area.

The mining operation would remove the coal and return non-coal material back into the Federal mining plan modification area, which would permanently alter the geology within the Federal mining plan modification area. The Proposed Action and potential new leases facilitated by the OBBB could result in additional impacts on geology within the incremental impact assessment area.

Oil and gas permittees would have access to oil and gas reserves after mining and could access oil and gas reserves using directional drilling technology. Resolution of impacts on existing oil and gas operations would be negotiated between BBCC and the oil and gas lease holders. The incremental impact on oil and gas development within the incremental impact assessment area would be minor and short term.

3.6 Hydrologic Conditions

The impact assessment area for alternatives and incremental impacts analyses for hydrologic conditions is the Federal mining plan modification area and the anticipated area of groundwater drawdown and the adjoining portion of the surface watershed. The issues identified for impact analysis for hydrologic conditions are the potential for loss of use of groundwater for other users, potential for pollution introduction into groundwater and surface water, loss of seeps/springs/wetland/riparian, and potential to increase surface water erosion/head cutting.

The past and present actions within the alternatives impact assessment area (i.e., Federal mining plan modification area and the anticipated area of groundwater drawdown and the adjoining portion of the surface watershed) for hydrologic conditions are scattered oil and gas exploration, production, and transport (i.e., pipelines); exploration drilling for coal in support of BBCM;

livestock grazing (i.e., cattle and sheep); and BBCM coal mining activities under a separate existing BLM ROW agreement.

The RFFAs within the incremental impact assessment area (i.e., Federal mining plan modification area and the anticipated area of groundwater drawdown and the adjoining portion of the surface watershed) for hydrologic conditions are scattered oil and gas exploration, production, and transport (i.e., pipelines); exploration for coal in support of BBCM; livestock grazing (i.e., cattle and sheep); BBCM coal mining activities under a separate existing BLM ROW agreement; and possible additional coal leasing facilitated by the OBBB.

Information in this section relies on the following technical reports that are included as appendices:

- Cumulative Hydrologic Impact Assessment (CHIA), dated January 2021, prepared by the WDEQ LQD (WDEQ 2021) (**Appendix C**)
- Probable Hydrologic Consequences (PHC) from the Mine Plan and Reclamation Plan, dated January 15, 2021 (BBCC 2021) and June 22, 2013 (BBCC 2013), respectively (**Appendix D**)
- 2024 Hydrologic Support Document for the BBCM (WET 2024) (**Appendix E**)

It should also be noted that information is summarized from these technical appendices as applicable to provide an overview of the affected environment, but these appendices provide a more detailed description of the hydrologic conditions.

3.6.1 Affected Environment

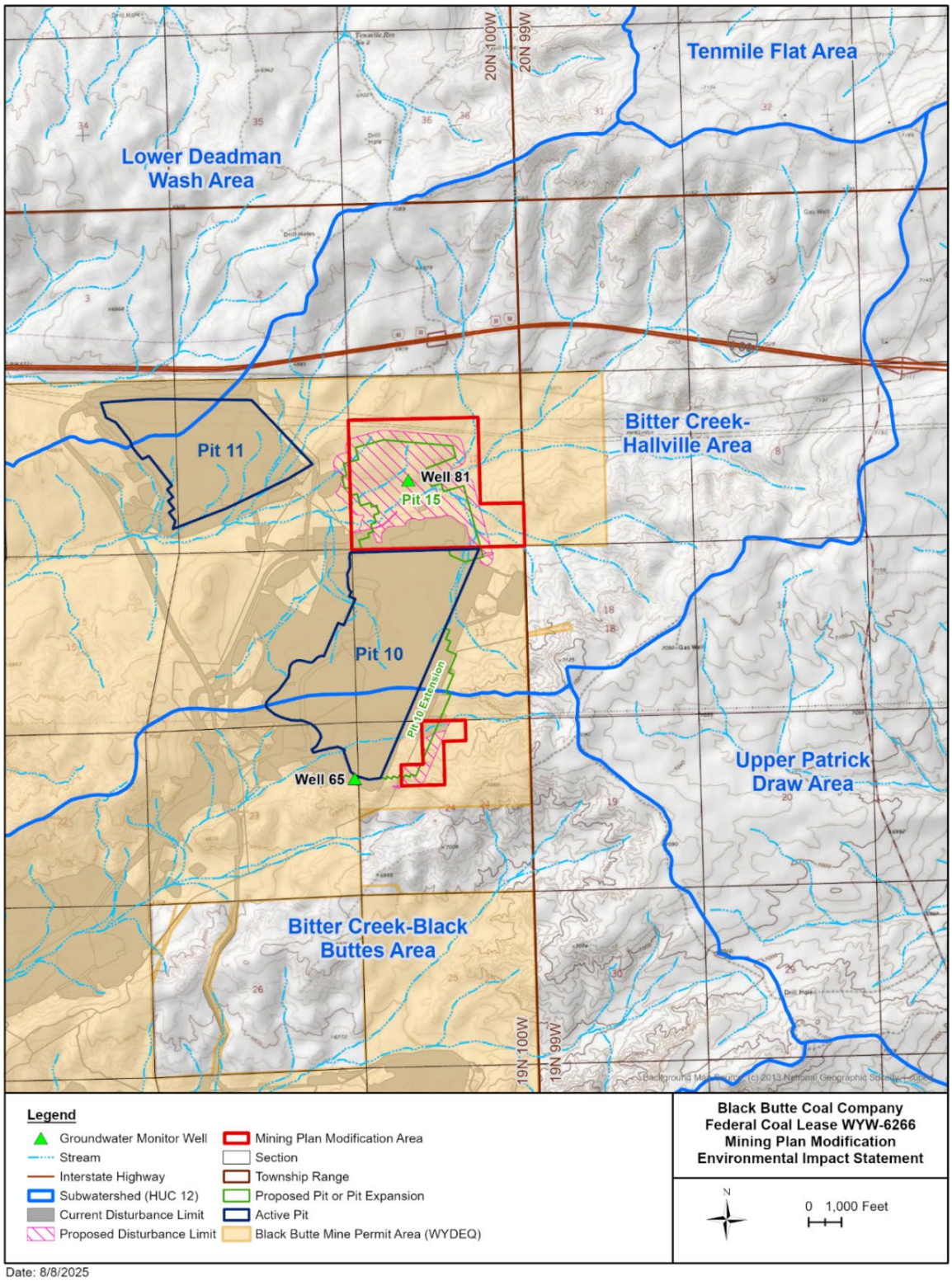
3.6.1.1 Regional Geology

BBCM is on a dissected arid upland situated on the eastern slope of a large anticlinal dome called the Rock Springs Uplift. The greater vicinity of the BBCM includes the Paleocene Fort Union Formation, which contains the Fort Union aquifer, which crops out encircling the Rock Springs Uplift. The Fort Union Formation consists of brown to gray sandstone, gray to black shale, and thin coal beds. The coal bearing units are mostly present in the lower half of the Fort Union Formation (**Appendix C**). Pits 15 and 10 are within the Deadman coal zone. The Deadman coal zone is exceptionally well developed along the eastern flank of the Rock Springs Uplift and is as much as 32 feet thick. In the Deadman coal zone, coal beds split and merge within distances of 1.5 to 6 miles (**Appendix C**).

Rocks along the southeastern flank of this uplift dip to the east-southeast at 3 to 10 degrees. The geologic formations that outcrop within the BBCM permit area are, in ascending order: the Ericson, Almond, Lewis Shale, Fox Hills Sandstone, and Lance formations of late Cretaceous age; the Fort Union and Wasatch formations of early Tertiary age; and the alluvial and colluvial deposits of Quaternary age. The southern area of the Federal mining plan modification area (Pit 10) contains no prominent drainages. The northern area of the Federal mining plan modification area (Pit 15) is bisected by an un-named ephemeral drainage. Both areas drain westerly, and surface water flows eventually enter Bitter Creek. **Figure 3-10** presents a map of hydrologic features (i.e., surface water drainages and groundwater monitoring wells) in the Federal mining

plan modification area. The Bitter Creek valley is broad and flat and underlain by alluvial deposits up to 80 feet thick.

Figure 3-10. Surface Water Drainages and Groundwater Monitoring Wells



3.6.1.2 Groundwater Quality and Quantity

Information in this section is based on the CHIA (**Appendix C**) and the 2024 Hydrologic Support Document for the BBCM (**Appendix E**). The Proposed Action is within the Greater Green River Basin (GGRB). Within the BBCM area, groundwater occurs in the alluvium of Bitter Creek, the localized alluvial/colluvial deposits of some of Bitter Creek's ephemeral tributaries, and the Fort Union, Lance, Almond, and Ericson formations. For the most part, the Fox Hills, Lewis Shale, and the Wasatch formations are dry. The Ericson Formation is a regionally significant aquifer capable of high yields and is an important industrial water supply. All the principal water-bearing strata in the general area are confined or semiconfined. The direction of groundwater movement for the formational strata is typically downdip off the eastern flank of the Rocks Springs Uplift toward the Washakie Basin to the east.

According to the CHIA (**Appendix C**), the six aquifer units of concern in the GGRB are as follows: (1) alluvial, (2) Fort Union, (3) Lance, (4) Almond, (5) Ericson Sandstone, and (6) backfill.

The CHIA **(Appendix C**) includes a 1,151-square mile analysis area for groundwater and indicates the combined maximum extent of the predicted 5-foot coal mine drawdown in the Ericson Sandstone coal aquifer and the lower overburden in the immediate vicinity of the Proposed Action. Typically, the overburden, coal, and underburden units are discontinuous, and interbedded with sandstone, claystone, and siltstone. In some cases, they are present in different stratigraphic units within the Fort Union, Lance, or Almond formations. In locations where the mined coal seams are in the Almond Formation, the Ericson Sandstone aquifer is separated from the coal seams by a thick, low permeable interbedded sandstone, claystone, and siltstone Almond Formation underburden unit.

In general, shallow groundwater present in the BBCM area is of poor quality. The Bitter Creek alluvial groundwater is typically a sodium-chloride or sodium-sulfate type having very high concentrations of chemical constituents. Groundwater in the formational, confined systems (Fort Union, Lance, and Almond formations) also exhibit high degrees of mineralization, usually of a sodium sulfate or sodium bicarbonate type. Little seasonal variation is noted. Due to high concentrations of dissolved ionic constituents (typically sulfate and chloride), groundwater from all of the water-bearing strata fails to meet the drinking water/domestic use standards. High dissolved solids concentrations and high sodium absorption rate values also make the waters unsuitable for irrigation. Groundwater from the Bitter Creek alluvial system has the highest ionic concentrations of all the shallow groundwater, making it unsuitable for livestock use. Groundwater sampled from some of the wells in the Fort Union and Lance formations has also been found to be unsuitable for livestock use.

Within the larger cumulative study area in the CHIA (**Appendix C)**, it is reported that groundwater quality varies both between and within aquifers throughout. The variation between aquifers is probably due to the differences in aquifer materials as well as geochemical and biochemical changes along the flow paths of the groundwater. Within aquifers the variability is partially due to the proximity of a given sampling location to recharge/discharge zones and structural features.

Well 65, south of Pit 10, is close to a structural fault. Groundwater sampled from this well showed general deterioration in quality through 1999 when laboratory measured total dissolved solids (TDS) concentrations peaked at 7,920 milligrams per liter (mg/L) (BBCC 2014b). The measured TDS concentrations at this well then declined to 6,140 mg/L prior to 2008. Subsequently, the well has maintained insufficient water to sample or has remained dry. Water quality variability through time at this location is believed to result from multiple sources of recharge along the fault zone and surface water influence in the open pit.

3.6.1.3 Surface Water Hydrologic Function, Quality, and Quantity

According to the 2024 Hydrologic Support Document for the BBCM (**Appendix E**), the mine is within the Bitter Creek watershed, which is a major tributary of the Green River, a large river basin in southwest Wyoming that is part of the Colorado River Basin. Bitter Creek flows through the existing BBCM area in a north-to-northwest direction and nearly dissects the mine in two with active or historic reclaimed pits on either side of the Bitter Creek valley (**Figure 3-10**). Bitter Creek is the major surface hydrologic feature of the area. It is highly incised, and its flow can be characterized as intermittent, flowing mainly in direct response to snowmelt and precipitation events. The area upstream of the BBCM consists of arid plains, which offer an abundant supply of fine-grained sediments. The Bitter Creek alluvial valley throughout the BBCM area consists of mostly unconsolidated fine-grained sands, silts, and clays. As a result of the fine-grained sediments available for transport and the makeup of deposited sediments within the Bitter Creek valley, the Bitter Creek channel consists of loosely compacted, fine-grained material that lends itself to unstable conditions.

The information below is based on the CHIA prepared for the project by WDEQ LQD in 2021 (**Appendix C**). The proposed mining disturbance occurs in ephemeral headwater drainages far removed from Bitter Creek. The major tributary within the vicinity of Pits 10 and 15 to Bitter Creek is Deadman Wash, which drains the majority of the Jim Bridger Coal Mine and Leucite Hills Coal Mine permit boundaries. Bitter Creek flows through the BBCM permit area. Major tributaries to Bitter Creek upstream of the BBCM include Patrick Draw, Antelope Creek, and Laney Wash.

Extensive surface water sampling has occurred in the Bitter Creek drainage since 2004. The purpose of the sampling is to evaluate potential sources of chloride and bacteria that contribute to exceedances of the WDEQ WQD Class 2C surface water quality standards (Chapter 1, Wyoming Water Quality Rules) for chloride and Escherichia coli (*E. coli*). A Total Maximum Daily Load (TMDL) for *E. coli* in Bitter Creek was finalized in 2018 (Tetra Tech 2018). Bacteria levels in Bitter Creek and Killpecker Creek exceed Wyoming's water quality standards. According to the WDEQ's list of impaired waters (i.e., Wyoming's 303(d) list) and based on samples collected over the last 13 years by the Sweetwater County Conservation District (SWCCD), high *E. coli* bacteria levels in Bitter Creek and Killpecker Creek impair the recreational uses of these waterbodies. *E. coli* bacteria are indicator species for pathogens that are harmful to human health. The *E. coli* bacteria and pathogens come from the digestive tracks of warm-blooded animals. TMDLs for the summer season were defined for two impaired stream reaches in the Bitter Creek watershed: a 58.1-mile reach of the main stem of Bitter Creek (from the confluence with the Green River upstream to the town of Point of Rocks) and a 6.3-mile reach of Killpecker Creek (from the confluence with Bitter Creek upstream to the town of Reliance).

The CHIA (**Appendix C**) documents a more in-depth investigation of chloride given recent exceedances noted on Bitter Creek at Point of Rocks. Chloride at this location has exceeded the 230 mg/L standard in 63 percent of the samples collected over the 2001 to 2020 period. The Deadman Wash drainage appears to be a higher source of chloride to Bitter Creek at Point of Rocks rather than the mainstem of the Bitter Creek watershed upstream of the confluence with Deadman Wash.

Within the CHIA (**Appendix C**), surface water quality sample data were analyzed for the baseline and during-mining periods in each of the major drainages of the cumulative study area. Summary statistics were compared between baseline and during-mining periods, as well as upstream and downstream of mining activity. The frequency of water quality standard exceedances was also examined, including the frequency of exceedances for the last 3 years of sampling. The analysis showed that WDEQ WQD surface water quality standards for Class 2AB, Class 2C, and Class 3B waters have occasionally not been met due to infrequent exceedances of dissolved metals. In most cases, these exceedances were also observed in pre-mining sampling and at monitoring stations upstream from mining activity.

BBCM is a total containment mine requiring the use of surface water control and containment structures to minimize surface water entrance into disturbed areas and to prevent discharge of surface water from disturbed areas. The exception to this is after high magnitude precipitation events that use up containment storage capacity needed for a 10-year 24-hour precipitation event and require treatment and discharge under the BBCM's WYPDES permit. However, typically, impounded storm water at BBCM evaporates or infiltrates and does not require discharge. Total containment ponds, sediment ponds, evaporation ponds, and retention ponds contain all disturbed land runoff.

Storm or snowmelt runoff events in the northern area (Section 12) drainages are predominately isolated from surface disturbance at Pit 11 and Pit 10 and flow without pond containment to Bitter Creek. As described in the Proposed Action, the majority of flows in Section 12 would be diverted north around Pit 15 during mining with no loss in stream flow quantities reaching Bitter Creek during storm and snowmelt runoff events. The southern area (Section 24) flows enter the Pit 10 disturbance area and evaporate, infiltrate, or are otherwise retained in the disturbance area or in the existing retention pond. The portion of the subwatershed that is associated with the southern portion of the Federal mining plan modification area is minor in area. **Figure 3-10** presents the drainages relative to the Federal mining plan modification area and surface disturbance boundaries.

Water sample tests from monitoring sites within BBCM since 1982 have registered no mercury above the level of detection. Water from SBC1-75 has been analyzed 23 times since 1982, and SBC2-75 has been sampled 20 times since 1982, the last of which for both sites was May 5, 2015 (BBCC 2015b). The three mercury reading exceptions occurred before March 2014, which was when Jim Bridger Power Plant was issued the permits to install mercury controls.

Mercury could be entrained in surface water through deposition from the burning of coal at the Jim Bridger Power Plant and other power plants upwind of the region. Once in the surface water system and under the anoxic conditions the mercury could be transformed into a biologically

available form and be accumulated in aquatic organisms. However, at this time based on the available analytical data, mercury does not appear to be an issue of concern.

Previous waters of the U.S. jurisdictional determinations by the USACE of the drainage system intersected by Pit 10 have indicated that they are not considered jurisdictional (USACE 2013). The southern portion of the Federal mining plan modification area drainages flow into the Pit 10 disturbance area and do not have the characteristic of a defined stream channel with adequate flow necessary to qualify as a jurisdictional water of the U.S. The northern Federal mining plan modification area contains a larger drainage that is not considered a jurisdictional Water of the U.S per a supporting study completed as part of the WDEQ mine permit. A temporary incorporation of this drainage channel into Pit 15 would not require Clean Water Act Section 404 permitting.

3.6.1.4 Water Rights

According to the CHIA (**Appendix C**), the coal mines (BBCM, Jim Bridger Coal Mine, and Leucite Hills Coal Mine) have identified all surface water rights within the mine permit boundaries and within a 0.5-mile radius and 3 miles downstream of the permit areas. There are few surface water rights within the Bitter Creek cumulative impact area (CIA) besides those owned by the three coal mines. Based on a water rights search performed through the WSEO e-permit online database, all water rights within at least 1 and 0.5 miles of the Federal mining plan modification area are registered to BBCC (WSEO 2024). The exceptions to this are for several coal bed CH_4 wells in sections 23, 26, and 25, T. 19 N., R. 100 W. that are greater than 2,000 feet deep. Most of these coal bed CH_4 well water rights have been cancelled. The other exception is for a 500-foot-deep water supply well owned by the Wyoming Department of Transportation (WYDOT) in Section 2 SW1/4 SW1/4, T. 19 N., R. 100 W. The well is over 1 mile northwest of the Pit 15 boundary and is separated from Pit 15 by geologic faulting and is 0.25 mile north of Pit 11. The well appears to be completed in the Lance or Fox Hills Sandstone formations. The static water level is listed at 60 feet bgs on the WSEO website. Water rights owned by BBCC listed on the website in or adjacent to the Federal mining plan modification area include monitoring wells, pit dewatering wells, Pit 10, and surface water retention ponds.

3.6.2 Environmental Consequences

3.6.2.1 Alternatives Impacts

Alternative I – No Action Alternative

Under the No Action Alternative, the Proposed Action would not be implemented and no additional impacts on hydrologic conditions other than those already authorized would occur.

Alternative II – Proposed Action

Groundwater Quantity/Water Rights

A typical way of expressing the influence a mine would have on the groundwater table drawdown extent is by calculating the probable 5-foot drawdown distance from the mine. Previous calculations of the 5-foot drawdown contour for Pit 10 can be reasonably extrapolated

for the northward extension of Pit 15, due to the similar geologic setting. The estimated 5-foot drawdown extends approximately 1 and a 0.25 mile east and north of Pit 10 (BBCC 2001). The drawdown is influenced by the presence of several northeast trending faults that limit the northward extension of drawdown resulting from Pit 10 to approximately Interstate 80. The proposed Pit 15 boundary would be similarly bound by the faulting and likely influenced by their presence.

No additional water supply wells would be required to supply consumptive needs (mostly dust suppression) for the Proposed Action. Groundwater usage rates for BBCM as a whole are not expected to change significantly with the continuation of mining, primarily because as mining develops in new or expanded pit areas it terminates in other areas. As an example, Pit 11 was mined out by early 2018 and only Pits 10 and 14 were in production that entire year. Pit 15 would likely produce enough groundwater to supply most or all of the consumptive needs for both Pit 15 and Pit 10 South.

The observed and predicted groundwater effects were compiled, cumulated, and evaluated within the CHIA (**Appendix C**) and the analysis area defined therein. Although coal mining would have effects within the permit boundaries, based on available data, information presented in the permits, and analysis in the CHIA (**Appendix C**), the potential for material damage outside the BBCM permit boundaries to groundwater quantity and groundwater quality is limited. The Pit 15/Pit 10 South Amendment at the BBCM is not expected to significantly change hydrologic conditions such that material damage would occur. Groundwater elevations in other areas in the BBCM where mining has ceased have stabilized or are recovering (BBCC 2014b).

For backfilled spoils to re-saturate and re-establish as an aquifer, there must be a recharge source. Recharge to the backfill spoils would occur from two sources: precipitation and lateral groundwater movement from adjacent undisturbed water-bearing strata. At the BBCM, precipitation would be insignificant compared to the lateral component of groundwater recharge. The rate of lateral recharge is a function of the permeability of the backfilled spoils, the permeability of the adjacent recharge aquifer, the surface area of contact between the two, and the hydraulic gradient (BBCC 2014b). Dragline placed spoils are generally much higher in permeability than other methods of spoil placement. However, a 1982 BBCM spoil study completed at the request of the WDEQ, indicated that spoil material would exhibit similar porosities and permeabilities as undisturbed overburden (BBCC 2008b). Previous calculations of spoil re-saturation time frames indicated a 60-to-240-year period would be required for groundwater elevation recovery. Actual recovery time frames may be less because the earlier calculations assumed recharge was from the coal seam aquifer only.

The Fort Union Formation is comprised of interbedded clay shale, siltstone, and sandstone with coal beds and is locally up to 800 feet thick. The coal beds are in the lower half of the Fort Union Formation. Mining in the Pit 15 area would extend to a depth of 300 feet. Depth to the static groundwater table is reported at 87 feet bgs in monitoring Well 81 (260-foot total well depth) within the proposed Pit 15 boundary (BBCC 2014b). Data from the BBCC's 2013 Annual Report Hydrology Section indicates that groundwater levels have declined in the Pit 15 area around 2005 and 2006 due to dewatering of Pit 11 (BBCC 2014b). Monitoring Well 81 has experienced a 20-foot decrease in its water table elevation. A fault acting as a groundwater flow boundary likely partially isolates the hydrologic system in the Pit 15 area from the Pit 10 area.

Monitoring Well 65 (165-foot total well depth), on the southern boundary of Pit 10 has experienced an approximate 45-foot drop in the water table elevation and has been dry since 2008.

Median hydraulic conductivity for the Fort Union Formation in the Green River Coal Region is reported as 0.385 feet per day (WDEQ 2008). Pit 10 inflows were reported at approximately 19 acre-feet per year in the early 1990s. Pit 11 inflows after several months of mining were reported at 32 acre-feet per year. These inflow rates are a reasonable extrapolation to what may occur in Pit 15 due to the similar geology and orientation.

Due to the limited availability present in the Fort Union Formation, and the absence of other Fort Union Formation water users in the groundwater drawdown zone, the groundwater level declines would have a minor impact on the local groundwater resource.

No water rights would be impacted by the mining of Pit 15, other than potentially those owned by BBCC. One well owned by WYDOT is over 1 mile northwest of the Pit 15 boundary. However, the well is not expected to be impacted due to its total depth in the underlying Lance or Fox Hills Sandstone formations which are below the Pit 15 bottom and geologic faulting between the well and Pit 15.

Groundwater Quality

Analysis in the CHIA (**Appendix C**) and information in the mine permits indicate that the potential for the backfill groundwater to migrate to and affect the adjacent undisturbed native aquifers outside the mine permit boundaries is minimal and localized. During removal and replacement of the overburden to backfill the mine pits, appropriate measures are taken to ensure that the water quality of the backfill aquifer would not be degraded to the extent that postmining land uses could not be supported.

Out of the 13 backfill monitor wells with water quality data available during the 2017-2019 period, six wells had a median TDS concentration greater than 5,000 mg/L. Backfill wells would continue to be monitored to evaluate water quality trends and additional backfill wells would be installed as more areas are reclaimed. It is generally expected that over time, the backfill aquifer would be flushed by groundwater flowing through the reclaimed material to the downdip native undisturbed aquifers. Thus, the water quality in the backfill is expected to improve over time. The data from the backfill aquifer need to be continuously evaluated, and it is highly recommended that further research be conducted on this topic to gain more understanding on the behavior of the backfill aquifer over time. Overall, evaluation of the three material damage indicators suggests that there is limited potential for the Proposed Action to cause material damage to the native aquifers outside the BBCM permit boundaries.

In general, Fort Union Formation groundwater is of poor quality. The formation's alluvial subcrop with Bitter Creek and an important recharge area is approximately 5.75 miles south of Pit 10. Water quality is reportedly of a lower quality near the subcrop's intersection with Bitter Creek (BBCC 2014b). The sodium adsorption ratio (SAR), TDS, chloride, sulfate, or boron concentrations in water derived from the formation in various wells in the BBCM permit area near the Bitter Creek subcrop are elevated and fail to meet Class I, II, or III use standards.

However, Class II and III use standards are met for groundwater collected from the nearest potable water wells which are approximately 8 and 15 miles away to the northwest, near the communities of Point of Rocks and Superior, respectively.

Fort Union Formation wells 65 and 81, in the Pit 10 area, have both been sampled since 1990 and most recently checked for the presence of water or sampled in 2013. **Figure 3-10** presents the location of the wells. Groundwater from both wells is poor in quality with high TDS concentrations present. The groundwater from both wells is predominately a sodium/potassium sulfate ion mix (BBCC 2014b). **Figure 3-11** and **Figure 3-12** are trilinear diagrams of historical analyses from wells 65 and 81, respectively. Both show variability in TDS and major constituent concentrations.

Figure 3-11. Groundwater Monitoring Well 65 Trilinear Diagram

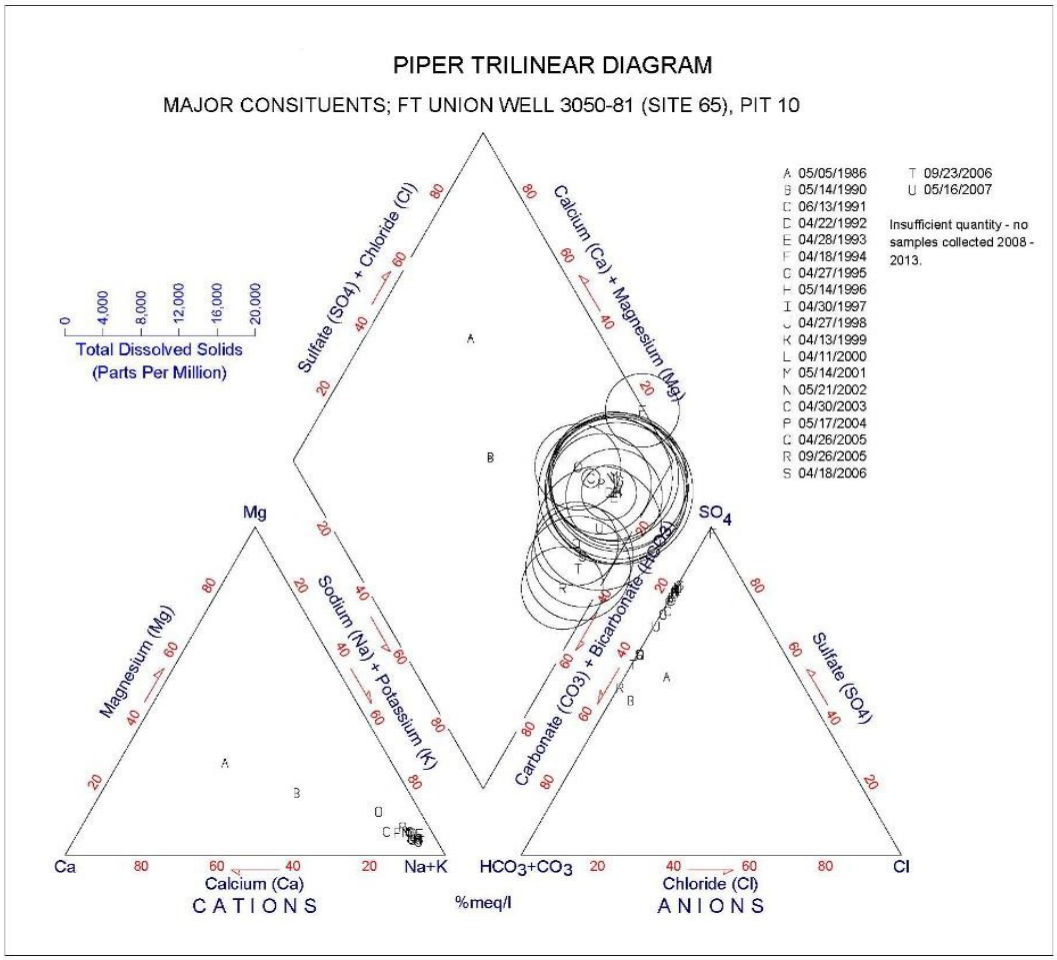
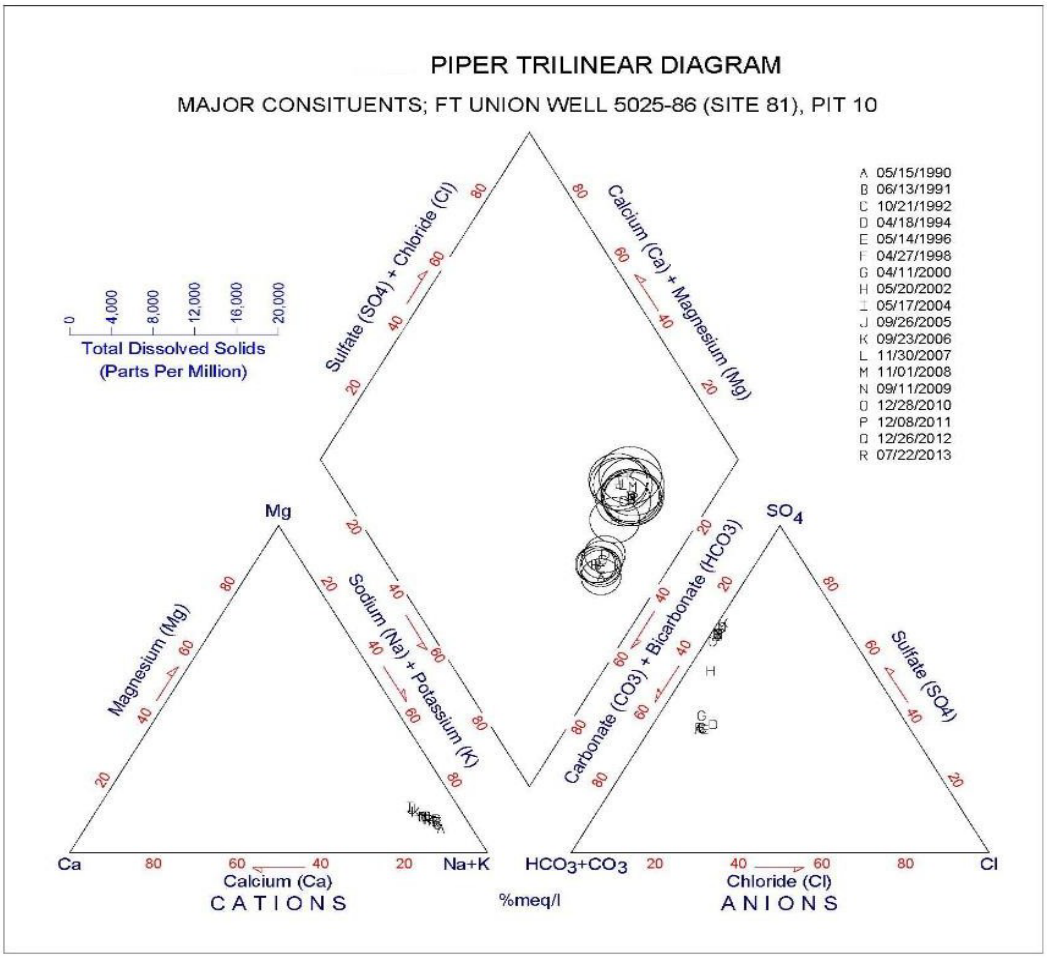


Figure 3-12. Groundwater Monitoring Well 81 Trilinear Diagram



Impacts on groundwater quality would be minor and long-term. Impacts from the deposition of mercury from the burning of coal at the Jim Bridger Power Plant are currently not considered an issue of concern based on historical water quality monitoring of Bitter Creek. Mercury emission control measures installed at the Jim Bridger Power Plant in April 2015 (PacifiCorp 2017) further reduce the potential for mercury to impact aquatic systems in Bitter Creek and surrounding water courses. Due to the poor water quality present within the Fort Union Formation, groundwater quality would have a minor impact on the local groundwater resource.

Surface Water Hydrologic Function, Quality, and Quantity

Hydrologic concerns are an expression of problems related to water use and the hydrologic balance that may occur as a result of coal mining. Hydrologic concerns identified and evaluated for surface water within the CHIA (**Appendix C**) and PHC (**Appendix D**) include the potential for changes to surface water quality and quantity, which have the potential to affect surface water rights and surface water classes of use.

Streamflow losses to Bitter Creek would be attributable to disturbed-land runoff captured by the BBCM's drainage control structures. Relative to the runoff volume over the entire Bitter Creek drainage basin area, this loss of runoff from the disturbed land area would be negligible and short

term. Given the available data, streamflow is constant throughout the BBCM area during baseflow conditions.

Analysis from the CHIA (**Appendix C**) and the information from the mine permits indicate that coal mining would not cause material damage to surface water quantity and surface water rights in the Bitter Creek CIA. Analysis of streamflow data from Bitter Creek, Deadman Wash, and their tributaries shows that runoff response can be variable, highly dependent upon precipitation and antecedent moisture. The potential for mining to cause measurable changes to surface water quantity is deemed low due to the high variability of the natural system, the extent of disturbance in relation to the analysis area within the CHIA (**Appendix C**), and ongoing reclamation practices. The Proposed Action is not expected to change conditions such that material damage would occur to surface water quantity and surface water rights. The proposed mining disturbance occurs in ephemeral headwater drainages far removed from Bitter Creek. The coal mines have identified all surface water rights within the mine permit boundaries and within 0.5-mile radius and 3 miles downstream of the permit areas. There are few surface water rights within the Bitter Creek CIA besides those owned by the three coal mines. Due to the limited impact area, there should be no impact on water rights further downstream of the Bitter Creek CIA. Existing mining to date has resulted in no known impacts on downstream surface water rights holders. In the event that a non-mine water right is impacted by mining activities, the law and permits require water supply to be replaced by a source suitable in quantity and quality.

In addition, once reclamation is completed on disturbed areas, approval is obtained from the WDEQ and drainage control structures are removed, this runoff volume would be allowed to re-establish its natural flow back into the reconstructed ephemeral stream channel and on to Bitter Creek. Reconstructed stream channels are typically constructed to be similar in profile and location to the pre-mining condition. The channel bottoms may be armored and water velocity slowing features are typically built at reclaimed areas where appropriate to create sustainable channel form that resists incising by storm water flow. Monitoring is performed by BBCM personnel on both drainage channels and uplands to ensure appreciable erosion is not occurring and that the BBCM is meeting its SMCRA permit conditions and eventually would be a candidate for reclamation bond release.

Drainage channel impacts would be minimized to the period when mining is occurring. Reconstruction of the drainage channels to their approximate pre-mining profile and location, and monitoring of the sustainability of the constructed channels would minimize the potential for head cutting and excessive erosion. Impacts on stream channel form and function would be moderate and short term.

With regard to surface water quality, analysis from the CHIA (**Appendix C**) and the information from the mine permits indicate that coal mining would not cause material damage to surface water quality. Specifically, the Proposed Action would not result in further degradation to the existing water quality of the impaired segment of Bitter Creek with respect to *E. Coli* and chloride based on existing data and monitoring. Surface water quality sample data were analyzed for the baseline and during-mining periods in each of the major drainages within the CHIA (**Appendix C**) analysis area. Summary statistics were compared between baseline and during-mining periods, as well as upstream and downstream of mining activity.

The frequency of water quality standard exceedances was also examined, including the frequency of exceedances for the last 3 years of sampling. The analysis showed that WDEQ WQD surface water quality standards for Class 2AB (ww), Class 2C, and Class 3B waters have occasionally not been met due to infrequent exceedances of dissolved metals. In most cases these exceedances were also observed in pre-mining sampling and at monitoring stations upstream from mining activity.

A more in-depth analysis was conducted within the CHIA (**Appendix C**) for chloride given recent exceedances noted on Bitter Creek at Point of Rocks. Chloride at this location has exceeded the 230 mg/L standard in 63 percent of the samples collected over the 2001 to 2020 period. The Deadman Wash drainage appears to be a higher source of chloride to Bitter Creek at Point of Rocks rather than the mainstem of the Bitter Creek watershed upstream of the confluence with Deadman Wash. Although the Deadman Wash watershed appears to have elevated chloride values at some stations, it is difficult to determine the effect that coal mining activities have on chloride concentrations. From the available information, it is not possible to determine the extent that mining activities may be increasing chloride concentrations in the Deadman Wash watershed relative to background sources.

Impacts on surface water would also be minimized by timely reclamation of disturbed areas and by construction of ditches and berms to divert the flow of water off of disturbed land back into the pits or sediment ponds. Clean water diversions would be constructed around disturbed areas and route water back into downstream drainages when technically and topographically feasible. Alternate sediment control measures or sediment ponds would also be developed in consultation with the WDEQ. Controlled discharges from sediment ponds would occur if the ponds received inflow from a 10-year 24-hour precipitation event. Discharges from the ponds are required to meet WYPDES permit discharge concentration limits. The Federal mining plan modification area is hydrologically isolated, so all surface drainage stays in the area. In addition, sediment erosion control measures such as culverts and rerouting of minor drainages have occurred in the Federal mining plan modification area to prevent unnecessary water erosion from occurring. Therefore, with continued implementation of monitoring and practices that include timely reclamation, the Proposed Action would minimally affect surface water quality.

Total Mine and Proposed Action Water Depletions

As described in the PHC (**Appendix D**), changes in surface water quality and quantity could be expected to occur where any natural drainage is disturbed by mining activity throughout the BBCM. Because there are no plans to mine through the primary channel of Bitter Creek, the hydraulics of the major drainage system would remain unchanged. Temporary changes in both quality and quantity of runoff may occur as mining progresses through the minor tributaries to Bitter Creek as a result of interception and diversion of runoff around mining areas. Detectable changes in either surface water quality or quantity are not expected because of the relatively small surface areas that would be impacted in this manner by the entire BBCM compared to the total surface area of the Bitter Creek watershed (at maximum development, the mining activities would have disturbed approximately 14,000 acres, slightly more than 4 percent of the total surface area of the watershed - approximately 400,000 acres),.

The BBCM is a total containment mine requiring a number of control or containment structures. These structures are built in order to control runoff from various disturbed areas within the mine. As a result of these structures, runoff from certain contributing areas to the Bitter Creek watershed is temporarily contained. The WSEO calls for the appropriated water to be returned to the original drainage basin as soon as it meets effluent standards structures. The contained water at BBCM typically evaporates, infiltrates, or is used for mining related uses, such as dust suppression on haul roads and is not discharged, which results in a reduction in runoff entering the drainages that flow into Bitter Creek. A total temporary reduction in contributing area to the Bitter Creek watershed for the entire BBCM, as measured at SBC2 (downstream gauging site), is on the order of 4 percent (**Appendix D**). Reclamation would entail removing the control and containment structures, at which time surface water runoff from reclaimed areas would again enter drainages flowing into Bitter Creek.

To further quantify the area involved and estimate the potential loss of runoff due to the control structures, a year-by-year life of mine study was conducted, as described in the PHC (**Appendix D**). The specific runoff for the Bitter Creek watershed is from 0.1 to 0.2 inches per year. Based on this specific runoff figure, flow in Bitter Creek, as measured at site SBC2 (downstream gauging station) is calculated at 4,000 to 8,000 acre-feet per year. A highest impact estimate can be made by using the lower end figure of 4,000 acre-feet per year. For any given year, the maximum disturbed area at the BBCM is 14,000 acres, and the maximum percent of temporary flow reduction is approximately 4 percent. The 4 percent figure equates to 160 acre-feet of water per year temporarily removed from Bitter Creek. This temporary loss of 160 acre-feet per year would not affect any downstream surface water rights (**Appendix D**).

The Proposed Action, comprising 257 acres of new surface disturbance in proposed Pit 15 and the Pit 10 Expansion area, would result in annual water depletions from Bitter Creek of between 3.7 to 7.5 acre-feet per year. However, the total disturbed area at the BBCM would be approximately 12,500 acres, and thus the temporary amount of water removed from Bitter Creek (and the Upper Colorado River Basin) as a result of interception and containment would remain less than 160 acre-feet per year on average

The overall results indicate that material damage has not occurred to surface water quality. The Proposed Action is not expected to significantly change surface water quality and impacts would be moderate and short term. Temporary changes in both quality and quantity of runoff may occur as a result of interception and diversion of runoff around the BBCM area. Because of the relatively small surface areas which would be impacted in this manner compared to the total surface area of the Bitter Creek watershed, the PHC (**Appendix D**) concludes that it is doubtful, based on studies to date, that any detectable changes in surface water quality or quantity would result.

3.6.2.2 Incremental Impacts

Alternative I – No Action Alternative

Under the No Action Alternative, the Proposed Action would not be implemented and there would be no increase in the effects in the incremental impact assessment area other than from RFFAs.

Alternative II – Proposed Action

Groundwater quality and quantity impacts would be similar to that described for impacts in ***Section 3.6.2.1***. Although coal mining would have impacts within the permit boundaries, the potential for material damage outside the permit boundaries to groundwater quantity and groundwater quality is limited. When combined with effects from other mining, energy, and oil and gas projects and livestock grazing, incremental groundwater impacts would be minor in intensity and long-term in duration.

Decreases in surface water flow to Bitter Creek would occur during mining. Following reclamation activities, surface water flows would be re-established in drainages that are designed to be similar in plan and profile morphology to the original drainages. Re-vegetation of disturbed surfaces would reduce the potential for erosion. However, livestock grazing, oil and gas development, and other surface uses in the watershed have the potential to increase erosion and sedimentation if not properly monitored and best management practices implemented. Monitoring following reclamation would be performed and areas developing increased erosion and/or head cutting in channels would undergo corrective action. Impacts during the BBCM bond release period from other land uses in the area may become evident and would likely be brought to the attention of the WDEQ if they impact BBCC's bond release schedule. Incremental impacts on surface water resources would be negligible to minor in intensity, and short term in duration. When combined with effects from other mining, energy, and oil and gas projects and livestock grazing, incremental surface water impacts would be moderate in intensity and long-term in duration.

3.7 Social and Economic Resources

The impact assessment area for alternative and incremental impact analyses for social and economic resources is Sweetwater County, Wyoming. The issues identified for impact analysis for social and economic resources are potential impacts on the population, housing, community services, local economy (primarily employment and earnings in the mining industry and other sectors of the economy), and local, State, and Federal tax revenues in Sweetwater County due to the Proposed Action and BBCM operation.

The past and present actions within the alternatives impact assessment area (i.e., Sweetwater County, Wyoming) for social and economic resources are BBCM; trona and other coal mines; Jim Bridger Power Plant; mining exploration; oil and gas exploration, production, and transport; electrical transmission and vehicle/railroad transportation corridors; livestock grazing; and recreation.

The RFFAs within the incremental impact assessment area (i.e., Sweetwater County, Wyoming) for social and economic resources are BBCM; trona and other coal mines; Jim Bridger Power Plant; mining exploration; oil and gas exploration, production, and transport; electrical transmission and vehicle/railroad transportation corridors; livestock grazing; recreation; and potentially new coal leases facilitated by the OBBB.

3.7.1 Affected Environment

3.7.1.1 Population

Sweetwater County is the largest county in Wyoming and the third most populous. Sweetwater County is also the most industrialized county in Wyoming due to the local abundance of coal, natural gas, oil, and trona (soda ash). Rock Springs and Green River are the two largest towns in Sweetwater County and are approximately 10 miles apart. The BBCM complex is approximately 25 miles east of Rock Springs and approximately 35 miles east of Green River.

The population of Sweetwater County and Green River were down in 2020 from 2010, while the population of Rock Springs was up in 2020 from 2010. Rock Springs is the closest major city to the Federal mining plan modification area and is the largest incorporated city in Sweetwater County. The second largest Sweetwater County population center is Green River (**Table 3-25**). According to the most recent population data available from the U.S. Census, the population in Sweetwater County has decreased between 2010 and 2020 (U.S. Census 2020). The most recent population forecasts available from the Wyoming Department of Administration and Information (WDAI) Economic Analysis Division (EAD) projects that the population levels in Sweetwater County will decrease by 3.4 percent by 2030, to 40,830 (WDAI 2025) (**Table 3-25**).

The majority of the workers employed by BBCC at the BBCM live in Rock Springs and Green River. The workforce at the BBCM is currently 56 full-time employees, but at full production this would expand to 110 full-time employees.

Table 3-25. Historic and Projected Population in Sweetwater County

Population			Projected Population		
Location	**2010**	**2020**	**2030**	**2040**	**2050**
Sweetwater County	43,806	42,272	40,830	40,650	40,440
Rock Springs	23,036	23,526	22,726	22,626	22,509
Green River	12,515	11,825	11,394	11,344	11,286

Sources: U.S. Census 2020 and WDAI 2025.

The median age of the population in Sweetwater County was 37.4 in 2023. The age profile of Sweetwater County shows that in 2023, 75.5 percent of the population was 18 years old and over. The largest age group is made up of those 40 to 44 years old (U.S. Census 2020).

The majority of the population (81.4 percent) of Sweetwater County in 2020 was made up of white persons. In 2020, very small percentages of the population were made up of African American (0.9 percent), Asian (0.7 percent), American Indian and Alaska Native (1.0 percent), and Native Hawaiian and Pacific Islander (0.2 percent) (U.S. Census 2020) (**Table 3-26**). Of the 2020 Sweetwater County population (42,272), 16.8 percent were Hispanic or Latino (U.S. Census 2020).

Table 3-26. 2020 Population of Sweetwater County by Race

Ethnicity	2020 Population	Percent (%) of Population
White	34,389	81.4
African American	366	0.9
Asian	295	0.7
American Indian and Alaska Native	433	1.0
Native Hawaiian and Pacific Islander	70	0.2
Other	2,508	5.9
Persons reporting two or more races	4,211	10.0

Source: U.S. Census 2020.

3.7.1.2 Housing

In 2020, the total housing units in Sweetwater County were 19,145 of which 16,625 (86.8 percent) were occupied and 2,520 were vacant (U.S. Census 2020). The median value of a home (structure) in Sweetwater County from 2019 to 2023 was $242,900 (the age of a structure influences its value). The median rent in Sweetwater County from 2019 to 2023 was $913 dollars as compared to $968 dollars statewide (U.S. Census 2020).

3.7.1.3 Community Services

Education – Sweetwater County has two school districts. Western Wyoming Community College is in Rock Springs and has a satellite campus in Green River. In-town facilities for young children include the Child Development Center in Rock Springs and Head Start. Head Start serves the development needs of preschool children and their low-income families (BLM 2006).

Law Enforcement – Green River, which is the Sweetwater County seat, is home to the District and Circuit courts. There are two police departments, Rock Springs and Green River. The Sweetwater County Sheriff's Office in Green River provides public safety services to the remainder of the unincorporated county. The Wyoming State Highway Patrol has an office in Rock Springs and serves the western two-thirds of Sweetwater County (BLM 2006).

Fire Protection – Rock Springs and Green River have municipal fire departments. In addition, there is the Sweetwater County Fire Department which is in Rock Springs (BLM 2006).

Ambulance and Health Care – Ambulance services are provided by Castle Rock Medical Center (Green River) and Vase Emergency Medical Services (Rock Springs). Air-Med provides service to out-of-area hospitals (such as Salt Lake City) for specialized care. Memorial Hospital of Sweetwater County, which is in Rock Springs, is the primary hospital in the county. There are also other medical centers and clinics in Rock Springs and Green River (BLM 2006).

Public Assistance, Libraries, Recreation, and Parks – There are numerous social services and welfare organizations in Green River and Rock Springs. There are three libraries and five rural branch libraries in Sweetwater County operating under the Sweetwater County Library System. Recreation opportunities include two indoor recreation centers in Rock Springs and one in Green River, a golf course in each of these cities, a whitewater park in Green River, and 18 community parks between the two communities. Green River also has a greenbelt walkway and other pedestrian-friendly municipal amenities. Flaming Gorge National Recreation Area is south of the two cities and provides a venue for fishing, boating, swimming, camping, picnicking, and hiking (BLM 2006).

3.7.1.4 Employment and Income

An area's economic base is made up of activities which bring money into the local economy from other areas of the State, nation, and world. Sweetwater County has a diversified natural resource-based economy. Basic sectors include oil and gas production and processing, coal mining, electric power generation, trona mining and the manufacturing of soda ash and related products, fertilizer manufacturing, agriculture, and transportation (primarily the Union Pacific Railroad). The portions of the retail and service sectors that serve visitors (travel, tourism, and recreation) are considered basic. In general, trona and coal mining and related mining support services account for a large portion of the region's existing economy (BLM 2006). The world's largest trona deposit covering about 1,300 square miles occurs near Green River and supplies about 90 percent of the nation's soda ash (BLM 2025). In 2022, the three industry sectors in Sweetwater County with the largest number of jobs were government (4,354 jobs), mining (including fossil fuels) (3,523 jobs), and retail trade (2,864 jobs) (Headwaters Economics 2025a).

In 2023, the education, health care, and social assistance was the largest employment sector, (22.2 percent) of the workforce in Sweetwater County. The second largest was agriculture, forestry, fishing and hunting, and mining industry (14.2 percent). Retail Trade employed 11.6 percent, followed by transportation, warehousing, and utilities at 8.8 percent, and arts, entertainment, recreation, accommodation, and food at 8.0 percent (U.S. Census 2020). According to the Wyoming Labor Market Information (WLMI), the total employment (number of jobs) in Sweetwater County in 2024 was 24,629 (WLMI 2025). Unemployment in 2023 for Sweetwater County was 33.1 percent (U.S. Census 2020). The median household income from 2019 to 2023 for Sweetwater County was $76,464. The average annual wage in the mining sector in Sweetwater County in 2024 was considerably higher at $121,580 (Headwaters Economics 2025b).

In 2023, Wyoming's 15 coal mines employed a total of 5,118 workers, a 27 percent decrease since 2011. Coal industry jobs are among the best paying in Wyoming. Wyoming coal miners take home an average of $102,592 before benefits which is almost twice the statewide average of $56,064 per worker. The estimates indicate that each coal industry position drives the need for two additional jobs in Wyoming (WMA 2025).

3.7.1.5 Local, State, and Federal Revenues

Coal remains a significant source of energy in the 21st century, generating nearly 16 percent of the nation's electricity in 2024. Wyoming is home to eight of the top 10 producing mines in the nation, and Wyoming's mines are still the low-cost leaders of the industry. Electrical power generation is by far the largest consumer of coal in the U.S., using about 67 percent of all of the coal mined. Coal is an important source of income for Wyoming and is the third largest source of tax revenue for local and State governments. Coal mining companies pay royalty payments and taxes to all branches of government—local, State, and Federal. In 2023, the coal industry's estimated contribution to Wyoming was over $653 M (WMA 2025).

Approximately 9.2 M tons of in-place mineable coal would be mined over the next 10 to 14 years if the Federal mining plan modification is approved. The average price for Wyoming coal in 2023 was $14.25 per ton, unchanged from 2022 (WMA 2025). BBCM's coal Btu per short ton (2,000 pounds or 1 ton) and quality is in between the Powder River Basin and the Uinta Basin. The value of this coal under current market conditions (Powder River Basin spot coal price is $14.30 dollars per short ton [EIA 2025]) would be $131,560,000. The exact price of the coal is determined by contracts negotiated between the BBCM and the power generator(s) and is not publicly available. The percentage of revenue from the sale of coal going to pay State rents and royalties, Federal mineral royalties, severance taxes, and ad valorem property and production would be approximately 93 percent (WMA 2025).

3.7.2 Environmental Consequences

3.7.2.1 Alternatives Impacts

Alternative I – No Action Alternative

Under the No Action Alternative, the Proposed Action would not be implemented and no additional beneficial impacts on social and economic resources other than those already authorized at the BBCM would occur. Operational costs at the BBCM would increase as the strip ratio of coal to overburden would increase without opening new pits; therefore, BBCM would not be competitive enough and would no longer be able to provide coal to their current customers without leasing additional reserves on public lands. The BBCM employees would drop by more than 100 people in the upcoming years as the focus at the BBCM would shift from production to reclamation in order to satisfy the State of Wyoming's bonding liability currently held by the BBCM. Future mining of other coal resources in the area could occur, but none has been identified at this time. The shortening of the BBCM life would eliminate an income source for mine employees and support service employees in the short term. A reduction in the demand for housing and community services would occur. Coal sales revenue to the State of Wyoming and the Federal government in the form of royalty payments would not occur. Property taxes and net proceeds of the mining taxes, as well as sales taxes, would not be paid to Sweetwater County.

The Jim Bridger Power Plant would seek other, potentially non-local, sources of coal to maintain production. The additional costs would be passed onto the utility consumers in the form of higher energy prices.

Alternative II – Proposed Action

Approval of the Proposed Action would allow BBCM to extend present production and employment levels for an additional approximately 6 to 7 years, resulting in continued economic benefits to Sweetwater County. A total of 110 BBCM employees would have an additional 6 to 7 years of employment. Continued BBCM employment would affect quality of life for workers and their families by providing income both directly to mine employees and indirectly to employees and owners of businesses providing personal and business support services.

Because the workforce needed to support the Proposed Action is already employed at the BBCM, the existing housing and community services in Rock Springs, Green River, and Sweetwater County would be sufficient to accommodate the continued workforce.

The Proposed Action would continue to provide revenue to the State of Wyoming and the Federal government in the form of royalty payments. The Federal government would also receive a reclamation fee on each ton of coal produced, which is deposited in the Abandoned Mine Reclamation Fund to help fund the reclamation of pre-SMCRA coal mine sites and other authorized uses. See 30 USC §§ 1231-1244. Property taxes and net proceeds of the mining taxes, as well as sales taxes, would be paid to Sweetwater County. Approximately 9.2 M tons of in-place mineable coal would be removed with the approval of the Proposed Action.

The Proposed Action would generate approximately $294,000,000 in local and county revenue, mainly in the form of wages and benefits, local business transactions, and gross tax proceeds. Estimated Wyoming State revenue is about $43,400,000, principally in the form of severance tax, gross tax proceeds, and mineral royalties (personal communication, BBCC, S. Gili, June 16, 2025).

The Proposed Action would provide the lowest transportation cost of coal to supply the Jim Bridger Power Plant, leading to less expensive generation of electricity for customers of the Jim Bridger Power Plant.

3.7.2.2 Incremental Impacts

Alternative I – No Action Alternative

Under the No Action Alternative, the Proposed Action would not be implemented and there would be no increase in the effects in the incremental impact assessment area (i.e., Sweetwater County, Wyoming) other than those from RFFAs. The cessation of mining at the end of the BBCM permitted reserves would create moderate to major adverse socioeconomic impacts that would decrease the rate of growth in population and personal income levels. The cessation of mining may also slow growth impacts associated with RFFAs in Sweetwater County.

Alternative II – Proposed Action

Implementation of the Proposed Action and RFFAs would provide an increase in the tax base to Sweetwater County, State, and Federal governments. This increase would be realized through wages; severance and ad valorem taxes; and royalty payments from proposed mining, energy, and oil and gas projects. Income from continued livestock grazing (i.e., cattle and sheep) would

also continue. Employment opportunities would also be expected to increase. Based on this, the population of Sweetwater County is expected to increase over the next several years. The increase in population and the anticipated continuation of this trend, due primarily to increased non-coal mineral exploration development and production, would, in combination with a stable employment rate at the BBCM, continue to increase property values and the need for more community services.

4 TRIBAL CONSULTATION

Consultation with potentially affected Native American tribes concerning the identification and management of specific traditional cultural properties and other sensitive sites is required under the NHPA and the DOI Policy on Consultation with Indian Tribes, intended to determine cultural resource sites that might not be archaeological sites or historical structures. Archaeological sites, historical structures, or non-archaeological/non-structural site types, such as springs, rivers, undeveloped trails, migration routes, procurement areas, hunting grounds, and vision quest locales, may be considered sacred to Native American tribes.

On February 8, 2012, letters were mailed to the following Native American tribes: Northern Arapaho, Eastern Shoshone, Shoshone Bannock, and Ute Tribe of the Uintah and Ouray Reservation. Two of these tribes, the Northern Arapaho and the Eastern Shoshone, requested a field visit. On April 16, 2012, the Northern Arapaho and Eastern Shoshone tribes visited four undisclosed ancestral sites, three of which are within a 0.25-mile of the Federal mining plan modification area. Both of these tribes did not oppose the leasing and pit projects, as long as the sites are not disturbed (Stadler 2015). Based on these conversations, OSMRE determined that there would be no effect on any sacred Native American sites. The BLM RSFO concurs that none of these sites would be disturbed by the Proposed Action (Stadler 2015).

OSMRE sent letters to the Northern Arapaho, Eastern Shoshone, Shoshone Bannock, and Ute Tribe of the Uintah and Ouray Reservation on January 4, 2022, and invited them to consult about the potential resolution of adverse effects to one archaeological site. The archaeological site was previously eligible for the National Register of Historic Places (NRHP), but the SHPO later recommended the BLM change the site significance to not eligible due to previous excavations and the BLM changed the site significance. The tribes provided no responses. OSMRE sent scoping letters to the four tribes on August 12, 2025, regarding the EIS, the NHPA review, and government-to-government consultation in accordance with DM Part 512 Chapter 4, the DOI Policy on Consultation with Indian Tribes.

The BLM consulted with Wyoming SHPO in 2017 for the proposed new Pit 15 and Pit 10 expansion lease modification area and SHPO concurred determinations of eligibility for historic properties. The BLM approved the new Pit 15 and Pit 10 expansion lease modification area in 2017. OSMRE consulted with the Wyoming SHPO in December 2021 on potential adverse effects to protected resources related to the proposed Federal mining plan modification. Wyoming SHPO requested that BLM revise the site eligibility for one site from eligible to not eligible for the NRHP because previous excavations have exhausted the data potential. SHPO also requested that OSMRE revise the finding of effect from adverse effect to no historic properties affected. On June 1, 2022, the Wyoming SHPO concurred with the No Historic Properties Affected determination for cultural/historic resources under the condition that OSMRE require that an archaeological monitor be present for surface stripping activities at one archaeological site that has previously undergone excavations in case previously unobserved feature types are discovered. Wyoming SHPO further agreed that OSMRE will provide expedited direction to the mining operator after providing the BLM, SHPO, the Advisory Council on Historic Preservation, and any applicable Indian tribe 48 hours to comment for any necessary site mitigation related to such a discovery.

5 PREPARERS AND REVIEWERS

Table 5-1. provides a list of preparers and reviewers for this EIS.

Table 5-1. List of Preparers and Reviewers

Name	Title	Responsibility
OSMRE		
Roberta Martinez-Hernandez	Natural Resource Specialist	Former EIS Lead
Charlie Kwak	Natural Resource Specialist	Current EIS Lead
Erica Trent	Biologist	Fish and Wildlife
Paul Clark	Hydrologist	Hydrology
Jeremy Iliff	Archaeologist	Cultural Resources
Marcello Calle	Division Chief, Acting Regional Director	Reviewer
BLM		
Jason Brown	Geologist	EIS Cooperating Agency Lead
Richard Jacoby	Air Quality Specialist	Reviewer
James Halperin	Field Manager, South River Field Office	Reviewer
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Craig Hults	Land Quality Natural Resources Program Principal	Reviewer
Brandi O'Brien	Land Quality Administrator	Reviewer
Tori Nye	Natural Resources Analyst	Reviewer
Noah Albrecht	Air Quality Planning Engineer	Reviewer
Zac Mangin	Air Quality Planning Supervisor	Reviewer
Eric Hargett	Water Quality Standards Program Supervisor	Reviewer

Name	Title	Responsibility
Tetra Tech, Inc.		
Keith Pohs	Senior Environmental Project Manager	Project Manager, NEPA Lead, and Document Preparation
Greg Kazmer	Senior Project Manager	Document Preparation
Bela Gadgil	Environmental Scientist/NEPA Specialist	Document Preparation
Jill Reid	Senior Project Manager/Biologist	Document Preparation and Project Record Compilation
Wendy Rieth	Senior Biologist/GIS Analyst	Fish and Wildlife Preparation and GIS
Kristin McClure	Environmental Scientist	Air Quality/GHG Preparation

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APPENDIX A –
BLM SPECIAL STIPULATIONS

Sec. 15. **SPECIAL STIPULATIONS** - In addition to observing the general obligations and standards of performance set out in the current regulations, the lessee shall comply with and be bound by the following special stipulations.

These stipulations are also imposed upon the lessee's agents and employees. The failure or refusal of any of these persons to comply with these stipulations shall be deemed a failure of the lessee to comply with the terms of the lease. The lessee shall require his agents, contractors and subcontractors involved in activities concerning this lease to include these stipulations in the contracts between and among them. These stipulations may be revised or amended, in writing, by the mutual consent of the lessor and the lessee at any time to adjust to changed conditions or to correct an oversight.

(a) ***CULTURAL RESOURCES -*** (1) Before undertaking any activities that may disturb the surface of the leased lands, the lessee shall conduct a cultural resource intensive field inventory in a manner specified by the Authorized Officer of the BLM or of the surface managing agency, if different, on portions of the mine plan area and adjacent areas, or exploration plan area, that may be adversely affected by lease- related activities and which were not previously inventoried at such a level of intensity. The inventory shall be conducted by a qualified professional cultural resource specialist (i.e. archeologist, historian, historical architect, as appropriate), approved by the Authorized Officer of the surface managing agency (BLM, if the surface is privately owned), and a report of the inventory and recommendations for protecting any cultural resources identified shall be submitted to the Regional Director of the Western Region of the Office of Surface Mining (the Western Regional Director), the Authorized Officer of the BLM, if activities are associated with coal exploration outside an approved mining permit area (hereinafter called Authorized Officer), and the Authorized Officer of the surface managing agency, if different. The lessee shall undertake measures, in accordance with instructions from the Western Regional Director, or Authorized Officer, to protect cultural resources on the leased lands. The lessee shall not commence the surface disturbing activities until permission to proceed is given by the Western Regional Director or Authorized Officer.

(2) Any existing Class III inventory report covering the lease area that has not received federal agency review must be reviewed and accepted by the agency, site National Registry of Historic Places (NRHP) eligibility determinations made, and consultation with the State Historic Preservation Officer completed before any surface disturbing activities take place.

(3) The lessee shall protect all cultural resource properties that have been determined eligible or unevaluated to the NRHP within the lease area from lease-related activities until the cultural resource mitigation measures or site evaluations can be implemented as part of an approved mining and reclamation or exploration plan unless modified by mutual agreement in consultation with the State Historic Preservation Officer.

(4) The cost of conducting the inventory, preparing reports, and carrying out mitigation measures shall be borne by the lessee.

(5) If cultural resources are discovered during operations under this lease, the lessee shall immediately bring them to the attention of the Western Regional Director or Authorized Officer, or the Authorized Officer of the surface managing agency, if the Western Regional Director is not available. The lessee shall not disturb such resources except as may be subsequently authorized by the Western Regional Director or Authorized Officer.

Within two (2) working days of notification, the Western Regional Director or Authorized Officer will evaluate or have evaluated any cultural resources discovered and will determine if any action may be required to protect or preserve such discoveries. The cost of data recovery for cultural resources discovered during lease operations shall be borne by the lessee unless otherwise specified by the Authorized Officer of the BLM or of the surface managing agency, if different.
(6) All cultural resources shall remain under the jurisdiction of the United States until ownership is determined under applicable law.

(b) ***PALEONTOLOGICAL RESOURCES***

If paleontological resources, either large and conspicuous, and/or of significant scientific value are discovered during mining operations, the find will be reported to the Authorized Officer immediately. Mining operations will be suspended within 250 feet of said find. An evaluation of the paleontological discovery will be made by a BLM approved professional paleontologist within five (5) working days, weather permitting, to determine the appropriate action(s) to prevent the potential loss of any significant paleontological value. Operations within 250 feet of such discovery will not be resumed until written authorization to proceed is issued by the Authorized Officer. The lessee will bear the cost of any required paleontological appraisals, surface collection of fossils, or salvage of any large conspicuous fossils of significant scientific interest discovered during the operations.

(c) ***THREATENED, ENDANGERED, CANDIDATE, OR OTHER SPECIAL STATUS PLANT AND ANIMAL SPECIES –***
(1) The lease area may now or hereafter contain plants, animals, or their habitats determined to be threatened or endangered under the Endangered Species Act of 1973, as amended, 16 USC 1531 *et seq.*, or that have other special status. The Authorized Officer may recommend modifications to exploration and development proposals to further conservation and management objectives or to avoid activity that will contribute to a need to list such species or their habitat or to comply with any biological opinion issued by the Fish and Wildlife Service for the proposed action. The Authorized Officer will not approve any ground-disturbing activity that may affect any such species or critical habitat until it completes its obligations under applicable requirements of the Endangered Species Act. The Authorized Officer may require modifications to, or disapprove a proposed activity that is likely to result in jeopardy to the continued existence of a proposed or listed threatened or endangered species, or result in the destruction or adverse modification of designated or proposed critical habitat.

(2) The lessee shall comply with instructions from the Authorized Officer of the surface managing agency (BLM, if the surface is private) for ground disturbing activities associated with coal exploration on federal coal leases prior to approval of a mining and reclamation permit or outside an approved mining and reclamation permit area. The lessee shall comply with instructions from the Authorized Officer of the Office of Surface Mining Reclamation and Enforcement, or his designated representative, for all ground-disturbing activities taking place within an approved mining and reclamation permit area or associated with such a permit.

(3) Any potential habitat that has not already been surveyed for Ute ladies'-tresses within the project area shall be identified and surveyed prior to surface mining activities.

(d) ***MULTIPLE MINERAL DEVELOPMENT -*** Operations will not be approved which, in the opinion of the Authorized Officer, would unreasonably interfere with the orderly development and/or production from a valid existing mineral lease issued prior to this one for the same lands.

(e) ***OIL AND GAS/COAL RESOURCES -*** The BLM realizes that coal mining operations conducted on Federal coal leases issued within producing oil and gas fields may interfere with the economic recovery of oil and gas; just as Federal oil and gas leases issued in a Federal coal lease area may inhibit coal recovery. BLM retains the authority to alter and/or modify the resource recovery and protection plans for coal operations and/or oil and gas operations on those lands covered by Federal mineral leases so as to obtain maximum resource recovery.

(f) ***RESOURCE RECOVERY AND PROTECTION -*** Notwithstanding the approval of a resource recovery and protection plan (R2P2) by the BLM, lessor reserves the right to seek damages against the operator/lessee in the event (i) the operator/lessee fails to achieve maximum economic recovery (MER) (as defined at 43 CFR § 3480.0-5(21)) of the recoverable coal reserves or (ii) the operator/lessee is determined to have caused a wasting of recoverable coal reserves. Damages shall be measured on the basis of the royalty that would have been payable on the wasted or unrecoverable coal.

The parties recognize that under an approved R2P2, conditions may require a modification by the operator/lessee of that plan. In the event a coal bed or portion thereof is not to be mined or is rendered unmineable by the operation, the operator/lessee shall submit appropriate justification to obtain approval by the Authorized Officer to lease such reserves unmined. Upon approval by the Authorized Officer, such coal beds or portions thereof shall not be subject to damages as described above. Further, nothing in this section shall prevent the operator/lessee from exercising its right to relinquish all or a portion of the lease as authorized by statute and regulation.

In the event the Authorized Officer determines that the R2P2, as approved, will not attain MER as the result of changed conditions, the Authorized Officer will give proper notice to the operator/lessee as required under applicable regulations. The Authorized Office will order a modification if necessary, identifying additional reserves to be mined in order to attain MER. Upon a final administrative or judicial ruling upholding such an ordered modification, any reserves left unmined (wasted) under that plan will be subject to damages as described in the first paragraph under this section.

Subject to the right to appeal hereinafter set forth, payment of the value of the royalty on such unmined recoverable coal reserves shall become due and payable upon determination by the Authorized Officer that the coal reserves have been rendered unmineable or at such time that the operator/lessee had demonstrated an unwillingness to extract the coal.

The BLM may enforce this provision either by issuing a written decision requiring payment of the Office of Natural Resources Revenue (ONRR) demand for such royalties, or by issuing a notice of non- compliance. A decision or notice of non-compliance issued by the lessor that payment is due under this stipulation is appealable as allowed by law.

(g) ***PUBLIC LAND SURVEY PROTECTION -*** The lessee will protect all survey monuments, witness corners, reference monuments, and bearing trees against destruction, obliteration, or damage during operations on the lease areas. If any monuments, corners or accessories are destroyed, obliterated, or damaged by this operation, the lessee will hire an appropriate county surveyor or registered land surveyor to reestablish or restore the monuments, corners, or accessories at the same locations, using the surveying procedures in accordance with the "Manual of Surveying Instructions for the Survey of the Public Lands of the United States." The survey will be recorded in the appropriate county records, with a copy sent to the Authorized Officer.

APPENDIX B –
IPAC REPORT

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Wyoming Ecological Services Field Office
334 Parsley Boulevard
Cheyenne, WY 82007-4178
Phone: (307) 772-2374 Fax: (307) 772-2358
Email Address: wyominges@fws.gov

In Reply Refer To: 08/19/2025 15:12:15 UTC
Project Code: 2025-0137710
Project Name: Black Butte Mine Federal Mining Plan Modification

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat that may occur within the boundary of the proposed project and / or may be affected by the proposed project. This species list fulfills requirements under section 7(c) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 *et seq.*).

New or updated information based on surveys, changes in the abundance and / or distribution of species, changed habitat conditions, or other factors could change this species list. Note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the ESA, the accuracy of this species list should be verified after 90 days. The U.S. Fish and Wildlife Service (Service) recommends that verification be completed by visiting the IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list can be requested through the IPaC tool by completing the same process used to receive the enclosed list.

The purpose of the ESA is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the ESA and its implementing regulations (50 CFR 402 *et seq.*), federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects they authorize, fund, carry out, in whole or in part may affect listed and proposed species as well as proposed and final designated critical habitat.

A biological assessment is required for construction projects (or other undertakings having similar physical impacts) that are major federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, a biological evaluation similar to a biological assessment should prepared to determine whether the project may affect listed or proposed species as well as proposed and final designated critical habitat. The necessary contents of a biological assessment for consultation are described at 50 CFR 402.14.

If the federal agency determines that proposed or listed species and / or designated critical habitat may be affected by the

proposed project, the federal agency is required to support that determination and consult with the Service pursuant to the ESA implementing regulations at 50 CFR 402. More information on the regulations and procedures for section 7 consultation, including the role of designated non-federal representatives, can be found in the 1998 Endangered Species Consultation Handbook.

We appreciate your efforts to ensure the conservation of endangered, threatened, proposed and candidate species. Contact our office for more information and / or assistance regarding potential impacts to federally proposed, listed, candidate species, or proposed and final designated critical habitat at (307) 772-2374 or visit the Wyoming Ecological Services website. **Please include the IPaC Project Code, located in the header of this letter, with any request for consultation or correspondence about your project that you submit to our office using our WyomingES@fws.gov email address**.

Attachment(s):

- Official Species List
- USFWS National Wildlife Refuges and Fish Hatcheries
- Bald & Golden Eagles
- Migratory Birds
- Wetlands

OFFICIAL SPECIES LIST

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

Wyoming Ecological Services Field Office
334 Parsley Boulevard
Cheyenne, WY 82007-4178
(307) 772-2374

PROJECT SUMMARY

Project Code: 2025-0137710

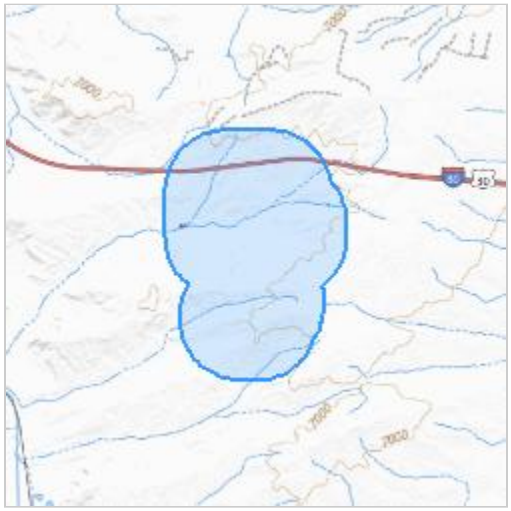
Project Name: Black Butte Mine Federal Mining Plan Modification

Project Type: Surface Extraction - Coal

Project Description: The Office of Surface Mining Reclamation and Enforcement (OSMRE) is preparing an Environmental Impact Statement analyzing the potential effects on the environment of issuing a modification to the existing Black Butte Coal Mine (BBCM) Federal mining plan to extract federal coal from and additional 450 acres within Federal Coal Lease WYW-6266. The Wyoming Department of Environmental Quality approved the mine permit revision in 2021. The BBCM is located in Sweetwater County, Wyoming. Both the surface lands and mineral estate are administered by the Bureau of Land Management (BLM) Rock Springs Field Office. Approval of the federal mining plan modification would allow for expansion of coal mining in the existing Pit 10 (50 acres) and development of a new pit (Pit 15) (400 acres). Approximately 68 acres have previously been disturbed in the mining plan modification area for surface uses under a separate existing BLM right-of-way agreement, including for access roads, surface water retention basin, topsoil stripping, and topsoil and overburden stockpiles. Mining would be accomplished using dragline/dozer strip/truck shovel surface mining operation methods, similar to what has previously been used in Pit 10, followed by reclamation. The majority of the coal would be transported by rail to the Jim Bridger Power Plan, approximately 13 miles to the northwest. Mining is anticipated to occur over a 10-to-14-year period.

Project Location:

The approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@41.6264243,-108.62881163496539,14z



Counties: Sweetwater County, Wyoming

ENDANGERED SPECIES ACT SPECIES

There is a total of 8 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species. Note that 4 of these species should be considered only under certain conditions.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

BIRDS

NAME	STATUS
Yellow-billed Cuckoo *Coccyzus americanus* Population: Western U.S. DPS There is **final** critical habitat for this species. Your location does not overlap the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/3911	Threatened

FISHES

NAME	STATUS
Bonytail *Gila elegans* There is **final** critical habitat for this species. Your location does not overlap the critical habitat. This species only needs to be considered under the following conditions: ▪ Water depletions in the upper Colorado River basin adversely affect this species and its critical habitat. Effects of water depletions must be considered even outside of occupied range. Species profile: https://ecos.fws.gov/ecp/species/1377	Endangered
Colorado Pikeminnow *Ptychocheilus lucius* Population: Wherever found, except where listed as an experimental population There is **final** critical habitat for this species. Your location does not overlap the critical habitat. This species only needs to be considered under the following conditions: ▪ Water depletions in the upper Colorado River basin adversely affect this species and its critical habitat. Effects of water depletions must be considered even outside of occupied range. Species profile: https://ecos.fws.gov/ecp/species/3531	Endangered
Humpback Chub *Gila cypha* There is **final** critical habitat for this species. Your location does not overlap the critical habitat. This species only needs to be considered under the following conditions: ▪ Water depletions in the upper Colorado River basin adversely affect this species and its critical habitat. Effects of water depletions must be considered even outside of occupied range. Species profile: https://ecos.fws.gov/ecp/species/3930	Threatened
Razorback Sucker *Xyrauchen texanus* There is **final** critical habitat for this species. Your location does not overlap the critical habitat. This species only needs to be considered under the following conditions: ▪ Water depletions in the upper Colorado River basin adversely affect this species and its critical habitat. Effects of water depletions must be considered even outside of occupied range. Species profile: https://ecos.fws.gov/ecp/species/530	Endangered

INSECTS

NAME	STATUS
Monarch Butterfly *Danaus plexippus* There is **proposed** critical habitat for this species. Your location does not overlap the critical habitat.	Proposed Threatened

NAME	STATUS
Species profile: https://ecos.fws.gov/ecp/species/9743	
Suckley's Cuckoo Bumble Bee *Bombus suckleyi* Population: No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/10885	Proposed Endangered

FLOWERING PLANTS

NAME	STATUS
Ute Ladies'-tresses *Spiranthes diluvialis* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/2159	Threatened

CRITICAL HABITATS

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

YOU ARE STILL REQUIRED TO DETERMINE IF YOUR PROJECT(S) MAY HAVE EFFECTS ON ALL ABOVE LISTED SPECIES.

USFWS NATIONAL WILDLIFE REFUGE LANDS AND FISH HATCHERIES

Any activity proposed on lands managed by the National Wildlife Refuge system must undergo a 'Compatibility Determination' conducted by the Refuge. Please contact the individual Refuges to discuss any questions or concerns.

THERE ARE NO REFUGE LANDS OR FISH HATCHERIES WITHIN YOUR PROJECT AREA.

BALD & GOLDEN EAGLES

Bald and Golden Eagles are protected under the Bald and Golden Eagle Protection Act [2] and the Migratory Bird Treaty Act (MBTA) [1]. Any person or organization who plans or conducts activities that may result in impacts to Bald or Golden Eagles, or their habitats, should follow appropriate regulations and consider implementing appropriate avoidance and minimization measures, as described in the various links on this page.

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1. The Bald and Golden Eagle Protection Act of 1940.
2. The Migratory Birds Treaty Act of 1918.
3. 50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)

There are Bald Eagles and/or Golden Eagles in your project area.

Measures for Proactively Minimizing Eagle Impacts
For information on how to best avoid and minimize disturbance to nesting bald eagles, please review the National Bald Eagle Management Guidelines. You may employ the timing and activity-specific distance recommendations in this document when designing your project/ activity to avoid and minimize eagle impacts. For bald eagle information specific to Alaska, please refer to Bald Eagle Nesting and Sensitivity to Human Activity.

The FWS does not currently have guidelines for avoiding and minimizing disturbance to nesting Golden Eagles. For site-specific recommendations regarding nesting Golden Eagles, please consult with the appropriate Regional Migratory Bird Office or Ecological Services Field Office.

If disturbance or take of eagles cannot be avoided, an incidental take permit may be available to authorize any take that results from, but is not the purpose of, an otherwise lawful activity. For assistance making this determination for Bald Eagles, visit the Do I Need A Permit Tool. For assistance making this determination for golden eagles, please consult with the appropriate Regional Migratory Bird Office or Ecological Services Field Office.

Ensure Your Eagle List is Accurate and Complete
If your project area is in a poorly surveyed area in IPaC, your list may not be complete and you may need to rely on other resources to determine what species may be present (e.g. your local FWS field office, state surveys, your own surveys). Please review the Supplemental Information on Migratory Birds and Eagles, to help you properly interpret the report for your specified location, including determining if there is sufficient data to ensure your list is accurate.

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to bald or golden eagles on your list, see the "Probability of Presence Summary" below to see when these bald or golden eagles are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON
Golden Eagle *Aquila chrysaetos* This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities. https://ecos.fws.gov/ecp/species/1680	Breeds Jan 1 to Aug 31

PROBABILITY OF PRESENCE SUMMARY

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read "Supplemental Information on Migratory Birds and Eagles", specifically the FAQ section titled "Proper Interpretation and Use of Your Migratory Bird Report" before using or attempting to interpret this report.

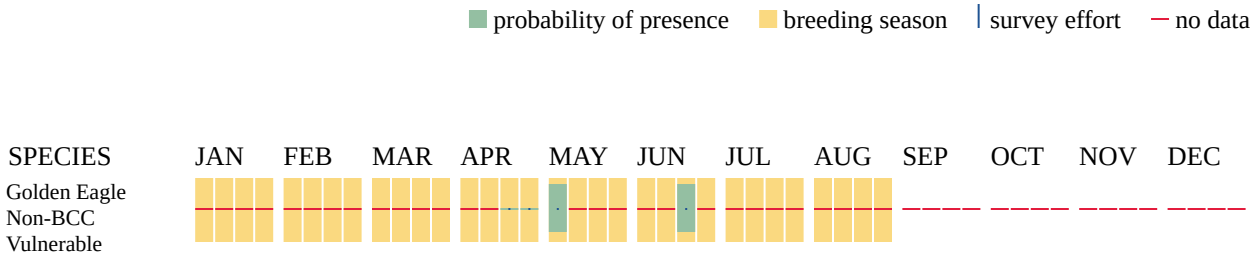
Probability of Presence (■)

Green bars; the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during that week of the year.

Breeding Season (▪)
Yellow bars; liberal estimate of the timeframe inside which the bird breeds across its entire range.

Survey Effort (|)
Vertical black lines; the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps.

No Data (–)
A week is marked as having no data if there were no survey events for that week.



Additional information can be found using the following links:

- Eagle Management https://www.fws.gov/program/eagle-management
- Measures for avoiding and minimizing impacts to birds https://www.fws.gov/library/collections/avoiding-and-minimizing-incidental-take-migratory-birds
- Nationwide avoidance and minimization measures for birds https://www.fws.gov/sites/default/files/documents/nationwide-standard-conservation-measures.pdf
- Supplemental Information for Migratory Birds and Eagles in IPaC https://www.fws.gov/media/supplemental-information-migratory-birds-and-bald-and-golden-eagles-may-occur-project-action

MIGRATORY BIRDS

The Migratory Bird Treaty Act (MBTA) [1] prohibits the take (including killing, capturing, selling, trading, and transport) of protected migratory bird species without prior authorization by the Department of Interior U.S. Fish and Wildlife Service (Service).

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1. The Migratory Birds Treaty Act of 1918.
2. The Bald and Golden Eagle Protection Act of 1940.
3. 50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, see the "Probability of Presence Summary" below to see when these birds are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON
Golden Eagle *Aquila chrysaetos* This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities. https://ecos.fws.gov/ecp/species/1680	Breeds Jan 1 to Aug 31

PROBABILITY OF PRESENCE SUMMARY

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read "Supplemental Information on Migratory Birds and Eagles", specifically the FAQ section titled "Proper Interpretation and Use of Your Migratory Bird Report" before using or attempting to interpret this report.

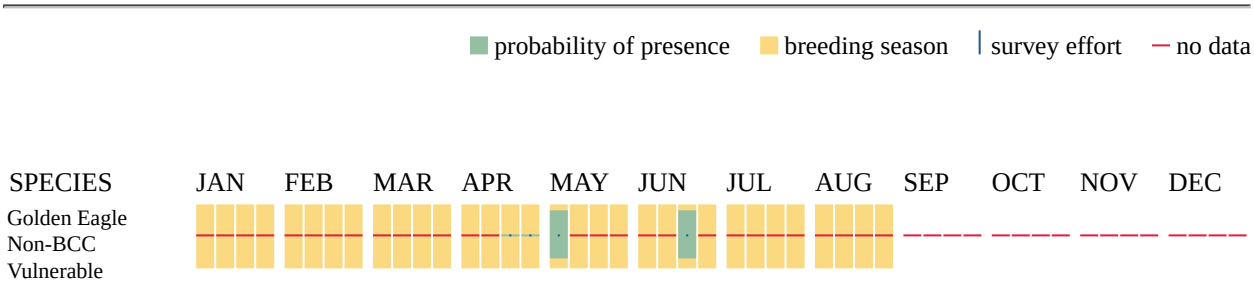
Probability of Presence (■)

Green bars; the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during that week of the year.

Breeding Season (■)
Yellow bars; liberal estimate of the timeframe inside which the bird breeds across its entire range.

Survey Effort (|)
Vertical black lines; the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps.

No Data (–)
A week is marked as having no data if there were no survey events for that week.



Additional information can be found using the following links:

- Eagle Management https://www.fws.gov/program/eagle-management

- Measures for avoiding and minimizing impacts to birds https://www.fws.gov/library/collections/avoiding-and-minimizing-incidental-take-migratory-birds
- Nationwide avoidance and minimization measures for birds
- Supplemental Information for Migratory Birds and Eagles in IPaC https://www.fws.gov/media/supplemental-information-migratory-birds-and-bald-and-golden-eagles-may-occur-project-action

WETLANDS

Impacts to NWI wetlands and other aquatic habitats may be subject to regulation under Section 404 of the Clean Water Act, or other State/Federal statutes.

For more information please contact the Regulatory Program of the local U.S. Army Corps of Engineers District.

Please note that the NWI data being shown may be out of date. We are currently working to update our NWI data set. We recommend you verify these results with a site visit to determine the actual extent of wetlands on site.

FRESHWATER POND

- PUBGx
- PUSCx
- PUSAh
- PUSAx

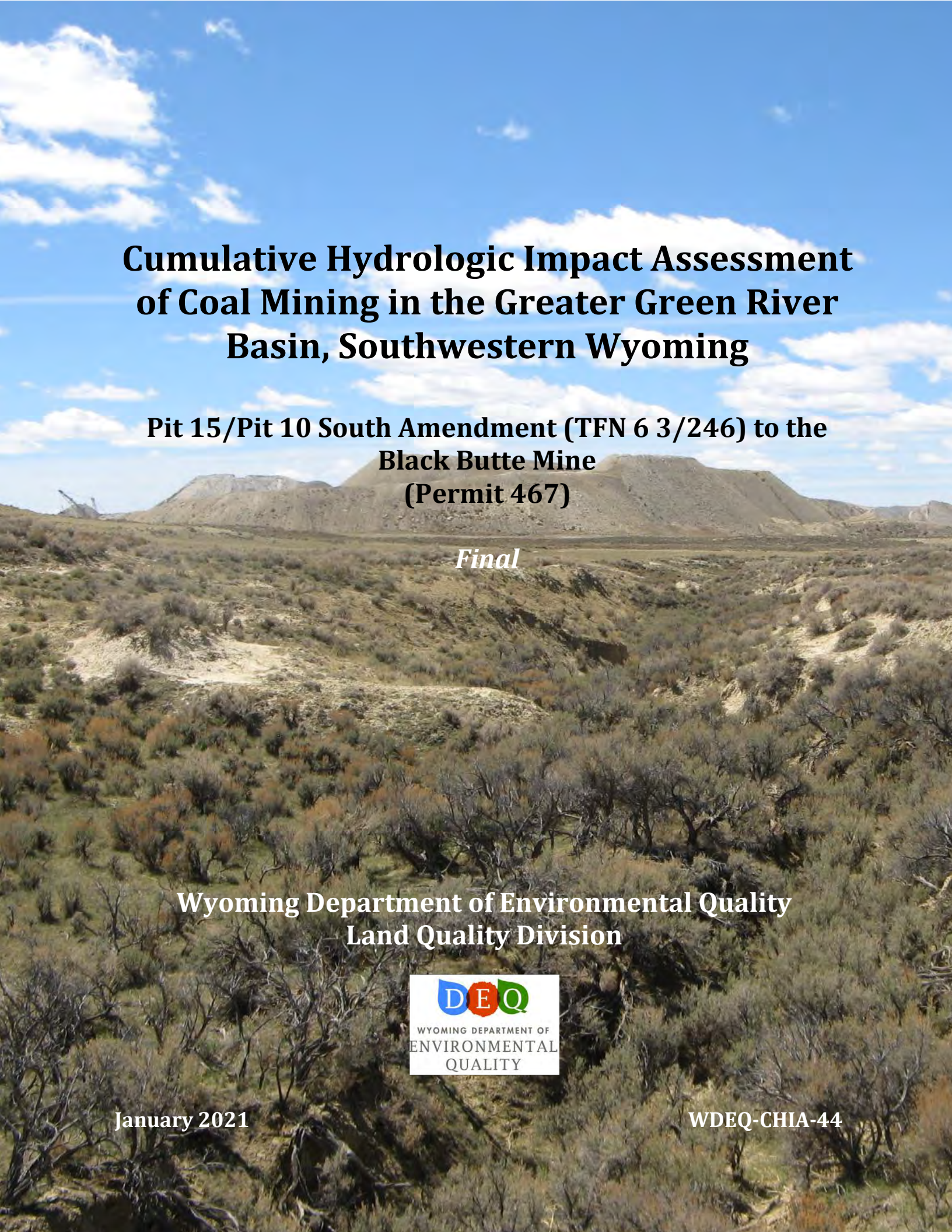
RIVERINE

- R4SBJ

IPAC USER CONTACT INFORMATION

Agency:	Office of Surface Mining Reclamation and Enforcement
Name:	Wendy Rieth
Address:	4750 West 2100 South
Address Line 2:	Suite 400
City:	Salt Lake City
State:	UT
Zip:	84120
Email	wendy.rieth@tetratech.com
Phone:	8016185886

APPENDIX C –
CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT



Cumulative Hydrologic Impact Assessment of Coal Mining in the Greater Green River Basin, Southwestern Wyoming

Pit 15/Pit 10 South Amendment (TFN 6 3/246) to the Black Butte Mine (Permit 467)

Final

Wyoming Department of Environmental Quality
Land Quality Division

WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY

January 2021

WDEQ-CHIA-44

Cover photo: Ephemeral stream channel within the Pit 15/Pit 10 South Amendment area at the Black Butte Mine. Photo facing downstream (southwest) to Pit 10. Photo taken by Craig Smith, Wyoming Department of Environmental Quality, Land Quality Division, April 28, 2020.

Cumulative Hydrologic Impact Assessment of Coal Mining in the Greater Green River Basin, Southwestern, Wyoming

Pit 15/Pit 10 South Amendment (TFN 6 3/246) to the Black Butte Mine (Permit 467)

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Cheyenne, Wyoming

January 2021

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LIST OF ABBREVIATIONS AND ACRONYMS

ac-ft	Acre-feet
ac-ft/mi^2	Acre feet per square mile
AF	Almond Formation
AOC	Approximate original contour
ASCM	Alternate Sediment Control Measures
AVF	Alluvial valley floor
b	Aquifer thickness
BKWAG	Bitter/Killpecker Watershed Assessment Group
BLM	Bureau of Land Management
C	Celsius
$CaCO_3$	Calcium carbonate
CARF	Coal annual report format
CBM	Coalbed methane
CFR	Code of Federal Regulations
cfs	Cubic feet per second
CHIA	Cumulative Hydrologic Impact Assessment
CIA	Cumulative Impact Area
DMR	Discharge monitoring report
E. coli	Escherichia coli
ESRI	Environmental Systems Research Institute
ºF	Fahrenheit
FGD	Flue gas desulphurization
ft	Feet
FUF	Fort Union Formation
GGRB	Greater Green River Basin
GIS	Geographic Information Systems
gpd	Gallons per day
gpm	Gallons per minute
K	Hydraulic conductivity
LF	Lance Formation
LIDAR	Light detection and ranging
LS	Slope length factor
Max	Maximum
Mg	Magnesium
mg/L	Milligrams per liter

mi^2	Square miles
Min	Minimum
N	Nitrogen
N/A	Not available
Na	Sodium
NED	National Elevation Dataset
NEPA	National Environmental Policy Act
NH_3	Ammonia
NHD	National Hydrography Dataset
Ni	Nickel
No.	Number
NO_2	Nitrite
NO_3	Nitrate
NTU	Nephelometric turbidity units
PHC	Probable Hydrologic Consequences
PMT	Post-mine topography
PPM	Parts per million
PRB	Powder River Basin
ROS	Regression on order statistics
RUSLE	Revised Universal Soil Loss Equation
S	Storage coefficient
SAR	Sodium absorption ratio
SMCRA	Surface Mining Control and Reclamation Act
SO_4	Sulfate
SU	Standard units
SWCCD	Sweetwater County Conservation District
T	Transmissivity
TCO	Temporary cessation of operations
TDS	Total dissolved solids
TFN	Temporary filing number
TSS	Total suspended solids
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WDEQ	Wyoming Department of Environmental Quality
WDEQ/LQD	Wyoming Department of Environmental Quality/Land Quality Division
WDEQ/WQD	Wyoming Department of Environmental Quality/Water Quality Division
WS	Wyoming Statute

WSEO	Wyoming State Engineer's Office
WYPDES	Wyoming Pollutant Discharge Elimination System
yr	Year

EXECUTIVE SUMMARY

The Wyoming Environmental Quality Act requires that no coal mining be approved unless the applicant affirmatively demonstrates and the administrator finds in writing that the operation is designed to prevent material damage to the hydrologic balance outside the permit area. Coal mine operations must also not cause material damage to the quantity and quality of water in surface or groundwater systems that supply alluvial valley floors (AVFs) not subject to statutory exclusions. The Wyoming Department of Environmental Quality Land Quality Division (WDEQ/LQD) defines material damage to the hydrologic balance as a significant long-term or permanent adverse change to the hydrologic regime. A cumulative hydrologic impact assessment (CHIA) is used to assess the probable cumulative impacts of all anticipated coal mining in an area to ensure the proposed operation has been designed to prevent material damage to the hydrologic balance outside the permit area.

The permitting action evaluated by this CHIA is the Pit 15/Pit 10 South Amendment at the Black Butte Mine. The Black Butte Mine is located in the Greater Green River Basin (GGRB) of southwest Wyoming, approximately 25 miles east of Rock Springs. The Pit 15/Pit 10 South Amendment proposes to extend existing Pit 10 to the south and mine a new pit (Pit 15) to the northeast of the existing permit. The amendment would add a total of 963.35 acres northeast of the existing Black Butte Mine permit boundary. The amendment proposes to disturb 331 acres. The amendment area is located within the headwaters of unnamed ephemeral tributaries to Bitter Creek. Mining in the amendment area is proposed from 2024 until 2038.

This CHIA analyzes the impact of the Pit 15/Pit 10 South Amendment along with existing coal mining and reclamation activities at the Jim Bridger, Leucite Hills, and Black Butte mines to determine whether mining will result in material damage to the hydrologic balance outside of the mine permit areas. Surface mining methods at the Jim Bridger and Black Butte mines include dragline and truck and shovel operations and longwall mining methods are used at the underground mine at Jim Bridger. The Leucite Hills Mine is in reclamation and no further mining is planned.

The CHIA delineates a cumulative impact area (CIA) where existing and proposed mining activities may have the potential to cause measurable changes to surface water and groundwater resources. The surface water CIA includes 758 square miles of the Bitter Creek watershed upstream from Point of Rocks. The surface water CIA includes the Deadman Wash watershed, which drains a majority of the Jim Bridger and Leucite Hills mines, while the mainstem of Bitter Creek runs through the Black Butte Mine permit area. The groundwater CIA was delineated using the groundwater model predicted life of mine drawdown contours presented in the individual mine permits. An interim groundwater CIA was delineated by qualitatively considering the overlapping mine drawdown impacts on each other using the principle of superposition. The final groundwater CIA was delineated by adding a two-mile buffer to the northern, eastern, and southern extent of the interim CIA to account for various uncertainties in the groundwater model predictions. The western extent of the Ericson Sandstone outcrop represents the western extent of the CIA. The horizontal extent of the groundwater CIA encompasses approximately 1,151 square miles, extending as far as 21 miles north, 14 miles east, and 13 miles west of the Jim Bridger Mine; and two miles south, two miles west, and three miles east of the Black Butte Mine. The vertical extent of

the groundwater CIA includes six aquifer units of concern that are within the horizontal extent of the groundwater CIA: alluvial, Fort Union Formation (FUF), Lance Formation (LF), Almond Formation (AF), Ericson Sandstone, and backfill.

Hydrologic concerns are an expression of problems related to water use and the hydrologic balance that may occur as a result of coal mining. Hydrologic concerns identified and evaluated for surface water include the potential for changes to surface water quality and quantity, which have the potential to affect surface water rights and surface water classes of use. Groundwater level declines or degradation of groundwater quality caused by mining are identified as the primary hydrologic concerns that will affect the existing groundwater uses in the CIA. Specific concerns related to the potential for decline of groundwater levels include: (1) reduced yield from existing wells in the CIA, (2) alteration of groundwater flow gradients and directions, (3) alterations to the recharge and discharge mechanisms, and (4) ability of the backfill aquifer to store and transmit water and to support the post-mining land use. Specific concerns related to the potential for degradation of groundwater quality include: (1) the effect of groundwater migrating from the backfill aquifer to the undisturbed native aquifers outside the permit boundaries, (2) the groundwater quality of the backfill aquifer within the permit boundaries and its ability to support the post-mining land use, and (3) the effect of the quality of base flow from the backfill aquifer to streams. The backfill aquifer is a new aquifer created by replacing overburden materials into the mined pit and trenches after the coal is removed.

The CHIA evaluates the potential for material damage to the hydrologic balance outside the mine permit areas using criteria developed by the WDEQ/LQD. These criteria are based on the identified hydrologic concerns and applicable statutes, rules, and regulations administered by the WDEQ Water Quality Division (WQD) and the Wyoming State Engineer's Office (WSEO). The potential for material damage is evaluated for surface water quantity and quality and groundwater quantity and quality. For surface water quantity, material damage occurs if the analysis demonstrates that coal mining has caused or will cause a decrease in surface water quantity such that downstream surface water rights will be affected, and the mine(s) have not committed to providing a replacement water source similar in quantity and quality. For surface water quality, material damage occurs if the analysis demonstrates that coal mining has caused or will cause a significant long-term or permanent adverse change such that WDEQ/WQD surface water quality standards and classes of use are no longer met. For groundwater quantity, material damage occurs if the analysis demonstrates that coal mining has caused or will cause a decrease in groundwater levels such that groundwater rights within the CIA will be affected and the mine(s) have not committed to providing a replacement water source similar in quantity and quality. For groundwater quality, material damage to groundwater quality occurs if the analysis demonstrates that coal mining has caused or will cause a long-term change in groundwater quality outside the coal mine permit boundaries that would preclude existing or reasonably foreseeable uses.

Typically, it will take several years to realize the groundwater impacts caused by mining to propagate outside the mine permit boundaries because of the relatively slow movement of groundwater. Contemporaneous reclamation has provided the opportunity to identify three material damage indicators that are related to the contemporaneously reclaimed backfill aquifer within the mine permit boundaries. It is important to note that the material damage indicators are not enforceable but will be used to initiate discussions and alert the mines of possible material damage. The three material damage indicators are physical characteristics of the backfill aquifer, groundwater level recovery within the backfill aquifer, and groundwater quality of the backfill

aquifer within the permit boundary. An additional key distinction between the material damage criteria and material damage indicators is that the identified material damage criteria are applied exclusively to areas outside the coal mine permit boundaries. The material damage indicators can include areas within the coal mine permit boundaries and are not restricted to outside the permit boundaries.

Surface Water Quantity

Analysis from the CHIA and the information from the mine permits indicate that coal mining will not cause material damage to surface water quantity and surface water rights in the Bitter Creek CIA. Analysis of streamflow data from Bitter Creek, Deadman Wash, and their tributaries shows that runoff response can be variable, highly dependent upon precipitation and antecedent moisture. The potential for mining to cause measurable changes to surface water quantity is deemed low due to the high variability of the natural system, the extent of disturbance in relation to the CIA, and ongoing reclamation practices. The mining proposed by the Pit 15/Pit 10 South Amendment at the Black Butte Mine is not expected to change conditions such that material damage would occur to surface water quantity and surface water rights. The proposed mining disturbance occurs in ephemeral headwater drainages far removed from Bitter Creek. The coal mines have identified all surface water rights within the mine permit boundaries and within one half-mile radius and three miles downstream of the permit area. There are few surface water rights within the Bitter Creek CIA besides those owned by the three coal mines. Due to the limited impact area, there should be no impact to water rights further downstream of the Bitter Creek CIA. Existing mining to date has resulted in no known impacts to downstream surface water rights holders. In the event that a non-mine water right is impacted by mining activities, the law and permits require water supply to be replaced by a source suitable in quantity and quality.

Surface Water Quality

Analysis from the CHIA and the information from the mine permits indicate that coal mining will not cause material damage to surface water quality in the Bitter Creek CIA. Surface water quality sample data were analyzed for the baseline and during-mining periods in each of the major drainages of the CIA. Summary statistics were compared between baseline and during-mining periods, as well as upstream and downstream of mining activity. The frequency of water quality standard exceedances was also examined, including the frequency of exceedances for the last three years of sampling. The analysis showed that WDEQ Water Quality Division (WQD) surface water quality standards for Class 2AB(ww), Class 2C, and Class 3B waters have occasionally not been met due to infrequent exceedances of dissolved metals. In most cases these exceedances were also observed in pre-mining sampling and at monitoring stations upstream from mining activity.

A more detailed analysis of selenium concentrations was conducted due to the higher number of exceedances noted on Tenmile Draw at the downstream monitoring station at the Jim Bridger Mine. It is not possible to conclusively determine that mining is the cause of the higher selenium concentrations. At other coal mines in the Powder River Basin of Wyoming, higher selenium concentrations in shallow alluvial aquifers have been attributed to seleniferous alluvium and overburden materials used for stream channel reconstruction. However, the Jim Bridger Mine has not and will not mine through and reconstruct the Tenmile Draw channel. Furthermore, a review of regraded spoils data from 27 reclamation units in the Tenmile Draw watershed indicated WDEQ/LQD suitability requirements for selenium have consistently been met. Since selenium exceedances occasionally occur on Tenmile Draw upstream of mining, natural sources of selenium

appear to exist in the Tenmile Draw watershed. The limited number of samples collected in the baseline period also makes it difficult to determine the extent selenium exceeded standards prior to mining in the drainage. The Jim Bridger Mine has installed four new monitoring stations in Tenmile Draw and has committed to monitoring selenium at permitted discharge outfalls. Although additional monitoring will be needed, results from September 2019 sampling at the four new stations showed selenium below laboratory detection limits.

Underground longwall mining at the Jim Bridger Mine is predicted to cause surface expressions of subsidence, ranging approximately from 6.8 to 10.2 feet. In most areas, visible evidence of subsidence is expected to be minimal, although some areas are predicted to develop tension fractures. Subsidence is also predicted to cause some headcutting and creation of small impoundments in the Deadman Wash channel. The Jim Bridger Mine permit contains a subsidence monitoring program to include monthly visual inspections over active longwall panels, semi-annual surveys of channel longitudinal profiles and cross-sections, and annual photogrammetric mapping and light detection and ranging (LIDAR) remote sensing. Based upon the limited amount of area that may be potentially affected by subsidence and the commitment to mitigation, changes in surface water quantity and water quality in Deadman Wash are not expected.

A more in-depth analysis was conducted for chloride given recent exceedances noted on Bitter Creek at Point of Rocks. Chloride at this location has exceeded the 230 mg/L standard in 63 percent of the samples collected over the 2001 to 2020 period. The Deadman Wash drainage appears to be a higher source of chloride to Bitter Creek at Point of Rocks rather than the mainstem of the Bitter Creek watershed upstream of the confluence with Deadman Wash. Although the Deadman Wash watershed appears to have elevated chloride values at some stations, it is difficult to determine the effect that coal mining activities have on chloride concentrations. From the available information, it is not possible to determine the extent that mining activities may be increasing chloride concentrations in the Deadman Wash watershed relative to background sources.

The overall results indicate that material damage has not occurred to surface water quality outside the mine permit areas. The additional mining proposed by the Pit 15/Pit 10 South Amendment at the Black Butte Mine is not expected to change the potential for material damage to surface water quality.

Groundwater Quantity

The observed and predicted groundwater effects were compiled, cumulated, and evaluated within the groundwater CIA. Although coal mining will have impacts within the permit boundaries, based on available data, information presented in the mine permits, and analysis in this CHIA, the potential for material damage outside the permit boundaries to groundwater quantity and groundwater quality is limited. The Pit 15/Pit 10 South Amendment at the Black Butte Mine is not expected to significantly change hydrologic conditions such that material damage would occur. The six aquifer units of concern in the GGRB are: (1) alluvial, (2) Fort Union, (3) Lance, (4) Almond, (5) Ericson Sandstone, and (6) backfill.

The 1,151 square mile groundwater CIA indicates the combined maximum extent of the predicted five-foot coal mine drawdown in the Ericson Sandstone coal aquifer and the lower overburden. To be conservative, the areal extent of the Ericson Sandstone drawdown and the

lower overburden drawdown is used to delineate the final vertical extent of the groundwater CIA. This final groundwater CIA is applicable for all six aquifers of concern.

Typically, the overburden, coal, and underburden units are discontinuous, and interbedded with sandstone, claystone, and siltstone. In some cases, they are present in different stratigraphic units (Fort Union Formation (FUF), Lance Formation (LF), or Almond Formation (AF)). Predicted drawdowns by the individual mines in these three units do not overlap with each other. Therefore, cumulative effects of mining in these three aquifers appear to be minimal. The facility wells at the mines pump water from the Ericson Sandstone aquifer. In general, coal mining has limited cumulative impacts with the pumping at the mine facility wells due to isolation of the Ericson Sandstone aquifer from the overlying units by the thick Lewis Shale. Specifically, at locations where the mined coal seams are in the FUF or AF, the Lewis Shale can be as thick as 1,000 feet. In locations where the mined coal seams are in the AF, the Ericson Sandstone aquifer is separated from the coal seams by a thick, low permeable interbedded sandstone, claystone, and siltstone AF underburden unit. Therefore, the groundwater quantity or quality impacts on the Ericson Sandstone aquifer would be minimal with no discernible effects that can be attributed to mining. The Pit 15/Pit 10 South amendment proposed by the Black Butte Mine is not expected to change the potential for material damage to groundwater quality in any of the aquifers of concern.

The physical characteristics, water level recovery, and water quality of the backfill aquifer were used as material damage indicators to evaluate the backfill aquifer and its effect on groundwater availability within the coal mine permit boundaries and flow to the undisturbed native aquifers. The backfill aquifer is not fully saturated and the current observed water level recovery rates are representative of the early stages of reclamation. The median hydraulic conductivity of the backfill aquifer is greater than the median hydraulic conductivity of the alluvial, overburden, coal, underburden, and Ericson Sandstone aquifers. It is expected that there will be some loss of permeability with time in the backfill aquifer as compaction and other physiochemical changes occur. Based on the limited data, it appears that the backfill aquifer will have sufficient permeability to allow interconnection between the outcrop recharge areas and the down dip to the discharge areas.

The mines predict that the time period for complete recovery of water levels in the backfill aquifer within the mine permit boundaries varies by pit, ranging from about six to 261 years. The recovery rate at a specific location in the backfill aquifer is dependent on the proximity to recharge sources, the hydraulic conductivity, and storage coefficients of the backfill aquifer. The viability of the backfill aquifer for beneficial uses could likely be attained prior to full recovery since there would be a rapid initial recovery followed by an asymptotic slower recovery towards the initial static water level. From the material damage evaluation perspective, the area of interest is outside of the permit areas (W.S. § 35-11-406(n)(iii)). It is important to note that these recovery time periods are for the backfill aquifer and the viability of other aquifers of interest outside the mine permit boundaries will not be impacted by mining.

Groundwater Quality

Analysis in the CHIA and information in the mine permits indicate that the potential for the backfill groundwater to migrate to and affect the adjacent undisturbed native aquifers outside the mine permit boundaries is minimal and localized. During removal and replacement of the overburden to backfill the mine pits, appropriate measures are taken to ensure that the water quality of the backfill aquifer will not be degraded such that post-mining land uses cannot be

supported. Out of the 13 backfill monitor wells with water quality data available during the 2017-2019 period, six wells had a median TDS concentration greater than 5,000 mg/L. Backfill wells will continue to be monitored to evaluate water quality trends and additional backfill wells will be installed as more areas are reclaimed. It is generally expected that over time, the backfill aquifer will be flushed by groundwater flowing through the reclaimed material to the downdip native undisturbed aquifers. Thus, the water quality in the backfill is expected to improve over time. The data from the backfill aquifer need to be continuously evaluated and it is highly recommended that further research be conducted on this topic to gain more understanding on the behavior of the backfill aquifer over time. Overall, evaluation of the three material damage indicators suggest that there is limited potential for the Pit 15/Pit 10 South Amendment at the Black Butte Mine to cause material damage to the native aquifers outside the coal mine permit boundaries.

Alluvial Valley Floors

No alluvial valley floors (AVFs) have been declared by the WDEQ/LQD on streams within the Bitter Creek CIA. Because of this, a material damage assessment for AVFs is not required.

Overall Findings

Based on the information presented in the revision application, the approved mining permits, and the analysis completed for this CHIA, no material damage to the hydrologic balance outside the permit areas will occur from approval of the Pit 15/Pit 10 South Amendment at the Black Butte Mine.

1. INTRODUCTION

The Wyoming Environmental Quality Act requires that no coal mining be approved unless the applicant affirmatively demonstrates and the administrator finds in writing that the operation is designed to prevent material damage to the hydrologic balance outside the permit area (W.S. § 35-11-406(n)(iii)). Coal mine operations must also not cause material damage to the quantity and quality of water in surface or groundwater systems that supply alluvial valley floors (AVFs) not subject to statutory exclusions (W.S. § 35-11-406(n)(v)).

The Wyoming Department of Environmental Quality Land Quality Division (WDEQ/LQD) defines material damage to the hydrologic balance as a significant long-term or permanent adverse change to the hydrologic regime (WDEQ Land Quality–Coal Rules, Ch. 1, § 2(cf)). A significant long-term or permanent adverse change is defined as changes to the surface or groundwater hydrology that are inalterable conditions contrary to: (1) the Wyoming State Constitution, (2) statutes administered by the Wyoming State Engineer's Office (WSEO), or (3) water quality standards administered by the WDEQ Water Quality Division (WQD) (Wyoming Department of Environmental Quality and Wyoming State Engineer's Office, 1996). A cumulative hydrologic impact assessment (CHIA) is used to assess the probable cumulative impacts of all anticipated coal mining in an area to ensure the proposed operation has been designed to prevent material damage to the hydrologic balance outside the permit area (WDEQ Land Quality–Coal Rules, Ch. 19, § 2(a)(i)).

The purpose of this CHIA is to evaluate the probable cumulative hydrologic impacts of the proposed Pit 15/Pit 10 South Amendment at the Black Butte Mine along with existing coal mining and reclamation activities at the Jim Bridger, Leucite Hills, and Black Butte mines. The three mines are located on the eastern flank of the Rock Springs Uplift in the Greater Green River Basin (GGRB), approximately 25 miles east of Rock Springs near Point of Rocks in Sweetwater County of southwest Wyoming (**Figure 1**).

On April 8, 2014, the Black Butte Mine applied for a coal lease modification to modify Federal Coal Lease WYW-6266 to include 450 acres of unleased Federal coal (Bureau of Land Management, 2017a). The lease modification proposed to extend existing Pit 10 to the south and mine a new pit (Pit 15) to the northeast of the existing permit. The BLM completed an Environmental Assessment, Finding of No Significant Impact, and Decision Record for the lease modification in 2017 (Bureau of Land Management, 2017a; Bureau of Land Management, 2017b; Bureau of Land Management, 2017c). The lease modification was issued in March 2018 (Bureau of Land Management, 2020).

The Pit 15/Pit 10 South Amendment would add a total of 963.35 acres northeast of the existing Black Butte Mine permit boundary (**Figure 1**). The amendment area is located within the headwaters of unnamed ephemeral tributaries to Bitter Creek (**Figure 2**). The amendment proposes to disturb 331 acres. Mining in the amendment area is proposed from 2024 until 2038 (Black Butte Mine Pit 15/Pit 10 South Amendment Application, 2020). Surface mining methods at the Jim Bridger and Black Butte mines include dragline and truck and shovel operations and longwall mining methods are used at the underground mine at Jim Bridger. The Leucite Hills Mine is in reclamation and no further mining is planned.

This CHIA analyzes the impact of the Pit 15/Pit 10 South Amendment along with existing coal mining and reclamation activities at the Jim Bridger, Leucite Hills, and Black Butte mines to

determine whether the operations have been designed to prevent material damage to the hydrologic balance outside the mine permit areas. To complete this determination, it is necessary to define a cumulative impact area (CIA) where existing and proposed mining activities may cause measurable hydrologic changes. Separate CIAs are delineated for surface water and groundwater. Baseline data are summarized to describe the pre-mining hydrologic conditions within the CIAs. Hydrologic concerns are identified and the potential hydrologic impacts are analyzed. The potential impacts are then evaluated against material damage criteria developed by the WDEQ/LQD. These criteria are based on applicable statutes, rules, and regulations administered by the WDEQ Water Quality Division (WQD) and the Wyoming State Engineer's Office (WSEO) (Wyoming Department of Environmental Quality and Wyoming State Engineer's Office, 1996). A finding is made regarding the potential for material damage.

The following sub-sections in the *Introduction* provide a brief overview of the site conditions at and near the three coal mines, including topography, geology, climate, soils, and vegetation, regional hydrology, current and anticipated mining operations, and oil and gas production. More detailed information on site conditions is available in the Black Butte Mine Pit 15/Pit 10 South Amendment application and the approved permits for the other coal mines in the area, available at the WDEQ/LQD offices in Cheyenne or Lander. The remaining sections of the CHIA are organized as follows:

- *Section 2 – Cumulative Impact Area*
  - Delineates the surface water and groundwater CIAs.

- *Section 3 – Baseline Hydrologic Conditions*
  - Provides a description of baseline surface water and groundwater quantity and quality in the CIAs.
  - Provides a description of alluvial valley floor (AVF) determinations in the CIA.

- *Section 4 – Hydrologic Concerns*
  - Provides the general hydrologic concerns associated with coal mining in Wyoming and more detailed concerns associated with mining at the three mines in the GGRB.

- *Section 5 – Material Damage Criteria*
  - Provides material damage criteria for surface water and groundwater.

- *Section 6 – Analysis of Current Hydrologic Conditions and Cumulative Hydrologic Impacts*
  - Provides an assessment of current during-mining conditions in surface water and groundwater quantity and quality in the CIAs.

- *Section 7 – Analysis of Predicted Post-Mine Hydrologic Conditions*
  - Provides the predicted future post-mine conditions in surface water and groundwater quantity and quality in the CIAs.

- *Section 8 – Material Damage Potential*
  - Provides the assessment of the potential for the proposed and existing coal mining to cause material damage to surface water and groundwater quantity and quality outside the mine permit areas.

- *Section 9 – Material Damage Statement of Findings*
  - Provides the overall finding that the proposed and existing coal mining and reclamation operations have been designed to prevent material damage to the hydrologic balance outside the mine permit areas, including signatures by the WDEQ Director and Wyoming State Engineer.

- *References Cited*
  - Provides list of reference materials used to develop the CHIA.

- *Addendum A – Agency Review Comments on CHIA 44*
  - Provides agency concurrence letters and associated review comments on the CHIA by the Wyoming State Engineer's Office and the WDEQ Water Quality Division, and responses to comments by the WDEQ/LQD.

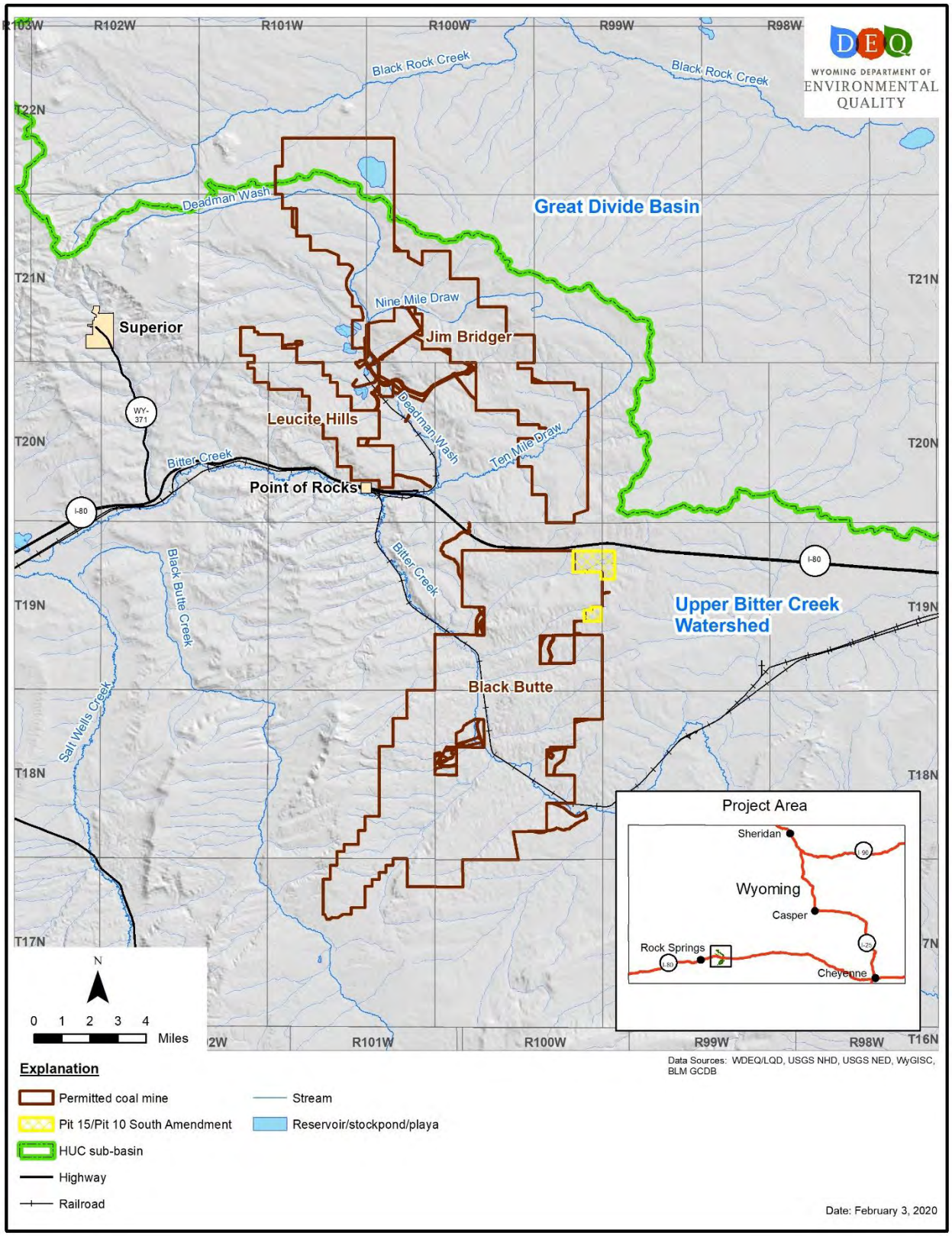


Figure 1. Location of the Jim Bridger, Leucite Hills, and Black Butte mines and the Pit 15/Pit 10 South Amendment at the Black Butte Mine.

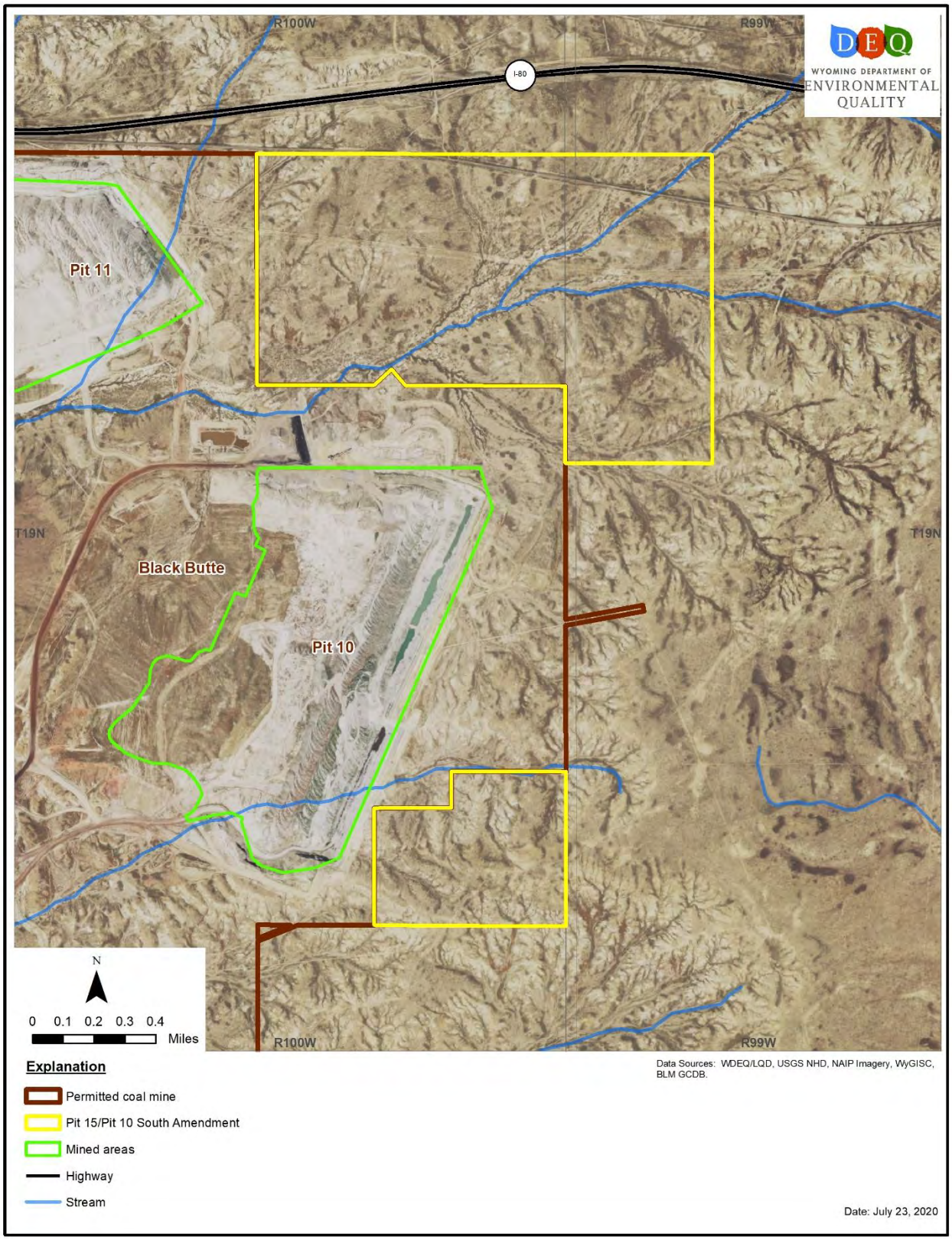


Figure 2. Location of the Pit 15/Pit 10 South Amendment Area at the Black Butte Mine.

1.1 TOPOGRAPHY

The Jim Bridger, Leucite Hills, and Black Butte mines reside in the Greater Green River Basin (GGRB) of southwestern Wyoming. The area is characterized by a dissected arid upland on the eastern slope of a large anticlinal dome, the Rock Spring Uplift. The terrain is undulating with greater relief along the ridges. Ridges and hogbacks are formed by sandstones of Tertiary and Cretaceous age. The softer, easily erodible shales form strike valleys between the more resistant outcrops. Elevations across the area range from 6,500 to 7,200 feet. The Continental Divide extends north and east through the area at an elevation of approximately 7,000 feet.

1.2 GEOLOGY

1.2.1 SURFICIAL GEOLOGY

Surficial geology in the area of the three coal mines consists of alluvium, bench, alluvial and gradational fan, eolian, slopewash and colluvium, residuum, grus, and bedrock and glaciated bedrock (Case et al., 1998) (**Figure 3**). Playa and landslide deposits are also present in local areas.

1.2.2 REGIONAL GEOLOGY

The GGRB of southwestern Wyoming consists of the Green River Basin, Great Divide Basin, and Washakie Basin. The Rock Springs Uplift divides the Greater Green River Basin into the Green River, Great Divide, and Washakie Basins, which are structural and sedimentary basins (**Figure 4**). The Wamsutter Arch is aligned with the eastward bulging of the Rock Springs Uplift and was postulated by Blackstone (1955) to be an extension of the uplift. The GGRB is bounded by the Uinta Mountains in Utah to the south, the Wyoming Overthrust Belt to the west, the Gros Ventre Range-Wind River to the north, and the Granite Mountains-Rawlins Uplift-Sierra Madre Mountains on the east. **Figure 5** is a geologic cross section across the GGRB, from the Overthrust Belt eastward across the Green River Basin, Rock Springs Uplift, and Washakie Basin (Clarey et al., 2010). The cross section shows the Precambrian basement rocks overlain by varying thicknesses of Paleozoic to Cenozoic formations, some large-scale geologic structures, and major faults. The structural basins are depressions in the crust in which thicker sedimentary rock units accumulated.

The three coal mines evaluated in this CHIA are located on the eastern flanks of the Rock Springs Uplift (**Figure 4**). The Rock Springs Uplift is a large anticlinal dome of Cretaceous and Tertiary rocks formed during the Laramide Orogeny. The major axis of the dome trends north-south and is approximately 50 miles long. The minor axis trends east-west and is approximately 35 miles long. The core of the uplift is composed of Upper Cretaceous rocks (**Table 1**) flanked by the Paleocene Fort Union Formation and Eocene Wasatch Formation (**Figure 6**). Uplift of the rocks resulted in development of resistant sandstone hogbacks on the west flank and cuestas on the east flank. The rocks on the west flank dip 10-15 degrees and on the east flank they dip 5-8 degrees to the subsurface in the center of the basins. There are several small anticlines and synclines developed upon the main dome, as well as numerous faults radiating outward from it. Some of the larger faults have been traced for a distance of more than 20 miles (Black Butte Mine Permit, 2020). The faults generally trend at right angles to the strike of the rocks and have horizontal displacements of up to three miles. Vertical movement was usually less than 100 feet, although few have several hundred feet of displacement. The faulting is believed to have occurred in the Eocene

during the final uplift of the Uinta Mountains to the south. Many northeast-trending normal and strike-slip faults break up the continuity of the outcrops.

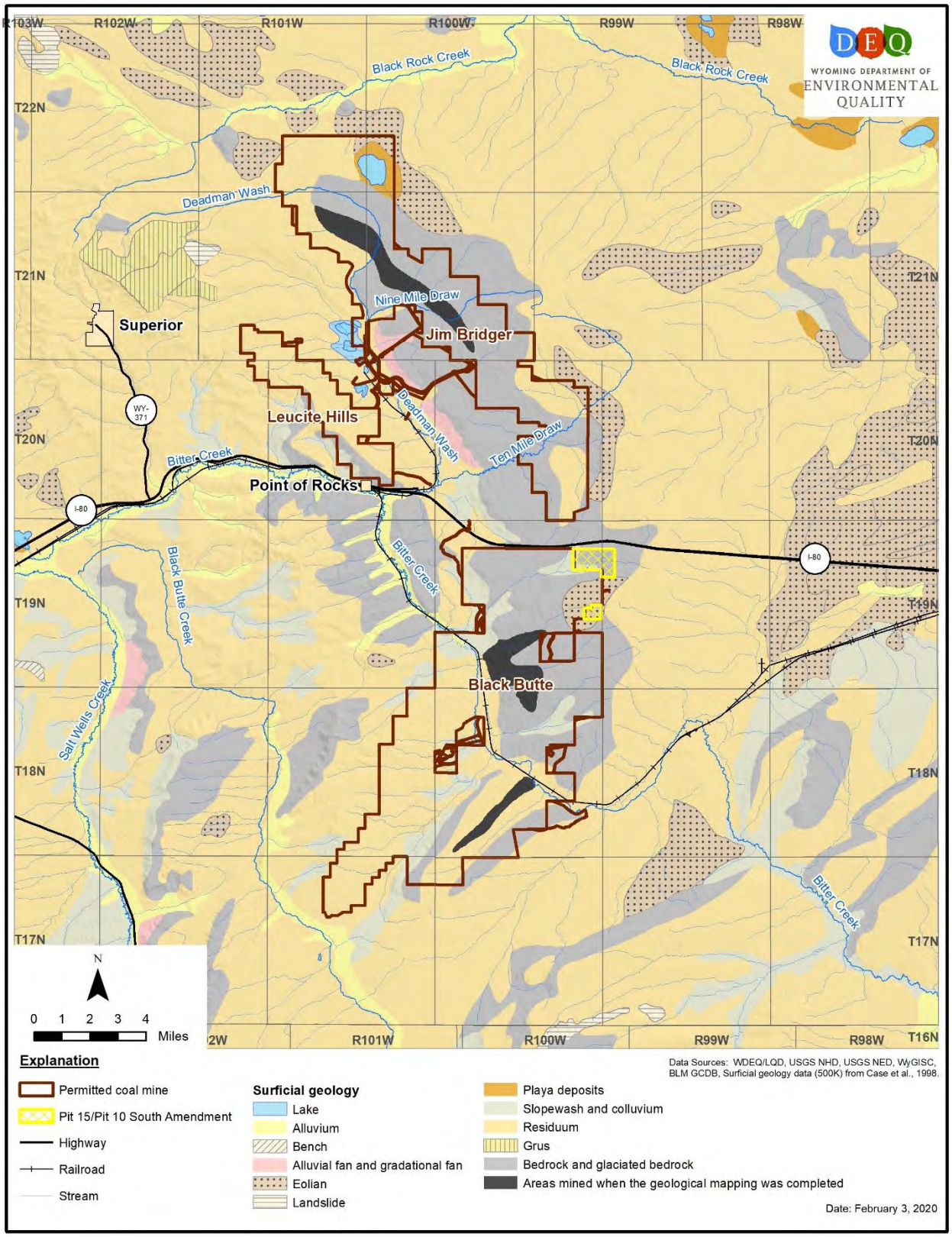


Figure 3. Surficial geology (500K scale) in the area of the Jim Bridger, Leucite Hills, and Black Butte mines.

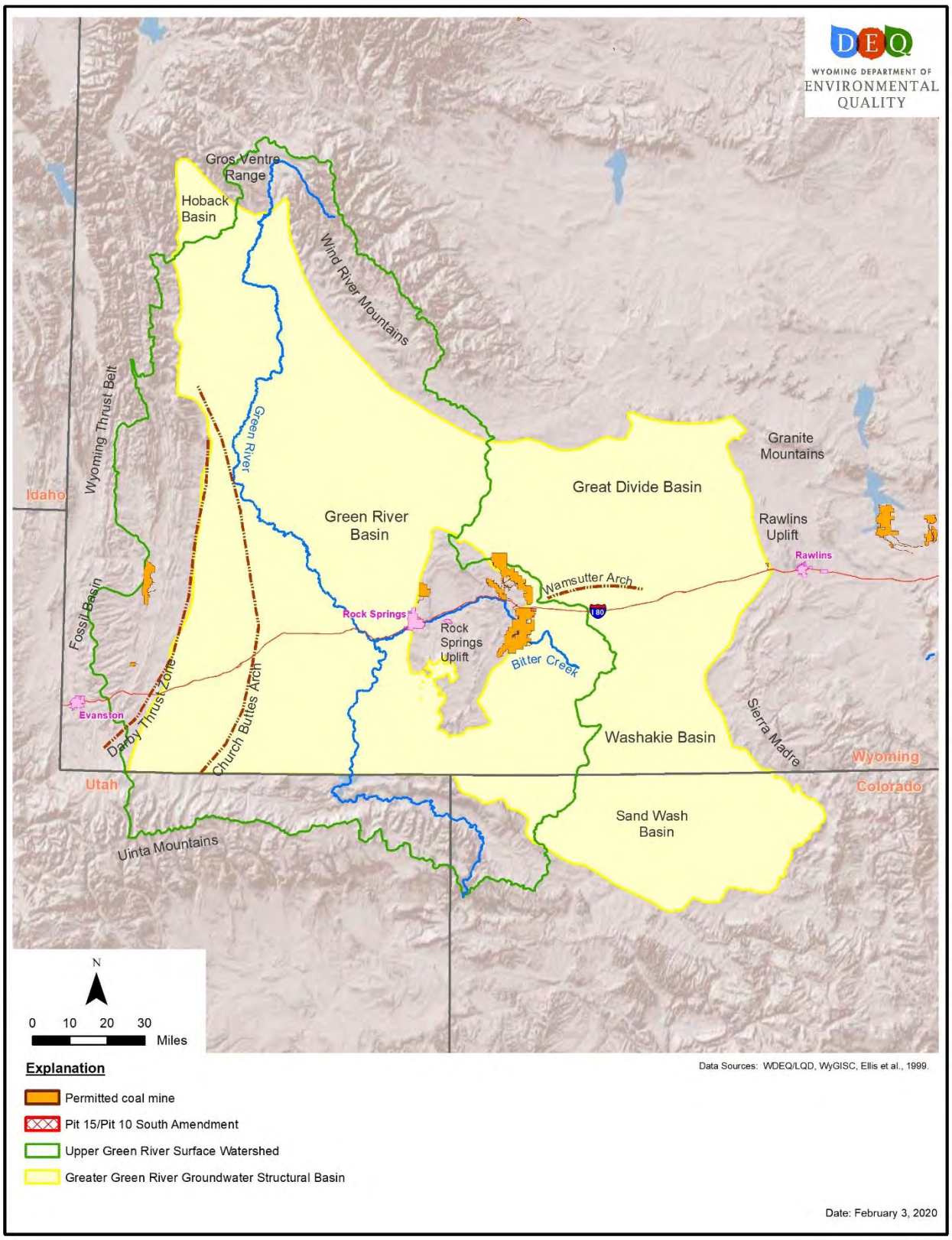


Figure 4. Greater Green River Basin of southwestern Wyoming, showing the Rock Springs uplift, permitted coal mines, and upper Green River surface watershed.

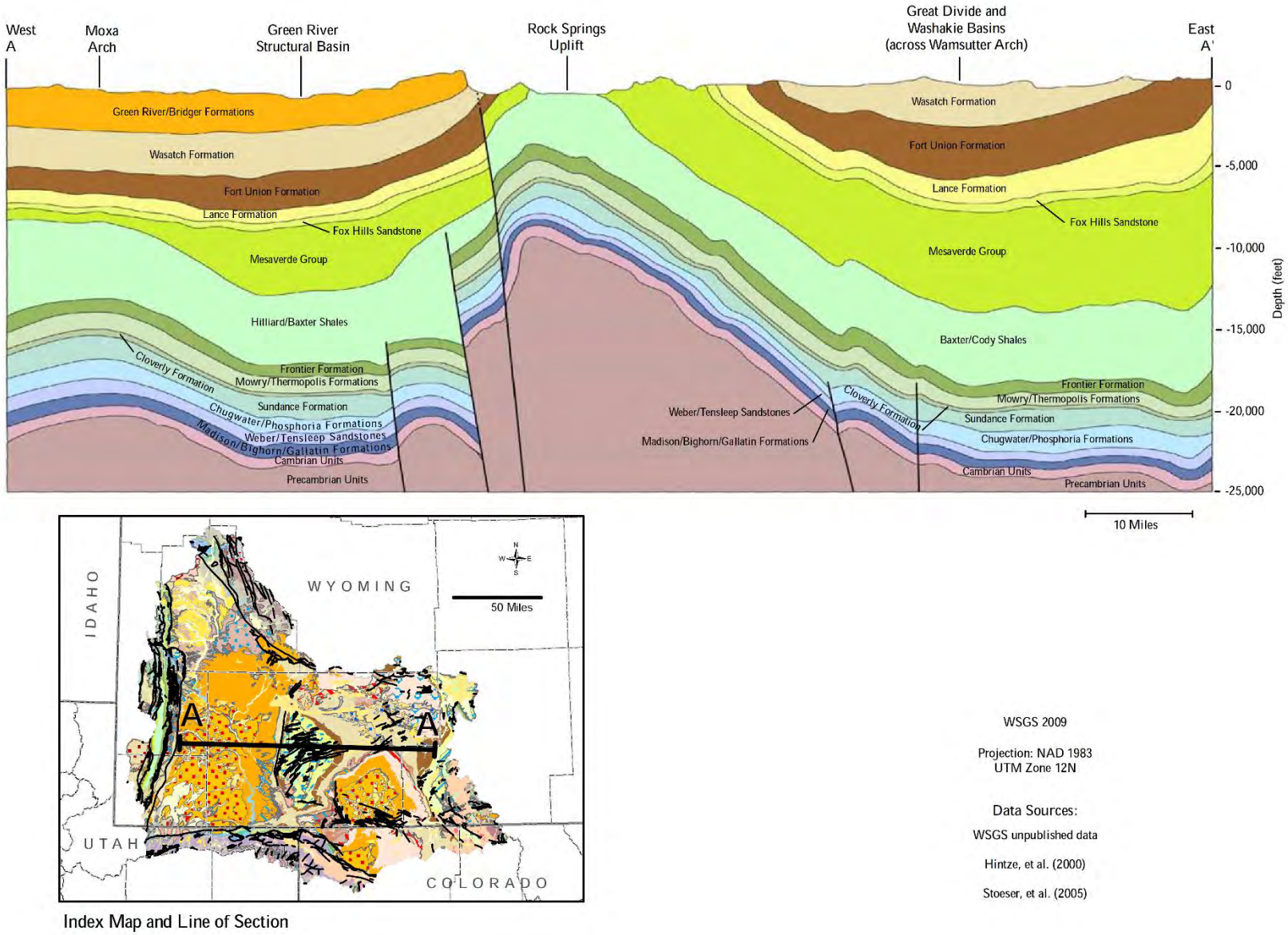


Figure 5. Geologic cross section for the Greater Green River Basin of Wyoming. Image scanned from Figure 2-5 in Clarey et al. (2010).

Table 1. Generalized stratigraphy and coal occurrence near the Jim Bridger, Leucite Hills, and Black Butte mines.

Erathem	System	Series	Approximate Stratigraphic Thickness (Feet)	Stratigraphic Unit	Number of Mineable Coal Seams	Mine and Pit Area	Approximate Coal Thickness (Feet)
Cenozoic	Quaternary		< 50	Alluvium and colluvium	--	--	--
	Tertiary	Oligocene or Miocene	< 50	Browns Park formation / Bishop Conglomerate	--	--	--
		Eocene	500 – 610	Uinta and Bridger formations	--	--	--
			400 – 700	Green River Formation / Battle Spring Formation	--	--	--
			1,000 – 4,000	Wasatch Formation	--	--	--
		Paleocene	800 - 1600	Fort Union Formation	1 to 3	**Black Butte Mine** - Pits 1*, 2*, 3*, 4*, 9*, 10, 11*, and 15	3 to 31
					3 to 5	**Jim Bridger Mine** – All areas	2 to 32
Mesozoic	Cretaceous	Late Cretaceous	250 - 650	Lance Formation	2 to 11	**Black Butte Mine** - Pits 5*, 6*,7*,12* and 13*	1 to 13
			200 - 700	Fox Hills Sandstone	--	--	--
			1,500	Lewis Shale	--	--	--
			200 - 400	Mesaverde Group: Almond Formation	4 to 7	**Black Butte Mine** - Pits 8* and 14	2 to 15
					6	**Leucite Hills Mine** – Pits 21*, 22N*, 22S* and Pit 24*	1 to 10
					--	--	--
			400 - 700	Mesaverde Group: Ericson Sandstone	--	--	--
			1,000 – 1,300	Mesaverde Group: Rock Springs Formation	--	--	--
			900 – 1,800	Mesaverde Group: Blair Formation	--	--	--
			2,700 – 4,500	Baxter Shale / Cody Shale	--	--	--

*Not active or in reclamation as of 2019

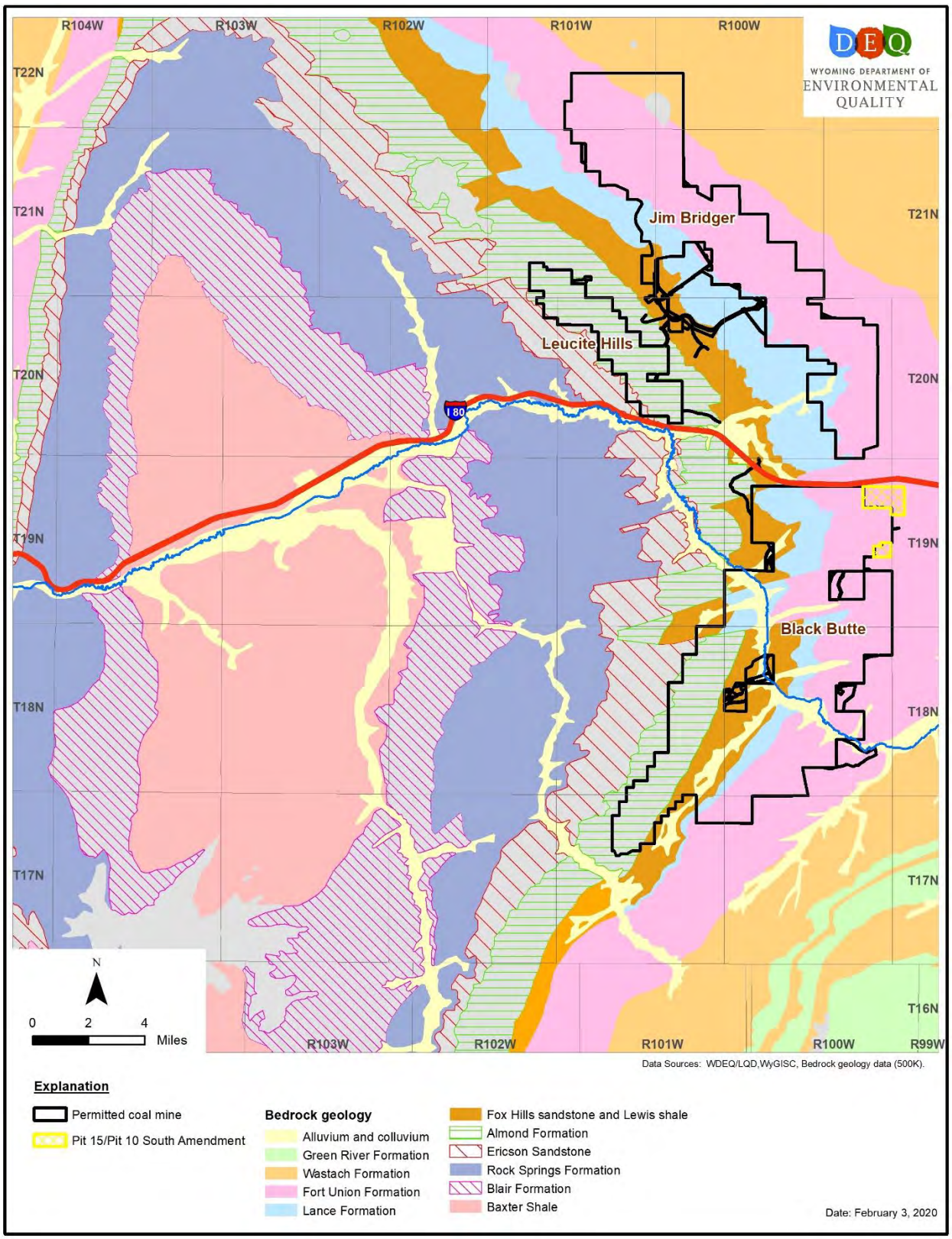


Figure 6. Bedrock geology (500K scale) in the area of the Jim Bridger, Leucite Hills, and Black Butte mines.

1.2.3 REGIONAL STRATIGRAPHY

This section describes the geologic characteristics of the lithologic units near the Rock Springs Uplift and introduces their hydrologic character. These geologic descriptions are based on Clarey et al. (2010), Bartos et al. (2006), Welder and McGreevy (1966), Welder (1968), Lines and Glass (1975), Ahern et al. (1981), Collentine et al. (1981), Love and Christiansen (1985) and the information presented in the three coal mine permits.

Generalized stratigraphy near the Rock Springs Uplift, brief descriptions of ages and thickness is shown in **Table 1**. The units that will be discussed in detail in this section include (from oldest to youngest): Baxter Shale, Blair Formation, Rock Springs Formation, Ericson Sandstone, Almond Formation, Lewis Shale, Fox Hills Sandstone, Lance Formation, Fort Union Formation, Wasatch Formation, Green River Formation, Uinta and Bridger formations, Browns Park formation/ Bishop Conglomerate, and the Quaternary alluvial/colluvial deposits.

1.2.3.1 BAXTER SHALE

The deepest and oldest geologic formation exposed at land surface in the core of the Rock Springs Uplift is the Upper Cretaceous Baxter Shale. The Upper Cretaceous Baxter Shale underlies Sweetwater County and adjacent GGRB areas, but outcrops only in the structural apex of the Rock Springs Uplift. Baxter Shale is predominantly marine shale, mudstone, and claystone interbedded with minor thin sandstone (Freethey and Cordy, 1991). The thickness of the Baxter Shale on the Rock Springs Uplift varies from approximately 2,700 to 4,500 feet (Ahern et al., 1981). These Upper Cretaceous shale units, which form the uppermost part of the Baxter-Mowry confining unit, act as a regional confining unit for the overlying Mesaverde aquifer and underlying Frontier Formation aquifer in the GGRB.

1.2.3.2 BLAIR FORMATION

In the Rock Springs Uplift area, the Mesaverde Group comprises of the Blair Formation, Rock Springs Formation, Ericson Sandstone, and Almond Formation. The Upper Cretaceous Blair Formation is the oldest and lowest formation of the Mesaverde Group on the Rock Springs Uplift. It consists of drab yellow to brown sandstone and interbedded sandy shale (Love and Christiansen, 1985). The thickness of the Blair Formation on the Rock Springs Uplift is approximately 900 to 1,800 feet (Ahern et al., 1981).

1.2.3.3 ROCK SPRINGS FORMATION

The Upper Cretaceous Rock Springs Formation underlies the Ericson Sandstone on the Rock Springs Uplift. The Rock Springs Formation consists of white to brown sandstone, shale, and claystone with numerous coal beds (Love and Christiansen, 1985). On the Rock Springs Uplift, the Rock Springs Formation is approximately 900 to 1,700 feet thick (Ahern et al., 1981).

1.2.3.4 ERICSON SANDSTONE

An early episode of the Laramide Orogeny interrupted the stable Rock Springs shoreline by causing uplift of the Church Buttes Arch to the west, as well as uplift of the forerunner of the Wind River Mountains (Leucite Hills Mine Permit, 2020). The erosion of these uplifts constituted a source area for a large delta, which covered most of the southern Wyoming, northwestern Colorado, and northeastern Utah during the Cretaceous period. The fluviatile deposits associated

with the uplift to the west formed the Ericson Sandstone, a noncoal-bearing formation of massive sandstone and thin shale units. These units were deposited in a low relief braided stream environment. The Ericson Sandstone consists of white massive sandstone, with lenticular chert-grit conglomerate in the upper part of the formation (Love and Christiansen, 1985). The Ericson Sandstone on the Rock Springs Uplift is approximately 400 to 700 feet thick (Ahern et al., 1981). The Ericson Sandstone outcrops to the eastern edge of the Leucite Hills and Jim Bridger mines (**Figure 6**).

1.2.3.5 ALMOND FORMATION

The Almond Formation is generally less than 200 to 400 feet thick and it is composed of three distinct lithologic types (Ahern et al., 1981). When the uplifted areas were sufficiently lowered by erosion, and the basin lowered by subsidence, the Lewis Sea shoreline moved westward. This caused a coastal paludal environment to move across the uplift area. The lower Almond Formation consists of dark-gray shale and interbedded dark-gray fine grained sandstone and some thin discontinuous coal beds. The unit was deposited in a paludal environment. The middle Almond Formation was deposited in a lagoonal environment. These rocks consist of dark-gray shale, interbedded gray siltstone, fine grained sandstone, and coal. The upper Almond Formation was deposited in a shallow marine environment. Almost the entire Leucite Hills Mine is located on the outcrop of the Almond Formation. The Almond Formation outcrops are also found on the southwestern portions of the Black Butte Mine (**Figure 6**).

1.2.3.6 FOX HILLS SANDSTONE AND LEWIS SHALE

The combined Upper Cretaceous Fox Hills Sandstone and Lewis Shale geologic unit is exposed along the eastern flank of the Rock Springs Uplift and in a few small outcrop areas in the eastern Great Divide Basin (**Figure 6**).

The Lewis Shale, which intertongues with the underlying Almond, was deposited when a shallow marine embayment covered the entire Rock Spring Uplift area. The Lewis marine shale is a gradational sedimentary transition from the underlying Almond Formation (Mesaverde Group) to the overlying Fox Hills Sandstone. The formation thickness is difficult to determine because of the gradational contact with the Fox Hills Sandstone; in some places, these two formations are mapped together, and in others they are mapped separately. The average thickness of Lewis shale is about 1,500 feet. The Lewis Shale produces natural gas in the Washakie Basin and on the Wamsutter Arch (De Bruin, 2002).

In the very late Cretaceous time, the sea moved out of the Rock Springs area. This created a transitional contact with the Fox Hills Sandstone. The formation is often mapped with the Lewis Shale (Lowry et al., 1973; Love and Christiansen, 1985). The Fox Hills Sandstone consists of yellow-gray, very fine- to fine-grained sandstone with a few beds of olive gray to dark gray sandy shale, thin carbonaceous shale, and thin impure coal beds (Gill et al., 1970). The formation is described as a shallow-marine, barrier-bar, and beach deposit that records the sedimentary transition from the underlying marine Lewis Shale to the overlying fluvial Lance Formation. The Fox Hills Sandstone represents the last marine deposition in the eastern GGRB. Gill et al. (1970) reported the formation thickness as ranging from 200 to 700 feet.

1.2.3.7 LANCE FORMATION

As the sea retreated eastward, the Lance paludal environment took precedence depositing coals, claystones and nonmarine shales and sandstones. This continental environment continued until the Laramide Orogeny uplifted the area. The Upper Cretaceous Lance Formation, which contains portions of the Lance-Fox Hills aquifer, is exposed in outcrop around the eastern margins of the Rock Springs Uplift. The Lance Formation consists of dark gray and brown carbonaceous shale; medium to light brown, very fine- to fine-grained, clayey, calcareous sandstone; and coal and lignite beds (Berry, 1960; Welder and McGreevy, 1966). The Lance produces natural gas in the Washakie Basin (De Bruin, 2002).

1.2.3.8 FORT UNION FORMATION

The Fort Union Formation was deposited during the Laramide Orogeny, when mountain ranges such as the Wind River Range, Sierra Madre, and Granite Mountains were actively uplifting contemporaneously with the subsidence of the adjacent structural basins. Love (1970) suggested that during the Paleocene, as the Great Divide Basin was subsiding, the Uplift area was subjected to extensive erosion following the Laramide uplift. The sediment derived from uplift areas filled the basin fast enough that the land surface in the basin remained at a nearly constant elevation. The Paleocene Fort Union formation was deposited on top of this erosion surface in fluviatile and paludal environments. The Paleocene Fort Union Formation, which contains the Fort Union aquifer, crops out encircling the Rock Springs Uplift (**Figure 6**). The Fort Union Formation consists of brown to gray sandstone, gray to black shale, and thin coal beds (Love and Christiansen, 1985). The coal bearing units are mostly present in the lower half of the Fort Union Formation. Compiled coal thicknesses of Almond and Lance formations are not readily available in a geospatial format. The thickness of the Fort Union Deadman coal zone is presented in **Figure 7** (Ellis et al., 1999). The Deadman coal zone is exceptionally well developed along the eastern flank of the Rock Springs uplift and is as much as 32 feet thick. In the Deadman coal zone, coal beds split and merge within distances of 1.5 to 6 miles. The thickness of the overlying material above coal seams are grouped as overburden and the thicknesses are shown in **Figure 8** (Ellis et al., 1999). In general, the overburden thins from east to west and ranges from 1,000 feet to less than 100 feet.

1.2.3.9 WASATCH FORMATION

Another period of erosion followed the deposition of the Fort Union, resulting in the unconformal contact between the Fort Union and the overlying Wasatch Formation. The Eocene main body of the Wasatch Formation crops out along the western margin of the Green River Basin, on the flanks of the Rock Springs Uplift, on the Wamsutter Arch, and in the southern Great Divide Basin (**Figure 4**, **Figure 6**). The upper part of the main body of the Wasatch Formation intertongues with some tongues and members of the Green River Formation. The lower part of the main body of the Wasatch Formation is older than Lake Gosiute and underlies the Green River Formation, rather than intertonguing with it. Love and Christiansen (1985) reported the main body of the Wasatch Formation in southwest Wyoming as drab sandstone, drab to variegated claystone and siltstone, and locally derived conglomerate around basin margins. Like the rest of the Wasatch Formation in the GGRB, most of the main body of the Wasatch Formation is fluvial sediment deposited up-paleogradient of Eocene Lake Gosiute. The main body of the Wasatch Formation in the GGRB ranges from less than 1,000 feet thick across the northern and middle Rock Springs Uplift (it has been eroded from the central uplift) to more than 4,000 feet thick in parts of the Green River Basin and Washakie Basin (Roehler, 1992). The Wasatch Formation produces natural gas via both

conventional and coal bed methane (CBM) extraction methods in southwestern Wyoming (De Bruin, 2002).

1.2.3.10 GREEN RIVER FORMATION

The stratigraphy of GGRB Eocene formations is highly complex; it records interfingering lithologies deposited in the ancient Lake Gosiute environment (Green River and Wasatch Formations). Fluctuations of the ancient lake level from early to middle Eocene time led to a complex intertonguing of lacustrine and fluvial deposits in the GGRB. These lake-level fluctuations also affected lacustrine water quality during accumulation of the sedimentary deposits in the basin. During times when water levels were low, mineral salts such as trona, nahcolite, shortite, dawsonite, and halite were deposited from high-salinity (brine) lake water within the sediment of the Green River Formation. The later dissolution of these mineral salts into the groundwater has adversely affected groundwater quality in many of the Eocene members/tongues/formations of the GGRB. During times when the lake level was high, when fresh water flowed from ancient rivers through Eocene Lake Gosiute, the evaporite minerals did not form within the lacustrine deposits of the Green River Formation.

The Green River Formation is divided into at least five members and one tongue: the Laney, Godiva Rim, Wilkins Peak, Tipton Shale, and Farson Sandstone Members, and the Luman Tongue (Love et al., 1993).

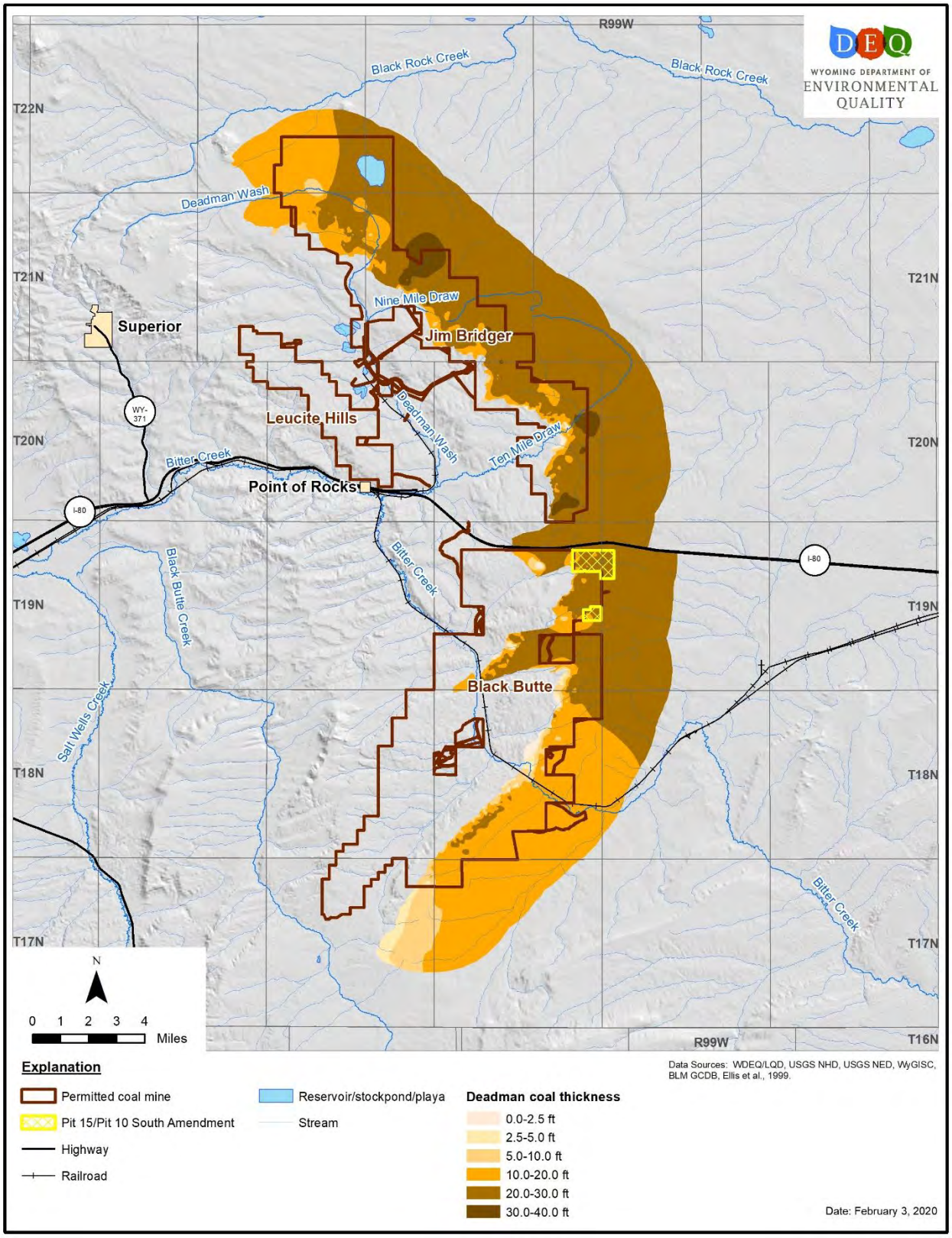


Figure 7. Net thickness of the Deadman coal zone for select areas at the Jim Bridger, Leucite Hills, and Black Butte mines (Ellis et al., 1999).

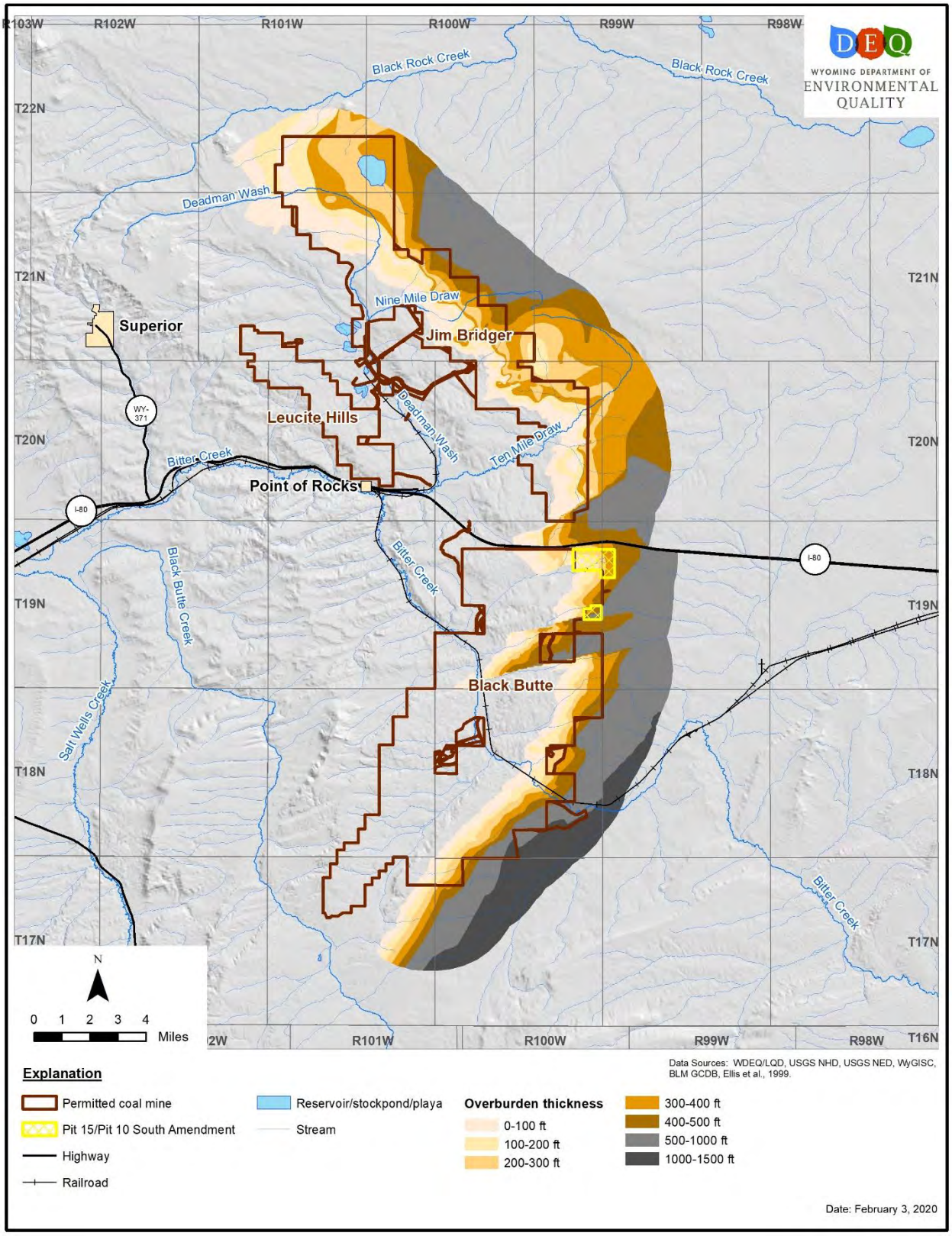


Figure 8. Overburden thickness for select areas at the Jim Bridger, Leucite Hills, and Black Butte mines (Ellis et al., 1999).

1.2.3.11 ALLUVIUM AND COLLUVIUM

The Quaternary alluvial/colluvial deposits in the GGRB are interbedded and unconsolidated mixtures of clay, silt, sand, and gravel located along stream and river channels. They are commonly less than 50 feet thick, although locally they may exceed 100 feet in thickness. The alluvial/colluvial deposits unconformably overlie bedrock formations or older unconsolidated deposits. Quaternary alluvium and colluvium occur in the major drainages of the GGRB and these surficial unconsolidated sedimentary deposits are also present in many of the minor stream drainages (Love and Christiansen, 1985). It consists of mixtures of clay, silt, mud, sand, and gravel, with coarser materials and cobbles near the higher elevations and uplifted areas (Berry, 1960; Lowry et al., 1973). The groundwater in the alluvial deposits is commonly connected hydrologically to local surface-water streams, and is unconfined. The groundwater quality in the alluvial deposits is similar to that of the associated surface water. Shallow groundwater flow is generally intergranular porous flow in this unconsolidated sediment, and flow direction is predominantly controlled by topography.

1.2.4 COAL OCCURRENCE

Coal beds in the GGRB are not only valuable from an energy standpoint, but also as valuable sources of groundwater for a variety of uses. The primary occurrences of coal in the Rock Springs Uplift occur within the Rock Springs, Almond, Lance, Fort Union and Wasatch formations. A detailed summary about the coal occurrence compiled from the mine permits is presented below.

1.2.4.1 JIM BRIDGER MINE

The Deadman coal zone of the Fort Union Formation is about 60 to 80 feet above the contact with the underlying Lance Formation. There are five coal seams in the Jim Bridger Mine permit area within the Deadman coal zone. The seams are designated D5 through D-1 from top to bottom. In the north central portion of the mine area, the five seams join together to form a single seam with a maximum thickness of 32 feet. The seams divide into two coal seams (D-5 and D-4 through D-1) toward the northwest and northeast. The single seam divides into two seams (D-5/D-4 and D-3 through D-1) toward the southeast. Further to the southeast, both of these coal seams divide once again forming a total of four seams (D-5, D-4, D-3 and D-2/D-1) from 2 to 15 feet thick. Five distinct seams occur locally within the permit area. Coal in the Jim Bridger Mine permit area is typically ranked in a range from subbituminous A to subbituminous B (Jim Bridger Mine Permit, 2020).

1.2.4.2 LEUCITE HILLS MINE

Coals within the Leucite Hills Mine permit area occur in the Cretaceous Almond Formation. The coal sequence is approximately 250 feet thick, 80 percent of which is interbedded shales and sandstones. Six mineable seams are present within the permit area. From top to bottom they are named 5, F, 4, 3, 2 and C. All seams dip to northeast at approximately eight percent (Leucite Hills Mine Permit, 2020).

1.2.4.3 BLACK BUTTE MINE

Coal beds at the Black Butte Mine occur within the Almond, Lance, and Fort Union formations. There are seven to 18 coal seams in the permit area. They range in thickness from 1 to 31 feet. The Almond Formation (Pits 8 and 14) contains four to seven mineral coal seams ranging in thickness from 2 to 15 feet. The Lance Formation (Pits 5 and 6 and undeveloped Pits 7, 12, and

13) contains two to eleven coal seams that range in coal thicknesses from one to 13 feet. There are one to three coal seams in the Fort Union Formation (Pits 1, 2, 3, 4, 9, 10, 11, and 15) ranging in thickness from three to 31 feet. The coal seams at the Black Butte mine are Subbituminous A in rank (Black Butte Mine Permit, 2020).

1.2.5 GEOLOGIC CROSS SECTIONS

A geologic cross section for the Greater Green River Basin was presented in **Figure 5**. Several cross sections are also found in the mine permits that illustrate the detailed structure and stratigraphy of the existing life of mine areas. **Table 2** below presents a summary of the number of geologic cross sections at the three coal mines in the Rock Springs Uplift area and the location where the cross sections are found in each permit or the Pit 15/Pit 10 South Amendment application.

Table 2. Number of geologic cross sections for the Jim Bridger, Leucite Hills, and Black Butte mines and the location where the cross sections are found in each permit.

Mine	Number of Geologic Cross Sections	Reference in the Mine Permit
Jim Bridger	39	Appendix D5, Volumes 12, 13, and 14A
Leucite Hills	13	Appendix D5C, Volume 5
Black Butte	45	Appendix D5, Volume 3; Mine Plan Volumes 13 and 14
Black Butte Pit 15/Pit 10 South Amendment	3	TFN 6 3/246, Pit 15/Pit 10 South Amendment, Volume 3, Exhibit D5-2c

1.3 CLIMATE, SOILS, AND VEGETATION

The climate in the area of the three coal mines is arid to semiarid with cool dry winters and warm dry summers. Windy conditions exist year-round with prevailing winds from the west at an annual average of approximately 11 miles per hour (Western Regional Climate Center, 2020a). Isolated, but often intense, thunderstorms occur during the warmer months and light to moderate snow falls during the colder months. The area receives approximately six to nine inches of precipitation annually, with nearly 60 percent of the precipitation occurring during the growing season which extends from April to September (Western Regional Climate Center, 2020b). The potential evapotranspiration rate greatly exceeds precipitation in the area. Average annual pan evaporation at Green River, approximately 14 miles west of Rock Springs, is 50.25 inches (Western Regional Climate Center, 2020c).

National Weather Service Cooperative Network stations Rock Springs FAA AP (Station 487845) and Bitter Creek 4 NE (Station 480761) are located near the mines. The Bitter Creek 4 NE station is located ten miles east of the Black Butte Mine but contains significant gaps in the precipitation data record. The Rock Springs FAA AP station is located at the Rock Springs airport approximately 20 miles west of the mines. The period of record climate data summaries for these two stations are shown in **Table 3** (Western Regional Climate Center, 2020b). **Figure 9** shows the annual precipitation at the two stations over the 1974 to 2019 period, which corresponds to the time period coal mining has been active in the area. Evapotranspiration data are not available for either the Rock Springs FAA AP or Bitter Creek 4 NE stations.

Table 3. Climate data summaries for the area of the Jim Bridger, Leucite Hills, and Black Butte mines.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
ROCK SPRINGS FAA AP, WYOMING (No. 487845) - 8/1/1948 to 12/31/2019													
Average Max. Temperature (°F)	29.4	33.6	42.3	53.0	63.6	75.0	83.7	81.2	70.9	57.1	40.8	30.7	**55.1**
Average Min. Temperature (°F)	11.5	14.6	21.5	28.9	37.5	46.2	53.6	51.6	42.5	32.0	20.7	12.8	**31.1**
Average Total Precipitation (in.)	0.46	0.47	0.62	0.92	1.20	0.81	0.65	0.60	0.78	0.78	0.51	0.47	**8.20**
Average Total Snow Fall (in.)	6.6	6.3	7.1	6.2	2.0	0.1	0.0	0.0	0.8	3.9	5.5	6.1	**45.1**
BITTER CREEK 4 NE, WYOMING (No. 480761) - 9/14/1962 to 12/31/2019													
Average Max. Temperature (°F)	32.7	36.0	44.7	54.6	65.6	76.7	84.8	82.4	73.0	59.6	43.2	33.2	**57.5**
Average Min. Temperature (°F)	8.0	11.8	19.6	25.7	33.5	41.2	47.9	45.7	36.9	27.4	17.8	9.1	**27.1**
Average Total Precipitation (in.)	0.26	0.29	0.34	0.50	1.17	0.79	0.61	0.57	0.72	0.60	0.41	0.29	**6.99**
Average Total Snow Fall (in.)	3.1	2.8	1.7	1.6	0.0	0.0	0.0	0.0	0.0	0.8	2.4	2.9	**22.3**

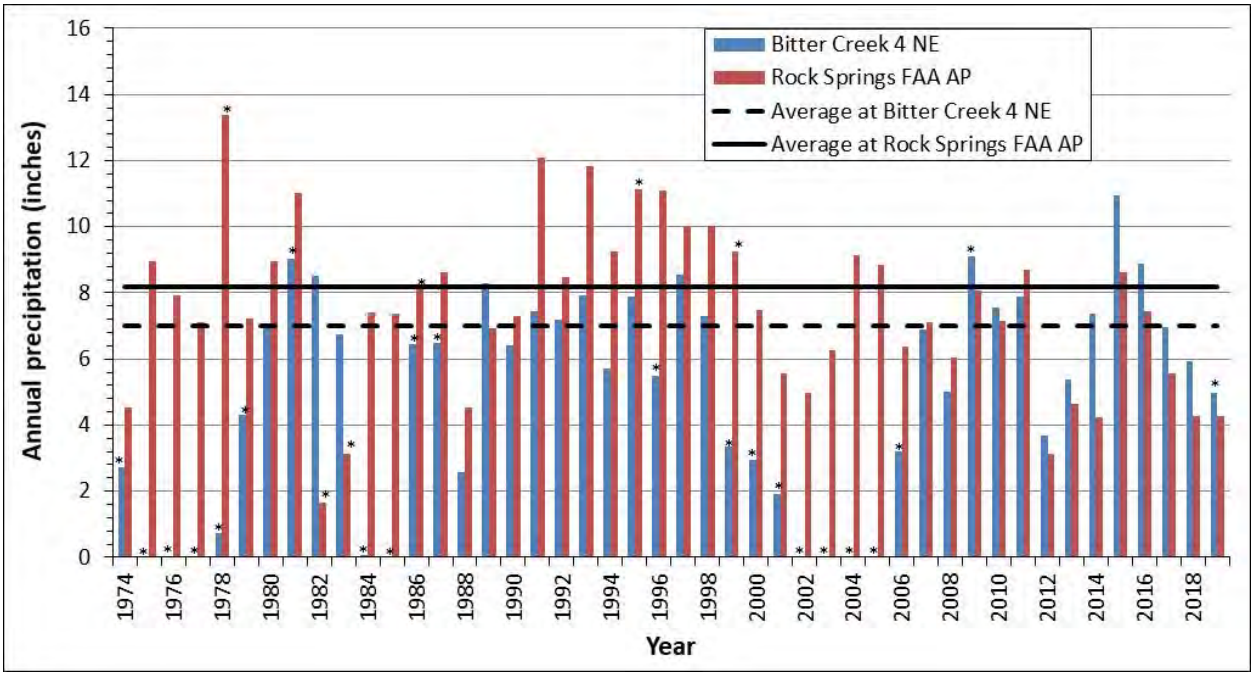


Figure 9. Annual precipitation at Rock Springs FAA AP and Bitter Creek 4 NE, 1974-2019.

The Wyoming General Soil Map classifies the soil associations within the area of the three coal mines as Torriothents-Haplargrids-Natrargids and Torriothents-Camborthids-Haplargrids (Young and Singleton, 1977). These associations are found on gently rolling to steep terrain and are developing in residuum on bedrock controlled uplands and in alluvium on playas. Soil depths for representative series in these associations range from shallow to very deep, with depths to bedrock generally ranging from ten to greater than 60 inches. On average, the soils are medium textured and moderately permeable (Young and Singleton, 1977). Each of the three coal mines have conducted extensive soils surveys and mapping across the mine permit areas (Jim Bridger Mine Permit, 2020; Leucite Hills Mine Permit, 2020; Black Butte Mine Permit, 2020).

Vegetation in the area of the three coal mines is dominated by the intermountain big sagebrush shrubland, intermountain big sagebrush steppe, intermountain montane sagebrush steppe, and intermountain mixed salt desert scrub Ecological System classes of the National Vegetation Classification System (United States Geological Survey, 2013). The dominant species include big sagebrush (*Artemesia tridentata*), shadscale saltbrush (*Atriplex confertifolia*), bluebunch wheatgrass (*Agropyron spicatum*), thickspike wheatgrass (*Elymus lanceolatus*), and a mixture of short grasses and alkali-tolerant plants (Jim Bridger Mine Permit, 2020; Leucite Hills Mine Permit, 2020; Black Butte Mine Permit, 2020). Other Ecological System classifications present include greasewood flats in drainages, limber pine-juniper woodlands, active and stabilized dunes, and shale badlands (United States Geological Survey, 2013). Active mine pits are generally devoid of vegetation while reclaimed areas demonstrate shrubland/grassland communities of varying age, structure, and composition. Each of the three coal mines have conducted extensive vegetation inventories and mapping across the mine permit areas (Jim Bridger Mine Permit, 2020; Leucite Hills Mine Permit, 2020; Black Butte Mine Permit, 2020).

1.4 CURRENT COAL MINING IN THE GREATER GREEN RIVER BASIN

The three coal mines were initially permitted in the mid-1970s to early 1980s (**Figure 10**). Each mine has added permit amendments since initial permit approval to expand permit acreage and mining. Coal was first removed in 1974 at the Jim Bridger Mine prior to issuance of the WDEQ/LQD mine permit. At the Black Butte Mine, coal was first removed in 1979, and coal was first removed at the Leucite Hills Mine in 1981 (**Figure 10**). No coal has been mined at the Leucite Hills Mine since December 2009 (Leucite Hills Mine Permit, 2020). The Leucite Hills Mine is in reclamation and no additional mining is expected to occur. Coal removal at Jim Bridger and Black Butte is expected to continue through 2037 to 2038, with surface reclamation estimated to be completed approximately 15 years after coal removal. Using this estimate, the Black Butte Mine will be the last mine to complete mine-wide surface reclamation in approximately 2053 (**Figure 10**).

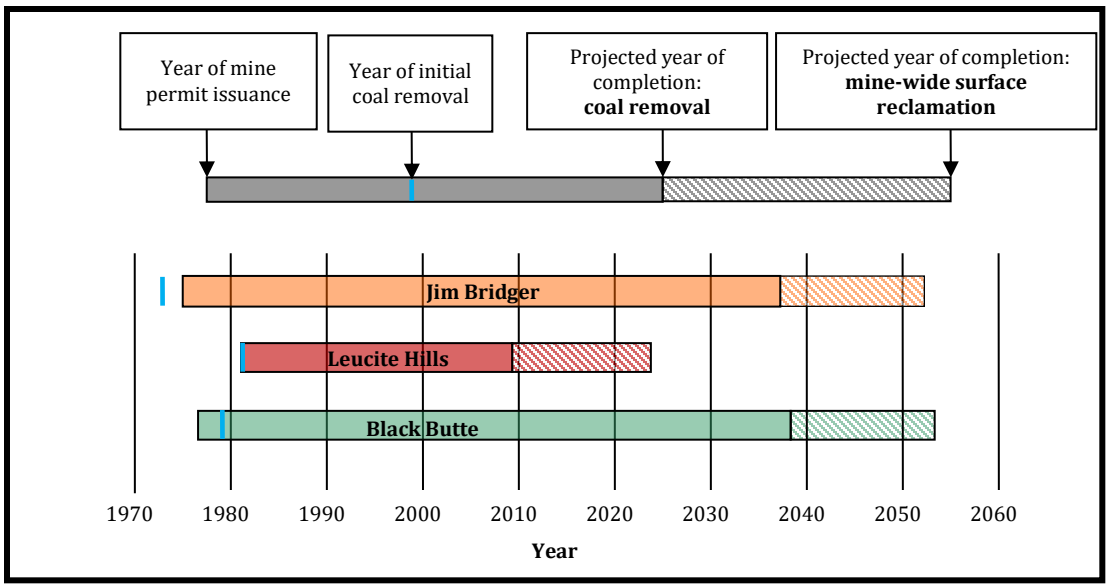


Figure 10. Mine permit history and mining and reclamation timelines for the Jim Bridger, Leucite Hills, and Black Butte mines.

The Black Butte Mine currently contains the largest permit area of the three mines at nearly 42,421 acres (**Table 4**). The acres approved to be affected by disturbance at the three mines is much lower than the permitted acreage at 32,499.14 acres. The Pit 15/Pit 10 South Amendment at the Black Butte Mine proposes to increase the affected area by 331.00 acres, which would result in a total affected area of 32,830.14 acres at the three mines (**Table 4**).

Table 4. Summary of current coal mining methods, permitted acres, and affected acres for the Jim Bridger, Leucite Hills, and Black Butte mines.

Mine	Highwall	Truck & Shovel & Scraper	Dragline	Cast Blasting	Longwall	Permitted Acres	Approved Acres to Affect
Jim Bridger	No[1,2]	Yes	Yes	Yes	Yes	28,673.71	11,924.59
Leucite Hills	No	No[3]	No	No	No	6,728.73	2,230.00
Black Butte	No	Yes	Yes	Yes	No	42,420.93	18,344.55
Pit 15/Pit 10 South Amendment	*No*	*Yes*	*Yes*	*Yes*	*No*	*963.35*	*331.00*
TOTAL						**78,786.72**	**32,830.14**

[1]Highwall mining occurred from 2003-2010.
[2]The mine plan allows for the evaluation and permitting of highwall mining on a pit by pit basis.
[3]Truck and shovel mining has not occurred since December 2009 and the mine is in reclamation.

Open pit surface mining occurs or did occur at all three coal mines. Draglines, truck and shovel, and/or scraper operations are used to remove overburden, mine the coal, and replace overburden (**Table 4**). Cast blasting is used at the Jim Bridger and Black Butte mines to move some of the overburden material directly to the bottom of the pit where the coal was previously removed. Highwall mining using auger and continuous miners was also used at the Jim Bridger Mine from 2003-2010 (Jim Bridger Mine Permit, 2020). The mine plan at Jim Bridger allows for the evaluation and permitting of highwall mining on a pit by pit basis.

Underground mining started in 2004 at the Jim Bridger Mine to mine coal that was not economically recoverable by either surface or highwall mining methods. The underground mine employs longwall mining methods using continuous miner equipment. Longwall mining allows

fairly rapid collapse of the roof material into the area where the coal has been removed. Underground mining at Jim Bridger accounted for the majority of coal production at the mine from 2007 to 2015. Production rates from underground mining are predicted to be higher than surface mining rates from 2018 through 2021. From 2022 until the underground mine ceases production in 2027, surface mining production is predicted to exceed the production from the underground mine (Jim Bridger Mine Permit, 2020).

At the Jim Bridger Mine, coal is transported by conveyor directly to the adjacent Jim Bridger Power Plant. Coal from the Leucite Hills Mine was transported to the Jim Bridger Power Plant by truck. The Black Butte Mine ships coal by rail to the Jim Bridger Power Plant and other power plants. Facilities at the mines include crushing, storage, loading, administrative, and equipment maintenance facilities. More details of the specific mining process at each mine may be found in the mine plan section of the respective permits.

At the Jim Bridger Mine, surface coal mining takes place in four general areas: Deadman North Area, Central Mine Area, Nine and One Half Mile South Area, and Ten Mile South Area (**Figure 11**). Underground coal mining occurs in the north portion of the permit boundary (Jim Bridger Mine Permit, 2020). At the Leucite Hills Mine, surface coal mining occurred from 1981 to 2009 from four pits: Pit 21, Pit 22N, Pit 22S, and Pit 24 (**Figure 11**) (Leucite Hills Mine Permit, 2020). At the Black Butte Mine, surface coal mining has taken place in 11 pits (**Figure 11**). As of 2019, Pits 1, 2, 3, 4, 5, 6, 8, 9, and 11 were either in reclamation or were not being mined while Pits 10 and 14 were active (Black Butte Mine Permit, 2020). An additional three pits (Pits 7, 12, and 13) in the Lance Formation have never been mined due to coal quality concerns. **Table 5** shows the formation of the coal seams mined in the pits at each of the three mines. Out of the two mines producing coal in 2019, the Jim Bridger Mine produced 5,838,730 short tons and the Black Butte Mine produced 2,292,541 short tons (Jim Bridger Mine Permit, 2020; Black Butte Mine Permit, 2020).

According to the WDEQ/LQD Coal Annual Report Format (CARF), coal mines report permit acreage in varying disturbance and reclamation categories (Wyoming Department of Environmental Quality, 2019a). A review of each annual report indicates that over the 4Q 2018 to 1Q 2020 period, the life-of-mine disturbed acreage at the three mines totals approximately 26,481 acres. Of this total, approximately 26 percent is being actively mined, 19 percent is in long-term mining or reclamation facilities, and 55 percent has been backfilled and graded. **Figure 11** shows the extent of backfilled and graded areas at the three mines, as indicated from the mine permit Annual Reports. Of the 14,603 acres that have been backfilled and graded, approximately 91 percent of the area has been topsoiled and seeded and 63 percent has been planted for at least ten years. The areas shown in **Figure 11** may also indicate areas where topsoil and seeding has taken place, as well as areas that have been planted for at least ten years.

Table 5. Formation of coal seams at mining pits at the Jim Bridger, Leucite Hills, and Black Butte mines.

Mine	Mining Pit/Area	Formation
Jim Bridger	Deadman North Area/Underground	Fort Union
	North Mine Area	Fort Union
	Central Mine Area	Fort Union
	Nine and One Half Mile South Area	Fort Union
	Tenmile South Area	Fort Union
Leucite Hills	Pit 21*	Almond
	Pit 22N*	Almond
	Pit 22S*	Almond
	Pit 24*	Almond
Black Butte	Pit 1*	Fort Union
	Pit 2*	Fort Union
	Pit 3*	Fort Union
	Pit 4*	Fort Union
	Pit 5*	Lance
	Pit 6*	Lance
	Pit 7^	Lance
	Pit 8*	Almond
	Pit 9*	Fort Union
	Pit 10	Fort Union
	Pit 11*	Fort Union
	Pit 12^	Lance
	Pit 13^	Lance
	Pit 14	Almond
	Pit 15 (proposed)	Fort Union

*Not active, reclaimed, or in reclamation as of 2019.
^No current plans to mine due to coal quality concerns.

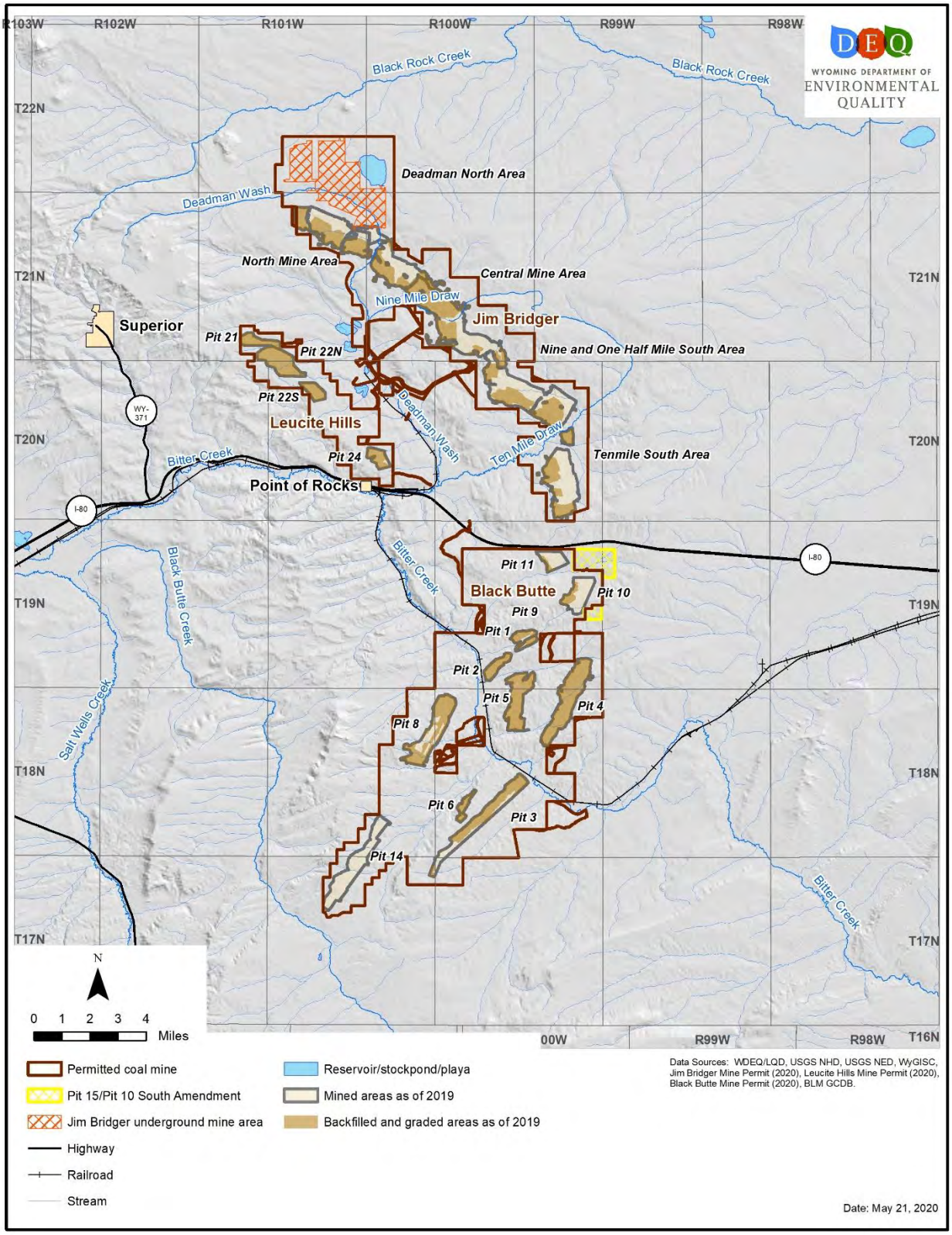


Figure 11. General extent of backfilled areas in relation to mined areas at the Jim Bridger, Leucite Hills, and Black Butte mines. The areas shown are in various stages of reclamation ranging from backfilled and graded to final permanent reclamation. Backfilled and reclaimed areas are only shown within the extent of pit boundaries.

1.5 ANTICIPATED COAL MINING IN THE GREATER GREEN RIVER BASIN

The WDEQ/LQD Coal Rules and Regulations require the WDEQ/LQD to assess the probable cumulative hydrologic impacts of the proposed operation and their interaction with the impacts of all anticipated mining. Anticipated mining shall be projected over the life of the operation, and includes all other existing coal mining operations, any proposed coal mining operation for which a permit application has been filed, and all proposed operations required to meet diligent development requirements for leased Federal coal where mine development and geological information is available (WDEQ Land Quality–Coal Rules, Ch. 19, § 2(a)(i)).

For the purposes of this CHIA, the mining progressions shown in the approved Jim Bridger Mine Permit (2020) and the proposed Black Butte Mine Pit 15/Pit 10 South Application (2020) represent the current known extent of planned coal mining in the area. There are no additional areas of anticipated mining.

1.6 OTHER LAND USES

Livestock grazing and wildlife habitat are the dominant land uses in the area of the three coal mines. The general area contains three other small mining operations, including a 96 acre decorative stone/rock operation (Permit SP0812), a small (<10 acre) sand and gravel mine (ET1226), and a small (~8 acre) inactive zeolite mine (Permit 566). Conventional oil and gas production is also a prominent land use in parts of the area. The Patrick Draw Field, located approximately three miles east of the Black Butte Mine, contains a high density of oil and gas wells.

A small number of CBM wells also exist in the area. CBM production consists of pumping groundwater from the coal seams to lower the potentiometric head. This reduces the confining pressure on the methane in the coal allowing the gas to flow and be collected at recovery wells. During the process groundwater is removed from the coal seam and then discharged to the surface, typically to unlined impoundments or storage tanks.

The WDEQ/LQD does not regulate CBM activities. CBM is regulated by various other State agencies including the Wyoming Oil and Gas Conservation Commission (WOGCC) (permitting and reclamation), the WSEO (water rights) and the WDEQ/WQD (discharge permits).

Figure 12 shows the location of 39 CBM wells near the mines that produced gas and/or water at some point over the life of the well. The CBM wells were permitted from 2000 to 2004. **Figure 12** also shows the status of the CBM wells, as indicated from December 2019 data from the WOGCC (Wyoming Oil and Gas Conservation Commission, 2020). Most of the wells are currently shut in or abandoned and are no longer producing. Only seven wells are currently producing, all from the Almond Formation located near the east central border of the Black Butte Mine. Of the 39 CBM wells, 31 target the Almond Formation with total depths ranging from 2,649 to 3,758 feet. Six wells are completed in the Rock Springs Formation with total depths ranging from 4,525 to 5,000 feet. One well is completed in the Lance Formation with a depth of 2,903 feet. The target formation for one well is not available. Data from the WOGCC indicate that gas and water production from the CBM wells in the Almond Formation peaked in 2003, and production levels declined rapidly until 2012. From 2012 to 2019, production was steady (Wyoming Oil and Gas Conservation

Commission, 2020). Production from the Rock Springs Formation only occurred in 2000, 2001, and 2007, while the well in the Lance Formation never produced.

The low number of CBM wells and associated production rates in the area of the three coal mines suggests CBM activities have little to no interaction with coal mining impacts on groundwater, unlike other CBM production areas in Wyoming such as the Powder River Basin. Furthermore, the CBM production from the Almond Formation near the Black Butte Mine occurs in coal seams much deeper than those targeted at the Black Butte Mine. For example, the median total well depth for CBM wells in the Almond Formation is 3,280 feet (Wyoming Oil and Gas Conservation Commission, 2020), while the coal seams mined in the Almond Formation at Pit 8 and Pit 14 the Black Butte Mine generally range 17 to 203 feet below the surface (Black Butte Mine Permit, 2020).

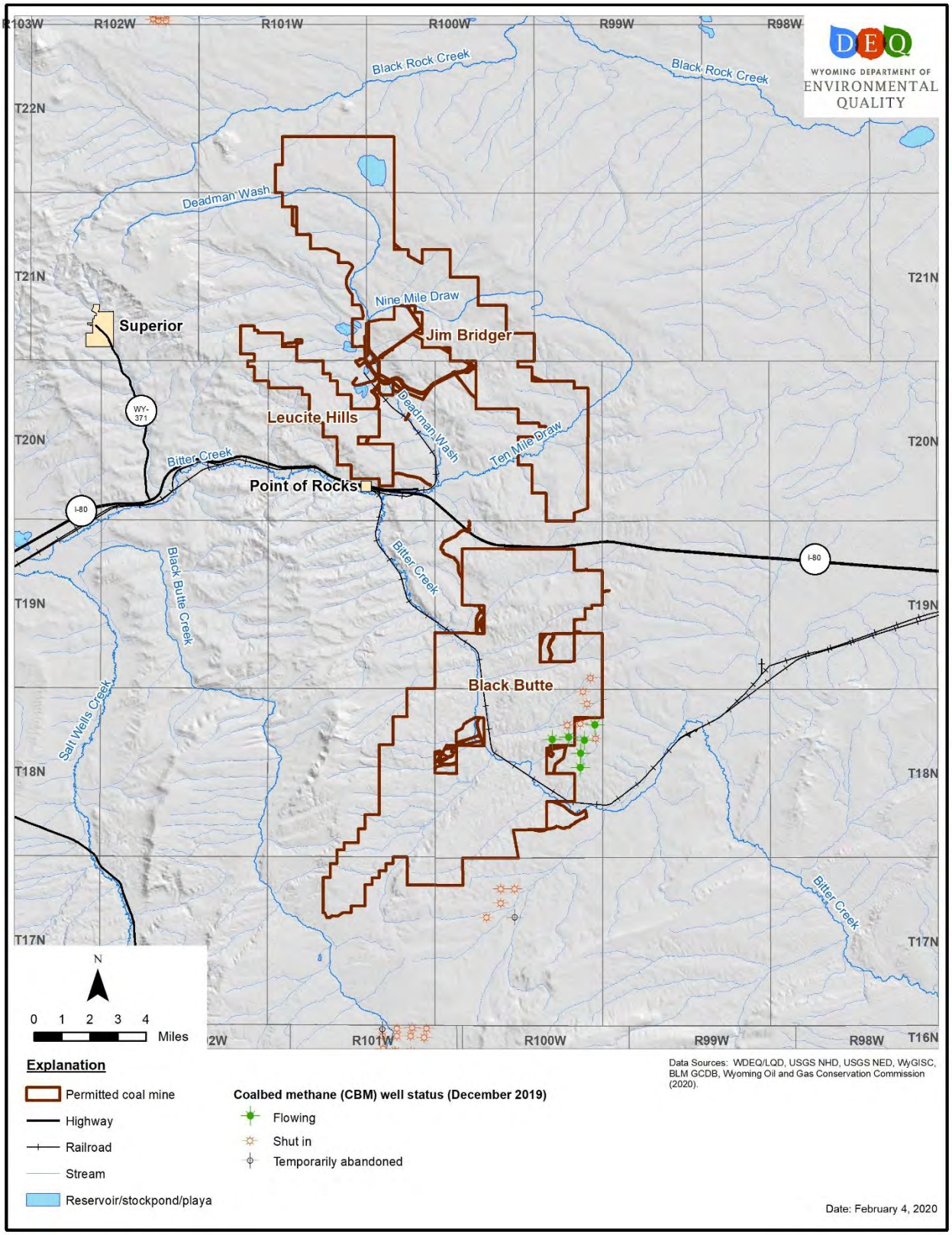


Figure 12. Location and status of coalbed methane (CBM) wells near the Jim Bridger, Leucite Hills, and Black Butte mines (Wyoming Oil and Gas Conservation Commission, 2020). CBM wells that have produced gas and/or water at some point over the life of the well are displayed.

2. CUMULATIVE IMPACT AREA

The cumulative impact area (CIA) is defined as "*…the area, including the permit area, within which impacts resulting from the proposed operation may interact with the impacts of all anticipated mining on surface- and ground-water systems"* (Code of Federal Regulations, 2018: 30 CFR § 701.5). The CIA is the area where existing and proposed mining activities may cause measurable hydrologic changes and may cause material damage to surface water and groundwater resources. The CIA depends on the characteristics of the surface and groundwater systems. Surface and groundwater CIAs are defined separately in this CHIA because of the differences in flow systems and areas of impact. The final CIA encompasses both the surface water and groundwater impact areas.

2.1 SURFACE WATER

2.1.1 DELINEATION OF THE CUMULATIVE IMPACT AREA

The surface water CIA includes the entire drainage area upstream from a point where mining impacts can be cumulated (Office of Surface Mining Reclamation and Enforcement, 1985). The surface water CIA delineated in this CHIA includes the Bitter Creek watershed upstream of United States Geological Survey (USGS) Station No. 09216550, *Bitter Creek near Point of Rocks, WY* (**Figure 13**). Bitter Creek is a major tributary of the Green River, a large river basin in southwest Wyoming that is part of the Colorado River Basin (see **Figure 4**).

The Bitter Creek CIA has a contributing area of 758 square miles (mi^2). The major tributary to Bitter Creek within the CIA is Deadman Wash, which drains the majority of the Jim Bridger and Leucite Hills mine permit boundaries. Bitter Creek flows through the Black Butte Mine permit area. Major tributaries to Bitter Creek upstream of the Black Butte Mine include Patrick Draw, Antelope Creek, and Laney Wash (**Figure 13**).

The CIA contains a majority of the Jim Bridger, Leucite Hills, and Black Butte mine permit areas (**Figure 13**), with the exception of the areas listed below. Mining will disturb a relatively small percentage of each of the following drainages, and therefore it is unlikely that changes in surface water quality or quantity could be detected downstream of the mines. Furthermore, each of the following areas are located in isolated parts of the three individual mines and do not contribute to cumulative surface water impacts. Therefore, the following areas were not considered as part of the surface water CIA for this CHIA:

- Unnamed ephemeral tributaries to Black Rock Creek and the Continental Divide Basin Drainage in the Great Divide Basin. This area is located in the northern portion of the Jim Bridger Mine permit area (**Figure 13**). This entire area is above the underground mine and will not be surface mined. Potential mining-related disturbance in this area includes surficial expressions of subsidence and surface disturbance from underground mine facilities such as pumping sites, roads, and ventilation shafts.
- Ephemeral tributaries to Coon Draw and other unnamed ephemeral tributaries to Bitter Creek on the west side of the Leucite Hills Mine permit area (**Figure 13**).

Nearly all of this area is undisturbed from surface mining with the exception of two small topsoil stockpiles and one small sediment pond.

- Unnamed ephemeral tributaries to Black Butte Creek in the southwest portion of the Black Butte Mine (**Figure 13**). This area will be disturbed from surface mining in the southern portion of Pit 14. The disturbance in this area represents approximately 1.2 square miles, or less than one percent of the Black Butte Creek drainage (Black Butte Mine Permit, 2020).

Over the current projected life of the three coal mines, it is anticipated that approximately 6.7 percent of the surface water CIA will be disturbed by coal mining activities. Approval of the Pit 15/Pit 10 South Amendment at the Black Butte Mine would increase this value to 6.8 percent. The current (2019) mining disturbance accounts for approximately 26,481 acres, or 5.5 percent of the CIA.

2.1.2 DESCRIPTION OF THE MONITORING NETWORK IN THE SURFACE WATER CIA

The surface water monitoring network in the CIA is comprised mostly of stations operated by the three coal mines, with additional data coming from former USGS stations and stations operated by the Sweetwater County Conservation District (SWCCD) and the Bitter/Killpecker Watershed Assessment Group (BKWAG), and the WDEQ Water Quality Division (WQD). **Figure 13** and **Table 6** show the location and period of record for all surface water stations used to evaluate baseline and during-mining hydrologic conditions in the Bitter Creek CIA. A brief description of these stations is provided below and further descriptions are provided in Sections 3.1 and 6.1.

The surface water CIA delineated in this CHIA includes the Bitter Creek watershed upstream of United States Geological Survey (USGS) Station No. 09216550, *Bitter Creek near Point of Rocks, WY* (**Figure 13**; **Table 6**). USGS Gaging Station No. 09216550 operated as a peak streamflow gage for a period of 14 years (1961-1975). The WDEQ/LQD has funded water quality sampling at the gage in 2015 and 2018 to present. The USGS also operated several other gages and water quality sampling sites during the 1961-1981 time period to help monitor and predict the effects of upstart coal mining in the area (Peterson, 1988). The USGS stations evaluated in this CHIA include Station No. 09216562 - *Bitter Creek above Salt Wells Creek near Salt Wells, Wyoming* (1976-1981), Station No. 09216550 - *Deadman Wash near Point of Rocks, Wyoming* (1961-1981), and Station No. 09216545 - *Bitter Creek near Bitter Creek, Wyoming* (1975-1981) (**Figure 13**; **Table 6**). Although the period of record for these stations is short, the data provide baseline hydrological information on the semi-arid region of southwestern Wyoming. The results of the monitoring in the late 1970s and early 1980s at these stations were published in several reports by the USGS (DeLong and Wells, 1988; Peterson, 1988; Nordlund and Liebermann, 1990).

Stations operated by the three coal mines provide a large portion of the data used in this CHIA. The Jim Bridger Mine has operated several stations in the Deadman Wash drainage, including sites on Deadman Wash, Tenmile Draw, and Ninemile Wash (**Figure 13**; **Table 6**) (Jim Bridger Mine Permit, 2020). The Leucite Hills Mine has monitored several small unnamed ephemeral tributaries to Deadman Wash (**Figure 13**; **Table 6**) (Leucite Hills Mine Permit, 2020). The Black Butte Mine has operated stations on Bitter Creek at the upstream and downstream mine permit boundary since 1975 (**Figure 13**; **Table 6**) (Black Butte Mine Permit, 2020).

The Sweetwater County Conservation District (SWCCD) and the Bitter/Killpecker Watershed Assessment Group (BKWAG) have conducted extensive surface water sampling in the Bitter Creek drainage since 2004 (Bitter/Killpecker Watershed Advisory Group and the Sweetwater County Conservation District, 2006; Environmental Design Engineering Consultants, 2018). The purpose of the sampling is to evaluate potential sources of chloride and bacteria that contribute to exceedances of the WDEQ/WQD Class 2C standards for chloride and *Escherichia coli* (*E. coli*). In 2000, the WDEQ/WQD placed Bitter Creek from Rock Springs upstream to Point of Rocks on the State 303(d) list for not supporting recreation use due to *E. coli* exceedances (Wyoming Department of Environmental Quality, 2018). A draft Total Maximum Daily Load (TMDL) for *E. coli* in Bitter Creek was prepared in 2017 (Tetra Tech, Inc., 2017). In 2002, Bitter Creek from Rock Springs upstream to Point of Rocks was again placed on the State 303(d) list for not supporting aquatic life other than fish due to chloride exceedances (Wyoming Department of Environmental Quality, 2018). Data from four of the SWCCD and BKWAG monitoring sites on Bitter Creek, Deadman Wash, and Tenmile Draw were incorporated into this CHIA. Data from an additional site sampled on Bitter Creek by the WDEQ/WQD was also included in the CHIA (**Figure 13**; **Table 6**).

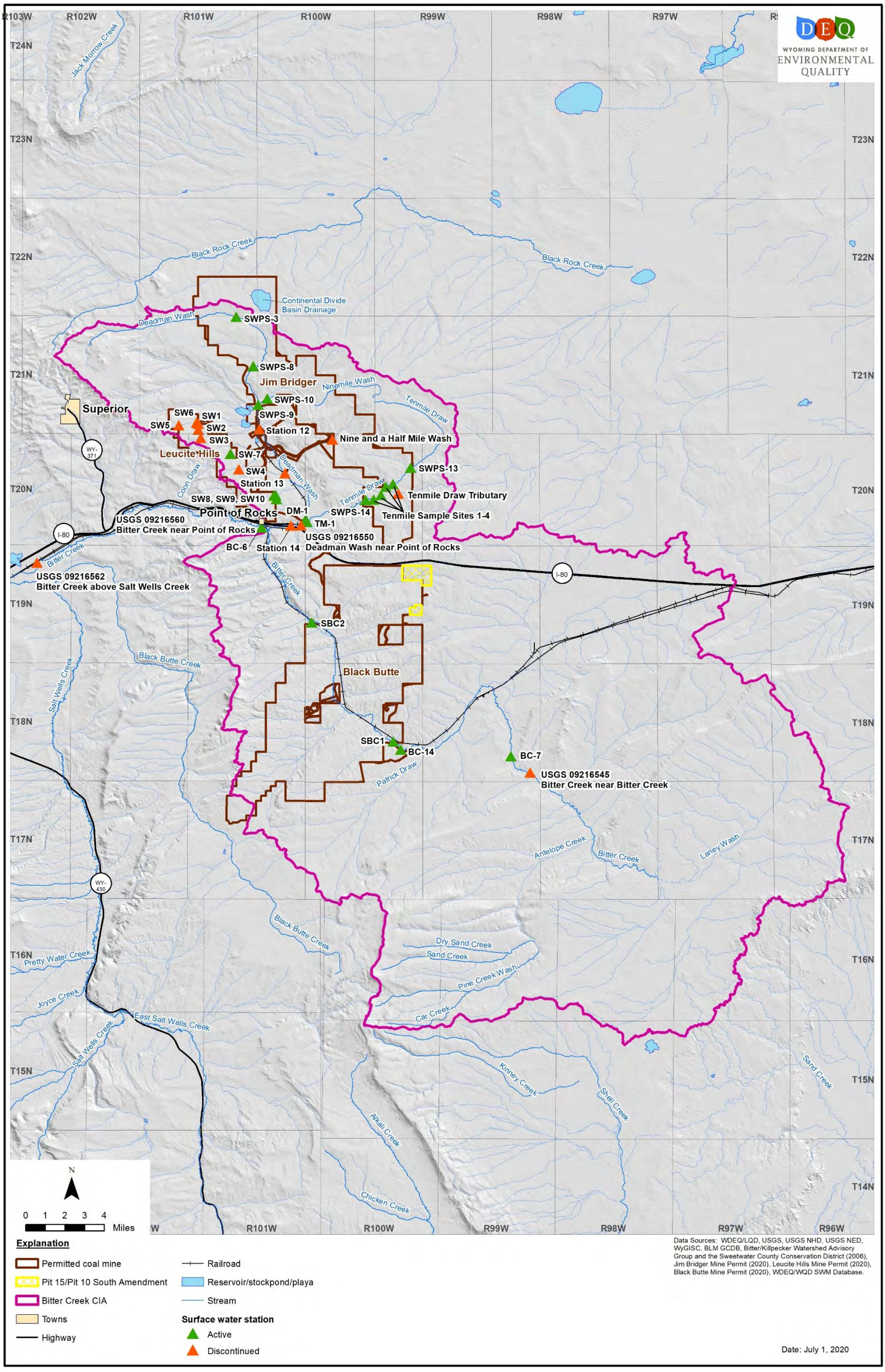


Figure 13. Location of active and inactive surface water gaging stations used to evaluate baseline and during-mining hydrologic conditions in the Bitter Creek surface water cumulative impact area (CIA).

Table 6. Surface water stations used to evaluate baseline and during-mining hydrologic conditions in the Bitter Creek surface water cumulative impact area (CIA). Stations in bold are currently active.

Station	Location	Drainage Area (mi^2)	Baseline Period	During-Mining Period
USGS 09216562 (USGS)	Bitter Creek above Salt Wells Creek near Salt Wells, WY	829	6/1976 to 9/1981	-
USGS 09216560 (USGS)	**Bitter Creek near Point of Rocks, WY**	**758**	**3/1961 to 3/1976**	**6/2015 and 4/2018 to 1/2020**
BC-6 (SWCCD, WDEQ/WQD)	**Bitter Creek downstream of railroad bridge near Point of Rocks**	**758**	**-**	**3/2004 to 7/2019**
Station 20 (Jim Bridger Mine)	Bitter Creek downstream of confluence with Deadman Wash	758	1974-1976	-
SBC2 (Black Butte Mine)	**Bitter Creek (downstream permit boundary)**	**596**	**1975-1981**	**3/1982 to 10/2019**
SBC1 (Black Butte Mine)	**Bitter Creek (upstream permit boundary)**	**494**	**1975-1981**	**3/1982 to 10/2019**
BC-14 (WDEQ/WQD)	**Bitter Creek below Patrick Draw**	**476.5**	**-**	**5/2009 to 7/2019**
BC-7 (SWCCD)	**Bitter Creek downstream of Road 4410 south of Bitter Creek town site**	**317[1]**	**-**	**3/2004 to 8/2015**
USGS 09216545 (USGS)	Bitter Creek near Bitter Creek, WY	308	7/1975 to 9/1981	-
Station 14 (Jim Bridger Mine)	Deadman Wash near Point of Rocks	152.3[1]	3/1974 to 11/1976	-
USGS 09216550 (USGS)	Deadman Wash near Point of Rocks, WY	152	3/1961 to 7/1981	-
DM-1 (SWCCD)	**Deadman Wash downstream of BLM wetland ponds near Point of Rocks**	**112[1]**	**-**	**3/2004 to 5/2010**
Station 13 (Jim Bridger Mine)	Deadman Wash downstream of Jim Bridger Power Plant	96[1]	3/1974 to 11/1976	-
Station 12 (Jim Bridger Mine)	Deadman Wash upstream of Jim Bridger Power Plant	43[1]	3/1974 to 3/1976	-
SWPS-9 (Jim Bridger Mine)	**Lower Deadman Wash**	**42[1]**	**5/1979 to 4/1980**	**5/1995 to 10/2019**
SWPS-3 (Jim Bridger Mine)	**Upper Deadman Wash**	**14.6[2]**	**3/1980 to 3/1980**	**5/1995 to 10/2019**
SWPS-8 (Jim Bridger Mine)	**Tributary to Deadman Wash**	**0.88**	**-**	**5/1995 to 10/2019**
TM-1 (SWCCD)	**Tenmile Draw upstream of confluence with Deadman Wash**	**40.3[1]**	**-**	**3/2004 to 8/2015**
SWPS-14 (Jim Bridger Mine)	**Lower Tenmile Draw**	**36.9**	**5/1979 to 4/1980**	**5/1996 to 10/2019**
SWPS-13 (Jim Bridger Mine)	**Upper Tenmile Draw**	**6.1**	**4/1979 to 4/1980**	**5/1995 to 10/2019**
Tenmile Draw Tributary (Jim Bridger Mine)	Tenmile Draw Tributary	2.1[1]	5/1979 to 4/1980	-
Tenmile Sample Site 1 (Jim Bridger Mine)	**Tenmile Draw**	**19.6[1]**	**-**	**9/2019**
Tenmile Sample Site 2 (Jim Bridger Mine)	**Tenmile Draw**	**22.0[1]**	**-**	**9/2019**
Tenmile Sample Site 3 (Jim Bridger Mine)	**Tenmile Draw**	**33.5[1]**	**-**	**9/2019**
Tenmile Sample Site 4 (Jim Bridger Mine)	**Tenmile Draw**	**33.9[1]**	**-**	**9/2019**

[1]Drainage area estimated by the WDEQ/LQD.
[2]Station moved in 2002; drainage area prior to this year was 16.3 mi^2.

Table 6 (continued).

Station	Location	Drainage Area (mi^2)	Baseline Period	During-Mining Period
SWPS-10 (Jim Bridger Mine)	**Ninemile Wash**	**3.1**	**5/1979 to 5/1980**	**5/1995 to 10/2019**
Nine and One Half Mile Wash (Jim Bridger Mine)	Nine and One Half Mile Wash	3.04[1]	5/1979 to 4/1980	-
SW1 (Leucite Hills Mine)	SW1 Watershed	0.10[1]	1979-1981	2/1983 to 4/1986
SW2 (Leucite Hills Mine)	SW2 Watershed	0.18[1]	1979-1981	2/1983 to 4/1986
SW3 (Leucite Hills Mine)	SW3 Watershed	0.25[1]	1979-1981	2/1983 to 4/1986
SW4 (Leucite Hills Mine)	SW4 Watershed	0.43[1]	1979-1981	2/1983 to 4/1986
SW5 (Leucite Hills Mine)	SW5 Watershed	0.54[1]	1979-1981	2/1983 to 4/1986
SW6 (Leucite Hills Mine)	SW6 Watershed	1.04[1]	1979-1981	2/1983 to 4/1986
SW7 (Leucite Hills Mine)	**Sub-Watershed 7**	**0.22[1]**	**-**	**7/1986 to 6/2019**
SW8 (Leucite Hills Mine)	**Sub-Watershed 8**	**3.86[1]**	**-**	**7/1986 to 6/2019**
SW9 (Leucite Hills Mine)	**Sub-Watershed 9**	**0.23[1]**	**-**	**7/1986 to 6/2019**
SW10 (Leucite Hills Mine)	**Sub-Watershed 10**	**3.26[1]**	**-**	**7/1986 to 6/2019**

[1]Drainage area estimated by the WDEQ/LQD.

2.2 GROUNDWATER

The groundwater CIA conceptually includes: (1) areas where aquifers are mined, (2) areas impacted by mine-induced groundwater drawdown, (3) the extent of measurable impacts of groundwater drawdown on the surface water system, and (4) areas where plumes of degraded groundwater may develop and migrate (Office of Surface Mining Reclamation and Enforcement, 1985).

2.2.1 DELINEATION OF THE CUMULATIVE IMPACT AREA

The surface coal mining process in the GGRB CHIA area generally consists of topsoil stripping and stockpiling, drilling and blasting, overburden removal, and coal removal. A detailed description of the surface mine pits and the mined coal formations are presented in Section 1.4. Surface mine pits may be dewatered by drains with the groundwater collected in pit sumps. Water is mostly then put to a permitted beneficial use such as dust control while little is discharged to a surface drainage system. Other groundwater controls such as dewatering wells may be used to reduce groundwater inflow into mine pits. The benefits of dewatering include more stable mining, lessening the risk of slope or spoil pile failure, and improved coal quality.

The Jim Bridger Mine also has a longwall underground mine that is located on the northeastern flank of the Rock Springs Uplift. The Fort Union Formation coal seams are covered with overburden ranging in thickness from 200 feet to about 1,000 feet in the underground mine area. Process water from underground mining will either be piped to a holding pond and discharged under Wyoming Pollutant Discharge Elimination System (WYPDES) discharge criteria limits or will be conveyed through a pipeline to the Jim Bridger Power Plant for use (Jim Bridger Mine Permit, 2020).

The reclamation process is contemporaneous with mining. For surface coal mines, the reclamation process begins as the stripped overburden is backfilled on the pit floor after coal is removed. The backfilled area is graded, covered with topsoil, and revegetated. The backfilled overburden material creates a backfill aquifer over time as the backfill saturates. In the underground longwall coal mine area, after mining, a planned surface subsidence will occur. The surface subsidence is expected to be six to ten feet (Jim Bridger Mine Permit, 2020). Aquifers that may be impacted by these coal mining and reclamation processes and other mining associated activities are identified and discussed below.

2.2.1.1 AQUIFERS OF CONCERN

A single groundwater CIA will encompass six aquifer units of concern in the GGRB: (1) alluvial, (2) Fort Union, (3) Lance, (4) Almond, (5) Ericson Sandstone, and (6) backfill. A brief discussion of each of these units is presented below. With the exception of backfill, more detailed descriptions of the aquifer units, including aquifer properties, potentiometric surfaces, and groundwater quality, are provided in Section 3.2. Additional details on current hydrologic conditions in each aquifer unit and the backfill aquifer are provided in Section 6.2.

When in hydrologic connection, materials classified as alluvium and colluvium are categorized together as alluvial deposits (see extent in **Figure 6**). The alluvium (Quaternary) along Bitter Creek, Deadman Wash, and segments of their tributaries store and transmit water in

sufficient quantities to be considered aquifers in some parts of the CIA. During mining, sections of the alluvial aquifer in the vicinity of the mines will be impacted in various ways, including removal and replacement, drawdown due to the influences of pit dewatering and temporary diversion of streams, or increased water levels due to the infiltration of pit and pond discharges. Alluvial aquifers are generally discontinuous and are present only along major drainages (**Figure 6**).

The coal mine pits are in the Fort Union, Lance, and Almond formations (**Table 5**). Within the Fort Union Formation lie economic coal deposits and vertebrate fossils of scientific significance (Bureau of Land Management, 2003). The Deadman Coal Zone of the Fort Union Formation is about 10 to 30 feet thick (**Figure 7**). All mining at the Jim Bridger Mine occurs in the Fort Union Formation. Eight of the 11 mine pits at the Black Butte Mine are in the Fort Union Formation (**Table 5**). The Black Butte Mine had two pits that mined coal from the Lance Formation. As of 2020, both these pits (Pit 5 and Pit 6) are in reclamation. All four pits at the Leucite Hills Mine mined coal from the Almond Formation. Two out of 11 mine pits (Pit 8 and Pit 14) at the Black Butte Mine are in the Almond Formation. As of 2020, Pit 14 is the only pit that is actively mining in the Almond Formation (**Table 5**). The mining in the surface pits along with underground mining are expected to cause hydrologic impacts on all these formations.

The Ericson Sandstone outcrops to the western edge of the Leucite Hills and Jim Bridger mines (**Figure 6**). It consists of massive beds of sandstone and conglomerate with a thickness of up to 700 feet. Because of yield and water quality as compared to other aquifers in the area, the Ericson Sandstone is generally used as a water supply for municipal and industrial use. The Ericson Sandstone is tapped as a potable water source for the Town of Superior and in 2010 the town was extracting approximately 40 acre-feet (ac-ft) per year (WWC Engineering, AECOM, ERO Resources Corp., 2010). The Town of Superior uses three wells for water supply. According to completion records on file with the WSEO, Superior Well #17 is completed in the Ericson Sandstone (Wyoming State Engineer's Office, 2020a). Superior Well #18 is screened primarily in the Ericson Sandstone, although a small portion of the screen is completed in the Almond Formation and Rock Springs Formation. Superior Well #19 is completed in the lower Almond Formation (Wyoming State Engineer's Office, 2020a).

Coal mine facility wells are also completed in the Ericson Sandstone. All three mine permits predict that pumping of the facility wells will create a cone of depression in the Ericson Sandstone (see Section 2.2.1.2). However, the active mine facility wells are completed at depths varying from 688 to 3,109 feet and in general are at least 130 feet below the coal mine pits. Therefore, minimal interaction is expected between the coal mining operations (pit dewatering, removal of overburden and coal aquifers, underground mining, and creating a backfill aquifer) and the pumping of the facility wells in the Ericson Sandstone.

The outcrops of Wasatch Formation, Fox Hills Sandstone and Lewis Shale are also in the vicinity of the coal mines (**Figure 6**). The Wasatch Formation outcrops to the east of the mine permit boundaries and the impacts caused by mining to this formation are expected to be minimal. The Wasatch Formation is discontinuous and of limited extent within the mine permit boundaries. It should be noted that some of the Jim Bridger Mine's Fort Union Formation wells are completed in both the Fort Union Formation and the Wasatch Formation. Fox Hills Sandstone and Lewis Shale have very low hydraulic conductivity and therefore the hydrologic impacts caused by mining are expected to be mostly limited to very short distances within the formation (Black Butte Mine Permit, 2020). Therefore, the hydrologic impacts caused by mining on Wasatch Formation, Fox Hills Sandstone, and Lewis shale are expected to be minimal and were not a focus of this CHIA.

The backfill aquifer is a new aquifer created by saturation of overburden materials placed into the mined pit after the coal is removed. The backfilled materials consist primarily of overburden materials removed to expose the coal seam for mining. The overburden is blasted and then physically removed. The overburden may be immediately placed in the pit or it may be stockpiled before placement in the pit. The methods of placement are dragline or truck and shovel. The mining process modifies important characteristics of the materials including the original sedimentary layering structure and permeability of the rocks. Additionally, the sediments are exposed to oxidation. The water quality of the backfill aquifer is intended to support livestock use - the approved post-mining land use for this CHIA area.

2.2.1.2 AVAILABLE GROUNDWATER MODELS

Analysis of groundwater drawdown resulting from pit dewatering is required as part of the permitting process to assess the impacts of mine progression and coal removal on the aquifers adjacent to the mined areas. The available groundwater predictions from the three mine permits are summarized below.

2.2.1.2.1 Jim Bridger

A MODFLOW (MODFLOW-96) numerical model was developed for the groundwater systems at the Jim Bridger Mine in the vicinity of the surface and underground mines (Jim Bridger Mine Permit, 2020). The horizontal extent of the model grid was extended to the east and northeast primarily in response to a large magnitude of drawdown in the coal and lower overburden near the underground mine area. The area within the model grid is approximately 713 square miles. The model grid has 95 rows by 200 columns. In addition, the model has six layers. Model layer 1 includes the alluvial aquifer and is limited to those alluvial systems in the vicinity of the mining area. Model layers 2, 3, and 4 are within the overburden and are defined as the upper overburden, middle overburden, and lower overburden, respectively. Model layer 5 is the coal/interburden and model layer 6 is the Lance Formation or the underburden (Jim Bridger Mine Permit, 2020).

The thicknesses of the model layers were obtained by the mapping and interpretation conducted by the Jim Bridger Mine. The general thickness of the upper overburden is 180 feet and the thickness tapers to zero near the coal outcrop. The thickness of the middle overburden is a constant one foot. The thickness of the lower overburden is generally one-half of the thickness from the top of land surface to the top of the coal/interburden. The available mapping of the coal structure was used to define the thickness of the coal/interburden (Jim Bridger Mine Permit, 2020).

The aquifer properties collected from field tests were used to estimate the hydraulic conductivities and storage coefficients to the numerical model. VCONT is the MODFLOW model parameter that determines the vertical conductivity between the model layers. The vertical conductance between the model layers is calibrated to match the observed drainage rates, drawdowns, and head differentials. A detailed description of the distribution of VCONT is provided in Section MP 5.6.1.2 of the Jim Bridger Mine Permit (2020). A constant areal recharge rate of 0.13 inches per year was used in the model. The recharge rate of 0.13 inches per year was estimated by the Jim Bridger Mine during the calibration of their steady state model. This value is considered a long-term average of local recharge to the overburden aquifer (Jim Bridger Mine Permit, 2020).

MODFLOW river boundary condition was used to simulate the Deadman Wash alluvium and the lower portion of the Tenmile Draw. MODFLOW drain boundary condition was used to simulate the existing and proposed pit progression for the surface mining and underground mining from

mid-2012 through 2039. The life of the Jim Bridger Mine is expected to extend through 2037, but surface mine drain cells are assumed to remain active for five years until the pits are backfilled. The sequence of drain cell activation and deactivation in the model is based on the planned mining sequence. The model calibration was conducted for a period of 1990 to 2003. The predictive period started from mid-2012 through Year 2100. Drawdowns, water level elevations, and dewatering rates were predicted by the model and are presented in Sections MP 5.6.2.5 through MP 5.6.2.11 of the Jim Bridger Mine Permit (2020).

In addition, the Jim Bridger Mine used a Theis model to predict the drawdown in the Ericson Sandstone from the mine water supply well. The details on the model are presented in Section MP 5.6.4.3 in the mine permit (Jim Bridger Mine Permit, 2020). The Theis model indicated that the five-foot drawdown limit would be 18 miles from the Bridger No. 1 well for a transmissivity of 14,000 gallons per day (gpd) per foot, pumping at an average rate of 400 gallons per minute (gpm) for 19 years. Another scenario, with a lower transmissivity (2,600 gpd per foot), indicated the five-foot drawdown limit would be 19 miles from the Bridger No. 1 well. The low transmissivity scenario that predicted the maximum drawdown extent was used to delineate the groundwater CIA for the CHIA (**Figure 14**, Section 2.2.1.5).

2.2.1.2.2 Leucite Hills

The impacts on groundwater resources caused by the Leucite Hills Mine will be relatively limited because the mine is located within a structurally and topographically elevated terrain near the outcrops of the coal seams and the mine excavation only intercepted the Almond Formation (Leucite Hills Mine Permit, 2020). The Ericson Sandstone, a major regional aquifer underlying the mine permit area, will not be directly affected by the mine pits because it lies at a depth of some 130 to 250 feet below the mine pit bottoms. In addition, the potentiometric elevations in the Ericson Sandstone are 50 to 150 feet below the proposed pit floors. There is minor potentiometric drawdown proximate to the mine's industrial water supply well, Well No. 4.

The quality and thicknesses of the individual coals that are mined stratigraphically above the Ericson Sandstone vary significantly over the mines area and the mine pits were developed to variable stratigraphic horizons. Furthermore, the natural variations in the extent of saturation within individual units will cause the mine pits to have variable impacts on the groundwater resources. Over the life of the mine, the most extensive and laterally continuous potentiometric head declines will occur in the minor aquifer units locally identified as the upper sandstone unit, the 2 coal seam, and a sandstone lying below the 2 coal known as 2 sandstone (Leucite Hills Mine Permit, 2020).

Structure contour maps of the upper sandstone, 2 coal, and 2 sandstone were superimposed digitally on their respective pre-mining potentiometric surface maps to derive the projected limits of five feet or less drawdown for each unit over the life of mine (Leucite Hills Mine Permit, 2020). With structure contour maps, saturation boundary lines and pre-mining potentiometric surface maps digitally superimposed, pit floor elevations at down dip boundaries were noted and the mine-life, five-foot drawdown limit were set at these same approximate elevations down the potentiometric gradients of each respective groundwater unit. The maximum extent of this predicted five-foot drawdown contour is about half a mile downdip of Pit 22S. This spatial extent is predicted to be smaller near the vicinity of other pits (Leucite Hills Mine Permit, 2020).

The Jim Bridger Mine, the nearest operating coal mine to Leucite Hills Mine, is located about two miles northeast of the permit area. The coal mined from the Jim Bridger Mine is from the

Deadman coal zone of the Fort Union Formation. The Almond Formation mined at the Leucite Hills permit area is separated from the Fort Union Formation by the Cretaceous Lance Formation, Fox Hills Sandstone, and Lewis Shale. The Lewis Shale is several hundred feet thick in the area between the mined properties and it is composed of low permeable strata. Vertical permeability of the upper portion of the Lewis Shale, measured north of the permit area was about 5 x 10^{-8} cm/sec (Leucite Hills Mine Permit, 2020). Therefore, the cumulative hydrologic impacts of these two mines on the groundwater system are expected to be limited and minimal.

The Leucite Hills Mine has one industrial supply well (Well No. 4) located in the Ericson Sandstone. A Theis non-equilibrium model was applied to predict the extent of the one-foot drawdown (**Figure 14**) using an average rate of 23,675 gpd (Leucite Hills Mine Permit, 2020). The model assumed a 270-day period of continuous pumping and a three-month (January, February, and March) period of no pumping. The model showed that the Leucite Hills Mine has essentially no hydrologic impact upon the Ericson Sandstone. Historical groundwater level hydrographs in the Ericson Sandstone monitoring wells indicates that the observed drawdowns are not significant (**Figure 51**).

2.2.1.2.3 Black Butte

Formations affected by the Black Butte Mine include the Fort Union, Lance, Almond, Ericson, and small sections of the Bitter Creek alluvium. The Black Butte Mine compiled historic water level data from wells monitored in Fort Union, Lance, and Almond formations for the purposes of evaluating distance versus drawdown trends in each formation. The objective of this trend analysis was to determine the projected distances to the five-foot drawdown values from the existing mined areas as well as proposed pits in each formation (Black Butte Mine Permit, 2020). A number of factors were considered in evaluating and projecting these long term trends from the existing monitor wells, including:

(1) Location of the well with respect to the mine pits,

(2) The aquifer formation in which the well was completed,

(3) Age of the well and the available water level data,

(4) Location of the well with respect to other hydrologic boundaries such as structural faults and recharge boundaries, and

(5) Potentiometric changes influenced by methane gas.

A detailed description of these analyses is presented in Volume 11 of the Mine Plan in the Black Butte Mine Permit (2020). Figures MP-5a, MP-5b, and MP-5c of the mine permit show the estimated five-foot drawdown in the Fort Union, Lance, and Almond formations, respectively. This five-foot drawdown prediction has been extended to include the Pit 15/Pit 10 South Amendment area, as shown in the revised Figure MP-5a presented in the mine plan of the Black Butte Pit 15/Pit 10 South Amendment Application (2020).

There are six mine water supply wells in the Ericson Sandstone at the Black Butte Mine. The ten-foot drawdown extent was simulated using a well field operations model written by Aqua Terra Consultants. A Theis non-equilibrium model was run with two pumping scenarios: 105 gpm and 144 gpm for a period of 40 years (Black Butte Mine Permit, 2020). The predicted drawdown using the higher pumping rate with the maximum extent (**Figure 14**) was used to delineate the CIA.

2.2.1.3 METHODOLOGY

The groundwater CIA was delineated by following the steps:

1. For each mine, the predicted life of mine drawdown contour for the individual aquifer units were overlaid in a geographic information system platform (ArcGIS, ESRI). The mine permit maps show drawdown contours ranging from one to ten-feet, depending on the mine and aquifer of interest.

    - For the Black Butte Mine, the predicted drawdown for the Ericson Sandstone is more spatially extensive than the predicted drawdown of the other affected aquifers. This is to be expected, as the Ericson Sandstone is more permeable than the other affected aquifers.

    - For the Jim Bridger Mine, the predicted drawdown for the lower overburden is more spatially extensive than the predicted drawdown of the other affected aquifers, except for a small area northwest of the permit boundary. In this area, the predicted drawdown for the Ericson sandstone is more spatially extensive than the predicted drawdown of other aquifers.

    - For the Leucite Hills Mine, the predicted drawdown for the 2 coal is more spatially extensive than the predicted drawdown of the other affected aquifers.

    - For Black Butte Mine, the predicted drawdown for the Ericson Sandstone is the most spatially extensive when compared to the other affected aquifers. For Jim Bridger Mine, the areal extents of the predicted drawdown of the lower overburden and the Ericson sandstone together will provide the maximum possible extent of potential drawdown impacts.

2. The extent of drawdown in the Ericson Sandstone from each mine along with the drawdown in the lower overburden was overlaid in ArcGIS to predict the maximum possible extent of drawdown as shown in **Figure 14**. An interim groundwater CIA was delineated by qualitatively considering the areal extent of the Ericson sandstone drawdown at each mine and the lower overburden drawdown at the Jim Bridger Mine.

3. The interim CIA was extended south, southeast, and southwest of the Ericson Sandstone drawdown predicted by the Black Butte Mine to include the extent of the Black Butte Mine permit boundary. The western extent of the Ericson Sandstone shown in the bedrock geology map (**Figure 6**) was used to delineate the western extent of the interim CIA.

4. A final groundwater CIA was delineated by adding a two-mile buffer to the eastern edge of the interim CIA. The buffer was not applied to the western edge of the interim CIA due to the presence of the Ericson Sandstone outcrop.

    - A two-mile buffer beyond the cumulative five-foot drawdown is considered conservative and accounts for uncertainties in the models. The final CIA and the predicted five-foot life of mine drawdown contour of the Ericson Sandstone at each of the mines and the lower overburden at the Jim Bridger Mine are shown in **Figure 14**.

There are several conservative measures built into the methodology of the delineation of both the horizontal and the vertical extents of the groundwater CIA, including: (1) selecting the maximum areal extent of the impacted areas of the individual aquifers, (2) considering that maximum extent for all the other aquifers vertically, and (3) adding a two-mile buffer to the interim CIA to account for uncertainties in the model predictions.

2.2.1.4 HORIZONTAL EXTENT OF THE GROUNDWATER CIA

The Jim Bridger Mine predicted five-foot life of mine Ericson Sandstone drawdown contour has the largest areal extent when compared to the other two coal mines (**Figure 14**). The overlap of the individual mine predicted drawdowns were qualitatively considered while delineating the interim CIA. The horizontal extent of the final groundwater CIA is about 1,151 square miles and includes the entire permit areas of all three coal mines (**Figure 14**). The CIA extends as far as 21 miles north, 14 miles east, and 13 miles west of the Jim Bridger Mine; and two miles south, two miles west, and three miles east of the Black Butte Mine.

The closest coal mine to the three mines considered in this CHIA is the Stansbury Mine, about 15 miles west of the Leucite Hills Mine on the western limb of the Rock Springs Uplift (see permit location in **Figure 4** – just north of Rock Springs, and in **Figure 14**). The Stansbury Mine operated as an underground coal mine over various periods from the 1940s until 1994 (Stansbury Mine Permit, 2020). The underground portals were reclaimed in 2001 and dewatering also ceased in 2001. Although a major permit revision was approved in 2007 that allowed a limited amount of surface mining, no surface mining has occurred to date with the exception of a very small test pit. As of July 2020, the mine is in Temporary Cessation of Operations (TCO) status. The Stansbury Mine mined coalbeds in the Rock Springs Formation, which is lower in the stratigraphic column than coalbeds mined at the Jim Bridger, Leucite Hills, and Black Butte mines (see **Table 1**). The Stansbury Mine predicted that any drawdown in the aquifers of the Rock Springs Formation would not extend east of the permit boundary since the units outcropped in this area (Stansbury Mine Permit, 2020). Therefore, it is expected that there will be no discernible overlapping groundwater drawdown impacts between the mines in this CHIA area and the Stansbury Mine to the west.

2.2.1.5 VERTICAL EXTENT OF THE GROUNDWATER CIA

To be conservative, the areal extent of the Ericson Sandstone drawdown and the lower overburden drawdown is used to delineate the final vertical extent of the groundwater CIA. This final groundwater CIA is applicable for all six aquifers of concern.

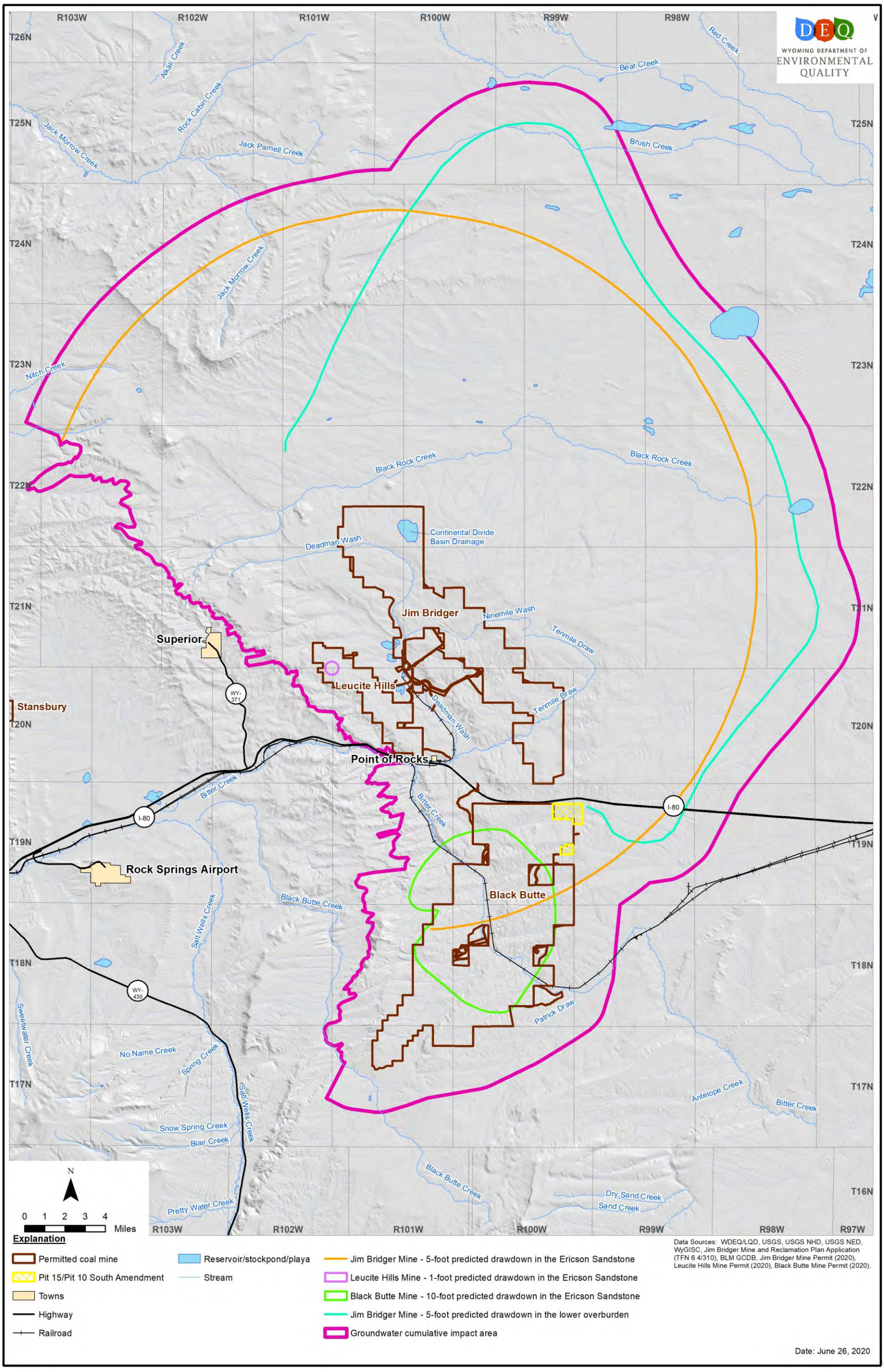


Figure 14. Maximum Ericson Sandstone drawdown extent predicted by each mine, lower overburden drawdown predicted by the Jim Bridger Mine, and final groundwater CIA delineated for the GGRB CHIA area.

2.2.2 DESCRIPTION OF THE MONITORING NETWORK IN THE GROUNDWATER CIA

Baseline and during-mining hydrologic conditions in the groundwater CIA were evaluated primarily using data from the monitoring well networks established by the three coal mines. A monitoring network was initially established by the mines in the late 1970s and early 1980s to evaluate baseline hydrologic conditions in the following aquifers and formations: alluvium, overburden (Fort Union Formation (FUF), Almond Formation (AF)), coal (FUF, AF, Lance Formation (LF)), underburden (FUF, AF, LF), and Ericson Sandstone. The spatial distribution of the monitoring network has changed over time as wells have been discontinued or mined through, or as new wells have been added for permit amendment areas. Additional wells have also been added over time to evaluate hydrologic conditions in the backfill aquifer created in the mined pits that have been reclaimed.

Static groundwater level and groundwater quality data collected at the mines are submitted annually to the WDEQ/LQD and stored and managed in the WDEQ/LQD Hydrology Database. For the purposes of the CHIA, only monitored wells completed and screened within a single geologic unit were evaluated; wells completed in multiple units were not considered.

A total of 273 monitoring wells across the three mines and aquifer strata and formations were considered to evaluate baseline and during-mining hydrologic conditions in the groundwater CIA. **Table 7** shows the status (as of February 2020) and number of monitoring wells within each aquifer and formation at each of the three mines. Twenty three wells in the interburden of the AF at the Leucite Hills Mine and two wells in the interburden of the FUF at the Jim Bridger Mine were not evaluated for the CHIA. Maps showing the location and status (as of February 2020) of the monitoring wells within each aquifer unit at the coal mines are provided in **Figure 15** (alluvial), **Figure 16** (overburden), **Figure 17** (coal), **Figure 18** (underburden), **Figure 19** (Ericson), and **Figure 20** (backfill). As of February 2020, there were 113 active monitoring wells at the three mines that were evaluated in the CHIA.

In the alluvial aquifer, a total of 58 monitoring wells were considered to evaluate baseline and during-mining hydrologic conditions in the groundwater CIA. As of February 2020, 21 wells were active while 37 have been discontinued (**Table 7**). Alluvial aquifer monitoring wells are located along the major stream channels within or adjacent to the mine permit boundaries, including Deadman Wash, Tenmile Draw, and Bitter Creek (**Figure 15**). Well depths are available for 56 of the 58 alluvial monitoring wells. Well depths range from 14 feet at two wells along Deadman Wash at the Jim Bridger Mine to 89 feet at a well along Bitter Creek in the northwest portion of the Black Butte Mine. The median well depth for the alluvial wells is 69 feet.

Table 7. Status and number of monitoring wells by aquifer, formation, and mine. Well status is current as of February 2020.

Aquifer	Formation	Mine	Well Status	Number of Monitoring Wells
Alluvial	-	Jim Bridger	Active	11
			Discontinued	13
		Leucite Hills	Active	0
			Discontinued	0
		Black Butte	Active	10
			Discontinued	24
		Total	***Active***	***21***
			Discontinued	***37***
Overburden	Fort Union	Jim Bridger	Active	27
			Discontinued	23
		Leucite Hills	Active	0
			Discontinued	0
		Black Butte	Active	1
			Discontinued	0
		Total	***Active***	***29***
			Discontinued	***23***
	Almond	Jim Bridger	Active	0
			Discontinued	0
		Leucite Hills	Active	0
			Discontinued	0
		Black Butte	Active	3
			Discontinued	0
		Total	***Active***	***3***
			Discontinued	***0***
Coal	Fort Union	Jim Bridger	Active	1
			Discontinued	26
		Leucite Hills	Active	0
			Discontinued	0
		Black Butte	Active	5
			Discontinued	6
		Total	***Active***	***7***
			Discontinued	***32***
	Almond	Jim Bridger	Active	0
			Discontinued	0
		Leucite Hills	Active	4
			Discontinued	11
		Black Butte	Active	3
			Discontinued	3
		Total	***Active***	***7***
			Discontinued	***14***
	Lance	Jim Bridger	Active	0
			Discontinued	0
		Leucite Hills	Active	0
			Discontinued	0
		Black Butte	Active	4
			Discontinued	4
		Total	***Active***	***4***
			Discontinued	***4***
Underburden	Fort Union	Jim Bridger	Active	3
			Discontinued	20
		Leucite Hills	Active	0
			Discontinued	0
		Black Butte	Active	1
			Discontinued	0
		Total	***Active***	***5***
			Discontinued	***20***
	Almond	Jim Bridger	Active	0
			Discontinued	0
		Leucite Hills	Active	0
			Discontinued	0
		Black Butte	Active	3
			Discontinued	0
		Total	***Active***	***3***
			Discontinued	***0***
	Lance	Jim Bridger	Active	11
			Discontinued	10
		Leucite Hills	Active	0
			Discontinued	0
		Black Butte	Active	0
			Discontinued	0
		Total	***Active***	***12***
			Discontinued	***9***
Ericson	Ericson	Jim Bridger	Active	0
			Discontinued	1
		Leucite Hills	Active	1
			Discontinued	6
		Black Butte	Active	1
			Discontinued	5
		Total	***Active***	***2***
			Discontinued	***12***
Backfill	-	Jim Bridger	Active	15
			Discontinued	1
		Leucite Hills	Active	2
			Discontinued	0
		Black Butte	Active	3
			Discontinued	8
		Total	***Active***	***20***
			Discontinued	***9***
Grand Total			***Active***	***113***
			Discontinued	***160***

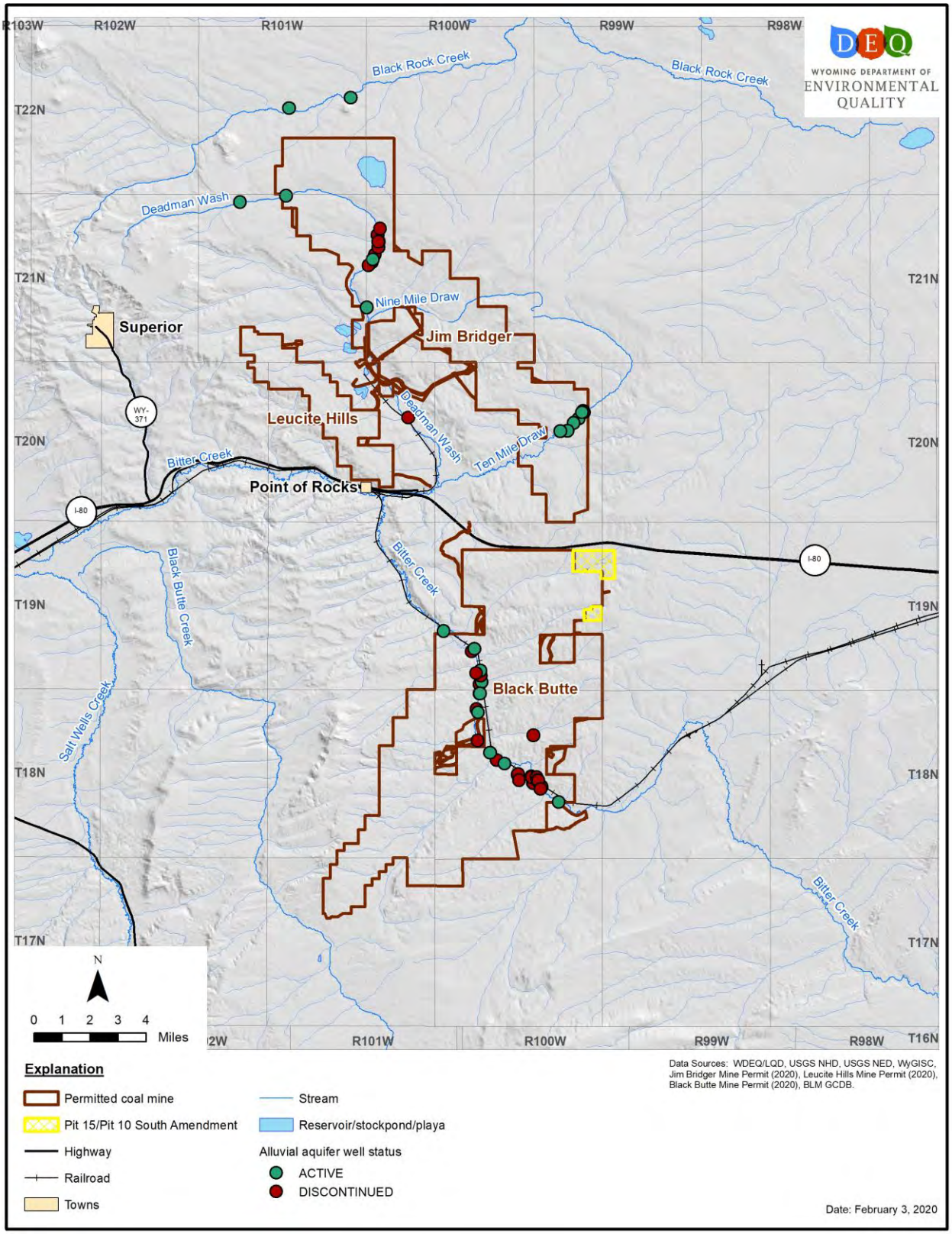


Figure 15. Location and status of monitoring wells in the alluvial aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines. Well status is current as of February 2020.

In the overburden aquifer of the Fort Union Formation (FUF), a total of 52 monitoring wells were considered to evaluate baseline and during-mining hydrologic conditions in the groundwater CIA. As of February 2020, 29 wells were active while 23 have been discontinued (**Table 7**). All of the overburden - FUF monitoring wells except for two are at the Jim Bridger Mine (**Figure 16**). Well depths are available for 51 of the 52 overburden – FUF wells. Well depths range from 60 to 1,280 feet, with a median of 225 feet.

In the overburden aquifer of the Almond Formation (AF), three monitoring wells were considered to evaluate baseline and during-mining hydrologic conditions in the groundwater CIA. As of February 2020, all three wells were active (**Table 7**), and all of the wells are at the Black Butte Mine (**Figure 16**). Well depths for the three wells range from 82 to 165 feet, with a median of 150 feet.

In the coal aquifer of the FUF, a total of 39 monitoring wells were considered to evaluate baseline and during-mining hydrologic conditions in the groundwater CIA. As of February 2020, seven wells were active while 32 have been discontinued (**Table 7**). Twenty seven of the coal - FUF monitoring wells are at the Jim Bridger Mine and 12 wells are at the Black Butte Mine (**Figure 17**). Well depths for the 39 wells range from 35 to 600 feet, with a median of 280 feet.

In the coal aquifer of the AF, a total of 21 monitoring wells were considered to evaluate baseline and during-mining hydrologic conditions in the groundwater CIA. As of February 2020, seven wells were active while 14 have been discontinued (**Table 7**). Six of the coal - AF monitoring wells are at the Black Butte Mine and 15 wells are at the Leucite Hills Mine (**Figure 17**). Well depths for the 21 wells range from 100 to 283 feet, with a median of 180 feet.

In the coal aquifer of the Lance Formation (LF), a total of eight monitoring wells were considered to evaluate baseline and during-mining hydrologic conditions in the groundwater CIA. As of February 2020, four wells were active while four have been discontinued (**Table 7**). All of the coal - LF monitoring wells are at the Black Butte Mine (**Figure 17**). Well depths for the eight wells range from 65 to 400 feet, with a median of 128 feet.

In the underburden aquifer of the FUF, a total of 25 monitoring wells were considered to evaluate baseline and during-mining hydrologic conditions in the groundwater CIA. As of February 2020, five wells were active while 20 have been discontinued (**Table 7**). 23 of the underburden - FUF monitoring wells are at the Jim Bridger Mine, with the remaining two being located at Black Butte Mine (**Figure 18**). Well depths for the 25 wells range from 40 to 500 feet, with a median of 270 feet.

In the underburden aquifer of the AF, a total of three monitoring wells were considered to evaluate baseline and during-mining hydrologic conditions in the groundwater CIA. As of February 2020, all three wells were active (**Table 7**). All of the underburden - AF monitoring wells are at the Black Butte Mine (**Figure 18**). Well depths for the three wells range from 150 to 300 feet, with a median of 290 feet.

In the underburden aquifer of the LF, a total of 21 monitoring wells were considered to evaluate baseline and during-mining hydrologic conditions in the groundwater CIA. As of February 2020, 12 wells were active while nine have been discontinued (**Table 7**). All of the underburden - LF monitoring wells are at the Jim Bridger Mine (**Figure 18**). Well depths for the 21 wells range from 80 to 1,580 feet, with a median of 250 feet.

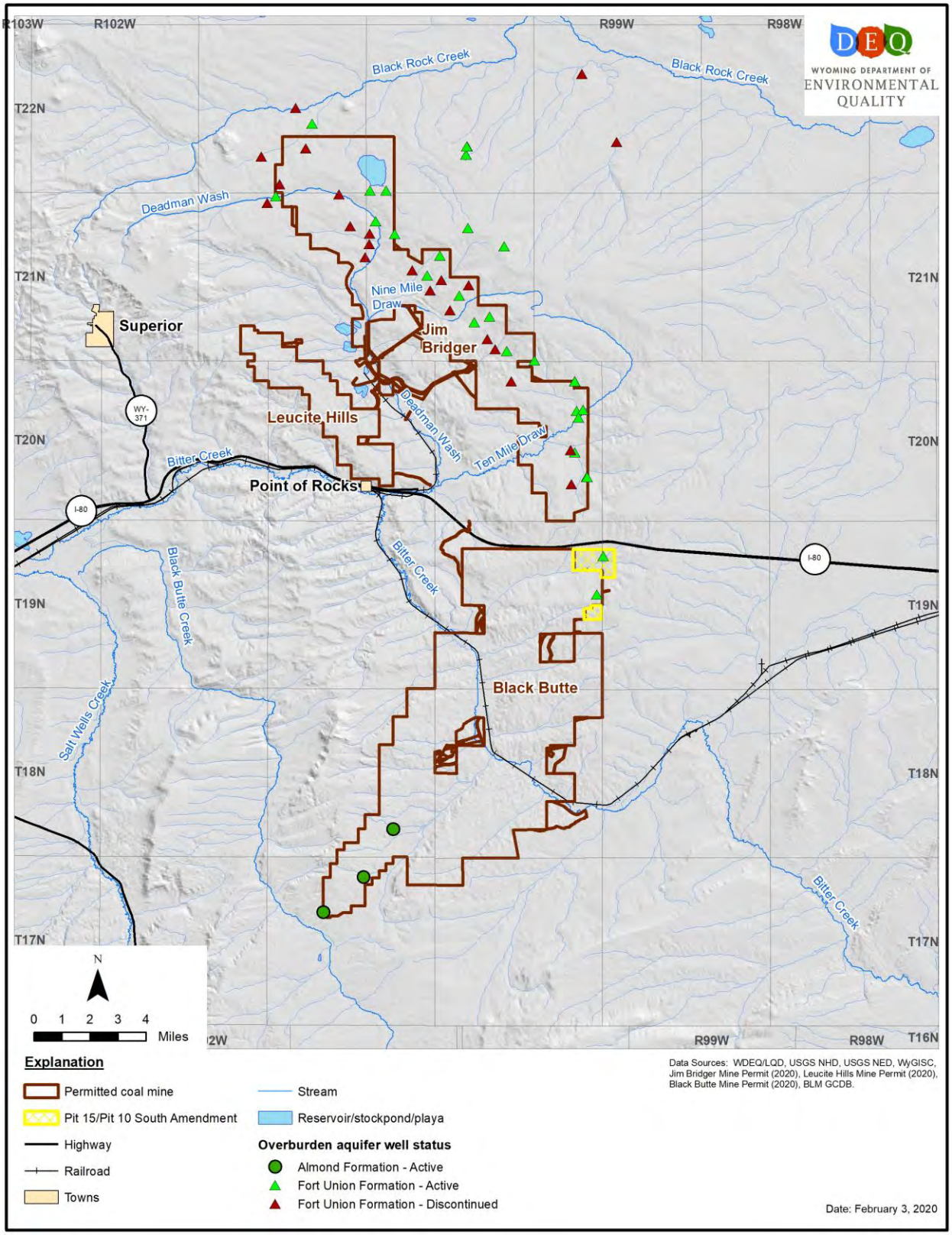


Figure 16. Location and status of monitoring wells in the overburden aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines. Well status is current as of February 2020.

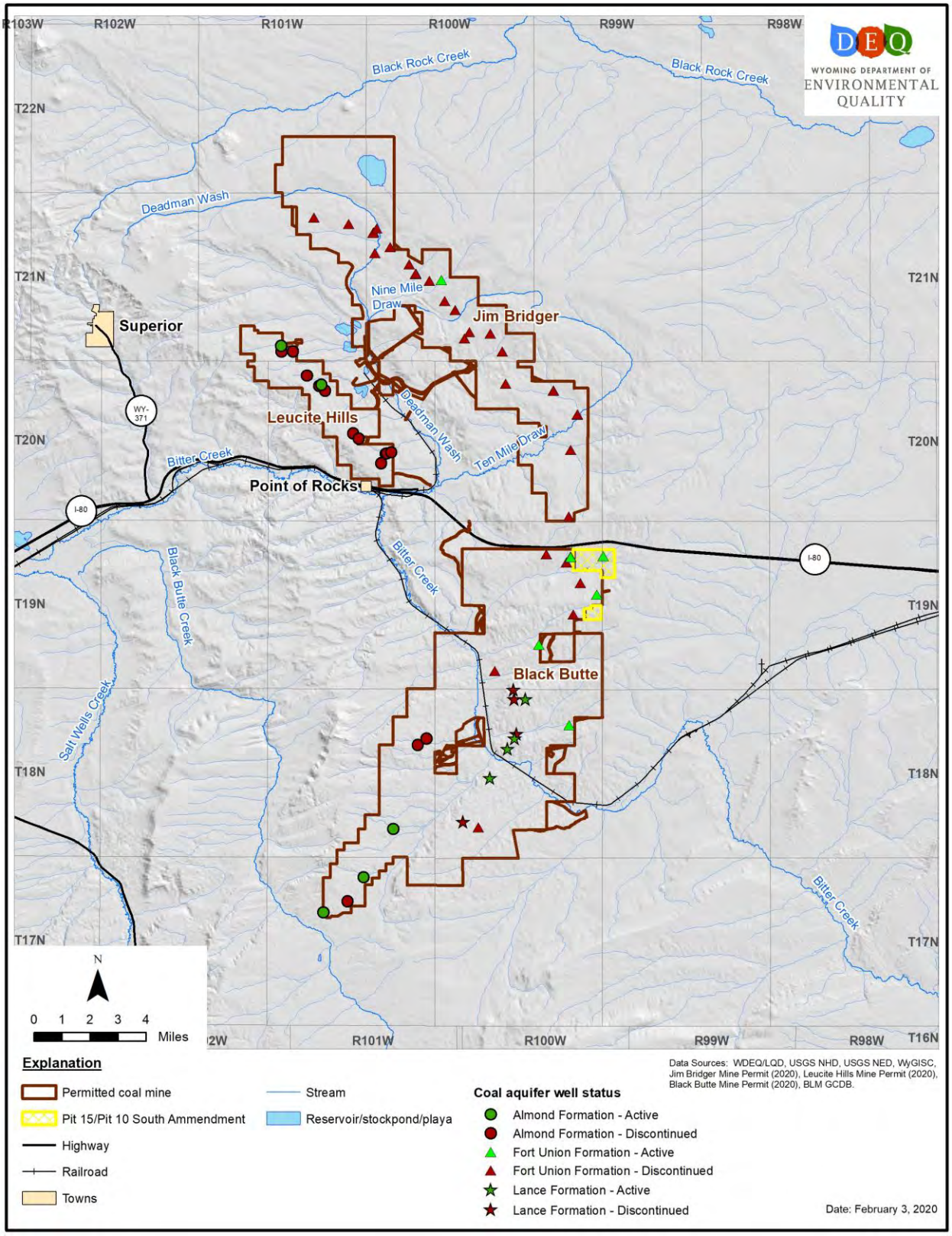


Figure 17. Location and status of monitoring wells in the coal aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines. Well status is current as of February 2020.

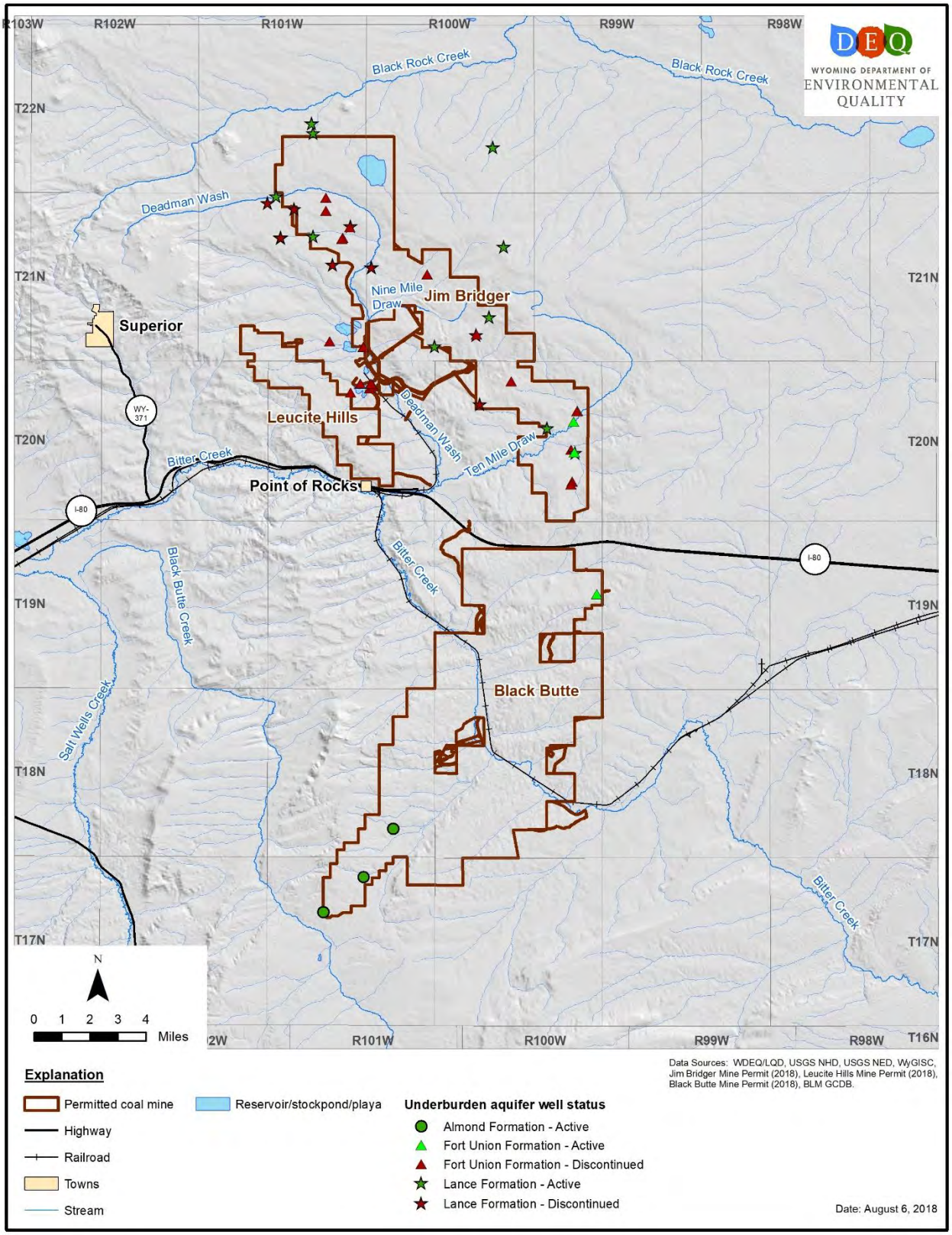


Figure 18. Location and status of monitoring wells in the underburden aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines. Well status is current as of February 2020.

In the Ericson Sandstone aquifer, a total of 14 monitoring wells were considered to evaluate baseline and during-mining hydrologic conditions in the groundwater CIA. As of February 2020, two wells were active while 12 have been discontinued (**Table 7**). One of the Ericson monitoring wells is at the Jim Bridger Mine, seven wells are at the Leucite Hills Mine, and six wells are at the Black Butte Mine (**Figure 19**). Well depths for the 14 wells range from 343 to 4,932 feet, with a median of 724 feet.

In the backfill aquifer, a total of 29 monitoring wells were considered to evaluate hydrologic conditions in the reclaimed areas at the three mines. As of February 2020, 20 wells were active while nine have been discontinued (**Table 7**). The location of the backfill wells roughly corresponds to the areas that have been permanently reclaimed at the mines (**Figure 20**). The Jim Bridger Mine has 15 backfill wells, while the Leucite Hills Mine has two wells and the Black Butte Mine has three wells (**Table 7**; **Figure 20**). For the backfill wells, depths range from 56 feet at a well at the Jim Bridger Mine to 240 feet at a well at the Jim Bridger Mine. The median depth for the backfill monitoring wells is 142 feet.

Static groundwater level and water quality data are currently collected from the monitoring wells at the mines on a monthly, quarterly, semi-annual, or annual basis depending on individual permit requirements. Static groundwater levels are monitored at all but two of the 112 active monitoring wells within the aquifer units at the three mines (**Figure 21**). Groundwater quality is monitored at a slightly smaller subset of wells (**Figure 21**).

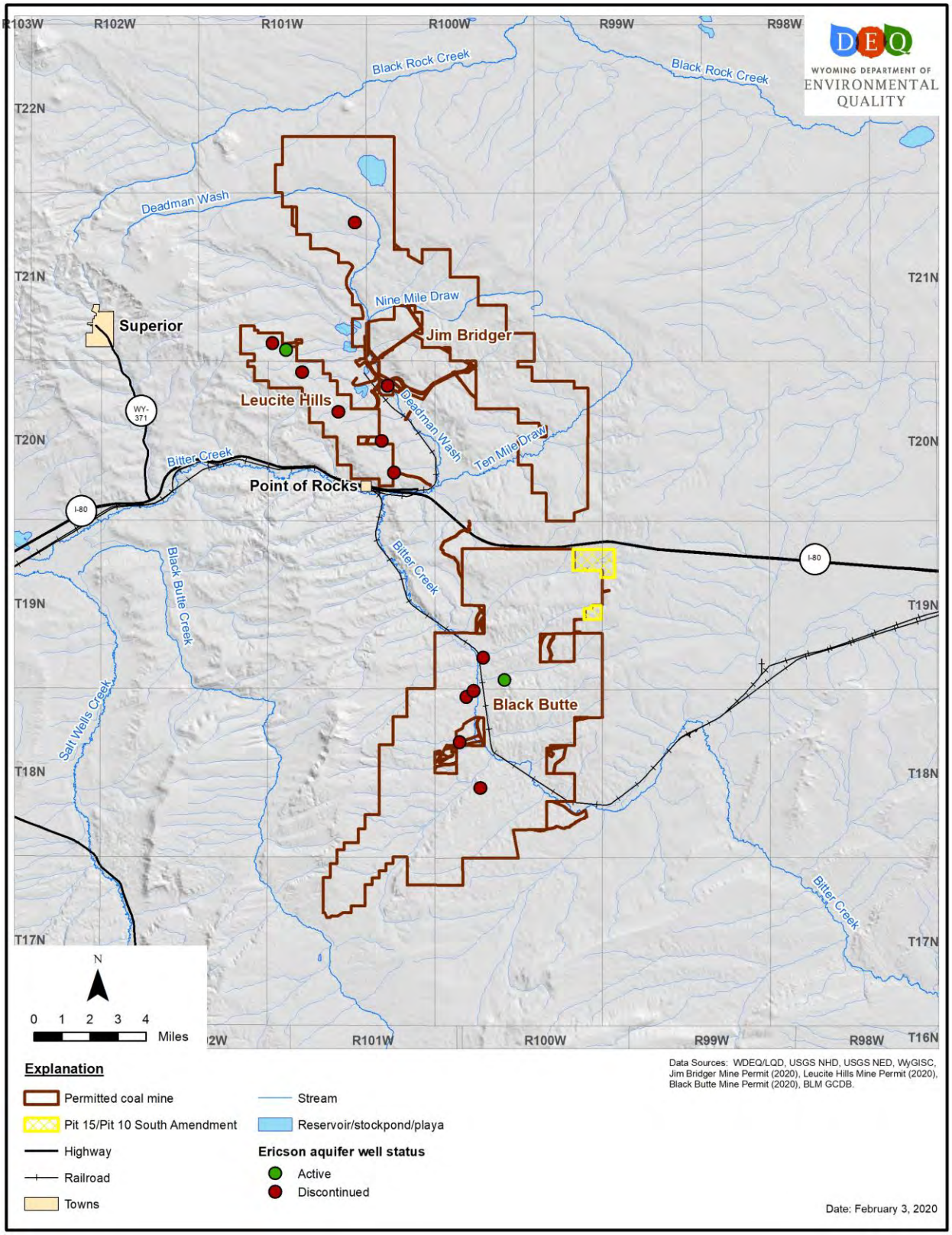


Figure 19. Location and status of monitoring wells in the Ericson Sandstone aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines. Well status is current as of February 2020.

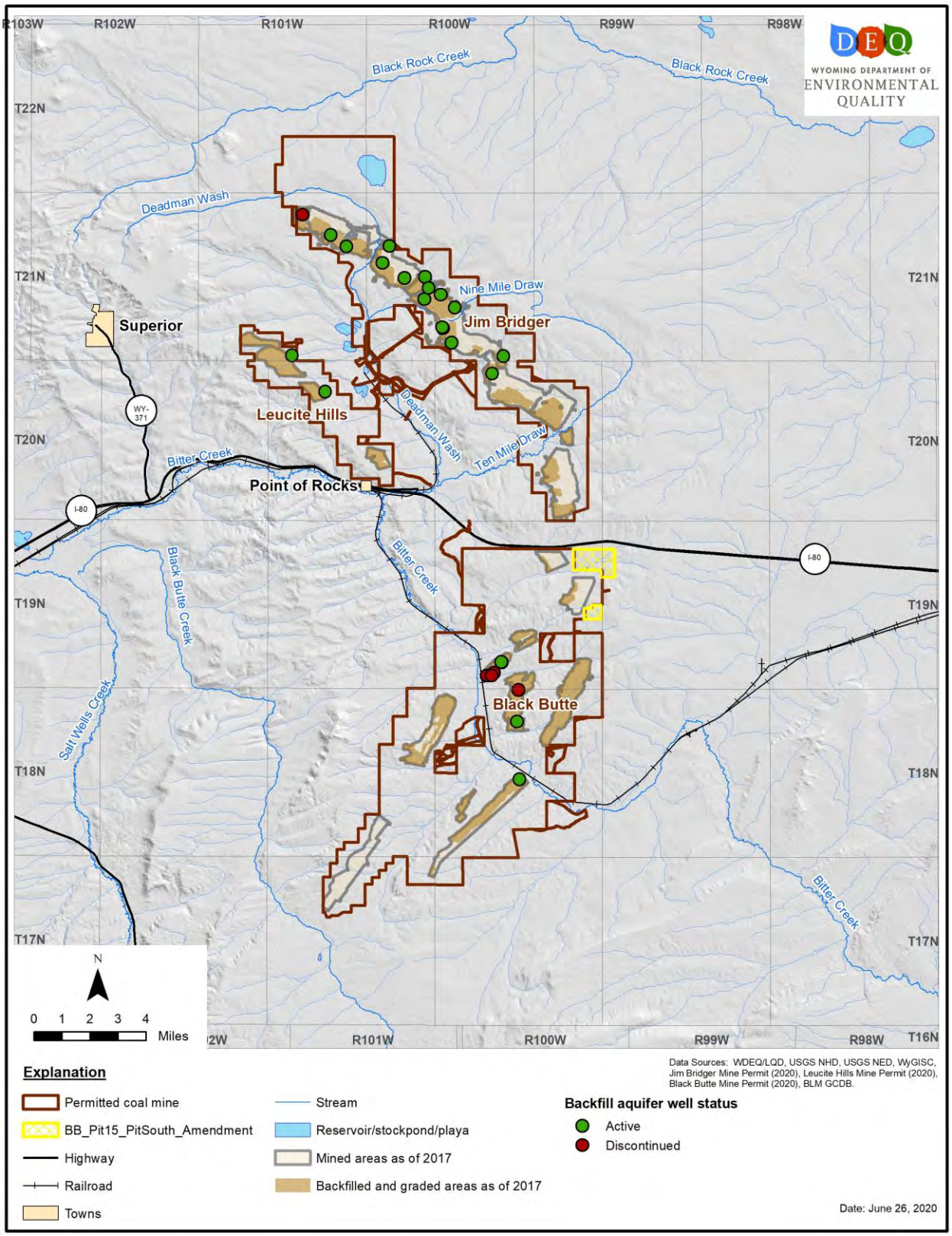
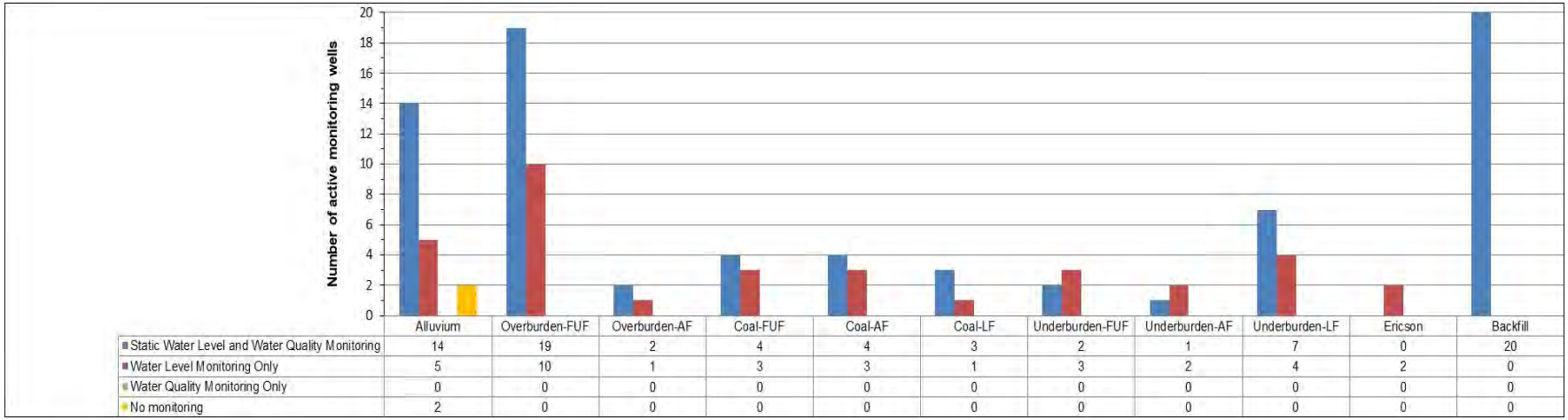


Figure 20. Location and status of monitoring wells in the backfill aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines. Well status is current as of February 2020.



	Alluvium	Overburden-FUF	Overburden-AF	Coal-FUF	Coal-AF	Coal-LF	Underburden-FUF	Underburden-AF	Underburden-LF	Ericson	Backfill
Static Water Level and Water Quality Monitoring	14	19	2	4	4	3	2	1	7	0	20
Water Level Monitoring Only	5	10	1	3	3	1	3	2	4	2	0
Water Quality Monitoring Only	0	0	0	0	0	0	0	0	0	0	0
No monitoring	2	0	0	0	0	0	0	0	0	0	0

Figure 21. Number of active monitoring wells by element monitored and aquifer unit (as of February 2020).

3. BASELINE HYDROLOGIC CONDITIONS

Baseline data are collected to characterize pre-mining hydrologic conditions. Baseline data from the surface water and groundwater CIAs are reflective of both temporal and spatial variability. As discussed in Section 1.4, not all mines initiated mining at the same time. In the interim, new lands were amended to existing permits. Thus, data collected at later permitted mines and at new amendment areas have the potential to be influenced by previous mining. Underlying those temporal changes, both aquifers and watersheds have natural spatial variability. This natural variability can be reflected when new data, via the additions of new mines and amendments, are collected to characterize hydrologic conditions.

3.1 SURFACE WATER

3.1.1 BASELINE WATER QUANTITY AND WATER QUALITY OF INDIVIDUAL DRAINAGES IN THE BITTER CREEK CIA

The baseline water quantity and water quality of individual drainages in the Bitter Creek CIA are described in the following sections. The primary drainages potentially affected by coal mining in the CIA include Bitter Creek and Deadman Wash and its tributaries.

3.1.1.1 DEADMAN WASH

3.1.1.1.1 Water Quantity

Deadman Wash is the primary tributary to Bitter Creek above the point of accumulation for the surface water CIA at USGS Gaging Station No. 09216560 (**Figure 13**). The Deadman Wash watershed at the confluence with Bitter Creek has a drainage area of approximately 152 mi^2 and a total relief of 820 feet. The drainage contains 80 percent of the Leucite Hills mine permit area and 86 percent of the Jim Bridger mine permit area. A small area (1.6 mi^2) of the Deadman Wash drainage is within the north part of the Black Butte Mine permit boundary. Most of this area will be unaffected by mining with the exception of the part of the drainage that lies within the north half of Pit 11.

Surface mining activities at the Jim Bridger Mine intersect Deadman Wash and many associated tributaries, including Tenmile Draw, Nine and One Half Mile Wash, and Ninemile Wash (**Figure 11**). Drainage areas for Tenmile Draw, Nine and One Half Mile Wash, and Ninemile Wash are approximately 40, 9, and 17.4, mi^2, respectively. Deadman Wash and its tributaries are ephemeral drainages with the exception of isolated reaches of Tenmile Draw and Deadman Wash where springs and seeps are present. The underground mining area at the Jim Bridger Mine also underlies a small portion (3.25 mi^2) of the Deadman Wash watershed (**Figure 11**). This portion of the drainage is mostly unaffected by surface disturbance, although isolated areas of disturbance currently exist due to underground mine facilities such as pumping sites, roads, and ventilation shafts. Potential mining-related disturbance in this area also includes surficial expressions of subsidence.

Surface mining activities at the Leucite Hills Mine intersect several small, unnamed ephemeral tributaries of Deadman Wash (**Figure 11**). The drainage areas for the tributaries range from 0.31 to 3.58 mi^2 (Leucite Hills Mine Permit, 2020). Some of the tributaries are intercepted by

facilities ponds at the Jim Bridger Power Plant, downstream of the Leucite Hills Mine permit boundary.

Downstream of the Jim Bridger Power Plant, Deadman Wash sustains perennial flow, almost to the confluence with Bitter Creek. The change in flow regime is due to seepage from the power plant surge pond. The surge pond supplies cooling water to the plant and has an adjudicated water right with a priority date of February 1, 1973 (Wyoming State Engineer's Office, 2020a). This precedes the first mining at the Jim Bridger Mine, which started in 1974 in the vicinity of Ninemile Wash (Jim Bridger Mine Permit, 2020). The surge pond intercepts runoff from tributaries to Deadman Wash at the Leucite Hills Mine, but water is also piped from Fontenelle Reservoir on the Green River. The power plant also has two flue gas desulfurization (FGD) ponds and one evaporation pond that historically contributed recharge to the near surface aquifers that may discharge to Deadman Wash. FGD Pond 1 no longer holds water and is in the process of being closed (GEI Consultants, Inc., 2009). A groundwater collection and pump back system is now used to recover the seepage from both FGD ponds and pump it back into FGD 2 (GEI Consultants, Inc., 2009).

Baseline surface water quantity and quality for the Deadman Wash watershed were evaluated using data from monitoring stations operated by the USGS, the Jim Bridger Mine, and the Leucite Hills Mine. Although coal was first removed at the Jim Bridger Mine in 1974, the period for baseline characterization on Deadman Wash was extended until 1981 to match the period of record from USGS Station No. 09216550 – *Deadman Wash near Point of Rocks*. USGS Station No. 09216550 was located near the confluence with Bitter Creek (**Figure 13**) and operated from 1961 to 1981 (**Table 6**). The record spans the pre-mining and early-mining periods, as well as the period before and after construction of the Jim Bridger Power Plant and associated facility ponds. Annual peak flows for the period of record ranged from a low of 86 cubic feet per second (cfs) (0.6 cfs/mi^2) on June 18, 1975 to a high of 1,320 cfs (8.7 cfs/mi^2) on August 9, 1979 (**Table 8**). Most peak flows were generally recorded in the spring of the year, presumably due to snowmelt. The 1,320 cfs is estimated to be approximately a 25-year event when using the regression equations developed by Miller (2003) for the High Desert Region of Wyoming (**Table 9**). **Table 9** provides a comparison of peak flow estimates by varying recurrence intervals for Deadman Wash and its major tributaries.

In 1979, the Jim Bridger Mine installed a comprehensive network of crest gages and continuous recorders throughout the Deadman Wash drainage. These included upper Tenmile Draw (SWPS-13), Lower Tenmile Draw (SWPS-14), Tenmile Draw Tributary, Ninemile Wash (SWPS-10), Nine and One Half Mile Wash, Lower Deadman Wash (SWPS-9), and Upper Deadman Wash (SWPS-3) (**Figure 13**; **Table 6**). The baseline data from 1979 to 1980 illustrate the ephemeral nature of streams in the area, with flows occurring only in response to summer rainfall, and to a lesser extent, snowmelt in the spring. Peak flows were highest in most of drainages during the August 1979 event that resulted in a peak of 1,320 cfs at USGS Station No. 09216550 on Deadman Wash. Peak flows for this event were 42 cfs (1.4 cfs/mi^2) at Lower Deadman Wash, 13 cfs (0.7 cfs/mi^2) at Ninemile Wash, 375 cfs (121 cfs/mi^2) at Nine and One Half Mile Wash, and 114 cfs (14 cfs/mi^2) at Tenmile Draw Tributary. The gage on Lower Tenmile Draw was washed out during the storm. The peak discharge on Nine and One Half Mile Wash was particularly impressive given the size of the drainage area. The regression equations in Miller (2003) estimate the flow to be on the order of a 100 to 200-year event.

Table 8. Peak flows and unit-area peak flows measured at USGS Station No. 09216550 on Deadman Wash near Point of Rocks, 1961 to 1981.

Date	Peak Discharge (cfs)	Peak Discharge (cfs/mi²)
March 12, 1961	325	2.1
March 27, 1962	1,070	7.0
August 13, 1963	1,240	8.2
March 1964	220	1.4
June 10, 1965	630	4.1
March 1966	260	1.7
May 29, 1967	700	4.6
August 19, 1968	135	0.9
July 29, 1969	160	1.1
April 24, 1970	290	1.9
March 1971	330	2.2
April 1972	230	1.5
July 13, 1973	660	4.3
March 1974	390	2.6
June 18, 1975	86	0.6
March 1976	370	2.4
July 24, 1977	830	5.5
April 29, 1978	310	2.0
August 9, 1979	1,320	8.7
May 5, 1980	570	3.8
July 26, 1981	390	2.6

Table 9. Peak flow estimates by recurrence interval for Deadman Wash and its major tributaries, based on equations of Miller (2003). Estimates were rounded to the nearest 10 cfs. Values in parentheses are the lower and upper 95% confidence intervals for the estimate.

Recurrence interval	USGS 09216550-Deadman Wash near Point of Rocks (152 mi²) (cfs)	Tenmile Draw (40 mi²) (cfs)	Ninemile Wash (17.4 mi²) (cfs)	Nine and One Half Mile Wash (9 mi²) (cfs)
$Q_{1.5}$	160 (40 – 600)	70 (20 – 260)	40 (10 – 160)	30 (7 – 100)
Q_{2}	250 (70 – 850)	110 (30 – 380)	70 (20 – 230)	40 (10 – 150)
$Q_{2.33}$	300 (90 – 990)	130 (40 – 440)	80 (30 – 270)	50 (20 – 180)
Q_{5}	570 (190 – 1,740)	270 (90 – 820)	170 (60 – 510)	110 (40 – 340)
Q_{10}	870 (290 – 2,580)	420 (140 – 1,250)	270 (90 – 800)	180 (60 – 540)
Q_{25}	1,320 (440 – 4,000)	660 (220 – 1,990)	430 (140 – 1,300)	300 (100 – 890)
Q_{50}	1,720 (550 – 5,380)	870 (280 – 2,740)	580 (190 – 1,810)	400 (130 – 1,250)
Q_{100}	2,150 (660 – 7,090)	1,120 (340 – 3,680)	750 (230 – 2,460)	520 (160 – 1,720)
Q_{200}	2,640 (760 – 9,230)	1,400 (400 – 4,870)	940 (270 – 3,290)	670 (190 – 2,330)
Q_{500}	3,350 (870 – 12,810)	1,810 (470 – 6,920)	1,240 (320 – 4,740)	890 (230 – 3,390)

Baseline surface water data collection at the Leucite Hills Mine began in 1979. Six crest gages were installed on unnamed ephemeral channels in the small watersheds that drain the permit area (SW1-SW6) (**Figure 13**, **Table 6**). Drainage areas for the watersheds range from 0.1 to 3.04 mi². From 1979 to 1981, estimated peak flows ranged from 0.24 to 193 cfs at the six gages within the permit boundary (Leucite Hills Mine Permit, 2020). Peak flows were highly variable across the gages for many of the same storm events. The 193 cfs recorded at SW-6 is equal to a unit-area discharge of 150 cfs/mi², which is approximately a 100-year event according to the regression equations of Miller (2003). Due to the small contributing areas, ephemeral flow regime,

and the influence of facility ponds at the Jim Bridger Power Plant that intercept runoff from some of the mine, the drainages within the Leucite Hills Mine permit area probably play a limited role in the overall hydrologic balance of the Deadman Wash watershed.

3.1.1.1.2 Water Quality

The Wyoming Department of Environmental Quality Water Quality Division (WDEQ/WQD) has two surface water classifications for Deadman Wash. Upstream of the Jim Bridger Power Plant, Deadman Wash is Class 3B water (Wyoming Department of Environmental Quality, 2020a). Class 3B waters are intermittent or ephemeral streams with sufficient hydrology to normally support and sustain communities of aquatic life including invertebrates, amphibians, or other flora and fauna which inhabit water of the state at some stage of their life cycles (WDEQ Water Quality Rules, Ch. 1, § 4). Supported uses include aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic value (**Table 10**). Class 3B waters must meet acute and chronic water quality standards for aquatic life other than fish. The WDEQ/WQD numeric standards for selected constituents for Class 3B waters are presented in **Table 11**.

Downstream of the Jim Bridger Power Plant, Deadman Wash is Class 2AB(ww) water (Wyoming Department of Environmental Quality, 2020a). The change in classification is presumably due to the flow contributed from the surge pond at the power plant that the WDEQ/WQD deems sufficient to support drinking water and fish. Class 2AB waters support game fish populations or spawning and nursery areas at least seasonally. Class 2AB waters are also presumed to have sufficient water quality and quantity to support drinking water supplies. Supported uses include drinking water, game fish, nongame fish, fish consumption, other aquatic life, recreation, wildlife, agriculture, industry, and scenic value (**Table 10**). The "ww" notation indicates a predominance of warm water species present (WDEQ Water Quality Rules, Ch. 1, § 4). In addition to meeting acute and chronic water quality standards for aquatic life, Class 2AB waters must meet standards for fish and drinking water. The WDEQ/WQD numeric standards for selected constituents for Class 2AB(ww) waters are presented in **Table 11**.

The WDEQ/WQD has classified Ninemile Wash, Nine and One Half Mile Wash, and Tenmile Draw as Class 3B water (Wyoming Department of Environmental Quality, 2020a) (**Table 11**). All other unnamed ephemeral tributaries to Deadman Wash would be also be classified as Class 3B under the unlisted waters guidance of Chapter 1 of the WDEQ/WQD Rules and Regulations (WDEQ Water Quality Rules, Ch. 1, Appendix A).

Table 10. Wyoming surface water classifications and supported uses, as defined by the WDEQ/WQD (Wyoming Department of Environmental Quality, 2020a; WDEQ Water Quality Rules, Ch. 1, § 4).

Class	Description	Sub-Class and Description	Uses Supported
Class 1	Outstanding Waters		Drinking water, game fish, non-game fish, fish consumption, other aquatic life, recreation, wildlife, agriculture, industry, scenic value
Class 2	Fisheries and/or Drinking Water	Class 2A (Drinking water only)	Drinking water, other aquatic life, recreation, wildlife, agriculture, industry, scenic value
		Class 2AB (Fish and drinking water)	Drinking water, game fish, non-game fish, fish consumption, other aquatic life, recreation, wildlife, agriculture, industry, scenic value
		Class 2B (Cold and warm water fish only)	Game fish, non-game fish, fish consumption, other aquatic life, recreation, wildlife, agriculture, industry, scenic value
		Class 2C (Non-game warm water fish only)	Non-game fish, fish consumption, other aquatic life, recreation, wildlife, agriculture, industry, scenic value
		Class 2D (Effluent-dependent, fish supporting)	Game fish (when present), non-game fish (when present), fish consumption, other aquatic life, recreation, wildlife, agriculture, industry, scenic
Class 3	Aquatic Life Other Than Fish	Class 3A (Isolated waters)	Other aquatic life, recreation, wildlife, agriculture, industry, scenic value
		Class 3B (Intermittent and ephemeral streams)	Other aquatic life, recreation, wildlife, agriculture, industry, scenic value
		Class 3C (Perennial streams)	Other aquatic life, recreation, wildlife, agriculture, industry, scenic value
		Class 3D (Effluent-dependent waters)	Other aquatic life, recreation, wildlife, agriculture, industry, scenic value
Class 4	Agricultural, Industry, Recreation and Wildlife (aquatic life uses not attainable)	Class 4A (Canals and ditches)	Recreation, wildlife, agriculture, industry, scenic value
		Class 4B (Intermittent and ephemeral streams)	Recreation, wildlife, agriculture, industry, scenic value
		Class 4C (Isolated waters)	Recreation, wildlife, agriculture, industry, scenic value

Table 11. Select numeric WDEQ/WQD standards for Class 2AB(ww), Class 2C, and Class 3B waters.

Constituent	Units	Class 2AB(ww)	Class 2C	Class 3B		
		DEADMAN WASH BELOW JIM BRIDGER POWER PLANT	BITTER CREEK	DEADMAN WASH ABOVE JIM BRIDGER POWER PLANT	TENMILE DRAW	NINEMILE WASH AND OTHER CLASS 3B STREAMS IN CIA
Aluminum (dissolved)	mg/L	0.75[1]	0.75[1]	0.75[1]	0.75[1]	0.75[1]
Ammonia (NH3 as N) (total)	mg/L	0.92[2]	1.09[2]	NA[3]	NA[3]	NA[3]
Arsenic	mg/L	0.01[4]	0.01[4]	0.15[5,12]	0.15[5,12]	0.15[5,12]
Barium (total)	mg/L	2	NA	NA	NA	NA
Cadmium (dissolved)*	mg/L	0.0006[6,12]	0.0004[12]	0.0004[12]	0.0003[12]	0.0006[12]
Chloride (total)	mg/L	230	230	NA	NA	NA
Chromium(III)*	mg/L	0.1[4]	0.136[5,12]	0.136[5,12]	0.087[5,12]	0.231[5,12]
Copper (dissolved)*	mg/L	0.029[6,12]	0.017[12]	0.017[12]	0.011[12]	0.029[12]
Dissolved oxygen	mg/L	> 3[7]	> 3[7]	NA[8]	NA[8]	NA[8]
Iron (dissolved)	mg/L	0.3	1	1	1	1
Lead (dissolved)*	mg/L	0.011[6,12]	0.005[12]	0.005[12]	0.002[12]	0.011[12]
Manganese (dissolved)*	mg/L	0.05[12]	2.188[12]	2.188[12]	1.621[12]	3.105[12]
Mercury	µg/L	0.05[4]	0.051[4]	0.77[5]	0.77[5]	0.77[5]
Nickel*	mg/L	0.168[6,12]	0.097[12]	0.097[5,12]	0.061[12]	0.168[12]
Nitrate+Nitrite as N (total)	mg/L	10	NA	NA	NA	NA
pH	SU	6.5 - 9.0	6.5 - 9.0	6.5 - 9.0	6.5 - 9.0	6.5 - 9.0
Selenium (dissolved)	mg/L	0.0046[6,12]	0.0046[12]	0.0046[12]	0.0046[12]	0.0046[12]
Temperature	°C	< 30	< 30	NA[9]	NA[9]	NA[9]
Turbidity	NTU	< 15[10,11]	< 15[10,11]	NA	NA	NA
Zinc (dissolved)*	mg/L	0.382[6]	0.222	0.222	0.139	0.382

Table developed from WDEQ/WQD Rules and Regulations, Chapter 1 (Adopted April 24, 2018). Criteria represent concentrations meant to protect both human health and aquatic life uses. Note that the constituents listed are not an exhaustive list of all constituents with standards established by WDEQ/WQD.

* Hardness dependent criteria for aquatic life, determined as follows: a hardness of 400 mg/L $CaCO_3$ was used for Deadman Wash below the Jim Bridger Power Plant and Ninemile Wash based on data from USGS Station 09216550 and Jim Bridger Mine station SWPS-10; a hardness of 220 mg/L $CaCO_3$ was used for Bitter Creek based on the median hardness from USGS Stations 09216545 and 09216560; a hardness of 210 mg/L $CaCO_3$ was used for Deadman Wash above the Jim Bridger Power Plant based on the median hardness from Jim Bridger Mine stations SWPS-3 and SWPS-9; a hardness of 121 mg/L $CaCO_3$ was used for Tenmile Draw based on the median hardness from Jim Bridger Mine stations SWPS-13 and SWPS-14. [1]Assumes pH ≥ 7.0 and hardness as $CaCO_3$ ≥ 50 mg/L; [2]Criterion Continuous Concentration (CCC) for fish early life stages present – calculated for Bitter Creek using median pH and temperature from USGS Stations 09216550 and 09216545; calculated for Deadman Wash using data from USGS Station 09216560; [3]Numeric criteria do not apply but concentrations of ammonia attributable to or influenced by human activities shall not be present in concentrations which could result in harmful acute or chronic effects to aquatic life, or which would not fully support existing and designated uses; [4]Total value; [5]Dissolved value; [6]Value is the aquatic life criterion since the human health value was less stringent or did not apply; [7]1-day minimum instantaneous concentration for other life stages – warm water criteria; [8]Minimum concentrations do not apply but pollution attributable to the activities of man shall not deplete dissolved oxygen amounts to a level which will result in harmful acute or chronic effects to aquatic life, or which would not fully support existing and designated uses; [9]A maximum allowable temperature does not apply, but pollution attributable to the activities of man shall not change ambient water temperatures to levels which result in harmful acute or chronic effects to aquatic life, or which not fully support existing and designated uses; [10]In all warm water or nongame fisheries, the discharge of substances attributable or influenced by the activities of man shall not be present in quantities which would result in a turbidity increase of 15 NTUs; [11]Due to the variable nature of turbidity and the difficulty in establishing an ambient turbidity value, turbidity data in this CHIA will not be evaluated against numeric criteria; [12] Chronic value, or four day average concentration for aquatic life; NA (not applicable).

Seven water quality samples were collected at USGS Station No. 09216550 on Deadman Wash from 1976 to 1978. However, only one sample contained a larger suite of parameters; the other six samples were mostly analyzed for total suspended solids (TSS). The one sample with a larger suite of parameters indicated a sodium sulfate water type (RockWare, Inc., 2015). Although few dissolved metals were analyzed, the sample met select WDEQ/WQD Class 2AB(ww) standards. One noteworthy aspect of the limited dataset includes the high TSS concentrations measured. TSS ranged from 48 mg/L at a flow of 0.12 cfs to 109,000 mg/L at a flow of 340 cfs. The 109,000 mg/L was also taken on the rising limb of the hydrograph, as two other samples taken during the same event had lower TSS values despite being taken at higher flows. This pattern is often typical in the Bitter Creek watershed, as more sediment is available for transport during the early stages of an event (Lowham et al., 1982). The focus on monitoring TSS implies that sediment is the primary water quality constituent of concern in the area; this focus is evident in the baseline and current water quality sampling conducted by the mines. High TSS concentrations in streams of the area are not unusual, particularly after high intensity precipitation events on areas that have erosive soils and low vegetative cover.

There are limited water quality data available from the Deadman Wash drainage during the baseline and early stages of mining at the Jim Bridger Mine. The Jim Bridger Mine Permit (2020) and Leucite Hills Mine Permit (2020) summarize data from 1974 to 1976 on sampling locations on Deadman Wash located above (Station 12) and below (Stations 13 and 14) the Jim Bridger Power Plant (**Figure 13**; **Table 6**). Individual sample data are not presented in the permits, so statistical analyses cannot be conducted. Although only two samples are available for Station 12, the data indicate an increase in major ion concentrations downstream of the power plant. The maximum total dissolved solids (TDS) concentration measured at Station 12 was 400 mg/L, compared to 5,399 mg/L at Station 13 and 10,050 mg/L at Station 14 near Point of Rocks (**Table 12**). The means of the major ions indicated sodium bicarbonate water at Station 12, and sodium sulfate water at Stations 13 and 14 (RockWare, Inc., 2015). The two samples at Station 12 showed no exceedances of WDEQ/WQD Class 3B standards. The maximum concentrations of lead exceeded Class 2AB(ww) standards at both Stations 13 and 14, and the maximum concentrations of chloride and manganese exceeded Class 2AB(ww) standards at Station 14 (**Table 12**).

Water quality data collected from 1979 to 1980 at the Jim Bridger Mine showed that TSS concentrations can get very high during runoff events. Maximum TSS concentrations were 826,500 mg/L on Ninemile Wash (35 cfs, March 1980), 3,211 mg/L on Nine and One Half Mile Wash (375 cfs, August 1979), 801,500 mg/L on Tenmile Draw Tributary (114 cfs, August 1979), and 834,500 mg/L on Upper Deadman Wash (32 cfs, March 1980). Some skepticism should be given to the TSS value reported greater than 800,000 mg/L, as this most likely includes larger particle sizes that would probably be better characterized as bedload. Over 1979 to 1980, a full suite of parameters were sampled on Lower Tenmile Draw (two samples), Upper Tenmile Draw (two samples), Tenmile Draw Tributary (one sample), and Nine and One Half Mile Wash (one sample) (**Table 13**). Water types included sodium sulfate on Upper Tenmile Draw, sodium bicarbonate on Lower Tenmile Draw and Tenmile Draw Tributary, and calcium bicarbonate on Nine and One Half Mile Wash (RockWare, Inc., 2015). Exceedances of WDEQ/WQD Class 3B standards occurred on Upper Tenmile Draw (aluminum, copper, nickel, zinc), Lower Tenmile Draw (aluminum, copper, iron), and Tenmile Draw Tributary (zinc) (**Table 13**).

Table 12. Baseline water quality statistics for selected constituents on Deadman Wash upstream and downstream of the Jim Bridger Power Plant, 1974-1976.

Constituent	Units	Deadman Wash (Jim Bridger Mine Station 12)[1] (1974-1976)			Deadman Wash (Jim Bridger Mine Station 13)[2] (1974-1976)			Deadman Wash (Jim Bridger Mine Station 14)[2] (1974-1976)		
		Number of samples	Min	Max	Number of samples	Min	Max	Number of samples	Min	Max
Arsenic (dissolved)	mg/L	2	<0.01	<0.01	6	<0.01	<0.01	6	<0.01	<0.01
Chloride (dissolved)	mg/L	2	9.70	37.0	6	18.0	175.0	6	40.0	1,730
Chromium (dissolved)	mg/L	2	<0.01	<0.05	6	<0.01	<0.01	6	<0.01	<0.05
Copper (dissolved)	mg/L	2	<0.01	<0.10	6	<0.10	0.02	6	<0.01	<0.05
Dissolved oxygen (field)	mg/L	2	4.70	10.40	6	4.50	8.10	6	4.90	9.50
Iron (dissolved)	mg/L	1	0.66	0.66	5	<0.05	0.24	4	<0.05	0.14
Lead (dissolved)	mg/L	2	<0.01	<0.05	6	<0.01	0.50	6	<0.01	0.30
Manganese (dissolved)	mg/L	2	<0.05	0.08	6	<0.05	0.01	6	0.04	0.23
Mercury (dissolved)	µg/L	2	unknown	<10	6	unknown	unknown	6	unknown	<90
pH (field)	S.U.	2	8.20	8.30	5	8.20	8.30	6	8.20	8.60
Temperature (field)	°C	2	0.10	1.50	6	0.20	20.00	6	0.20	7.20
Zinc (dissolved)	mg/L	2	<0.05	<0.10	6	<0.10	0.30	6	<0.10	0.03
Boron (dissolved)	mg/L	1	<0.10	<0.10	6	0.05	0.70	5	0.20	1.90
Fluoride (dissolved)	mg/L	2	0.30	1.00	6	0.20	0.60	6	0.20	1.10
Sodium (dissolved)	mg/L	2	<1.0	50.0	6	80.0	350.0	6	58.0	1,800
Sulfate (dissolved)	mg/L	2	50.0	125.0	6	160.0	3,449	6	115.0	4,499
TDS dried at 180 °C	mg/L	2	230	400	6	540	5,399	6	570	10,050
Total suspended solids	mg/L	2	375	1,460	6	33	170	5	82	3,710

[1]Classified as 3B by the WDEQ/WQD; [2]Classified as 2AB(ww) by the WDEQ/WQD. Maximum concentrations shown in red exceed WDEQ/WQD surface water quality standards.

Table 13. Baseline water quality statistics for selected constituents on Tenmile Draw, Tenmile Draw Tributary, and Nine and One Half Mile Wash at the Jim Bridger Mine, 1979-1980.

		Upper Tenmile Draw (Jim Bridger Mine) (1979-1980)			Lower Tenmile Draw (Jim Bridger Mine) (1979-1980)			Tenmile Draw Tributary (Jim Bridger Mine) (1979-1980)			Nine and One Half Mile Wash (Jim Bridger Mine) (1979-1980)		
Constituent	**Units**	**Number of samples**	**Min**	**Max**	**Number of samples**	**Min**	**Max**	**Number of samples**	**Min**	**Max**	**Number of samples**	**Min**	**Max**
Aluminum (total)	mg/L	2	0.01	1.1	2	0.03	2.03	1	0.002	0.002	1	0.014	0.014
Arsenic (total)	mg/L	2	<0.001	0.003	2	0.006	0.01	1	<0.001	<0.001	1	0.005	0.005
Barium (total)	mg/L	2	0.546	0.60	2	0.04	0.08	1	0.13	0.13	1	0.08	0.08
Cadmium (total)	mg/L	2	<0.001	<0.001	2	<0.001	<0.001	1	<0.001	<0.001	1	<0.001	<0.001
Chloride (dissolved)	mg/L	2	178	596	2	82	322	1	48	48	1	<0.1	<0.1
Chromium (total)	mg/L	2	<0.001	0.04	2	<0.001	0.004	1	<0.001	<0.001	1	<0.001	<0.001
Copper (total)	mg/L	2	0.002	0.014	2	0.003	0.023	1	0.01	0.01	1	0.005	0.005
Iron (dissolved)	mg/L	2	0.06	0.60	2	0.52	1.42	1	0.56	0.56	1	0.35	0.35
Manganese (dissolved)	mg/L	2	0.21	0.26	2	0.033	0.19	1	0.21	0.21	1	0.45	0.45
Mercury (dissolved)	µg/L	2	<0.2	<0.2	2	<0.2	<0.2	1	<0.2	<0.2	1	<0.2	<0.2
Nickel (total)	mg/L	2	<0.001	0.075	2	<0.001	<0.001	1	<0.001	<0.001	1	<0.001	<0.001
pH (field)	S.U.	2	7.3	8.3	2	8.3	8.9	1	8.3	8.3	1	7.6	7.6
Selenium (total)	mg/L	2	<0.001	<0.001	2	<0.001	0.003	1	<0.001	<0.001	1	<0.001	<0.001
Zinc (total)	mg/L	2	<0.001	0.39	2	0.029	0.123	1	0.51	0.51	1	0.04	0.04
Boron (dissolved)	mg/L	2	0.35	0.95	2	0.41	0.53	1	0.28	0.28	1	0.11	0.11
Sodium (dissolved)	mg/L	2	1,202	2,730	2	155	580	1	317	317	1	24	24
Sulfate (dissolved)	mg/L	2	1,253	5,200	2	254	600	1	466	466	1	122	122
TDS dried at 180 °C	mg/L	2	3,790	8,450	2	530	1,620	1	1,000	1,000	1	198	198

Maximum concentrations shown in red exceed WDEQ/WQD Class 3B surface water quality standards.

At the Leucite Hills Mine, TSS samples were collected in 1979 and 1980 from five of the six baseline stations (SW-1, SW-3, SW-4, SW-5, SW-6) (Leucite Hills Mine Permit, 2020). TSS ranged from 16.7 to 29,743 mg/L, with the higher values recorded after high-intensity rainstorm events rather than after snowmelt. However, the relationship between peak runoff rate and TSS concentration was highly variable among the stations. The limited number of parameters sampled precludes a comparison to Class 3B standards.

3.1.1.2 BITTER CREEK

3.1.1.2.1 Water Quantity

Bitter Creek is a major tributary of the Green River, part of the Colorado River Basin. Within the surface water CIA, Bitter Creek flows in a northwesterly direction, has a drainage area of 758 mi^2, and a total relief of approximately 1,000 feet. Bitter Creek within the CIA is an intermittent stream due to the presence of localized springs and seeps (Black Butte Mine Permit, 2020). As discussed in Section 3.1.1.1, the reach of Bitter Creek downstream of Deadman Wash is influenced by flows contributed by leakage from the surge pond at the Jim Bridger Power Plant.

Bitter Creek is the primary drainage at the Black Butte Mine, flowing in a northwesterly direction across the center of the permit area (**Figure 13**). The entire Black Butte Mine resides in the Bitter Creek drainage with the exception of 2.3 percent of the permit area that drains to Black Butte Creek near Pit 14 in the southwest corner of the permit boundary. Surface mining activities at the Black Butte Mine intersect several small, unnamed ephemeral tributaries of Bitter Creek (**Figure 11**). The channel of Bitter Creek within the permit area is undisturbed by mining; the channel has not been mined through or diverted. However, historic construction activities associated with the Union Pacific Railroad resulted in rechannelization and straightening of Bitter Creek along short reaches within the mine permit boundary (Black Butte Mine Permit, 2020). Major tributaries to Bitter Creek upstream of the Black Butte Mine include Patrick Draw, Antelope Creek, and Laney Wash (**Figure 13**). The Pit 15/Pit 10 South Amendment Area lies within unnamed headwater ephemeral drainages to Bitter Creek (**Figure 2**).

Baseline surface water quantity and quality for Bitter Creek were evaluated using data from monitoring stations operated by the USGS, the Jim Bridger Mine, and the Black Butte Mine. Although coal was first removed at the Jim Bridger Mine in 1974 and the Black Butte Mine in 1979, the period for baseline characterization on Bitter Creek was extended until 1981 to match the period of record from several of the USGS stations in the drainage.

The Bitter Creek CIA is delineated as the watershed upstream of USGS Station No. 09216560, *Bitter Creek near Point of Rocks, WY* (**Figure 13**; **Table 6**). USGS Gaging Station No. 09216560 operated as a peak streamflow gage for a period of 14 years (1961-1975). The WDEQ/LQD funded water quality sampling at the gage in 2015 and 2018 to present. Annual peak flows for the period of record ranged from a low of 70 cfs (0.1 cfs/mi^2) on June 18, 1975 to a high of 1,650 cfs (2.2 cfs/mi^2) on March 27, 1962 (**Table 14**). Most peak flows were generally recorded in the spring of the year, presumably due to snowmelt. The 1,650 cfs is estimated to be approximately a five to ten year event when using the regression equations of Miller (2003) (**Table 15**). **Table 15** provides a comparison of peak flow estimates by varying recurrence intervals for Bitter Creek at varying stream gages evaluated in this CHIA.

Table 14. Peak flows and unit-area peak flows measured at USGS Station No. 09216560 on Bitter Creek near Point of Rocks, 1961 to 1975.

Date	Peak Discharge (cfs)	Peak Discharge (cfs/mi²)
March 12, 1961	659	0.9
March 27, 1962	1,650	2.2
August 13, 1963	1,300	1.7
1964[1]	105	0.1
June 9, 1965	1,270	1.7
March 1966[1]	175	0.2
June 23, 1967	495	0.7
August 19, 1968	225	0.3
April 23, 1969	196	0.3
April 24, 1970	510	0.7
May 30, 1971	450	0.6
April 1972[1]	385	0.5
July 20, 1973	1,380	1.8
April 20, 1974	470	0.6
June 18, 1975	70	0.1

[1]Exact date not reported.

Table 15. Peak flow estimates by recurrence interval for Bitter Creek at select gaging station locations, based on equations of Miller (2003). Estimates were rounded to the nearest 10 cfs. Values in parentheses are the lower and upper 95% confidence intervals for the estimate.

Recurrence interval	USGS 09216560- Bitter Creek near Point of Rocks (758 mi²) (cfs)	SBC2 – Bitter Creek at downstream Black Butte Mine boundary (596 mi²) (cfs)	SBC1 – Bitter Creek at upstream Black Butte Mine boundary (494 mi²) (cfs)	USGS 09216545- Bitter Creek near Bitter Creek (308 mi²) (cfs)
$Q_{1.5}$	440 (120 – 1,650)	400 (110 – 1,490)	380 (100 – 1,420)	290 (80 – 1,080)
Q_2	660 (190 – 2,260)	600 (180 – 2,060)	580 (170 – 1,970)	440 (130 – 1,510)
$Q_{2.33}$	780 (240 – 2,600)	720 (220 – 2,380)	690 (210 – 2,280)	530 (160 – 1,750)
Q_5	1,420 (470 – 4,320)	1,310 (430 – 4,010)	1,280 (420 – 3,890)	1,000 (330 – 3,040)
Q_{10}	2,070 (700 – 6,170)	1,940 (650 – 5,770)	1,890 (640 – 5,640)	1,500 (500 – 4,450)
Q_{25}	3,040 (1,010 – 9,190)	2,870 (950 – 8,660)	2,820 (930 – 8,520)	2,250 (750 – 6,800)
Q_{50}	3,850 (1,230 – 12,050)	3,640 (1,170 – 11,400)	3,600 (1,150 – 11,270)	2,900 (930 – 9,080)
Q_{100}	4,710 (1,430 – 15,500)	4,480 (1,360 – 14,730)	4,440 (1,350 – 14,600)	3,600 (1,100 – 11,850)
Q_{200}	5,670 (1,620 – 19,770)	5,400 (1,550 – 18,850)	5,370 (1,540 – 18,740)	4,390 (1,260 – 15,310)
Q_{500}	6,980 (1,820 – 26,720)	6,680 (1,740 – 25,590)	6,670 (1,740 – 25,530)	5,490 (1,430 – 21,030)

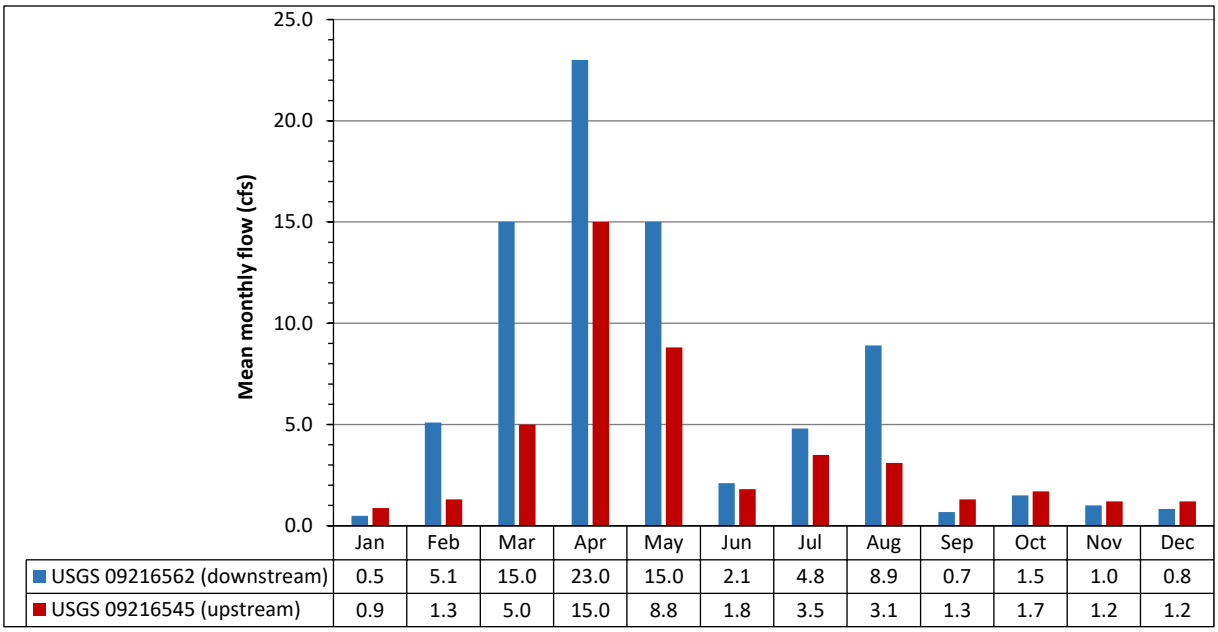
A more detailed analysis of streamflow characteristics on Bitter Creek was evaluated using data from two continuous recording gages that operated during the baseline period: USGS Station No. 09216562 - *Bitter Creek above Salt Wells Creek near Salt Wells, Wyoming* (1976-1981) and Station No. 09216545 - *Bitter Creek near Bitter Creek, Wyoming* (1975-1981) (**Figure 13**; **Table 6**). Station No. 09216562 is located approximately 12 miles downstream of the mines, outside of the surface water CIA, and Station No. 09216562 is located upstream of the Black Butte Mine within the surface water CIA (**Figure 13**).

The majority of streamflow at USGS Station No. 09216562 on Bitter Creek above Salt Wells Creek occurs during snowmelt runoff in the spring (March through May) (**Figure 22**). A smaller peak in streamflow occurs in July and August due to runoff from high-intensity rainfall. This pattern is also shown at USGS Station No. 09216545 on upper Bitter Creek, but the mean monthly

flow values during snowmelt and summer rainstorms are lower (**Figure 22**). However, mean monthly streamflows were higher during the months of September through January, indicating a more consistent baseflow component in the winter months, possibly due to contributions from springs (**Figure 22**).

The average annual runoff for the period of record at USGS Station No. 09216562 on lower Bitter Creek was 4,784 ac-ft with a mean unit area annual runoff of 5.8 ac-ft/mi^2. For comparison, the average annual runoff at USGS Station No. 09216545 on upper Bitter Creek was 2,768 ac-ft with a mean unit area annual runoff of 9.0 ac-ft/mi^2. The lower annual unit area runoff at the lower Bitter Creek station is presumably due to losses that increase with increasing drainage area.

Annual daily peak flows at USGS Station No. 09216545 on upstream Bitter Creek ranged from 75 cfs on July 13, 1981 to 346 cfs on May 18, 1980. The peak flows recorded at the gage over the period were frequent events (<5 years) when compared to the peak flow regression equations of Miller (2003) (**Table 15**).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
USGS 09216562 (downstream)	0.5	5.1	15.0	23.0	15.0	2.1	4.8	8.9	0.7	1.5	1.0	0.8
USGS 09216545 (upstream)	0.9	1.3	5.0	15.0	8.8	1.8	3.5	3.1	1.3	1.7	1.2	1.2

Figure 22. Distribution of mean monthly flow on Bitter Creek at USGS Station Nos. 09216562 and 09216545 on Bitter Creek, 1975-1981.

Hydrographs and flow duration curves for the USGS stations on Bitter Creek indicate the differences in daily streamflow between sites (**Figure 23**; **Figure 24**). The maximum mean daily flow recorded at USGS Gaging Station No. 09216562 was 411 cfs on August 10, 1979. At USGS Station No. 09216545 on upper Bitter Creek, the mean daily discharge on this same date was only 10 cfs, indicating the flow at the downstream station was most likely caused by a localized storm over another part of the watershed. The maximum mean daily flow recorded over the period of record at USGS Gaging Station No. 09216545 on upper Bitter Creek was 225 cfs on May 18, 1980. This was likely a snowmelt event, and resulted in a mean daily flow of 224 cfs the next day on May 19, 1980 at the downstream USGS station (**Figure 23**).

The downstream USGS station on Bitter Creek showed a higher frequency of higher daily flows, and this is to be expected given the larger drainage area (**Figure 24**). However, there was a higher frequency of low daily flows (<1 cfs) at the upstream USGS station, most likely owing to a

more consistent baseflow contribution from springs. It is also possible that lower flows were reduced at the downstream gage due to diversions. The Pierotto Ditch, located approximately 2.5 miles upstream from USGS Station No. 09216562, has held a water right since 1950 to divert 0.57 cfs (Wyoming State Engineer's Office, 2020a). At the downstream USGS gaging station, flow was not recorded 31 percent of the time. In contrast, the upstream station on Bitter Creek had no flow for only four percent of the period (**Figure 24**). The variability in mean daily streamflow between the two gages precludes an attempt to estimate daily flows at the point of accumulation for the surface water CIA at USGS Station No. 09216560 near Point of Rocks.

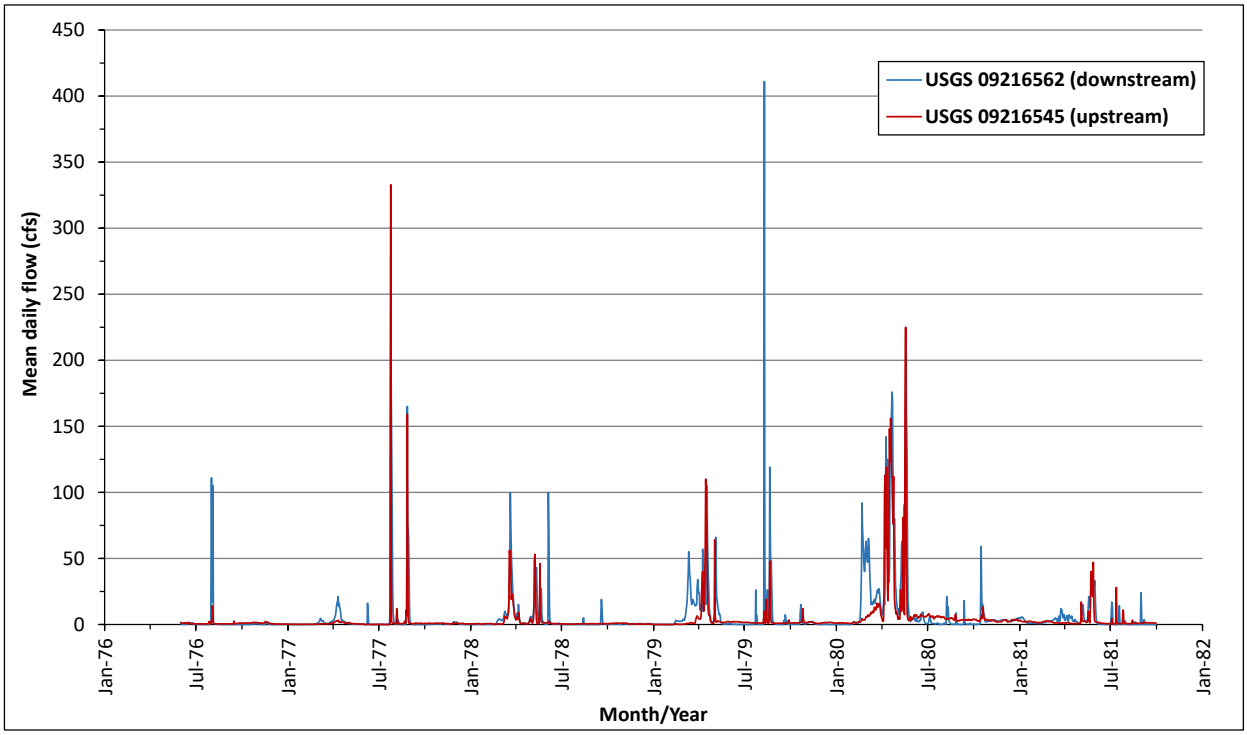


Figure 23. Mean daily flow on Bitter Creek at USGS Station Nos. 09216562 and 09216545, 1976 to 1982.

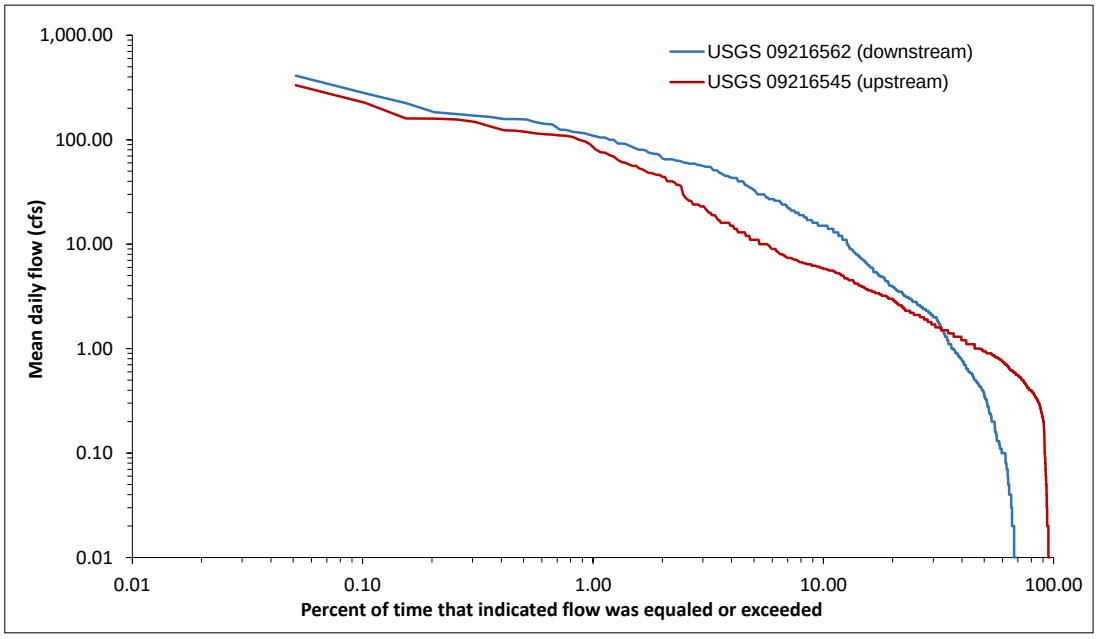


Figure 24. Flow duration curves for Bitter Creek at USGS Station Nos. 09216562 and 09216545, June 1, 1976 to September 20, 1981.

The Black Butte Mine installed Parshall flumes with continuous recorders on Bitter Creek at locations upstream (SBC1) and downstream (SBC2) of the mine permit boundary (**Figure 13**; **Table 6**) (Black Butte Mine Permit, 2020). These flumes operated from 1975 to 1987, but numerous operational problems forced the mine to switch to crest gages to monitor instantaneous peak flows. Raw data are not available in the WDEQ/LQD Hydrology Database, but the hydrographs from the continuous monitoring from April 1975 through September 1979 in the Black Butte Mine Permit (2020) shows that flow at the downstream gage was usually higher than the upstream gage. Runoff was very sporadic at SBC1 in the summer months, with long periods of little or no flow. Winter periods often showed no flow due to ice blockage. Flow at SBC2 was supplemented by an oil test well that yielded approximately 0.5 to 1 cfs into Bitter Creek within the mine permit area. Based on the results of the baseline monitoring, the Black Butte Mine considered Bitter Creek an intermittent stream, although there are no obvious springs along the channel of Bitter Creek within the mine permit boundaries (Black Butte Mine Permit, 2020).

Precipitation data from the Rock Springs Airport downstream of the Bitter Creek CIA show that most of the period used for baseline characterization had annual precipitation that was at or below the long-term average of 8.6 inches. The exception was 1978, which had 13.4 inches of precipitation. It should be cautioned that the short periods of record at the gages on Bitter Creek and its tributaries are probably not suitable for determining long-term average conditions. Lowham (1988) suggests that a minimum of 25 years of data are required to reasonably establish flow characteristics such as annual runoff, mean daily flows, and unit-area runoff on intermittent and ephemeral drainages in Wyoming.

3.1.1.2.2 Water Quality

The WDEQ/WQD has classified Bitter Creek as Class 2C water (Wyoming Department of Environmental Quality, 2020a). Class 2C waters are known to support or have the potential to support only nongame fish populations or spawning and nursery areas at least seasonally (WDEQ Water Quality Rules, Ch. 1, § 4). Class 2C waters include all permanent and seasonal nongame

fisheries and are considered warm water. Supported uses include nongame fish, fish consumption, other aquatic life, recreation, wildlife, agriculture, industry, and scenic value (**Table 10**). The WDEQ/WQD numeric standards for selected constituents for Class 2C surface waters are presented in **Table 11**.

The WDEQ/WQD Class 2C classification for Bitter Creek is warranted because there are native non-game fish present in parts of the drainage. The Black Butte Mine conducted a baseline fish monitoring study in 1980 along four sites along Bitter Creek within the permit boundary (Black Butte Mine Permit, 2020). Three species were captured, with speckled dace being the most common. Mountain sucker was the second most common, and two flannelmouth suckers were caught. The flannelmouth sucker is considered a NSS1(Aa) species by the Wyoming Game and Fish Department (WGFD) (Wyoming Game and Fish Department, 2010). The NSS1(Aa) listing indicates: (1) the population status is greatly restricted in numbers and distribution and extirpation possible, and (2) the species is declining in genetic purity due to introgression with nonnative sucker species (Wyoming Game and Fish Department, 2010). In 2003-2005, the WGFD conducted native fish surveys throughout the Green River Basin drainage and found flannelmouth suckers in Bitter Creek above the Black Butte Mine (Kern et al., 2006). This is the only known Wyoming population of flannelmouth suckers that are not hybridizing with white suckers, making the population the only unique genetic assemblage in the Green River Basin upstream of Flaming Gorge Dam.

Anecdotes from travelers along the Overland Trail provide historical insight into the water quality of Bitter Creek and its suitability for human consumption. As retold by Gardner (2013), on June 7, 1863, one such traveler named A. Howard Cutting reached the Black Butte Stage Station, located within the present-day Black Butte Coal Mine permit boundary:

> *…the water in Bitter Creek…is so strongly impregnated with Alkali we can hardly drink it… The creek the water is stagnate so low it can't run, the sides of the bank crusted . . . by the water evaporating in the sun and leaving Alkali. The water is a dirty reddish color and tastes no one can know how till they try it. The water grows worse, so bad now, that even Whiskey won't help it. It gives us a kind of pain in the stomach which is hard to bear.*

Very few water quality samples were collected at USGS Station No. 09216560 on Bitter Creek near Point of Rocks over its 15 year period of record. Over 1975 to 1976, six TSS samples were collected and one sample was analyzed for an additional, albeit limited, set of parameters (**Table 16**). Sodium and sulfate were the dominant ions, and TSS ranged from 46 to 4,040 mg/L. Given the limited number of samples, it is not possible to evaluate the data against WDEQ/WQD Class 2C standards.

The Jim Bridger Mine collected water quality samples from Bitter Creek from 1974 to 1976 at Station 20, located near Point of Rocks approximately in the same location as USGS Station No. 09216560 (see **Figure 13**). Although approximately 14 samples were collected, limited statistics could be calculated since the Jim Bridger Mine Permit (2020) only presents summaries and not individual sample data. The maximum concentrations of chloride, lead, and zinc exceeded Class 2C standards (**Table 16**). Since individual sample data were not presented in the permit, it is not possible to determine the number of exceedances that occurred for each of these parameters.

Table 16. Baseline water quality statistics for selected constituents on Bitter Creek near Point of Rocks, 1974-1976.

Constituent	Units	USGS Station No. 09216550 Bitter Creek near Point of Rocks (1975-1976)			Station 20 (Jim Bridger Mine) (1974-1976)		
		Number of samples	Min	Max	Number of samples	Min	Max
Arsenic (dissolved)	mg/L	0	-	-	14	<0.01	<0.01
Chloride (dissolved)	mg/L	1	65	65	14	38	670
Chromium (dissolved)	mg/L	0	-	-	13	<0.01	<0.05
Copper (dissolved)	mg/L	0	-	-	14	<0.01	<0.10
Iron (dissolved)	mg/L	1	0.1	0.1	7	0.05	0.20
Lead (dissolved)	mg/L	0	-	-	14	<0.01	0.30
Manganese (dissolved)	mg/L	0	-	-	14	0.02	0.36
Mercury (dissolved)	µg/L	0	-	-	14	unknown	<0.02
pH (field)	S.U.	1	8.40	8.40	13	7.80	8.60
Zinc (dissolved)	mg/L	0	-	-	14	<0.01	2.00
Boron (dissolved)	mg/L	1	0.12	0.12	13	<0.01	2.60
Fluoride (dissolved)	mg/L	1	0.5	0.5	0	-	-
Sodium (dissolved)	mg/L	1	150	150	14	64	590
Sulfate (dissolved)	mg/L	1	210	210	14	140	1,050
Total suspended solids	mg/L	6	46	4,040	0	-	-

Maximum concentrations shown in red exceed WDEQ/WQD Class 2C surface water quality standards.

A larger set of baseline water quality data for Bitter Creek come from stations upstream of Point of Rocks at the Black Butte Mine and USGS Station No. 09216545 near the town of Bitter Creek. Beginning in 1981, water quality samples were collected from Black Butte Mine stations SBC1 and SBC2. The 1981 data from these two stations were evaluated for baseline characterization; the data collected after 1981 are analyzed in Section 6. Upstream of the Black Butte Mine, a total of 155 water quality samples were collected at USGS Station No. 09216545 from 1975 to 1981. A statistical summary of the baseline water quality data collected at SBC1, SBC2, and USGS Station No. 09216545 is presented in **Table 18**. The medians in **Table 18** for constituents with non-detect concentrations were calculated using methods recommended by Helsel (2005). Non-detect concentrations are defined as concentrations that fall somewhere between zero and the laboratory reporting limit. For constituents with < 50 percent non-detects, the non-parametric Kaplan-Meier method was used to calculate the median concentration. For constituents with 50-79 percent non-detects, the robust regression on order statistics (ROS) method or the Kaplan-Meier method was used to calculate the median concentration. For constituents with ≥ 80 percent non-detects, medians were not calculated, rather the proportion of data below the maximum detection limit was reported. Minitab software (Minitab, Inc., 2007; Minitab, Inc., 2017) was used to calculate Kaplan-Meier and ROS estimates using macros available from Practical Stats (2012), Practical Stats (2019), and Helsel (2012).

The three samples collected in 1981 at SBC1 and SCB2 indicate very similar water quality on Bitter Creek above and below the Black Butte Mine. Sodium sulfate water occurred in each sample from each station (RockWare, Inc., 2015). The median TDS was 117 mg/L at SBC1 at the

upstream permit boundary and 128 mg/L at SBC2 at the downstream permit boundary (**Table 18**). Dissolved metal concentrations were low at both stations, with numerous values below detection limits. At SBC1, WDEQ/WQD Class 2C exceedances occurred for aluminum (one sample), ammonia as nitrogen (two samples), iron (one sample), and field pH (one sample). At SBC2, Class 2C exceedances occurred for aluminum (one sample) and ammonia as nitrogen (one sample) (**Table 18**).

At USGS Station No. 09216545 on upper Bitter Creek, the 1975 to 1981 data also indicate that sodium sulfate was the dominant water type (RockWare, Inc., 2015). Dissolved metal concentrations were low, with numerous values below detection limits. Class 2C exceedances were noted for mercury (one sample) and field pH (eight samples) (**Table 18**). TDS, calculated as the sum of constituents, ranged from 295 to 2,740 mg/L, with a median of 1,265 mg/L. TDS generally decreased with increasing flow due to dilution (**Figure 25**). The relationship followed a power function, although the coefficient of determination (R^2) of the predictive equation was only marginal at 0.52. TSS concentrations ranged from 22 to 21,900 mg/L with a median of 246 mg/L (**Table 18**). TSS increased with flow following a power function, resulting in a coefficient of determination (R^2) of 0.67 (**Figure 25**). The equation for the relationship was used to develop sediment discharge rating curves to predict daily suspended sediment yields using mean daily streamflow. The daily values were then used to estimate annual suspended sediment yields (**Table 17**). Annual yields over the four full years of record were variable. Yields ranged from 8,500 to 98,400 tons, with a median of 28,300 tons (**Table 17**).

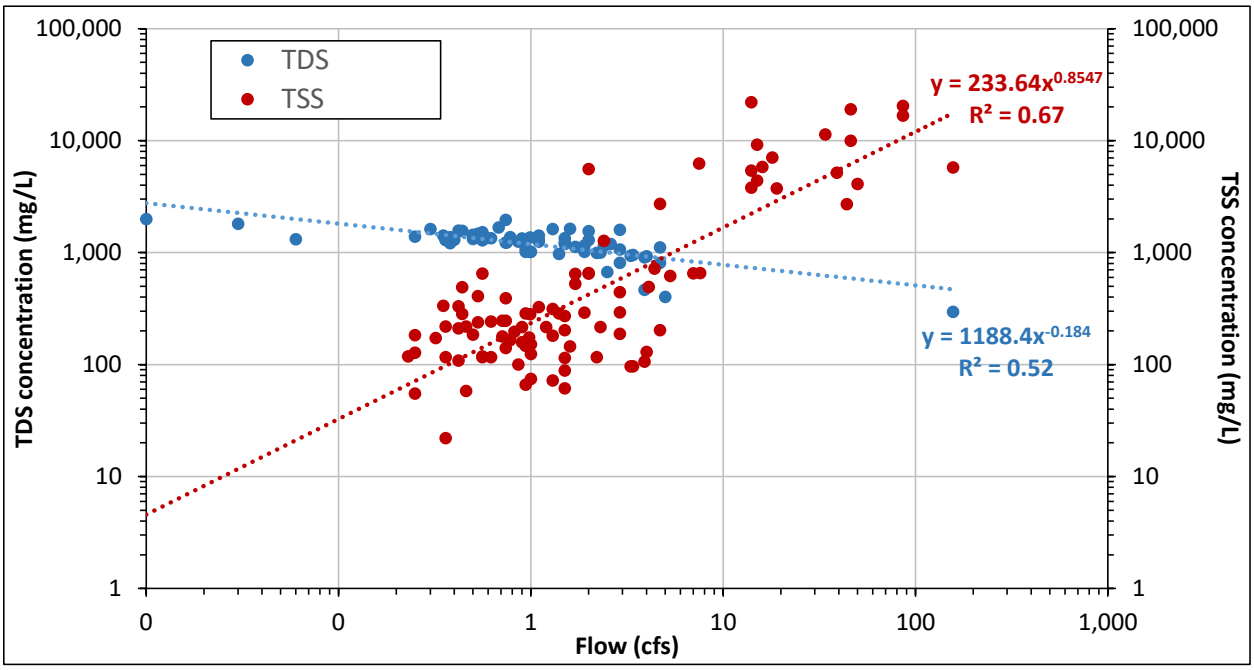


Figure 25. Relationship between flow and TDS and TSS on Bitter Creek at USGS Station No. 09216545.

Table 17. Estimated annual suspended sediment yields on Bitter Creek at USGS Station No. 09216545.

Year	Tons	Tons/mi²
1977	40,200	131
1978	8,500	28
1979	16,300	53
1980	98,400	319
Median	*28,300*	*92*

Table 18. Baseline water quality statistics for selected constituents on Bitter Creek near the Black Butte Mine, 1975-1981.

		USGS Station No. 09216545 Bitter Creek near Bitter Creek (1975-1981)					SBC1 – Bitter Creek upstream mine permit boundary (Black Butte Mine) (1981)					SBC2 – Bitter Creek downstream mine permit boundary (Black Butte Mine) (1981)				
Constituent	**Units**	**Number of samples**	**Min**	**Max**	**Median**	**Number of exceedances**	**Number of samples**	**Min**	**Max**	**Median**	**Number of exceedances**	**Number of samples**	**Min**	**Max**	**Median**	**Number of exceedances**
Aluminum (dissolved)	mg/L	6	<0.1	0.02	0.02	0	3	<0.5	1.0	Unavailable[2]	1	3	<0.5	1.0	0.6	1
Ammonia as N (total)	mg/L	76	<0.01	0.46	0.06	0	2	1.3	1.8	1.55	2	3	0.8	6.5	1.1	2
Arsenic (dissolved)	mg/L	6	0.001	0.002	0.0015	0	3	<0.005	<0.005	100% <0.005	0	3	<0.005	<0.005	100% <0.005	0
Barium (dissolved)	mg/L	0	-	-	-	NA	3	<0.1	<0.1	100% <0.1	NA	3	<0.1	<0.1	100% <0.1	NA
Cadmium (dissolved)	mg/L	6	<0.001	<0.002	100% <0.002	0	3	<0.03	<0.03	100% <0.003	0	3	<0.03	<0.03	100% <0.003	0
Chloride (dissolved)	mg/L	78	4.9	92	38	0	3	76[1]	130[1]	100[1]	0	3	62	140	71	0
Chromium (dissolved)	mg/L	6	<0.02	<0.02	100% <0.02	0	0	-	-	-	-	0	-	-	-	-
Copper (dissolved)	mg/L	0	-	-	-	-	3	<0.04	<0.04	100% <0.04	0	3	<0.04	<0.04	100% <0.04	0
Dissolved oxygen (field)	mg/L	80	6.7	11.9	9.4	0	0	-	-	-	-	0	-	-	-	-
Iron (dissolved)	mg/L	76	<0.01	0.77	0.07	0	2	0.24	1.20	0.72	1	0	-	-	-	-
Lead (dissolved)	mg/L	6	<0.2	<0.2	100% <0.2	0	3	<0.2	<0.4	100% <0.4	0	3	<0.2	<0.4	100% <0.4	0
Manganese (dissolved)	mg/L	0	-	-	-	-	3	<0.05	<0.05	100% <0.05	0	3	<0.05	<0.05	100% <0.05	0
Mercury (dissolved)	µg/L	6	<0.5	0.5	83% <0.5	1	3	<1	<1	100% <1	0	3	<1	<1	100% <1	0
Nickel (dissolved)	mg/L	6	<0.05	<0.05	100% <0.05	0	3	<0.1	<0.1	100% <0.1	0	3	<0.1	<0.1	100% <0.1	0
Nitrite plus nitrate as N (total)	mg/L	75	<0.1[1]	0.95[1]	0.08	NA	0	-	-	-	NA	0	-	-	-	NA
pH (field)	S.U.	81	7.80	9.30	8.50	8	3	7.90	9.12	8.19	1	3	7.36	8.23	7.80	0
Selenium (dissolved)	mg/L	6	<0.001	<0.001	0.001	0	3	<0.005	<0.005	100% <0.005	0	3	<0.005	<0.005	100% <0.005	0
Temperature (field)	°C	151	0	29	10	0	2	3.5	12.3	7.9	0	2	1.0	14.0	7.5	0
Turbidity	NTU	31	1.4	5,000	130	-	3	18	170	95	-	3	63	140	97	-
Zinc (dissolved)	mg/L	6	<0.02	0.02	0.01	0	3	<0.02	<0.02	100% <0.02	0	3	<0.02	<0.02	100% <0.02	0
Boron (dissolved)	mg/L	77	0.01	0.46	0.2	NA	2	0.04	0.18	0.11	NA	2	0.15	0.40	0.28	NA
Fluoride (dissolved)	mg/L	78	0.3	2.0	0.8	NA	3	0.9[1]	1.4[1]	1.3[1]	NA	3	0.7	1.2	1.1	NA
Sodium (dissolved)	mg/L	78	58	840	340	NA	3	300[1]	590[1]	370[1]	NA	3	240	450	310	NA
Sulfate (dissolved)	mg/L	78	56	1,400	600	NA	3	500[1]	910[1]	600[1]	NA	3	470	790	660	NA
TDS dried at 180 °C	mg/L	0	-	-	-	NA	3	1,170	1,870	1,290	NA	3	1,010	1,620	1,290	NA
Total suspended solids	mg/L	105	22	21,900	246	NA	3	20	230	117	NA	3	62	170	128	NA

Maximum concentrations shown in red exceed WDEQ/WQD Class 2C surface water quality standards; NA=no numeric standard established for stream classification. [1]Total value. [2]Not enough data to produce a median using methods recommended by Helsel (2005).

3.2 GROUNDWATER

3.2.1 DESCRIPTION OF AQUIFERS AND AQUIFER PROPERTIES

The following sub-section will provide a description of the aquifers of concern in the CIA as well as key aquifer properties such as hydraulic conductivity, transmissivity, storage coefficients, and other key characteristics. Some of the basic definitions that will be used in this section are discussed below.

Unconfined and confined are the two basic types of aquifers. An aquifer is considered unconfined if water only partially fills the aquifer materials and water freely rises and declines along the unsaturated/saturated zone boundary. These unconfined aquifers are often referred to as water-table aquifers. A confined aquifer is generally defined when water completely fills the aquifer materials and is overlain by a confining bed. A common term for a confined aquifer is an artesian aquifer. The water level from a well that permits water solely from a confined aquifer to enter the well will be above the structural top of the confined aquifer but not necessarily above the land surface. In addition to unconfined and confined aquifers, there is also perched groundwater where groundwater is sitting on top of a low permeable layer.

Hydraulic conductivity (K) is dependent on the aquifer properties and is a measure of the ease with which a geologic medium transmits water; higher K materials transmit water more easily than lower K materials. The unit used for K in this CHIA is feet per day (feet/day). Transmissivity (T) is hydraulic conductivity (K) multiplied by aquifer thickness (b); the unit used for T in this CHIA is feet^2/day. The storage coefficient (S) of an aquifer is the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in potentiometric head. Storage coefficient is presented as a unitless parameter in this CHIA. The magnitude of the storage coefficient indicates whether the aquifer is unconfined or confined. Confined aquifers are typically indicated by storage coefficients less than 0.001 (Freeze and Cherry, 1979).

The mines have conducted numerous aquifer tests to characterize the hydraulic properties of the aquifers of concern within the CIA. Summary statistics of hydraulic conductivity and storage coefficient grouped by aquifer unit and by mine are presented in **Table 19**. In many cases, the mines analyzed the aquifer test results using multiple analytical techniques and therefore analysis of a single aquifer test might result in multiple hydraulic conductivity or storage coefficients. For the purposes of this CHIA, multiple analyses or tests reported at a single well were averaged to represent the aquifer properties at that location. The aquifer tests at the mines focused on determining the horizontal hydraulic conductivity and no tests reported the vertical hydraulic conductivity of the aquifers of concern. Therefore, use of the term hydraulic conductivity in this CHIA refers to the horizontal hydraulic conductivity.

Table 19. Summary statistics of hydraulic conductivity and storage coefficients by aquifer unit and mine.

Aquifer unit	Formation	Mine	Hydraulic conductivity (feet/day)				Storage coefficient (unitless)			
			Number of wells tested	Minimum	Maximum	Median	Number of wells tested	Minimum	Maximum	Median
Alluvial	-	Jim Bridger	6	2.2	166	4.2	---	---	---	---
		Leucite Hills	---	---	---	---	---	---	---	---
		Black Butte	16	0.2	46	5.0	7	1.0×10^{-4}	2.5×10^{-3}	5.0×10^{-4}
		Total for all mines	***22***	***0.2***	***166***	***4.2***	***7***	***1.0×10^{-4}***	***2.5×10^{-3}***	***5.0×10^{-4}***
Overburden	Fort Union	Jim Bridger	23	0.01	16	1.2	7	8.1×10^{-5}	1.0×10^{-2}	4.3×10^{-4}
		Leucite Hills	---	---	---	---	---	---	---	---
		Black Butte	---	---	---	---	---	---	---	---
		Total for all mines	***23***	***0.01***	***16***	***1.2***	***7***	***8.1×10^{-5}***	***1.0×10^{-2}***	***4.3×10^{-4}***
	Almond	Jim Bridger	---	---	---	---	---	---	---	---
		Leucite Hills	---	---	---	---	---	---	---	---
		Black Butte	3	0.30	1.2	0.30	---	---	---	---
		Total for all mines	***3***	***0.30***	***1.2***	***0.30***	---	---	---	---
Coal	Fort Union	Jim Bridger	9	0.32	20	0.90	5	5.0×10^{-5}	7.1×10^{-4}	2.6×10^{-4}
		Leucite Hills	---	---	---	---	---	---	---	---
		Black Butte	4	0.04	2.2	0.10	---	---	---	---
		Total for all mines	***13***	***0.04***	***20***	***0.8***	***5***	***5.0×10^{-5}***	***7.1×10^{-4}***	***2.6×10^{-4}***
	Lance	Jim Bridger	---	---	---	---	---	---	---	---
		Leucite Hills	---	---	---	---	---	---	---	---
		Black Butte	2	0.003	0.16	0.08	---	---	---	---
		Total for all mines	***2***	***0.003***	***0.16***	***0.08***	***---***	***---***	***---***	***---***
	Almond	Jim Bridger	---	---	---	---	---	---	---	---
		Leucite Hills	12	0.02	2.9	0.20	5	4.0×10^{-6}	3.9×10^{-4}	1.3×10^{-4}
		Black Butte	3	0.03	1.5	0.40	---	---	---	---
		Total for all mines	***15***	***0.02***	***2.9***	***0.20***	***5***	***4.0×10^{-6}***	***3.9×10^{-4}***	***1.3×10^{-4}***
Underburden	Fort Union	Jim Bridger	9	0.01	0.90	0.10	5	1.0×10^{-4}	1.0×10^{-2}	1.0×10^{-2}
		Leucite Hills	---	---	---	---	---	---	---	---
		Black Butte	---	---	---	---	---	---	---	---
		Total for all mines	***9***	***0.01***	***0.90***	***0.10***	***5***	***1.0×10^{-4}***	***1.0×10^{-2}***	***1.0×10^{-2}***
	Lance	Jim Bridger	9	0.01	0.8	0.10	1	2.0×10^{-5}	2.0×10^{-5}	--
		Leucite Hills	---	---	---	---	---	---	---	---
		Black Butte	---	---	---	---	---	---	---	---
		Total for all mines	***9***	***0.01***	***0.8***	***0.10***	***1***	***2.0×10^{-5}***	***2.0×10^{-5}***	--
	Almond	Jim Bridger	---	---	---	---	---	---	---	---
		Leucite Hills	---	---	---	---	---	---	---	---
		Black Butte	3	0.17	0.40	0.18	---	---	---	---
		Total for all mines	***3***	***0.17***	***0.40***	***0.18***	---	---	---	---
Ericson	Ericson	Jim Bridger	1	0.60	0.6	---	---	---	---	---
		Leucite Hills	4	0.10	2.6	1.4	1	1.5×10^{-1}	1.5×10^{-1}	---
		Black Butte	2	4.9	5.5	5.2	---	---	---	---
		Total for all mines	***7***	***0.10***	***5.5***	***2.2***	***1***	***1.5×10^{-1}***	***1.5×10^{-1}***	---

3.2.1.1 ALLUVIAL AQUIFER

Alluvial (Quaternary) deposits occur along major stream channels within or adjacent to the mine permit boundaries, including Deadman Wash, Tenmile Draw, Ninemile Wash, Bitter Creek, and several unnamed tributaries to these major stream channels. These alluvial deposits store and transmit water in sufficient quantities to be considered aquifers in some parts of the CIA. Unconsolidated mixtures of clay, silt, sand, and gravel characterize the alluvial materials.

The alluvial groundwater at the coal mines is generally perched and unconfined in localized permeable zones. The major unconfined groundwater system is the Bitter Creek alluvium. Isolated areas within the valley may give a confined appearance due to fine silts and clays overlaying coarser-grained material. Groundwater is encountered at many locations throughout the alluvium, especially near the channel thalweg. Monitor wells produced from 5 to 30 gpm when completed in the Bitter Creek alluvium. However, lesser yields (in some instances, less than one gpm) were observed at wells located in the alluvium away from Bitter Creek (Black Butte Mine Permit, 2020).

The alluvial aquifer is primarily recharged from the surface water infiltration along the stream channels. In select areas, depending on the local conditions, the alluvial aquifer may both recharge to and receive discharge from the underlying aquifers. Groundwater losses can also occur in the alluvial aquifer due to evapotranspiration.

A total of 22 alluvial aquifer tests were compiled from the three mines (**Figure 26**; **Table 19**). A majority (15) of the tests were located along Bitter Creek at the Black Butte Mine, while the Jim Bridger Mine conducted four tests on Tenmile Draw and two tests on Deadman Wash (**Figure 26**). No tests were conducted at the Leucite Hills Mine, owing to the lack of major stream channels and associated alluvium. Saturated thicknesses from the tests ranged from 9.0 to 72.0 feet, with a median of 60.0 feet. Hydraulic conductivities ranged from a low of 0.2 feet/day at several wells along Bitter Creek to a high of 166 feet/day at a well on Tenmile Draw (**Figure 26**). The median hydraulic conductivity of the alluvial aquifer was 4.2 feet/day (**Table 19**). Storage coefficients were reported from seven aquifer tests along Bitter Creek at the Black Butte Mine (**Figure 26**). These storage coefficients ranged from 1.0×10^{-4} to 2.5×10^{-3}, with a median of 5.0×10^{-4} (**Table 19**).

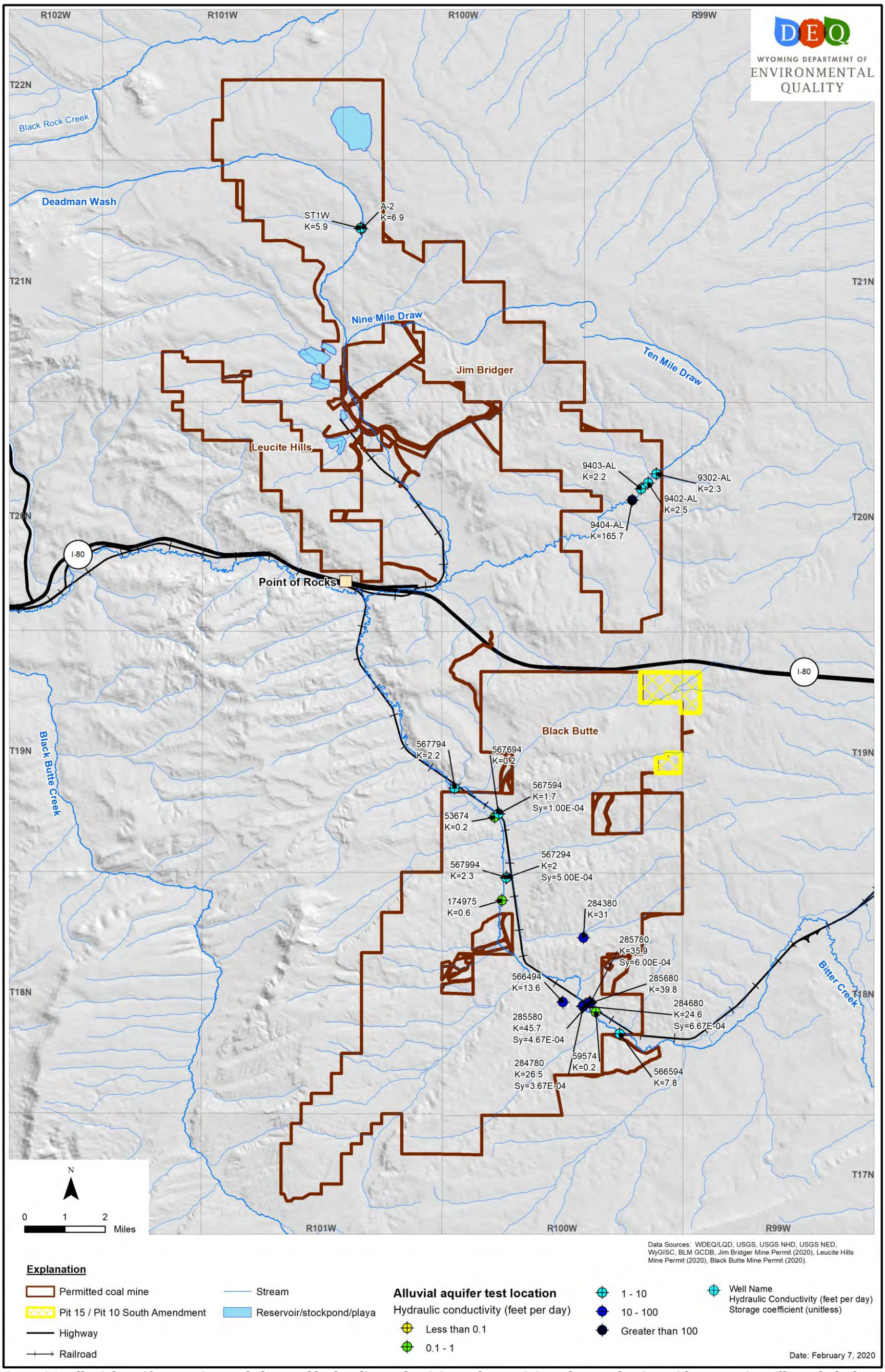


Figure 26. Alluvial aquifer test sites and observed hydraulic conductivity and storativity values at the Jim Bridger, Leucite Hills, and Black Butte mines.

3.2.1.2 OVERBURDEN AQUIFER

The overburden aquifer includes any overlying units lying above the coal seams. The overburden includes the Fort Union Formation (FUF) and Almond Formation (AF) units lying above the coal seams in these respective formations. These discrete overburden units do not constitute a single aquifer and are grouped together for the ease of discussion and presentation in the CHIA.

In the Jim Bridger Mine area, the major sedimentary units of the FUF are sandstone, siltstone, claystone, and coal. These units interbed and interfinger forming a complex stratigraphic section. The proportions and stratigraphic position of sandstone, siltstone, and claystone that form the overburden also differ considerably from one area of the mine to another. The north and south portions of the Jim Bridger Mine area consist of predominantly coarser-grained sediments, while the central area contains, in general, a greater portion of finer-grained material (Jim Bridger Mine Permit, 2020). The sandstones in the overburden have been found to contain zones of higher permeability and can yield up to 25 gpm. The Jim Bridger Mine has characterized the FUF overburden into upper, middle, and lower overburden units (Jim Bridger Mine Permit, 2020). The units within the overburden are often limited in extent and are discontinuous. Therefore, for the purposes of the CHIA, different overburden units within the Jim Bridger Mine are grouped into a single FUF overburden unit. The thickness of the overburden strata increases to the east in response to the coal dip and rising topography. A good source of potential recharge to FUF overburden is its subcrop area below the alluvial aquifer (Black Butte Mine Permit, 2020).

The AF in the Leucite Hills Mine and Black Butte Mine is composed of sandstones, siltstones, shales, clays, and coal seams. Typically, sandstones and siltstones overlie the AF coal seam (Leucite Hills Mine Permit, 2020). Sandstones in the AF are water bearing; however, they are not considered significant aquifers because of their relatively low permeability and limited areal extent. Recharge to the overburden zones are limited by the low annual precipitation and high evapotranspiration rates. Most of the recharge to the overburden AF occurs along outcrop areas, generally to the western edge of the Leucite Hills Mine and Black Butte Mine permit boundaries. Depending on the local hydrogeology, the overburden units vary from unconfined to semi-confined to confined conditions.

Aquifer tests were conducted at 23 wells in the FUF overburden at the Jim Bridger Mine (**Figure 27**; **Table 19**). Saturated thicknesses for the tests ranged from 10 to 313 feet, with a median of 106 feet. Hydraulic conductivity for the tests ranged from a low of 0.01 feet/day at well 81-06-OB to a high of 16 feet/day at well 81-03-OB (**Figure 27**). The median hydraulic conductivity was 1.2 feet/day (**Table 19**). The variability in conductivity is likely due to the discontinuous nature of the sediments and the difficulty in testing wells that are low yielding. The lack of mine facility wells and only a few stock wells in the FUF overburden aquifer is a direct reflection of the low permeability of the unit. Storage coefficients were calculated for seven of the FUF overburden tests and ranged from 8.1×10^{-5} to 0.01 (**Table 19**), a range that is reflective of generally unconfined conditions with some confined lenses. The median storage coefficient for the tests was 4.3×10^{-4}.

In the AF overburden, aquifer tests were conducted at three wells at the Black Butte Mine (**Figure 27**; **Table 19**). Each AF overburden test had a saturated thickness of 20 feet. Hydraulic conductivity for the AF overburden tests ranged from a low of 0.3 feet/day at wells SW4-OB and SW1-OB to a high of 1.2 feet/day at well SW3-OB (**Figure 27**). The median hydraulic conductivity was 0.3 feet/day (**Table 19**). Storage coefficients were not calculated for any of the AF overburden tests (**Table 19**).

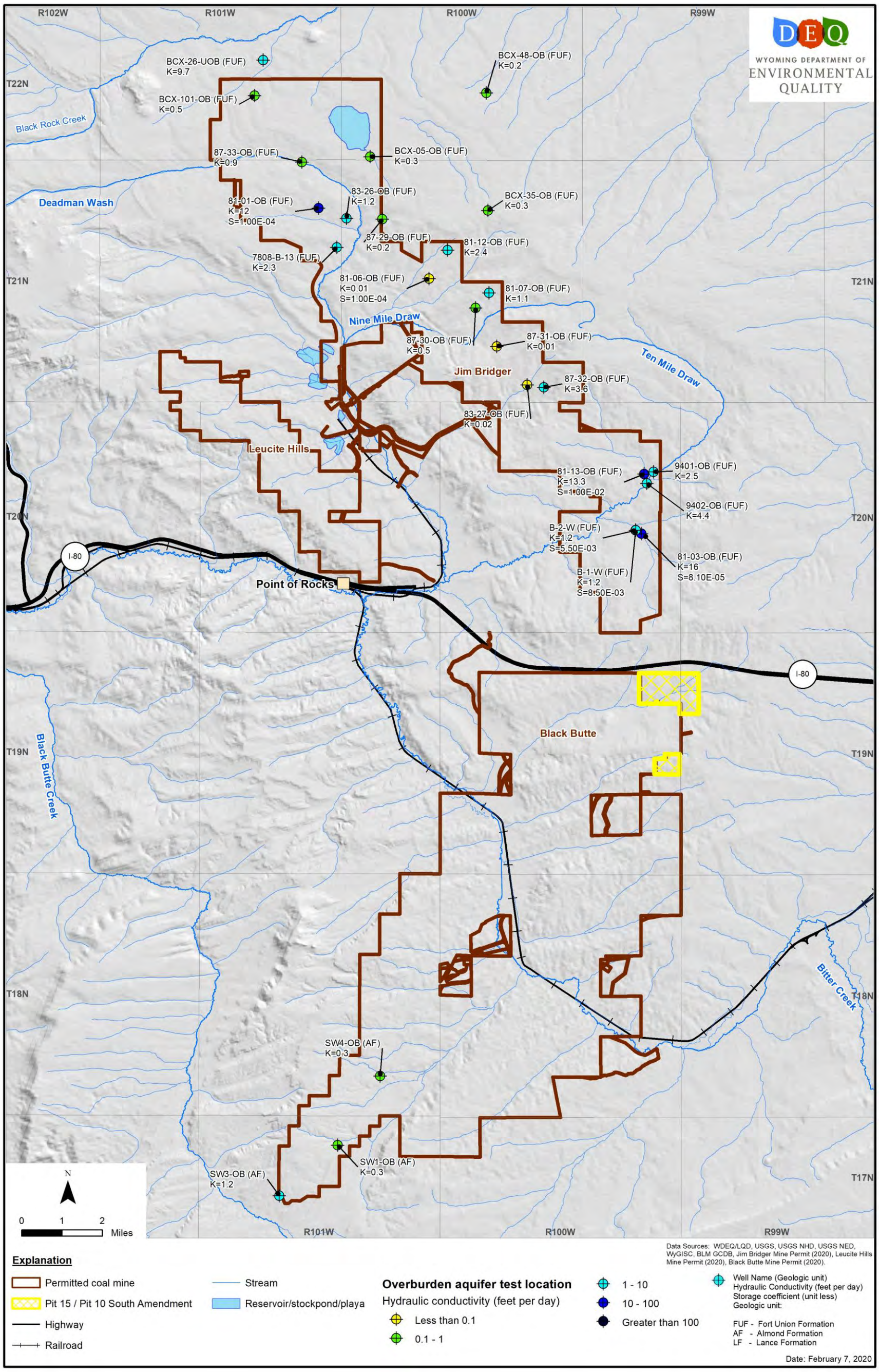


Figure 27. Overburden aquifer test sites and observed hydraulic conductivity and storativity values at the Jim Bridger, Leucite Hills, and Black Butte mines.

3.2.1.3 COAL AQUIFER

The coal mine pits in the CIA are in the FUF, LF, and AF (**Table 5**). These discrete coal seams do not constitute a single aquifer and are grouped together for the ease of discussion and presentation in the CHIA.

In the Jim Bridger Mine area, there are several coal partings (Jim Bridger Mine Permit, 2020). The coal bearing units are mostly present in the lower half of the FUF. The thickness of the Fort Union Deadman coal zone is presented in **Figure 7**. The coal aquifer is generally confined to semi-confined within the Jim Bridger Mine.

The principal coal-bearing unit in the Leucite Hills Mine is the AF. The coal sequence is approximately 250 feet thick, 80 percent of which is interbedded shales and sandstones. The coal aquifer is generally confined to semi-confined within the mine area. The recharge to the groundwater in the coal seams is provided mostly by direct infiltration of rainfall and snowmelt in the areas of outcrops of the permeable portions of AF. No natural discharge points, springs, or seeps within the AF were encountered in the permit area (Leucite Hills Mine Permit, 2020).

The coal bearing strata within the Black Butte Mine are the FUF, AF, and LF (**Table 5**). The coal seams within the FUF and LF are the only important lithological units that are often continuous and can be projected down structure over the mine area. The coal aquifers are generally unconfined near the outcrops and are confined with increasing depths (Black Butte Mine Permit, 2020).

Groundwater generally flows through fractures and cleats in the coal. Aquifer tests were conducted at 13 wells in the FUF coal, with nine tests at the Jim Bridger Mine and four tests at the Black Butte Mine (**Figure 28**; **Table 19**). Saturated thicknesses for the FUF coal tests ranged from 12 to 150 feet, with a median of 115 feet. Hydraulic conductivity for the FUF coal tests ranged from a low of 0.04 feet/day at well 54574 at the Black Butte Mine to a high of 19.7 feet/day at well 717-W(B) at the Jim Bridger Mine (**Figure 28**). The median hydraulic conductivity was 0.8 feet/day (**Table 19**). Storage coefficients were calculated for five of the tests and ranged from 5.0×10^{-5} to 7.1×10^{-4} (**Table 19**). The median storage coefficient for the FUF coal tests was 2.6×10^{-4}.

In the Lance Formation (LF) coal, aquifer tests were conducted at two wells at the Black Butte Mine (**Figure 28**; **Table 19**). Saturated thicknesses for the two tests were 11 and 12 feet. Hydraulic conductivity for the LF coal tests were 0.003 and 0.2 feet/day (**Figure 28**). Storage coefficients were not calculated for any of the LF coal tests (**Table 19**).

Aquifer tests were conducted at 15 wells in the coal of the AF, with 12 tests at the Leucite Hills Mine and three tests at the Black Butte Mine (**Figure 28**; **Table 19**). Saturated thicknesses for the AF coal tests ranged from four to 60 feet, with a median of eight feet. Hydraulic conductivity for the AF coal tests ranged from a low of 0.02 feet/day for well LE18 at the Leucite Hills Mine to a high of 2.9 feet/day at well LHM06 at the Leucite Hills Mine (**Figure 28**). The median hydraulic conductivity was 0.2 feet/day for the AF coal tests (**Table 19**). Storage coefficients were calculated for five of the AF coal tests and ranged from 4.0×10^{-6} to 3.9×10^{-4} (**Table 19**). The median storage coefficient for the AF coal tests was 1.3×10^{-4}.

3.2.1.4 UNDERBURDEN AQUIFER

The lithologic units immediately below the coal seams at the different formations are considered as underburden. These discrete underburden units do not constitute a single aquifer and are grouped together for the ease of discussion and presentation in the CHIA.

In the Jim Bridger Mine area, the underburden units include the FUF that extends vertically downward from the bottom of the lower coal seam and the LF that underlies the FUF. The change in formations is recognized by a clear increase in claystone in the LF. The low vertical and horizontal hydraulic conductivity of the underburden limits the effects of mining to the units below the underburden zone. The observed vertical hydraulic conductivity values of the underburden zone are three orders of magnitude lower than the horizontal hydraulic conductivity (Jim Bridger Mine Permit, 2020).

Sandstone strata of the AF of varying thickness are located below the AF coal seams in the Leucite Hills Mine area (Leucite Hills Mine Permit, 2020). In the Black Butte Mine area, depending on the location, the underburden can be in the FUF, AF, or LF.

Aquifer tests were conducted at nine wells in the FUF underburden, with all the tests at the Jim Bridger Mine (**Figure 29**; **Table 19**). Saturated thicknesses for the FUF underburden tests ranged from 30 to 130 feet, with a median of 59 feet. Hydraulic conductivity for the FUF underburden tests ranged from a low of 0.01 feet/day at wells 81-01-UB and 81-02-UB to a high of 0.9 feet/day at well 9403-UB (**Figure 29**). The median hydraulic conductivity was 0.10 feet/day (**Table 19**). Storage coefficients were calculated for five of the tests and ranged from 1.0×10^{-4} to 1.0×10^{-2} (**Table 19**). The median storage coefficient for the FUF underburden tests was 1.0×10^{-2}.

In the LF underburden, aquifer tests were conducted at nine wells at the Jim Bridger Mine (**Figure 29**; **Table 19**). Saturated thicknesses for the tests ranged from 55 to 140 feet, with a median of 80 feet. Hydraulic conductivity for the LF underburden tests ranged from a low of 0.01 feet/day at well 81-17-LA to a high of 0.8 feet/day at well BCX-37-LA (**Figure 29**). The median hydraulic conductivity was 0.10 feet/day (**Table 19**). Only one test reported a storage coefficient (2.0×10^{-5}) (**Table 19**).

In the AF underburden, aquifer tests were conducted at three wells at the Black Butte Mine (**Figure 29**; **Table 19**). Each AF underburden test had a saturated thickness of 20 feet. Hydraulic conductivity for the AF underburden tests ranged from a low of 0.2 feet/day at wells SW4-UB and SW1-UB to a high of 0.4 feet/day at well SW3-UB (**Figure 29**). The median hydraulic conductivity was 0.18 feet/day (**Table 19**). Only one test reported a storage coefficient (2.0×10^{-5}) (**Table 19**).

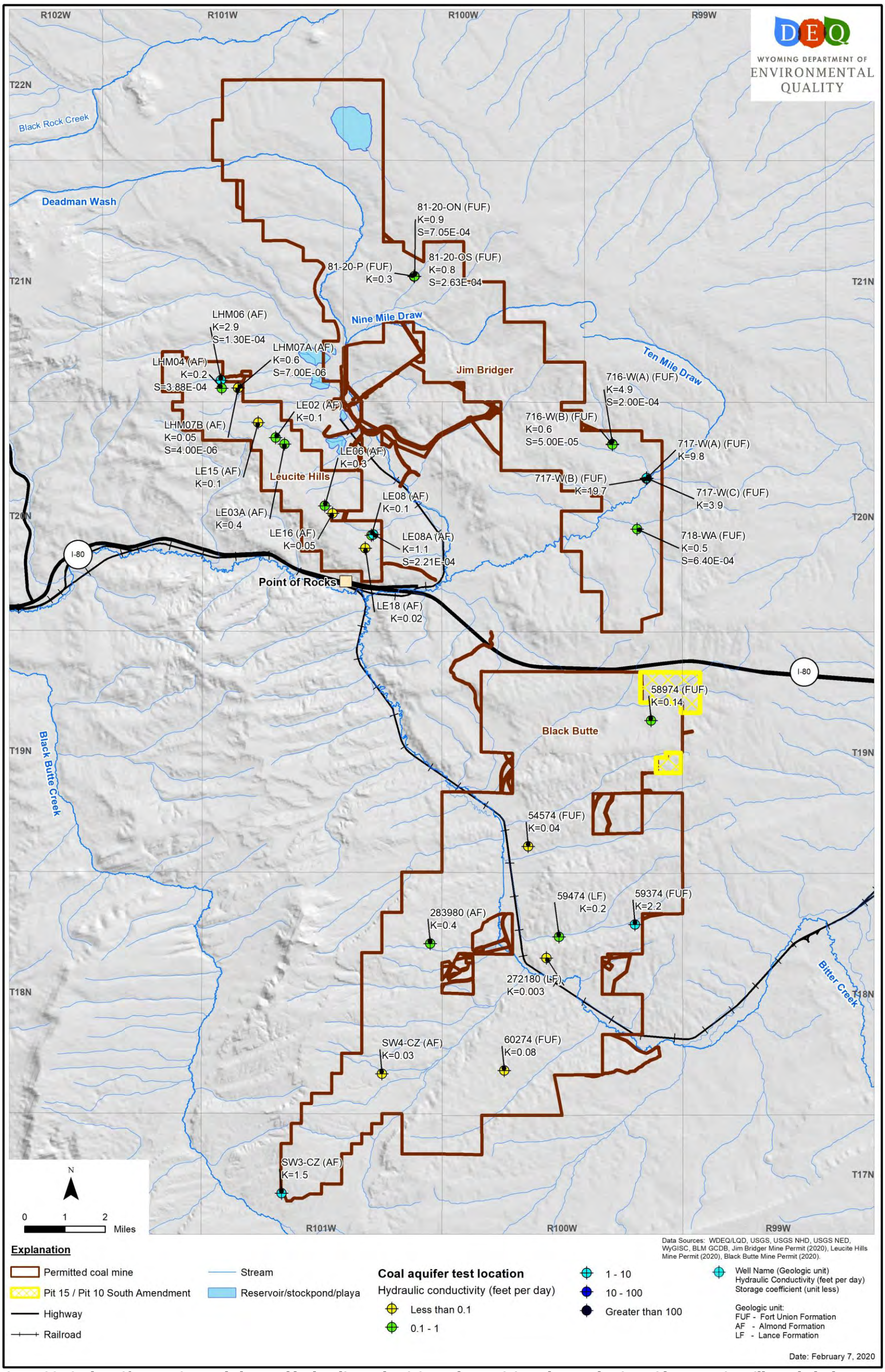


Figure 28. Coal aquifer test sites and observed hydraulic conductivity and storativity values at the Jim Bridger, Leucite Hills, and Black Butte mines.

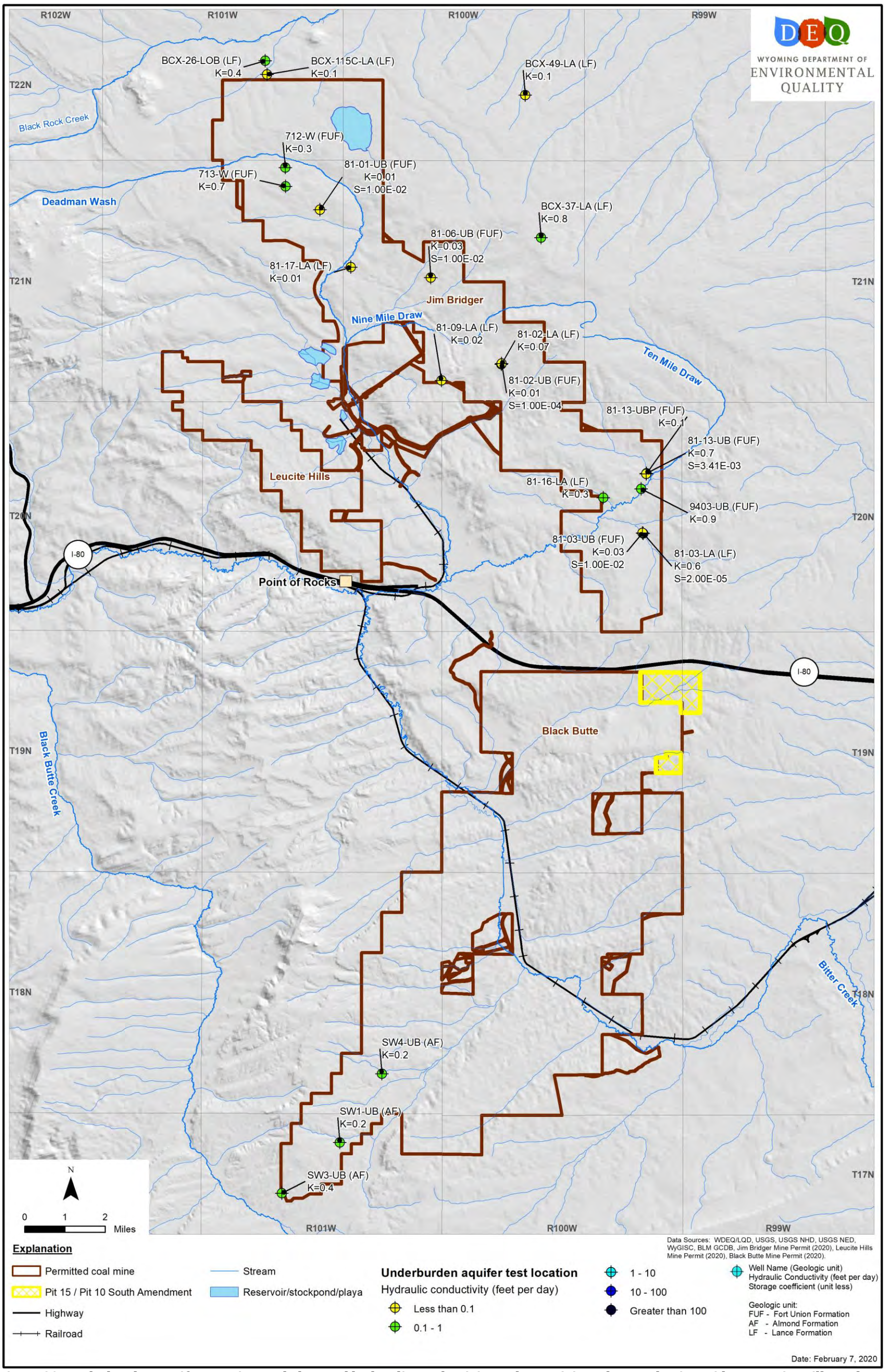


Figure 29. Underburden aquifer test sites and observed hydraulic conductivity and storativity values at the Jim Bridger, Leucite Hills, and Black Butte mines.

3.2.1.5 ERICSON SANDSTONE AQUIFER

The Ericson Sandstone outcrops to the eastern edge of the Leucite Hills and Jim Bridger mines. It consists of massive beds of sandstone and conglomerate with a thickness of up to 700 feet (Leucite Hills Mine Permit, 2020). The Ericson sandstone is mostly fine to medium grained arkosic sandstone with a combination of primary and secondary permeability. The sandstone strata is under unconfined conditions near the outcrop and under confined conditions in the deeper portions. Because of yield and water quality as compared to other aquifers in the area, the Ericson Sandstone is generally used as a water supply for municipal and industrial use. The Ericson Sandstone is tapped as a potable water source for the Town of Superior. Most coal mine facility wells are also completed in the Ericson Sandstone.

Aquifer tests were conducted at seven wells in the Ericson Sandstone aquifer. One test was at the Jim Bridger Mine, four were at the Leucite Hills Mine, and two were at the Black Butte Mine (**Figure 30**; **Table 19**). Saturated thicknesses for the tests ranged from 32 to 600 feet, with a median of 117 feet. Hydraulic conductivity for the tests ranged from a low of 0.10 feet/day at well LHOW06 at the Leucite Hills Mine to a high of 5.5 feet/day at well WSF285 at the Black Butte Mine (**Figure 30**). The median hydraulic conductivity was 2.2 feet/day (**Table 19**). Only one test reported a storage coefficient (0.15) (**Table 19**).

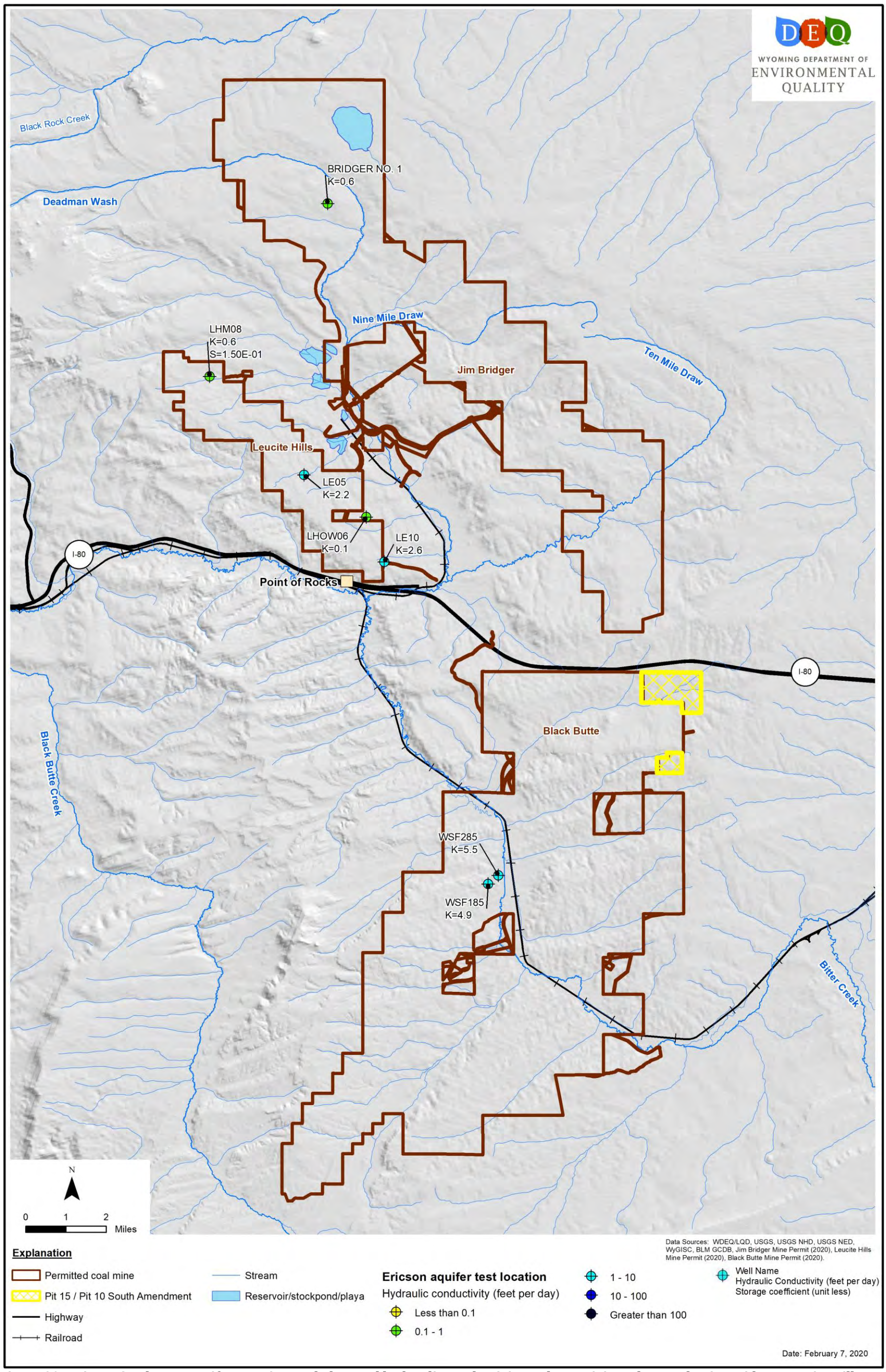


Figure 30. Ericson Sandstone aquifer test sites and observed hydraulic conductivity and storativity values at the Jim Bridger, Leucite Hills, and Black Butte mines.

3.2.2 BASELINE TIME PERIODS FOR GROUNDWATER LEVELS AND GROUNDWATER QUALITY

The intent of this section is to characterize the pre-mining groundwater levels and groundwater quality in the aquifers of concern in the CIA. However, there are some significant challenges in constructing a reasonable representation of the pre-mining conditions within the CIA, as discussed below:

- The Jim Bridger Mine carried out the earliest mining in the CIA in 1974. Mining operations started at the Black Butte Mine in 1979 and at the Leucite Hills Mine in 1981. Ideally, the pre-mining conditions for the CIA would be the average groundwater conditions that existed pre-1974. However, at that time an extensive monitoring network did not exist at the Leucite Hills and Black Butte mines. For example, only seven monitoring wells existed pre-1974 in the CIA. The lack of a robust monitoring network across the three mines deterred the consideration of using only the pre-1974 data to represent the baseline groundwater conditions. Therefore, the general baseline period for the CIA was determined based on the year mining started and the data availability in the WDEQ/LQD Hydrology Database.

- Typically, coal mines establish local groundwater monitoring networks in the areas they are applying for a mine permit from WDEQ/LQD. The monitoring network expands as the mines apply for permit amendments to mine additional regions. However, there is a time lapse between the year mining started and when the expanded monitoring networks were established. Therefore, monitoring wells designed to characterize baseline conditions in subsequent amendment areas may be completed long after the original mining operations began.

- The areas within the CIA but outside the mine permit boundaries do not have a well-defined monitoring network, and data from the limited wells outside the mine permit boundaries are scarce.

The WDEQ/LQD Hydrology Database was used as the primary data source for groundwater levels and water quality data for baseline characterization. After carefully considering the available data in the WDEQ/LQD Hydrology Database, it was decided to use pre-1982 period as the representative baseline conditions for the CIA. Data from the wells during the pre-1982 period were analyzed for extreme variability, potential data entry errors, or any impacts caused by mining operations before incorporating them in the baseline analysis.

The extent of baseline characterization varies by mine and by aquifer. For example, of the three coal mines, the Jim Bridger Mine has the least number of wells available in the WDEQ/LQD Hydrology Database to characterize baseline conditions for this CHIA. The Jim Bridger Mine has one baseline monitoring well and this is located in the alluvial aquifer. The Leucite Hills Mine has seven baseline monitor wells. Of these seven wells, four are completed in the AF coal seams and three are completed in the Ericson Formation. The Black Butte Mine has the greatest number of baseline monitoring wells available in the WDEQ/LQD Hydrology Database. The Black Butte Mine has 31 baseline monitoring wells. Of these 31 wells, 16 are completed in the alluvial aquifer and the remaining eight are in the coal seams of the FUF, LF, and AF. In addition to the water level data from the baseline wells in the WDEQ/LQD Hydrology Database, data and information pertinent to

water levels, hydraulic gradients, flow directions, and other aquifer properties presented in the mine permits were also reviewed and qualitatively discussed in this CHIA.

The WDEQ/LQD Hydrology Database does not have any groundwater quality data for the Leucite Hills and Black Butte mines prior to 1984. The baseline groundwater quality for the aquifers of concern at these mines are summarized from the permits and is presented qualitatively in this CHIA.

3.2.3 GROUNDWATER LEVELS

Water level measurements obtained from an unconfined aquifer represents the water table, and water levels obtained from a confined aquifer represent the potentiometric head. Groundwater flows in the direction of decreasing head. The rate of groundwater flow is dependent on the magnitude of the hydraulic gradient (defined as the change in head per unit distance), effective porosity, and the hydraulic conductivity of the aquifer.

The following methodology was used for obtaining the baseline water levels and potentiometric surfaces for each aquifer of concern:

1. For the Pre -1982 baseline time period (Section 3.2.2), the available water level data were obtained from the WDEQ/LQD Hydrology Database.

    a. If there were multiple water level data points for a well, a median was calculated to represent the baseline water level.

    b. If the baseline groundwater level data from a specific well showed significant changes (standard deviation of greater than 10 feet) caused by mine operations (aquifer dewatering, etc.), the affected water level data were omitted to best represent groundwater level conditions prior to mining activities. Typically these effects were observed to occur closer to the year mining started.

2. If there were no groundwater level data available in the WDEQ/LQD Hydrology Database, the information from mine permits were used to conduct a qualitative review and assessment of the baseline groundwater regime.

3.2.3.1 ALLUVIAL AQUIFER

The WDEQ/LQD Hydrology Database had 17 wells with baseline groundwater level data for the alluvial aquifer (**Figure 31**). Of the 17 wells, 16 wells were located at the Black Butte Mine and one well was located in Deadman Wash at the Jim Bridger Mine. There are no significant alluvial deposits within the Leucite Hills Mine area (**Figure 6**).

Potentiometric surfaces were not contoured for the alluvial water level data due to the discrete location of the monitoring wells along stream channels and the discontinuous nature of the alluvial sediments. The general direction of groundwater flow in the alluvial aquifer follows the topography towards the downstream or down valley direction. Groundwater gradients appear to mimic the elevation gradient of the alluvial valleys, as groundwater levels decrease in the downstream direction (**Figure 31**). The flow in the Bitter Creek alluvial aquifer parallels the flow in the drainages.

Hydrograph insets for the baseline period are shown on **Figure 31** for alluvial wells ST-2-W on Deadman Wash at the Jim Bridger Mine, and 53674 and 59574 on Bitter Creek at the Black Butte Mine. The hydrographs for these three wells show that the seasonal fluctuations of the alluvial groundwater levels over the baseline period were typically within five feet.

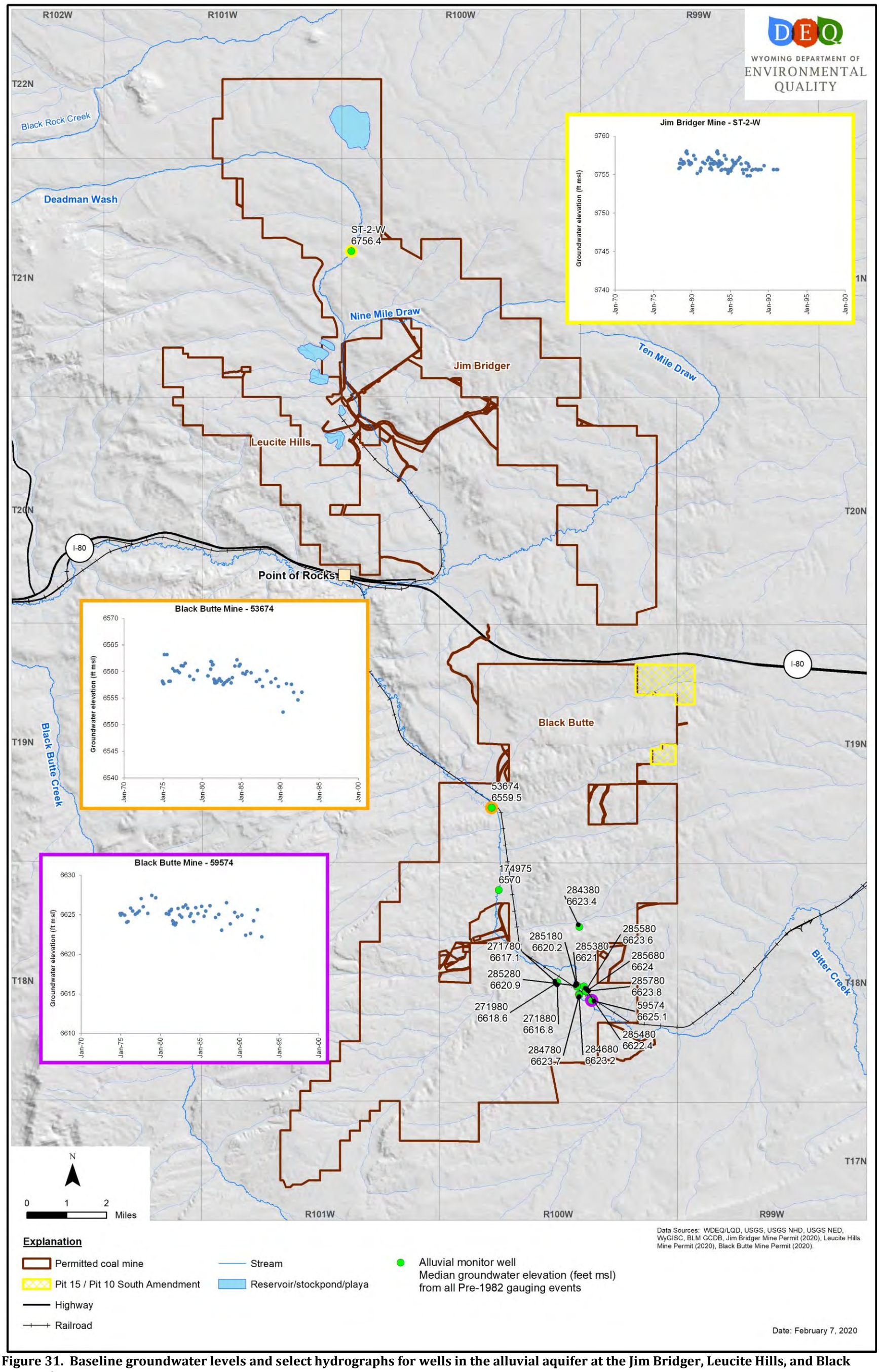


Figure 31. Baseline groundwater levels and select hydrographs for wells in the alluvial aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines.

3.2.3.2 OVERBURDEN AQUIFER

The overburden aquifer includes any overlying units lying above the coal seams. The overburden includes the FUF, AF, and LF units lying above the coal seams in these respective formations. The WDEQ/LQD Hydrology Database did not have any water level data for the Pre-1982 baseline conditions for these overburden units. A qualitative review and assessment of the overburden units is presented below.

The discrete overburden zones from different stratigraphic units do not constitute a single aquifer. Therefore, water levels from wells screened in different stratigraphic intervals cannot be interpreted as a single overburden aquifer. Within the Jim Bridger Mine permit boundary, the potentiometric gradient of the overburden FUF is towards the southwest and generally mimics the groundwater topography (Plate D-6-2; Jim Bridger Mine Permit, 2020). The potentiometric surface in the Jim Bridger Mine area is generally within 200 feet below the land surface. At specific locations along the alluvial channels, the overburden discharge saturates the alluvial aquifer forming minor groundwater seeps.

The overlying unit above the Almond coal seam in the Leucite Hills Mine is the Almond sandstone strata. The hydraulic gradient of this unit is about 0.015. The groundwater flow direction in the mine permit area is generally towards the northeast (Plate D6-a-2, Leucite Hills Mine Permit, 2020). The estimated range of groundwater velocity in the overburden sandstone strata is from 5.3×10^{-4} to 8.4×10^{-4} feet per day.

In the Black Butte Mine area, depending on the location, the overburden can be FUF, AF, or LF (Exhibit D6-4, Exhibit D6-5 and Exhibit D6-4; Black Butte Mine Permit, 2020). The general groundwater flow direction in the Black Butte Mine area is towards northeast. Groundwater movement near the Pit 14 area appears to be structurally controlled and the overlying shale formation likely prevents any upward vertical leakage from the AF.

3.2.3.3 COAL AQUIFER

A total of 18 coal monitor wells were used to construct the coal aquifer water level map shown in **Figure 32**. Of the 18 wells, five wells are located in the FUF coal, six wells are located in the AF coal, and seven wells in the LF coal. These discrete coal seams do not constitute a single aquifer and the map shown in **Figure 32** cannot be used to interpret a continuous, single coal aquifer.

No regional groundwater flow or gradient is evident in the coal seams of the FUF within the Jim Bridger Mine (Jim Bridger Mine Permit, 2020). The average hydraulic gradient in the AF coal seam within the Leucite Hills Mine is about 0.040 and estimated groundwater velocity ranges between 3.9×10^{-2} to 6.3×10^{-1} feet per day (Leucite Hills Mine Permit, 2020). The coal seams in the CIA are generally less than about 20 feet and the mines have not presented distinct potentiometric surfaces for the coal seams.

Hydrograph insets for the baseline period are shown on **Figure 32** for AF coal well LHM06 at the Leucite Hills Mine, and FUF well 59374 and LF coal well 305181 at the Black Butte Mine. At Leucite Hills Mine well LHM-06, it appears that mine-related dewatering activities caused some drawdown during the baseline pre-1982 water levels. There were some initial fluctuations in the water levels for Black Butte Mine well 59374. However, the water levels after 1977 and through the pre-1982 baseline period are relatively stable. Black Butte Mine well 305181 was stable with minor fluctuations of around an average of two feet during the baseline period (**Figure 32**).

3.2.3.4 UNDERBURDEN AQUIFER

The underburden aquifer includes any underlying units below the coal seams. The underburden includes the FUF, LF, and AF units lying below the coal seams in these respective formations. The WDEQ/LQD Hydrology Database did not have any water level data for the Pre-1982 baseline conditions for these underburden units. The stratigraphically distinct underburden units underlying the coal seams do no not constitute a single aquifer. Therefore, water levels from wells screened in different stratigraphic intervals cannot be interpreted as a single underburden aquifer. A qualitative review and assessment of the overburden units is presented below.

In the Jim Bridger Mine area, depending on the location, the underburden units can be of either the FUF or LF. In several areas, these underburden units are not able to sustain a yield of one gallon per minute for more than 20 days (Jim Bridger Mine Permit, 2020). The unit below the Almond coal seam in the Leucite Hills Mine is the Almond sandstone strata. The hydraulic gradient of this unit is about 0.030. The groundwater flow direction in the mine permit area is generally towards the northeast (Leucite Hills Mine Permit, 2020). The FUF, LF, or AF forms the underburden units in the Black Butte Mine. There are no known significant structural barriers to groundwater flow or fault-dependent preferential flow conditions near the Pit 14 area (Black Butte Mine Permit, 2020).

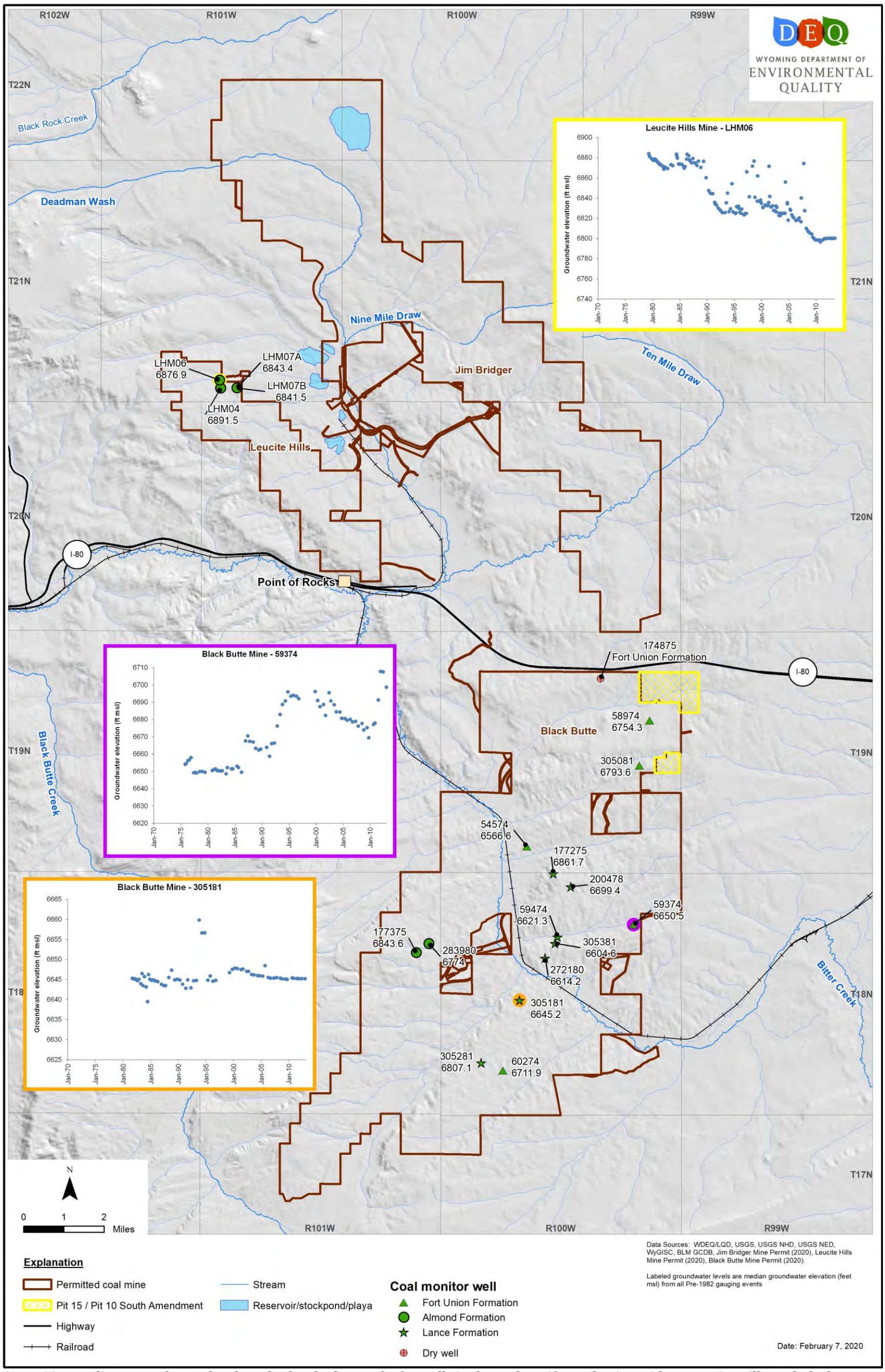


Figure 32. Baseline groundwater levels and select hydrographs for wells in the coal aquifer at the Jim Bridger, Leucite Hills, and Black Butte coal mines.

3.2.3.5 ERICSON SANDSTONE AQUIFER

As noted earlier in Section 2.2, the Ericson Sandstone aquifer in the area of the coal mines is affected by the mine facility wells. Except at locations where Almond coal seams are mined, the Ericson Sandstone is separated from the mined coal seams by the thick Lewis Shale. The thickness of AF is about 200 to 400 feet in the CIA and the coal seams about 10 to 15 feet thick. There are thick Almond sandstone strata that separate the coal seams from the Ericson Sandstone. Therefore, the overlap between the impacts caused by mining the coal seams and the impacts caused by pumping of the mine facility wells are expected to be minimal.

Several minor seeps occur along the extreme western edge of the Black Butte Mine permit boundary where the topography intersects the sandstone beds. Typically, these seeps flow a few hundred feet and then they discharge into the alluvium (Black Butte Mine Permit, 2020).

Three wells screened in the Leucite Hills Mine area had baseline water level data in the WDEQ/LQD Hydrology Database. The water levels at these wells are relatively stable. These wells are at an average depth of about 400 feet from the land surface. The estimated average hydraulic gradient in this aquifer in the Leucite Hills Mine area is about 0.015 (Leucite Hills Mine Permit, 2020). The potentiometric heads in the Almond coal seams are about 100 feet higher than the potentiometric heads observed in the Ericson sandstone, indicating that these units are discrete and have a good confining zone between them.

3.2.4 GROUNDWATER QUALITY

Groundwater quality varies both between and within aquifers in the CIA. The variation between aquifers is probably due to the differences in aquifer materials as well as geochemical and biochemical changes along the flow paths of the groundwater. Within aquifers the variability is partially due to the proximity of a given sampling location to recharge/discharge zones and structural features. Water quality of selected constituents is compared throughout this CHIA to groundwater quality standards established by the WDEQ/WQD (**Table 20**) (WDEQ Water Quality Rules, Ch. 8, § 5). It is important to note that the WDEQ/WQD is responsible for, and has the sole authority to classify groundwaters of the State (WDEQ Water Quality Rules, Ch. 8, § 4). The comparisons of the water quality parameters against the WDEQ/WQD groundwater standards in the CHIA should not be interpreted as an attempt to classify the aquifers.

The WDEQ/LQD Coal Rules and Regulations, Chapter 4, Section 2 (w), state that "*The operator shall conduct all operations in such a manner as to minimize disturbance of the hydrologic balance within the permit and adjacent areas, to prevent material damage to the hydrologic balance outside the permit area, to assure the protection or replacement of water rights, and to support approved postmining land uses in accordance with the terms and conditions of the approved permit and the performance standards of this Chapter.*" The approved post-mining uses of the mine permit areas and the predominant existing uses within the CIA are livestock grazing and wildlife habitat. Therefore, groundwater quality in this CHIA is evaluated primarily by comparing data against the WDEQ/WQD Class III livestock groundwater quality standards (**Table 20**) (WDEQ Water Quality Rules, Ch. 8, § 5).

Table 20. Selected WDEQ/WQD groundwater quality class of use standards.

Underground Water Class Use Suitability			
Constituent	**Class I, Domestic Concentration**	**Class II, Agriculture Concentration**	**Class III, Livestock Concentration**
Aluminum	---	5.0	5.0
Ammonia (NH_3 as N)	0.5	---	---
Arsenic	0.05	0.1	0.2
Barium	2.0	---	---
Boron	0.75	0.75	5.0
Cadmium	0.005	0.01	0.05
Chloride	250	100	2,000
Chromium	0.10	0.1	0.05
Copper	1.0	0.2	0.5
Fluoride	4.0	---	---
Iron	0.3	5.0	---
Lead	0.015	5.0	0.1
Manganese	0.05	0.2	---
Mercury	0.002	---	0.00005
Nickel	---	0.2	---
Nitrate (NO_3 as N)	10.0	---	---
Nitrite (NO_2as N)	1.0	---	10.0
Nitrate + Nitrite (NO_3 + NO_2 as N)	---	---	100
Selenium	0.05	0.02	0.05
Sulfate	250	200	3,000
Total Dissolved Solids	500	2,000	5,000
Zinc	5.0	2.0	25.0
pH	6.5-8.5 s.u.	4.5-9.0 s.u.	6.5-8.5 s.u.

From WDEQ/WQD Rules and Regulations, Chapter 8 (WDEQ Water Quality Rules, Ch. 8, § 5). Values in milligrams per liter unless otherwise indicated. Note that the constituents listed are not an exhaustive list of all constituents with standards established by WDEQ/WQD.

The WDEQ/LQD Hydrology Database has limited groundwater quality information prior to 1984 for the three coal mines evaluated in this CHIA (Section 3.2.2). Therefore, a qualitative review and assessment of the baseline groundwater quality using the information presented from the three mine permits is presented.

3.2.4.1 ALLUVIAL AQUIFER

Wells ST-25-W and ST-26 along Tenmile Draw had some baseline information presented in the Jim Bridger Mine Permit (2020). The groundwater sampled in 1979 from wells ST-25-W and ST-26-W were of sodium bicarbonate type with high chloride content. Except for chloride, which may have been picked up from the evaporate rocks common in this part of the Jim Bridger Mine area, the alluvial groundwater resembled the water from the underlying FUF. The high bicarbonate is likely derived by the solution of calcium carbonate, which is the cementing agent for some of FUF sandstone strata. Cation exchange is probably responsible for the high sodium concentrations in the groundwater. Cation exchange is a reaction in which the calcium and magnesium in the water are exchanged for sodium that was adsorbed to aquifer solids such as clay minerals, resulting in higher sodium concentrations in the groundwater. The water quality type along Deadman Wash alluvium was primarily sodium bicarbonate or sodium sulfate (Jim Bridger Mine Permit, 2020).

Groundwater from wells completed in the Bitter Creek alluvium at Black Butte Mine was primarily of sodium chloride type. Alluvial groundwater differed markedly from other groundwater and surface water in the area. The highest concentrations of several constituents

were found in the alluvial groundwater. High chloride concentrations can be attributed to the very fine-grained clay and silt nature of the Bitter Creek alluvial sediments. Because the chloride ion is physically large compared to many of the other major ions in groundwater, it could be expected to be retained in interstitial or pore water in clay or shale (Black Butte Mine Permit, 2020).

Almost all of the alluvial groundwater exceeded the domestic water quality standards for TDS and several alluvial wells exceeded the standards for livestock use (Jim Bridger Mine Permit, 2020). Larger concentrations of TDS were generally associated with the alluvial aquifer in the area of the Black Butte Mine, while the lower concentrations were associated with the alluvial aquifer in the area of the Jim Bridger Mine (Jim Bridger Mine Permit, 2020; Black Butte Mine Permit, 2020).

3.2.4.2 OVERBURDEN AQUIFER

The groundwater in the overburden FUF units within the Jim Bridger Mine area generally contained sodium as the dominant cation and bicarbonate as the dominant anion (Jim Bridger Mine Permit, 2020). Groundwater in the overburden AF units within the Leucite Hills Mine area had bicarbonate, sulfate, calcium, and magnesium as the dominant ions. TDS ranged from 980 to 2,910 mg/L (Leucite Hills Mine Permit, 2020). Sodium was the principal cation in the majority of the overburden units.

Two factors may be responsible for sodium not being the principal cation in some wells. These wells could have been completed in strata where clays and shale are rare or absent, limiting the amount of cation exchange that can occur. Another possibility is that of calcite and dolomite dissolution taking place at a higher degree near these wells. In general, LF overburden units are of poorer groundwater quality than that of the FUF overburden. This is most likely due to constituents present in formations due to the depositional environment. The lagoonal barrier bar system of the LF would have deposited sediments high in constituents than the swamp and forested flood plain depositions of the FUF (Black Butte Mine Permit, 2020).

Physical and chemical differences exhibited in the overburden units were an indicator of a highly variable geologic environment. The absence of chemical continuity also indicated that these separate stratigraphic units do not constitute a regional scale overburden aquifer. However, in general the groundwater from all the overburden units was suitable for livestock use (Jim Bridger Mine Permit, 2020; Leucite Hills Mine Permit, 2020; Black Butte Mine Permit, 2020).

3.2.4.3 COAL AQUIFER

The major composition of the FUF coal seams was quite mixed. The most common major cation was sodium. The most common anion was either bicarbonate or sulfate. Sulfate might be a solution product of gypsum or pyrite and may also be an indicator of local recharge (Jim Bridger Mine Permit, 2020). Groundwater in the AF coal seams within the Leucite Hills Mine area was of relatively good quality with a great variation of the principal anions and cations. The principal cations varied between sodium, calcium and magnesium. The dominant anions are primarily sulfate or bicarbonate (Leucite Hills Mine Permit, 2020). Groundwater quality within wells completed in the LF also showed a wide range of variation. The primary cation in the LF coal seam is sodium and the primary anions showed considerable variability between bicarbonate, sulfate, and chloride (Black Butte Mine Permit, 2020).

The overall groundwater quality was generally suitable for livestock use (Jim Bridger Mine Permit, 2020; Leucite Hills Mine Permit, 2020; Black Butte Mine Permit, 2020). However, the

spatial variation in groundwater quality in the coal seams was indicative of differing local geochemistry in the stratigraphy with limited hydraulic communication.

3.2.4.4 UNDERBURDEN AQUIFER

The overall underburden groundwater quality was generally suitable for livestock use (Jim Bridger Mine Permit, 2020; Leucite Hills Mine Permit, 2020; Black Butte Mine Permit, 2020). In general, the groundwater quality type at each of the FUF, AF, and LF underburden wells was sodium bicarbonate. The Leucite Hills Mine Permit (2020) noted a greater temporal variability in the AF underburden wells. The underburden units displayed physical and chemical variability both horizontally and vertically. This suggested the absence of any significant hydraulic connection and the zones are subject to localized geochemical influences (Jim Bridger Mine Permit, 2020).

3.2.4.5 ERICSON AQUIFER

The groundwater quality type of Ericson aquifer wells in the Leucite Hills Mine area was also highly variable and was either sodium bicarbonate, calcium bicarbonate, or sodium sulfate (Leucite Hills Mine Permit, 2020). The TDS of Ericson aquifer wells in the Black Butte Mine ranged from 500 to 1,100 mg/L. The major anion was sulfate with the general range of 200 to 600 mg/L (Black Butte Mine Permit, 2020). In general, the groundwater quality in the Ericson aquifer was better than the other aquifers in the groundwater CIA.

3.3 ALLUVIAL VALLEY FLOORS

The Wyoming Environmental Quality Act defines alluvial valley floors (AVFs) as "*the unconsolidated stream laid deposits holding streams where water availability is sufficient for subirrigation or flood agricultural activities but does not include upland areas which are generally overlain by a thin veneer of colluvial deposits composed chiefly of debris from sheet erosion, deposits by unconcentrated runoff or slope wash, together with talus, other mass movement accumulation and windblown deposits*" (W.S. § 35-11-103(e)(xviii)). Coal mining operations may not interrupt, discontinue, or preclude farming on AVFs that are irrigated or naturally subirrigated, provided that the AVF is not subject to statutory exclusions (W.S. § 35-11-406(n)(v)). Statutory exclusions for AVFs include: (1) AVFs on undeveloped rangelands which are not significant to farming, (2) AVFs on lands as to which the Administrator finds that if farming will be interrupted, discontinued, or precluded, it is of such small acreage as to be of negligible impact to the farm's agriculture production, and (3) AVFs part of surface coal operations that produced coal in commercial quantities prior to August 3, 1977. Significance to farming is determined by calculating the percent farm production loss as a result of disturbing the AVF. A loss greater than 10 percent is considered to exceed a negligible impact to both small and large Wyoming farming operations, and thus mining of the AVF is prohibited (Wyoming Department of Environmental Quality, 2000). If a farm's total production is less than 5,000 animal units or their equivalent, Chapter 3 of the LQD Rules and Regulations provides an equation to estimate the negligible impact percentage (WDEQ Land Quality-Coal Rules, Ch. 3, § 2(f)). Coal mining also must not materially damage the quantity or quality of water in surface or underground systems that supply AVFs not subject to statutory exclusions (W.S. § 35-11-406(n)(v)). This includes AVFs adjacent to the permit area.

AVFs in Wyoming can be mined provided that either: (1) the AVF is not significant to farming or is on undeveloped rangeland, or (2) the mine produced coal in commercial quantities prior to the effective date of SMCRA (August 3, 1977). However, in each of these cases the mine

must restore the essential hydrological functions of the AVF after mining. Essential hydrologic functions are defined as "*those conditions of surface and groundwater hydrology that support or enhance subirrigation or flood irrigation agricultural activities*" (WDEQ Land Quality–Coal Rules, Ch. 1, § 2(at)). If the AVFs are located off-site and will not be mined, the essential hydrologic functions still must be preserved.

The WDEQ/LQD has made AVF determinations at the Jim Bridger, Leucite Hills, and Black Butte mines. The determinations were made using baseline studies conducted by the mines. AVF investigations are typically interdisciplinary, involving an analysis of surface water quantity and quality, alluvial aquifer water levels and quality, vegetation, soils, geomorphology, and surficial geology. Some of these baseline data have been previously discussed in Section 3.1 and Section 3.2.2.1. Categories of WDEQ/LQD AVF determinations include:

- **AVF – Significant to Farming**: The AVF is significant to farming and cannot be mined. Mining must not materially damage the quantity or quality of water in surface or underground systems that supply the AVF.

- **AVF – Not Significant to Farming**: The AVF is not significant to farming and can be mined provided that the essential hydrologic functions are restored after mining. If the AVF is not mined, the essential hydrologic functions still must be preserved.

- **AVF – Grandfathered**: The area is an AVF, but significance to farming test is not required since the mine produced coal in commercial quantities prior to the effective date of SMCRA (August 3, 1977). The AVF can be mined provided that the essential hydrologic functions are restored after mining. If the AVF is not mined, the essential hydrologic functions still must be preserved.

- **AVF – No Significance to Farming Test Required**: The area is an AVF, but it was determined that a significance to farming test was not required since the AVF would not be affected. The essential hydrologic functions still must be preserved. Mining must not materially damage the quantity or quality of water in surface or underground systems that supply the AVF if statutory exclusions do not apply.

- **Not an AVF**: The area does not meet the definition of an AVF. The area can be mined.

A description of the AVF determinations in the Bitter Creek CIA is presented below.

3.3.1 DEADMAN WASH

An AVF study was conducted at the Jim Bridger Mine in 1980 (Jim Bridger Mine Permit, 2020). The study found that there were a few small areas of subirrigated alluvial deposits in Deadman Wash and Tenmile Draw. However, the study concluded that the poor water quality, limited water quantity, small areal extent, poor soil quality, variable growing season, and predominance of plant species of limited grazing quality precluded the viable development of agriculture activities beyond grazing. Since 1980, no AVFs have subsequently been declared at the Jim Bridger Mine (Jim Bridger Mine Permit, 2020).

At the Leucite Hills Mine, there are no designated AVFs in the portion of the Deadman Wash watershed within the permit area. The absence of AVFs is due to a lack of geomorphologic and hydrologic criteria (Leucite Hills Mine Permit, 2020).

3.3.2 BITTER CREEK

In October 1978, the WDEQ/LQD determined that there are no AVFs along Bitter Creek within the Black Butte Mine permit area (Black Butte Mine Permit, 2020). Unconsolidated streamlaid deposits are present along Bitter Creek, but a negative AVF determination was made because water availability, water quality, and soil quality were deemed not sufficient nor acceptable for subirrigation or flood irrigation agricultural activities. Since 1978, no AVFs have subsequently been declared at the Black Butte Mine (Black Butte Mine Permit, 2020).

As part of the Pit 15/Pit 10 South Amendment, the Black Butte Mine evaluated potential AVF characteristics within the amendment area (Black Butte Mine Pit 15/Pit 10 South Amendment Application, 2020). On August 14, 2020 the WDEQ/LQD determined that the ephemeral stream that drains the proposed amendment area known as Subbasin 3 is not an AVF. The following was noted in the determination: (1) the stream does not contain unconsolidated streamlaid deposits, (2) there is no evidence of subirrigation or natural flood irrigation, (3) a field visit showed no evidence of artificial irrigation, and (4) there is insufficient water quantity to be conducive for flood irrigation activities (Wyoming Department of Environmental Quality, 2020b).

4. HYDROLOGIC CONCERNS

The objective of this CHIA is to determine the probable cumulative hydrologic impacts of the existing and proposed mine operations within the delineated CIAs and to determine if the operations have been designed to prevent material damage to the hydrologic balance outside the proposed permit areas. Probable impacts to the quantity and quality of surface water and groundwater are addressed. The following discussion in this section identifies the general hydrologic concerns that are associated with surface coal mining in Wyoming. Specific concerns applicable for the CIAs evaluated in this CHIA are also addressed. Hydrologic concerns are an expression of problems related to water use and the hydrologic balance that may occur as a result of coal mining (Office of Surface Mining Reclamation and Enforcement, 1985).

4.1 SURFACE WATER

4.1.1 SURFACE WATER USE

The identification of surface water hydrologic concerns is integral to the existing surface water uses within the surface water cumulative impact areas. There are 18 valid surface water rights in the Bitter Creek CIA (**Figure 33**). These surface water rights were obtained from the WSEO (Wyoming State Engineer's Office, 2020a) and evaluated according to their permitted beneficial use. Only surface water rights with a status of complete, incomplete, fully adjudicated, or unadjudicated were considered. Surface water rights owned by the coal mines were also excluded from **Figure 33** since impacts to these water rights will be by the companies owning the water rights rather than by cumulative impacts of all other existing or anticipated coal mining operations.

Surface water rights in the Deadman Wash watershed are entirely held by the Jim Bridger Power Plant (Wyoming State Engineer's Office, 2020a). Surface water rights are held for industrial and steam engine purposes (**Figure 33**).

Surface water rights in the Bitter Creek watershed (not including Deadman Wash) are held by the Union Pacific Railroad, BLM, and private individuals (Wyoming State Engineer's Office, 2020a). There is one surface water right held for a stockpond at Point of Rocks (**Figure 33**). Upstream of the Black Butte Mine, surface water rights are held for stock, irrigation, railroad, and domestic use. The domestic uses are associated with 1920s-era water rights held on Antelope Springs, located on the Antelope Creek tributary to Bitter Creek in the southern end of the surface water CIA (**Figure 33**).

The State of Wyoming has agreed to several river compacts and court decrees that address the allocation of surface water flows out of Wyoming (W.S. §41-12-101, -201, -301, -401, -501, -601, and -701). The coal mines in the Bitter Creek CIA lie within the Green River Basin, which is part of the Colorado River Compact of 1922, the Upper Colorado River Compact of 1948, and international treaty between the United States and Mexico (Wyoming State Engineer's Office, 2006).

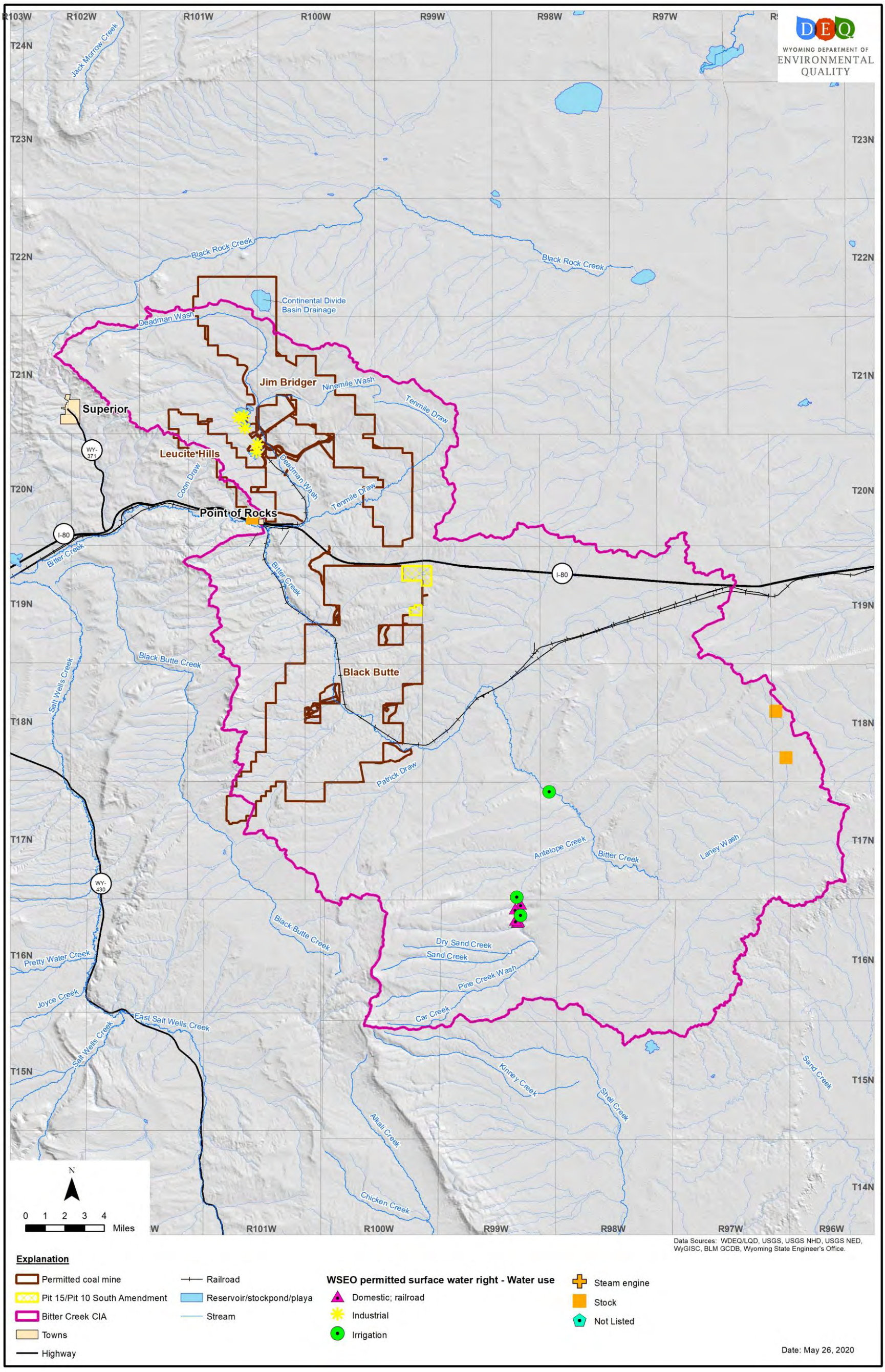


Figure 33. Location of active WSEO-permitted surface water rights by use within the Bitter Creek CIA. Surface water rights held by the coal mines are not shown.

4.1.2 HYDROLOGIC CONCERNS

4.1.2.1 WATER QUANTITY

4.1.2.1.1 During Mining

Surface water runoff is affected by climate, geomorphology, topography, soil characteristics, vegetation, and land use. Mining has the potential to affect all of these factors except climate.

Increased Runoff: Runoff can increase during mining if mines are dewatering aquifers and discharging the water into ponds or stream channels. However, the potential for increased runoff is probably limited in the Bitter Creek CIA. Operations at the mines generally take place under dry pit conditions with a limited amount of pit dewatering. Much of the water intercepted by the mine pit is used for dust suppression. There are some instances when water may be discharged downstream, temporarily changing the flow regime. Runoff can also increase during mining due to an increase in impervious surfaces that decrease infiltration rates. These include the presence of unpaved access or haul roads and infrastructure associated with mine facilities. Since the mines progress with contemporaneous reclamation, the entire permit area is not completely disturbed at any one time. This practice serves to lessen the impact of mining on runoff.

Decreased Runoff: Runoff from areas upstream of a mine is usually either captured by flood control reservoirs or the mine pit or routed around the active mining and reclaimed areas. This capture or diversion effectively isolates the mine area from contributing flow downstream. At the Black Butte Mine, Bitter Creek is not impounded or diverted because the channel and area adjacent to the channel have not been mined.

Sediment control is required for all areas disturbed by mining activities. Runoff from disturbed areas is required to pass through some type of treatment structure. These can range from simple rock check dams to large settling ponds. All sediment ponds greater than two ac-ft are required to be permitted individually with the WSEO. The WSEO will issue a single WSEO permit for a number of small sediment ponds whose individual capacity is equal to or less than two acre-feet as long as the cumulative capacity of all ponds in this category does not exceed 19.8 acre-feet per individual permit (Wyoming Department of Environmental Quality, 2003).

Water collected by sediment ponds is often used for dust control, equipment wash down, or livestock and wildlife use, rather than being released once WYPDES standards are met. Evaporation and seepage may result in additional surface water losses. Subsurface contributions to streamflow may also be temporarily disconnected as a result of disruptions to the local aquifer during overburden and coal excavation. The cumulative effect of these activities may cause a reduction in runoff volumes and peak flows, which have the potential to temporarily impact downstream water rights. However, these actions are often necessary to protect downstream water quality.

Subsidence is a potential hydrologic concern associated with underground longwall mining at the Jim Bridger Mine. Longwall mining induces concurrent subsidence as the overburden collapses above the underground mine workings. The final subsidence profile is determined by multiple factors such as local geology, the width and length of the longwall panels, the thickness of the mined coal seam, and the type and thickness of the overburden.

The impacts of subsidence on surface water can range from no discernable impact to appreciable ponding, capture, and retention of runoff. The formation of subsidence-induced cracks

and depressions near surface water features can lead to complete or partial loss of water due to leakage to the underlying strata (Bhattacharya and Singh, 1985). Changes in the surface slope of streams can affect channel hydraulics. Water lost from streams may not always recharge the mine void, but instead may migrate downward through subsidence fractures to an intermediate aquifer where it can migrate laterally. The relationship between underground mining and the local surface water hydrology is well documented in coal regions in the eastern United States. Cifelli and Rauch (1986) studied an underground mining operation in north central West Virginia and found that baseflow in streams was significantly impacted when at least ten percent of the watershed was undermined and had subsided. Channels dried up when at least 25 to 30 percent of the watershed was affected by subsidence (Cifelli and Rauch, 1986). Interactions between surface hydrology and subsidence at underground mines have not been extensively studied in Wyoming.

The potential for reduced water yields due to storage in sediment ponds and mining pits also has implications at a much larger scale in the Upper Colorado River Basin. The listing of four fishes in Colorado (humpback chub, bonytail, Colorado pike minnow, and razorback sucker) under the Endangered Species Act prompted the United States Fish and Wildlife Service (USFWS) to initiate the Recovery and Implementation Program for Endangered Fishes in the Upper Colorado River Basin in January 1988 (United States Fish and Wildlife Service, 1987; United States Fish and Wildlife Service, 2012). One aspect of the recovery plan requires maintenance of instream flows in order to protect the species' habitat. Under the program, the USFWS considers any depletions of water from tributaries to the Colorado River drainage system to jeopardize the continued existence of the species. The program requires a one-time payment to offset any depletions to the system caused by projects in the basin. In 2003, the USFWS issued an amended biological opinion for the Black Butte Mine that required the mine to pay $2,548.80 for 160 ac-ft of annual depletions (Kelly, 2003; Bureau of Land Management, 2006). No additional payments have been required of the Black Butte Mine since 2003, and the Jim Bridger and Leucite Hills mines have not been required to make any payments for depletions (United States Fish and Wildlife Service, 2018).

4.1.2.1.2 Post-Mining

Increased Runoff: Surface mine reclamation has the potential to change runoff volumes and peak flows. Most mines use a combination of direct topsoil placement and topsoil stockpiles. If topsoil salvaged for site reclamation is stockpiled for long periods of time, it can lack structure when it is reapplied over the reclaimed surface. Soils with diminished structure have lower infiltration rates when compared to native soils, which may result in increased runoff.

Several studies have shown that after reclamation, infiltration rates increase over time as root and soil structure develops. Rainfall simulation experiments conducted from 1979-1983 at the Belle Ayr Mine found that over time, reclaimed areas develop an infiltration-runoff response that closely reflects that of undisturbed areas (Belle Ayr Mine Permit, 2020). Schafer et al., (1979) examined soil genesis on mine spoils that ranged in age from 1 to 50 years at a surface coal mine in the Powder River Basin (PRB) near Colstrip, Montana. The results showed that between four and six years were required for water use patterns in mine spoil to become similar to native soils. The study found no difference between infiltration rates on mine spoil and undisturbed soils. The study also illustrated the effects that different machinery and methods of soil placement can have on soils; dozers and draglines resulted in un-compacted soils while scrapers caused compacted zones (Schafer et al., 1979). Use of scrapers to replace topsoil has also been noted to cause compaction in early coal mining in the Wyoming PRB. More recently, Reynolds and Reddy (2012) compared infiltration rates between native sites and reclamation that was 10-15 years old and 20-25 years old at two coal mines in the PRB of Wyoming. The study found that infiltration rates on 20-25-year

old reclamation was similar to native sites, and significant differences were found between infiltration rates on 10-15 year old reclamation and both 20-25 year old reclamation and native sites (Reynolds and Reddy, 2012).

Vegetation plays an important role in runoff generation. Early in the reclamation phase there is the potential for increased runoff due to reduced interception losses and limited root structure. Additionally, the thickness and extent of litter during the early stages of reclamation is less than pre-mine conditions, which may result in increased runoff.

Decreased Runoff: Following backfilling of the mine pit, there is the potential for some differential settling to occur, resulting in the creation of small depressions. Because of their small size, any decrease in drainage area is generally considered negligible. This may not be the case if larger features such as sediment ponds are not reclaimed but rather left behind as permanent post-mine impoundments. Justification to leave these features is associated with maintaining or enhancing the post-mining land use or replacement of a pre-mine feature. If there is an increase in the number of post-mine features compared to what existed pre-mine, there could be a reduction in runoff volume due to a net increase in storage capacity. All features that have the potential to capture and detain runoff generally require WSEO approval of appropriated water rights. Further discussion on permanent post-mine impoundments is provided in Section 6.1.1 and Section 7.1.1.

A decrease in runoff may also occur due to differential settling in reconstructed stream channels. Stream channel reconstruction at some Powder River Basin mines involves using an impermeable layer such as clay to prevent streamflow losses to backfill material, which is then overlaid with a material that will sustain the properties and function of the pre-mine alluvium. In areas of settling, depressions or pools may be develop within the channel. Evidence of evaporation has been noted at the edges of these pools, indicating loss of water in the alluvial system due to evaporation.

After reclamation, most reconstructed drainage basins have comparable drainage areas to the pre-mining drainage area although individual sub-basins may vary somewhat from the pre-mining configuration. A change in contributing drainage area at the sub-basin scale may result in a change in runoff volumes for individual sub-basins. However, changes in sub-basin contributing areas should be compensated for at a larger watershed scale, resulting in little or no change in total contributing drainage area. This implies that runoff volumes after mining should be similar to pre-mining since the total contributing drainage area has not changed. Further discussion on post-mine drainage basin characteristics is provided in Section 6.1.1 and Section 7.1.1.

Runoff may also decrease in the reclamation period due to increased infiltration and reduced overland flow resulting from an increase in vegetative cover. Anecdotal evidence from coal mines in the PRB suggests that groundcover, particularly litter, tends to be much higher post-mine than pre-mine. This increase is due in part to a reduction in grazing. In addition, exotics and annuals such as cheat grass can rapidly invade a reclamation site and result in an increase in cover. Higher ground cover generally results in increased interception, increased infiltration, and slowed overland flow velocities, which translates to less runoff. The implication is that the resumption of grazing practices to pre-mine levels would help offset any decrease in runoff following reclamation.

Wetlands are replaced on a one-to-one area basis as regulatory statutes require, and in most cases, playas will also be replaced. Isolated wetlands associated with playas are no longer considered jurisdictional wetlands by the U.S. Army Corps of Engineers (USACE) and are excluded from regulatory commitments. While the final placement of wetlands and playas may not always

reflect the locations of the original features, they are designed to function as hydrologic features that will preserve the hydrologic balance and support the post-mining land use.

While subsidence associated with longwall mining is relatively quick and will most likely be expressed during mining, there is the potential for delayed surface expressions of subsidence to occur after mining. Depending on how the longwall panels are oriented in relation to surface drainage networks, there is potential for subsidence expressions to disrupt the surface water flow regime. Longwall panels that pass under a drainage axis in a perpendicular fashion may cause segmentation through the creation of a series of shallow depressions. The long-term effect of subsidence would likely be a decrease in water quantity if a significant number of surface cracks and depressions remain in channels after mining. The effects of subsidence on channels can be mitigated by monitoring channel dimensions and water quantity in the reclamation period, and using corrective measures to address problems. The Jim Bridger Mine Permit (2020) contains commitments to monitor and mitigate subsidence, and these will be discussed in later sections of the CHIA.

4.1.2.2 WATER QUALITY

4.1.2.2.1 During Mining

Degraded Quality: The removal of vegetation and topsoil exposes overburden and can result in increased erosion potential. Runoff from disturbed areas may contain increased concentrations of sediments or other constituents which may degrade water quality. Erosion can also increase during mining due to an increase in impervious surfaces that decrease infiltration rates. These include the presence of unpaved access or haul roads and infrastructure associated with mine facilities. All surface water runoff from disturbed areas is required to pass through a sediment pond or alternate sediment control measure (ASCM) and meet specific water quality criteria prior to discharge. The proper design of diversion ditches and culvert crossings will ensure that downstream water quality impacts are mitigated.

Water generated from dewatering operations has the potential to degrade surface water quality in two ways. The first is the potential to accelerate erosion with the change in flow regime. This can result in gullying and downcutting, increasing the transport capacity of channels. Secondly, the water quality of several aquifers may be poorer compared to surface water. If this is the case, if groundwater is discharged into a stream channel rather than being used for industrial uses, there is potential to degrade surface water quality.

Selenium is a naturally occurring element that is essential to humans and animals. Selenium has been identified as a constituent of concern in backfill groundwater quality at coal mines in the PRB of Wyoming (Martin et al., 1988; Dreher and Finkelman, 1992; Reddy et al., 1995). Oxidization of overburden materials brought to the surface during mining may decrease the stability of the selenium containing sulfides and organic matter, increasing dissolved selenium concentrations in backfill (Naftz and Rice, 1989; Reddy et al., 1995). Murphree (2005) also suggested that high selenium concentrations in backfill can occur due to oxidation of organic matter and sulfides from native alluvium used for stream reclamation. Studies in British Columbia (McDonald and Strosher, 1998), Alberta (Casey and Siwik, 2000), and West Virginia (Lemly, 2008) have shown elevated selenium in surface water downstream of coal mines. The concern for aquatic environments is that selenium can bioaccumulate in food chains and potentially be toxic for aquatic life (Lemly, 2008). In the upper Green River Basin of Wyoming, selenium in surface water downstream of the coal mines has not been known to be a concern. Nonetheless, an analysis of the

frequency of selenium exceedances upstream and downstream of the coal mines in the Bitter Creek CIA is warranted to further evaluate the potential for mining to affect selenium concentrations.

Changes in surface water quality associated with subsidence over a mined longwall panel may be induced through three processes: (1) alterations to the quality of the groundwater, which subsequently may contribute baseflow to streams, (2) changes in channel slope which lead to changes in the stream's associated sediment load, and (3) changes in the configuration of the land surface drained by a stream channel which results in increased or decreased sediment production. The formation of subsidence troughs can potentially increase or decrease slope lengths depending upon the pre-existing topography. Erosion and transport of sediment is directly proportional to slope length because increased slope length results in increased runoff volume and velocity. An increase in the steepness of slope will also result in an increase of flow velocity and the capacity for erosion.

Improved Quality: All surface water leaving areas affected by mining is treated and released after WYPDES regulations are met. Water which has passed through these treatment facilities typically has a much lower TSS concentration than water in native/undisturbed drainages.

4.1.2.2.2 Post-Mining

Changes in various landscape characteristics, such as vegetation, hillslope profile, channel morphology, and soils, have the potential to affect surface water quality.

Degraded Quality: A decrease in vegetation density and/or infiltration rates can result in increased runoff and ultimately the transport of additional sediment to reclaimed channels. Increased erosion and sedimentation can develop if stream channels are designed improperly. For example, if the reclaimed gradient is too steep, incision or other forms of channel adjustment may occur, resulting in erosion of the channel bed and/or banks. Conversely, if the gradient is not sufficiently steep to transport the sediment load through the system, sediment is deposited, which increases channel gradient and ultimately results in channel incision as the channel attempts to find a slope that balances sediment load and discharge. These adjustments in channel morphology have the potential to result in temporary increases in sediment load.

While subsidence associated with longwall mining is relatively quick and will most likely be expressed during mining, there is the potential for delayed surface expressions of subsidence to occur after mining. The potential impacts to surface water quality following subsidence were previously discussed. The effects of subsidence on channels can be mitigated by monitoring channel dimensions and water quantity in the reclamation period, and using corrective measures to address problems. The Jim Bridger Mine Permit (2020) contains commitments to monitor and mitigate subsidence, and these will be discussed in later sections of the CHIA.

Improved Quality: Surface water quality has the potential to be improved because of permit commitments by the mining companies to cover all unsuitable material with a minimum of four feet of material. The burial depth is generally increased to eight feet under major drainages. Therefore, the potential to expose problematic material is reduced. As part of the Stream Channel Verification in the Phase 1 Bond release process, the WDEQ/LQD verifies that an operator has sampled the material beneath stream channels and floodplains to ensure water quality will not be impaired (Wyoming Department of Environmental Quality, 2019b).

Reclaimed hillslope profiles are generally concave up, similar to what can be expected of a mature landscape. This profile shape tends to reduce the sediment loading of stream channels because a substantial portion of the sediment is deposited at the toe of the slope.

Prior to the release of bond for any mined area, the WDEQ/LQD requires the operator to demonstrate that the reclaimed land exhibits sufficient surficial stability and development of post-mining vegetation to show that runoff does not need to pass through a sediment pond or an ASCM. Final bond release requires that the post-mining vegetation cover meets or exceeds pre-mining conditions. If post-mining vegetation cover meets bond release requirements, it is assumed that interception losses and protection of the soil surface closely resembles pre-mining conditions. An increase in vegetative cover following reclamation will increase infiltration and slow overland flow velocities. This will help trap and filter sediment before entering stream channels, helping to improve water quality.

Toy (1989) studied sheetwash erosion of natural and reclaimed hillslopes at the Dave Johnston Mine near Glenrock, Wyoming. The study concluded that the difference in sheetwash erosion between native and reclaimed slopes was virtually non-detectible. The Big Horn Mine near Sheridan, Wyoming performed a series of plot studies on reclaimed and native lands between 1982 and 1996. The Big Horn Mine concluded that sediment yield from reclaimed lands was less than that from native lands (Big Horn Mine Permit, 2020).

4.2 GROUNDWATER

The identification of groundwater hydrologic concerns is integral to the existing and foreseeable groundwater uses within the CIA. An inventory of existing groundwater uses within the CIA is discussed below.

4.2.1 GROUNDWATER USE

As of May 2020, there are 87 valid groundwater rights in the groundwater CIA (**Figure 34**). These groundwater rights were obtained from the WSEO database and evaluated according to their permitted beneficial use. Only groundwater rights (wells) with a status of complete, incomplete, fully adjudicated, or unadjudicated were considered. Groundwater rights for exclusive monitoring and CBM dewatering uses were not considered since the impacts from the coal mine operations do not affect the intended use of these water rights. Groundwater rights owned by the coal mines were also excluded from **Figure 34** since impacts to these water rights will be by the companies owning the water rights rather than by cumulative impacts of all other existing or anticipated coal mining operations.

Fifty two percent of the WSEO groundwater rights in the CIA are permitted for miscellaneous use (**Figure 34**). Many of these are associated with the Jim Bridger Power Plant located in between the Jim Bridger and Leucite Hills mine permit boundaries. There are 22 groundwater rights in the CIA permitted for stock use, most of which are several miles north, northeast, and east of the Jim Bridger Mine. There are eight groundwater rights for domestic use; three of these are located at Point of Rocks. Four groundwater rights are permitted for industrial use. There are six groundwater rights for municipal use by the Town of Superior. These are located northwest of the Jim Bridger Power Plant (**Figure 34**). Identification of the aquifer in which the

groundwater rights are completed is not readily available from the WSEO database. Well depths are also not available for all the permitted groundwater rights in the CIA.

4.2.2 HYDROLOGIC CONCERNS

Groundwater level declines or degradation of groundwater quality caused by mining may affect the existing groundwater uses in the CIA. In the areas where groundwater will be migrating from the backfill aquifer to the native undisturbed aquifers outside the permit boundaries, the groundwater quality is dependent on the backfill aquifer groundwater quality, which in turn, is dependent on the physical characteristics of the backfill aquifer and recharge source.

In general, there is a significant time lapse for the groundwater impacts caused by mining to propagate outside the mine permit boundary. The timing of these impacts will vary spatially depending on the proximity of a well to mining operations, the aquifer in which the well was completed, the depth to water, and the yield and quality required from the well to maintain its intended purpose. The two primary hydrologic concerns, the decline of groundwater levels and degradation of groundwater quality, are discussed in the sub-sections below.

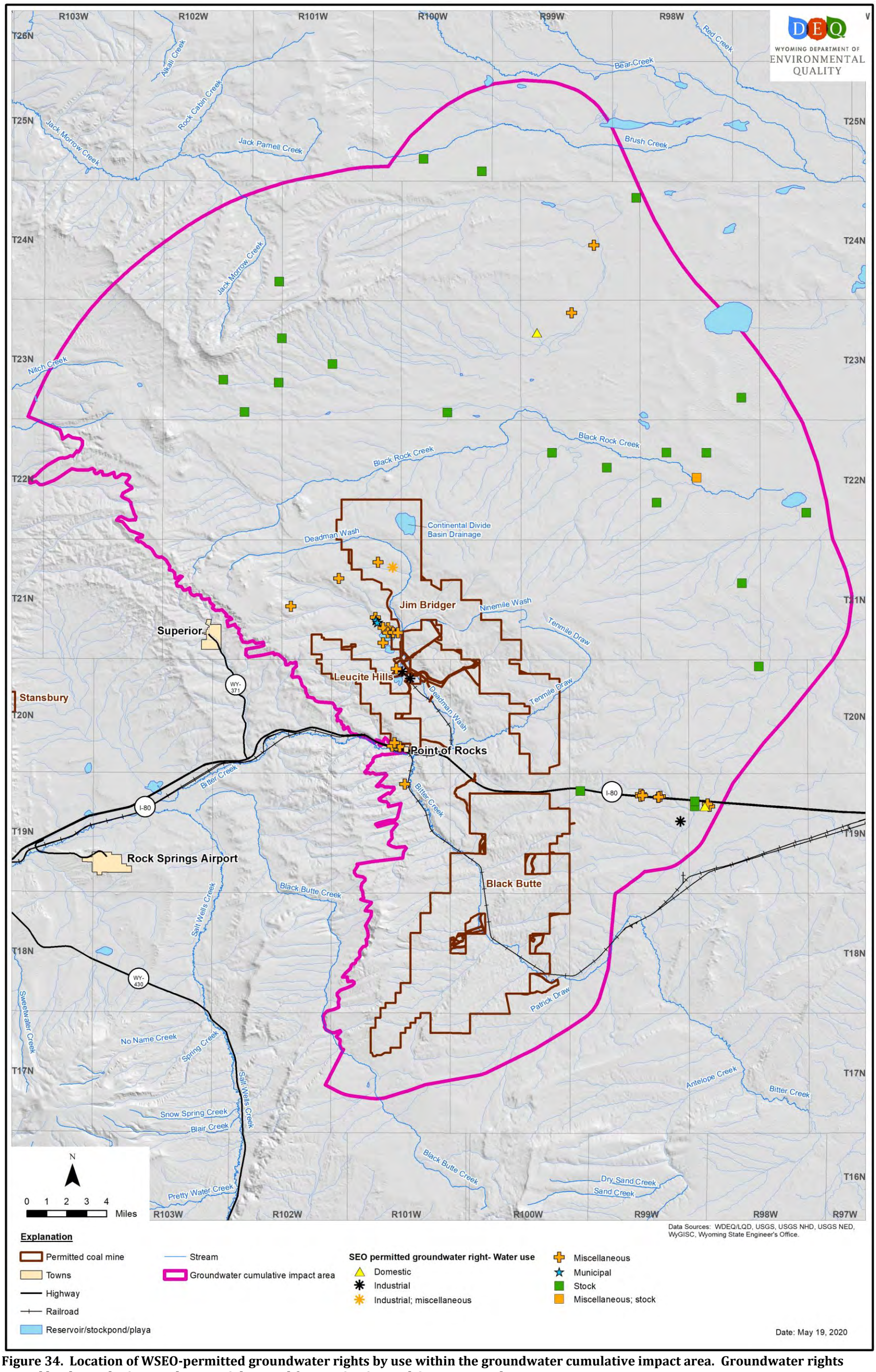


Figure 34. Location of WSEO-permitted groundwater rights by use within the groundwater cumulative impact area. Groundwater rights owned by the coal mines and water rights used for monitoring and CBM are not shown.

4.2.2.1 DECLINE OF GROUNDWATER LEVELS

The coal mining operations will lower the groundwater levels to some extent in all the aquifers of concern within the CIA. This lowering of water levels can manifest as several different types of impacts on the water use and the hydrologic balance, including:

(1) Reduced yield from existing wells in the CIA:

Groundwater elevations in the wells located within and adjacent to a mine permit boundary may be lowered by de-watering, pit inflow, and mine facility wells completed in the deeper aquifers. The changes in depth to water and the potentiometric surface could potentially decrease groundwater available to wells with existing water rights (**Figure 34**). The magnitude of the decrease in the water level is generally a log-normal function of distance, thus the amount of drawdown of the water levels decreases with distance from the mine pits. The water level drawdowns, however, are additive where they intersect, which commonly happens when mines are in close proximity. The drawdowns also have the potential to be affected by other activities, including water for conventional oil and gas development, municipal development, and pumping from private wells for households and livestock use.

(2) Alteration of groundwater flow gradients and directions:

The removal of coal and the dewatering of the overburden and coal aquifers result in a change in groundwater flow directions. In some instances flow direction is reversed. When the backfill aquifer is saturated to the pre-mining groundwater levels, the groundwater gradients should return to the pre-mining condition. Until that time, the pit and the backfill aquifer act as groundwater sinks that will have an impact on the hydrologic balance of the aquifer system.

(3) Alterations to the recharge and discharge mechanisms:

The impacts of coal mining might alter the existing recharge and discharge mechanisms resulting in a change to the hydrologic balance. For example, in some areas of the GGRB, groundwater from the coal and overburden aquifers contribute to stream baseflow by discharging to the alluvium or directly to streams. Lowering the groundwater potentiometric surface will decrease the amount of groundwater available to discharge. If the decreased quantity is large, there is the potential to affect surface water flow rates, possibly affecting downstream water rights. In addition, there might be changes in the interaction between the backfill and the reclaimed and native aquifers.

(4) Backfill aquifer properties:

Mining and reclamation will result in the replacement of the overburden and coal aquifers with unconsolidated overburden materials commonly referred to as backfill. The backfill aquifer is predicted to saturate over time. Although the lithologic materials in the backfill aquifer will be the same as the overburden, the bedding and arrangement of materials will be different. The differences between the reclaimed and pre-mine aquifer characteristics may alter the groundwater flow regime. The ability of the backfill aquifer to store and transmit water will determine how productive the backfill

aquifer will be to support the post-mining land use. Hydraulic conductivity, porosity, storage coefficient, and infiltration rate are the key indicators to assess the ability of the backfill aquifer to support the post-mining land use and also to maintain the pre-mining hydrologic balance.

4.2.2.2 DEGRADATION OF GROUNDWATER QUALITY

Groundwater flowing through the backfill aquifer may have higher concentrations of dissolved constituents because more fresh mineral surfaces are exposed for chemical reaction in the backfill than in the undisturbed sediments. Initial conditions in the backfill include a more oxidized environment when compared to the undisturbed conditions. This increase in exposed mineral surfaces and difference in oxidation state may cause an increase in TDS and other constituents in groundwater.

The identified concerns related to the degradation of groundwater quality include:

(1) The effect of groundwater migrating from the backfill aquifer to the undisturbed native aquifers outside the mine permit boundaries.

(2) The groundwater quality of the backfill aquifer within the mine permit boundaries and its ability to support the approved post-mining land use.

(3) The effect of the quality of base flow from the backfill aquifer to the streams.

The first two identified concerns can be evaluated by comparing the existing and expected groundwater quality of the backfill aquifer against the WDEQ/WQD groundwater standards. The third concern can be evaluated against the surface water standards using surface water quality monitoring data.

4.3 ALLUVIAL VALLEY FLOORS

There are no AVFs in the Bitter Creek CIA (see Section 3.3). Because there are no AVFs, hydrologic concerns related to AVFs are not identified in the CHIA.

5. MATERIAL DAMAGE CRITERIA

The objective of this section is to develop appropriate material damage criteria for surface water, groundwater, and alluvial valley floors.

The Wyoming Environmental Quality Act requires that no coal mining be approved unless the applicant affirmatively demonstrates and the administrator finds in writing that the operation is designed to prevent material damage to the hydrologic balance outside of the permit area (W.S. § 35-11-406(n)(iii)). The WDEQ/LQD defines material damage to the hydrologic balance as a significant long-term or permanent adverse change to the hydrologic regime (WDEQ Land Quality–Coal Rules, Ch. 1, § 2(cf)). A significant long-term or permanent adverse change is defined as changes to the surface or groundwater hydrology that are inalterable conditions contrary to the Wyoming State Constitution, or of statutes administered by the WSEO, or water quality standards administered by the WDEQ/WQD (Wyoming Department of Environmental Quality and Wyoming State Engineer's Office, 1996). An evaluation of the available monitoring data and information in the mining permits is used to indicate when material damage to the hydrologic balance may have occurred as a result of coal mining. The material damage criteria for surface water and groundwater are described in more detail below.

5.1 SURFACE WATER

The material damage criteria for surface water are examined for water quantity and water quality.

5.1.1 WATER QUANTITY

Surface water quantity is evaluated to predict if coal mining will cause cumulative impacts to downstream surface water rights. The available surface water quantity data are evaluated for the baseline and during-mining periods in each of the major drainages within the CIA. Specific data elements evaluated include mean daily flows, peak flows, flow duration, and monthly, seasonal, and annual runoff volumes. In addition to this analysis, the assessment considers factors such as the proximity of downstream water rights, extent of dewatering, extent of surface disturbance, extent and capacity of water retention features, and changes to post-mine drainage basins. Material damage to surface water quantity occurs if the analysis demonstrates that coal mining has caused or will cause a decrease in surface water quantity such that downstream surface water rights will be affected, and the mine(s) have not committed to providing a replacement water source similar in quantity and quality.

The State of Wyoming has agreed to several river compacts and court decrees that address the allocation of surface water flows out of Wyoming (W.S. §41-12-101, -201, -301, -401, -501, -601, and -701). The coal mines in the GGRB within the Green River Basin, which is part of the Colorado River Compact of 1922, the Upper Colorado River Compact of 1948, and international treaty between the United States and Mexico (Wyoming State Engineer's Office, 2006).

5.1.2 WATER QUALITY

Except where authorized by permit, it is prohibited to cause, threaten, or allow discharge of pollution into waters of the state (W.S. § 35-11-301(a)(i)). Pollution is defined as contamination or other alteration of the physical, chemical, or biological properties of waters of the State which creates a nuisance or renders waters harmful, detrimental or injurious to public health, safety or welfare, to domestic commercial, industrial agricultural, recreational, or other legitimate beneficial uses, or to livestock, wildlife or aquatic life, or degrades the water for its intended use, or adversely affects the environment (W.S. § 35-11-103(c)(i)).

The effects of coal mining on surface water quality are evaluated using available water quality sample data and applicable WDEQ/WQD Rules and Regulations to determine if coal mining has caused or will cause a significant long-term or permanent adverse change such that WDEQ/WQD surface water quality standards and classes of use are no longer met. The WDEQ/WQD has classified surface waters according to their use or potential use (Wyoming Department of Environmental Quality, 2020a). Each surface water classification has a set of numeric criteria established to meet the defined use (WDEQ Water Quality Rules, Ch. 1, § 4).

The available surface water quality data are analyzed for the baseline and during-mining periods in each of the major drainages within the CIA. Summary statistics, including the minimum, maximum, and median concentrations are compiled. The frequency of WDEQ/WQD water quality standard exceedances is examined. For the identified during-mining period, the frequency of exceedances is evaluated for the last three years of sampling. Discussion of changes between baseline and during-mining periods, as well as upstream and downstream of mining activity is included. The potential for material damage outside the mine permit areas is assessed by evaluating the frequency of surface water quality standard exceedances over the last three years of sampling.

All streams evaluated in this CHIA are either Class 2AB(ww), Class 2C, or Class 3B streams and must meet WDEQ/WQD water quality standards for aquatic life other than fish. WDEQ/WQD Rules and Regulations require that numeric standards for aquatic life other than fish will not be exceeded more than once every three years (WDEQ Water Quality Rules, Ch. 1, § 4). According to methods established by *Wyoming's Methods for Determining Surface Water Quality Condition*, if representative data show that at least one aquatic life other than fish criterion is exceeded for at least two separate years in a three-year period, than uses are not fully supported (Wyoming Department of Environmental Quality, 2017). Class 2AB(ww) streams such as Deadman Wash below the Jim Bridger Power Plant have additional protected uses such as drinking water, game fish, non-game fish, and fish consumption. As such, additional criteria exist for the human health consumption of fish and drinking water. According to the WDEQ/WQD, the uses of drinking water and fish consumption are fully supported when there are no exceedances of any related criterion within at least two separate years of any three year period (Wyoming Department of Environmental Quality, 2017). Therefore, for the purposes of the CHIA, if an exceedance for a given constituent is observed in at least two separate years over the last three years of sampling, a more detailed analysis is conducted to determine if coal mining activity is the cause of the exceedance. Comparisons to data from the pre-mining period and stations upstream of mining activity are used to indicate when coal mining may be the cause of the exceedance. When appropriate, statistical tests are used to compare data between stations.

5.2 GROUNDWATER

The identified material damage criteria in this CHIA for groundwater are related to:

(1) Protection of Water Uses: Protection of existing and reasonably foreseeable water uses within the CIA, and
(2) Existing Groundwater Quality Standards: The CHIA material damage criteria considers and incorporates the WDEQ/WQD approved groundwater quality standards as part of the impact assessment.

It should be noted that material damage indicators which are not enforceable, but act as an early potential sign of possible material damage in the future are identified in this CHIA. The intent of identifying a material damage indicator is to alert the coal mines and the WDEQ/LQD of potential water resource impacts of concern so coal mines may take appropriate actions to prevent material damage. Continuous monitoring and evaluation of these material damage indicators are required so that measures may be taken to prevent material damage to the hydrologic balance outside the permit area. The exceedance of material damage criteria would result in a finding that material damage to the hydrologic balance outside the permit area had occurred.

An additional key distinction between the material damage criteria and material damage indicators is that the identified material damage criteria are applied exclusively to areas outside the coal mine permit boundaries. The material damage indicators can include areas within the coal mine permit boundaries and are not restricted to outside the permit boundaries.

5.2.1 MATERIAL DAMAGE CRITERIA

Material damage to groundwater occurs if the CHIA demonstrated that coal mining has caused or will cause an irretrievable loss of the groundwater resource to support existing or reasonably foreseeable uses outside of the coal mine permit boundaries and if the mine(s) have not committed to providing a replacement water source similar in quantity and quality. The material damage criterion is examined for water quantity and water quality and is presented below.

5.2.1.1 GROUNDWATER QUANTITY

Material damage to groundwater quantity occurs if the analysis demonstrates that coal mining has caused or will cause a decrease in groundwater levels such that groundwater rights within the CIA will be affected and the mine(s) have not committed to providing a replacement water source similar in quantity and quality.

Groundwater levels and drawdowns are evaluated to predict if coal mining has caused or will cause cumulative impacts to existing water rights within the CIA. The available groundwater level data are evaluated for the baseline and during-mining periods. The assessment considers factors such as the extent of drawdown caused by mine dewatering, depth of the well with the associated water right, proximity of the well to the mine(s), aquifer in which the well is located, local hydrogeology, and cumulative calculation of the model predictions from individual mines.

5.2.1.2 GROUNDWATER QUALITY

Material damage to groundwater quality occurs if the analysis demonstrates that coal mining has caused or will cause a long-term change in groundwater quality outside the coal mine permit boundaries that would preclude existing or reasonably foreseeable uses.

The available groundwater quality data are evaluated for the baseline and during-mining periods against applicable WDEQ/WQD groundwater quality standards. Summary statistics, including the minimum, maximum, and median concentrations are compiled and analyzed for both baseline and during-mining periods. In addition, the model predictions from individual mines are used to determine the post-mining groundwater quality. The potential for material damage is assessed by evaluating the effect of groundwater migrating from the backfill aquifer or other coal mining affected aquifers within the coal mine permit boundaries to the undisturbed native aquifers outside the coal mine permit boundaries.

5.2.2 MATERIAL DAMAGE INDICATORS

Typically, it will take several years to realize the groundwater impacts caused by mining to propagate outside the mine permit boundaries because of the relatively slow movement of groundwater. These transient observed groundwater impacts will vary depending on the mining and reclamation methods and sequence, the aquifer of interest, and the distance of the location of interest from the disturbed or reclaimed area. Therefore, the following material damage indicators were identified for groundwater levels and groundwater quality. It is important to note that the following indicators are not enforceable but will be used to initiate discussions and alert the mines of a possible material damage.

It is critical to assess how physical characteristics, recovery rates, and the groundwater quality of the backfill aquifer will affect groundwater availability within the coal mine permit boundaries and flow through the backfill aquifer to the undisturbed native aquifers. The backfill aquifer is a critical component of the hydrologic balance. The material damage indicators are:

(1) Comparison of physical characteristics of the backfill aquifer to the pre-mining baseline conditions.

- The ability of the backfill aquifer to store and transmit water will determine the ability of the backfill aquifer to support the post-mining land use. The physical characteristics of the backfill aquifer are compared to the pre-mining baseline conditions to determine the magnitude of changes in hydraulic properties. Hydraulic conductivities and storage coefficients of the backfill aquifers are examined on a CIA scale to determine if these changes would affect the availability of groundwater on the adjacent native aquifers outside the coal mine permit boundaries.

(2) Evaluation of groundwater level recovery in the backfill aquifer.

- The groundwater level recovery rates will be estimated based on the model predictions provided in the individual mine permits and the available data from the contemporaneously reclaimed areas within the mine permit boundaries. These data will be evaluated to determine if the backfill aquifer

could act as a viable supply source to support the WDEQ/LQD approved post-mining land use of livestock and wildlife. In addition, the recovery rate of the backfill aquifer will be used as an indicator to evaluate the impacts on the adjacent native aquifers outside the coal mine permit boundaries.

(3) The groundwater quality of the backfill aquifer within the permit boundary and its ability to support the WDEQ/LQD approved post-mining land use of livestock and wildlife.

- The coal mine predictions presented in the individual mine permits on post-mining groundwater quality of the backfill aquifer along with the available data from the contemporaneously reclaimed backfill aquifer will be used to determine if the backfill groundwater quality can meet the WDEQ/WQD Class III livestock groundwater quality standards. The effect of backfill groundwater migrating to the adjacent undisturbed native aquifers outside the permit boundaries will be an indicator of the probable impact on the existing water uses outside the permit boundaries.

5.3 ALLUVIAL VALLEY FLOORS

There are no AVFs at the Jim Bridger, Leucite Hills, and Black Butte mines (see Section 3.3). Because this, the CHIA will not conduct a material damage assessment for AVFs.

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6. ANALYSIS OF CURRENT HYDROLOGIC CONDITIONS AND CUMULATIVE HYDROLOGIC IMPACTS

6.1 SURFACE WATER

The following section discusses current hydrologic conditions and potential during-mining impacts to surface water quantity and quality in the Bitter Creek CIA. For the purposes of the CHIA, the period for current conditions and during-mining analysis extends from 1982 to present.

6.1.1 DURING-MINING WATER QUANTITY AND WATER QUALITY OF INDIVIDUAL DRAINAGES IN THE BITTER CREEK CIA

6.1.1.1 DEADMAN WASH

6.1.1.1.1 Water Quantity

Current and during-mining hydrologic conditions in the Deadman Wash watershed were evaluated using data from stations operated by the Jim Bridger Mine, Leucite Hills Mine, and SWCCD and BKWAG. No USGS station data were evaluated since the peak flow station on Deadman Wash near Point of Rocks was discontinued in 1981.

The current surface water stations at the Jim Bridger Mine in the Deadman Wash watershed are located in roughly the same location as the baseline stations, with the exception of SWPS-3 (Upper Deadman Wash). In 2002, SWPS-3 was moved approximately two miles upstream, reducing its contributing drainage area from 16.3 to 14.6 mi^2. Nine and One Half Mile Wash is now only monitored by conducting annual surveys of channel cross sections. Ten Mile Draw Tributary is no longer monitored, but a station has been installed on an unnamed tributary to Deadman Wash (SWPS-8) (**Figure 13**; **Table 6**). The current stations comprise the sediment control (SEDCO) network to monitor mine impacts and the effectiveness of ASCMs. SEDCO stations consist of flow recorders and automated pump samplers. The SEDCO network includes SWPS-3, SWPS-9, SWPS-13 (undisturbed), and SWPS-8, SWPS-10, and SWPS-14 (disturbed) (**Figure 13**; **Table 6**). The Jim Bridger Mine considers SWPS-9 a "receiving" station for the purposes of evaluating ASCMs because ASCMs are not in use in the contributing area above the gage. However, the mining pit intercepted Deadman Wash above SWPS-9 in 1988. Because of this, for the purposes of this CHIA, data from SWPS-9 are used to evaluate mining impacts to surface water quantity and quality since the contributing area above the gage has been disturbed by surface mining.

Analysis of during-mining surface water quantity data from the SEDCO stations is limited to mean daily flows from 1995 to present, because these data were available in the WDEQ/LQD Hydrology Database. Flow data from the SEDCO stations for the during-mining period show that runoff varies dramatically from year to year and is highly dependent on the occurrence of summer storm events. Without summer rainfall, there are long periods of no flow recorded at each station, sometimes over the course of entire monitoring season. The stations are typically operated from May through September, so not all events, particularly early snowmelt, may be captured throughout the year.

Flow duration curves were constructed for the six SEDCO stations using mean daily flows (May through September) from 1995 through 2019 (**Figure 35**). The curves demonstrate the highly ephemeral nature of runoff in the Deadman Wash drainage, as flow was only recorded less than or equal to three percent of the time at each station. The disturbed Deadman Wash watershed (SWPS-9) had the most frequent flows of the six stations, with flow occurring roughly 3.1 percent of time. The Deadman Wash upstream site (SWPS-3), had the most infrequent flows, as flow occurred less than 1.5 percent of the time. On the mainstem of Deadman Wash, flow was more frequent across a range of flow values at the downstream station (SWPS-9) compared to SWPS-3 (**Figure 35**), which drains an undisturbed area above the mining pits.

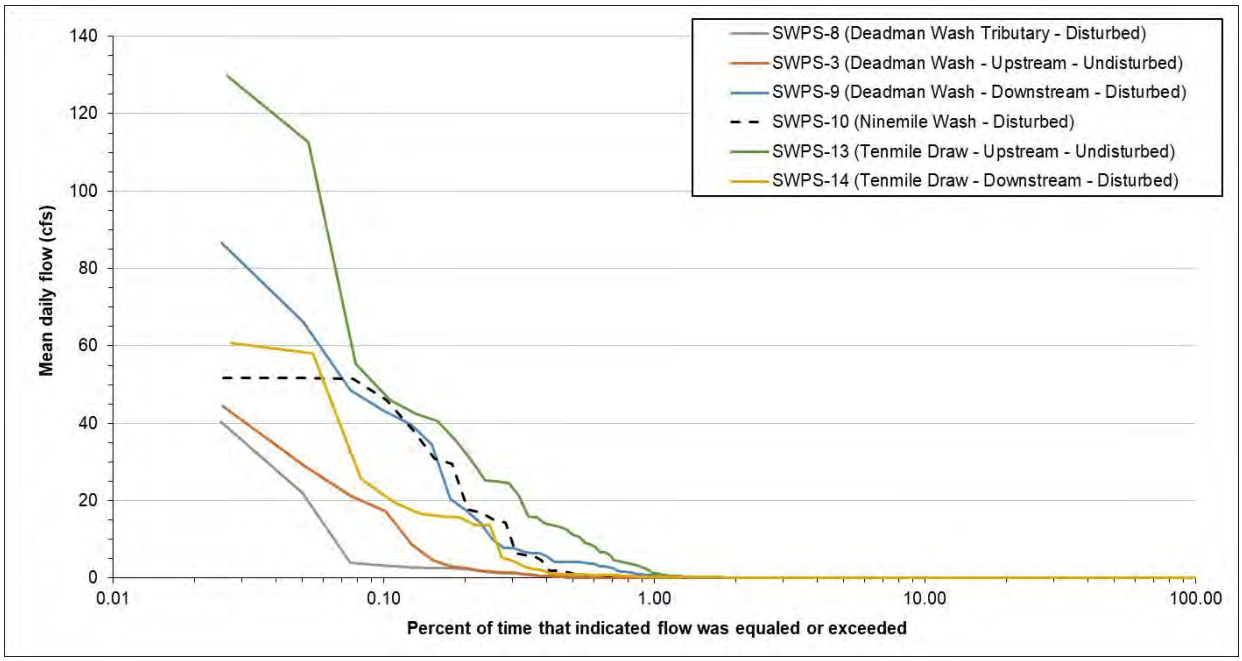


Figure 35. Flow duration curves for SEDCO stations at the Jim Bridger Mine, 1995-2019. Mean daily flows were generally monitored from May through September in each year.

On Tenmile Draw, flow occurred 2.3 percent of the time at the station downstream of mining disturbance (SWPS-14) and 2.5 percent of the time at SWPS-13 at the upstream permit boundary (**Figure 35**). Flows at SWPS-13 were more frequent across a range of flows. This difference may be due to ASCMs in the disturbed portion of the watershed below SWPS-13 that may be detaining runoff and slowing runoff velocities, helping to attenuate storm runoff. Although mining will not progress through the Tenmile Draw alluvium, the Jim Bridger Mine has predicted that drawdown in the alluvium is expected to reduce discharge to a spring in upper Tenmile Draw, which will presumably reduce streamflows in the drainage (Jim Bridger Mine Permit, 2020). The springs are predicted to recover by 2300, and the mine has prepared a plan to mitigate the jurisdictional wetlands that may be impacted by the drawdown in Tenmile Draw (see Section 7.1.1). SWPS-13 had the highest mean daily discharge recorded amongst the stations from 1995 to 2019 (130 cfs on June 1, 2009). The same event resulted in a mean daily flow of 58 cfs downstream at SWPS-14.

The WDEQ/LQD Hydrology Database contains limited data on peak flows at the SEDCO stations at the Jim Bridger Mine. However, the Jim Bridger Mine Permit (2020) provides the maximum peak flows recorded at each SEDCO station from 1984 to 2002 (**Table 21**). The highest peak flow for this 18-year period was 350 cfs (9.5 cfs/mi^2), recorded at SWPS-14 on Tenmile Draw

downstream of mining disturbance. This flow is approximately a ten-year event (Miller, 2003). On Deadman Wash, the maximum peak discharge at SWPS-9 downstream of the pits was 242 cfs (8.7 cfs/mi^2), which is lower than the 326 cfs (20 cfs/mi^2) recorded at SWPS-3 upstream of the mining pits. The 326 cfs at SWPS-3 is approximately a 25-year event (Miller, 2003). Since the mine plan does not provide dates for the peak flow data shown in **Table 21**, it is difficult to compare responses across event dates and watersheds with varying levels of mining disturbance. As noted in Section 3.1.1.1.1 for baseline conditions, the spatial variability in summer rainfall also makes it difficult to compare responses among the watersheds draining the mine.

Table 21. Maximum peak flows and unit-area peak flows measured at the SEDCO stations at the Jim Bridger Mine, 1984-2002. Specific dates for the events are not available.

SEDCO Station	Description	Drainage area (mi^2)	Peak Flow (cfs)	Peak Flow (cfs/mi^2)
SWPS-3	Deadman Wash – upstream (undisturbed)	16.3[1]	326	20
SWPS-8	Tributary to Deadman Wash (disturbed)	0.88	138	157
SWPS-9	Deadman Wash – downstream (disturbed)	27.8	242	8.7
SWPS-10	Ninemile Wash (disturbed)	3.1	161	52
SWPS-13	Ten Mile Draw – upstream (undisturbed)	6.1	344	28
SWPS-14	Ten Mile Draw – downstream (disturbed)	36.9	350	9.5

[1]The current drainage area at SWPS-3 is 14.6 mi^2 because the station was moved upstream in 2002.

There is little surface disturbance associated with underground mining at the Jim Bridger Mine, which should translate to minimal impacts to surface water quantity in the Deadman Wash drainage. Existing surface disturbance associated with the underground mine facilities include pumping sites, roads, and ventilation shafts. Dewatering of the underground mine is not expected to increase surface water flows, as the mine has installed a pumping and clarifying system to send water for use at the Jim Bridger Power Plant (Jim Bridger Mine Permit, 2020).

Underground mining at the Jim Bridger Mine is predicted to cause surface expressions of subsidence, ranging approximately from 6.8 to 10.2 feet (Jim Bridger Mine Permit, 2020). In most areas, visible evidence of subsidence is expected to be minimal, although some areas are predicted to develop tension fractures. Depending on the severity, location, and potential to harm humans, wildlife, or livestock, tension fractures will be allowed to self-heal or will be backfilled (Jim Bridger Mine Permit, 2020).

Subsidence is also predicted to cause some headcutting and creation of small impoundments in the Deadman Wash channel above SWPS-3 (Jim Bridger Mine Permit, 2020). The mine permit contains a subsidence monitoring program to include monthly visual inspections over active longwall panels, semi-annual surveys of channel longitudinal profiles and cross-sections, and annual photogrammetric mapping and light detection and ranging (LIDAR) remote sensing (Jim Bridger Mine Permit, 2020). The most recent summary of subsidence monitoring in the mine's 2019 annual report showed that subsidence was forming small impoundments (< 0.5 ac-ft) in the Deadman Wash channel. The channel above several panels was surveyed: Panel 1 subsidence contained 0.35 ac-ft impounded volume, Panel 2 contained 0.12 ac-ft, Panel 3 contained 0.22 ac-ft, Panel 8 contained 0.03 ac-ft, and no other panels showed subsidence. Since future longwall panels will be narrower than the initial panels, the mine predicts that subsidence impoundment volumes along the Deadman Wash channel will continue to decrease over time. In the event that subsidence impoundments total greater than 0.5 ac-ft in volume, the impoundments will be permitted with the WSEO (Jim Bridger Mine Permit, 2020).

The Jim Bridger Mine will allow headcuts to advance in Deadman Wash over the un-subsided section between any depressions that develop over subsided longwall panels (Jim Bridger Mine Permit, 2020). The downstream depression will trap sediment of the un-subsided section between the depressions until the headcut reaches the next upstream depression. Headcutting will only be allowed where the water elevation of the downstream depression is above or equal to the bottom elevation of the upstream depression. This will limit the headcut to the un-subsided portion of the channel only and will reduce sediment to the downstream depression. Rip-rap will be placed to control erosion on the upstream inlet of any depressions that do not meet the above criteria or depressions that are close to the permit boundary. Any headcuts developing in depressions with riprap will be repaired. Additional mitigation strategies for subsidence depressions will be developed between the Jim Bridger Mine and the WDEQ/LQD as needed to ensure the post-mine land use is supported and disturbance to the hydrologic balance is minimized (Jim Bridger Mine Permit, 2020).

At the Leucite Hills Mine, very little surface water data have been collected during the history of the mining operation. This is mostly likely due to the infrequent nature of runoff and the small contributing area of the drainages on the permit area. The Leucite Hills Mine approaches sediment control from a total containment perspective, using detention ponds and ASCMs (Leucite Hills Mine Permit, 2020). The mine currently uses ten sediment control ponds, with design capacities ranging from 1.2 to 19.1 ac-ft. Two other ponds serve as flood control to keep water from entering the mine pits. The mine also had four other sediment control ponds at the facilities area, but these were reclaimed in 2002. Much of the water held in ponds is used for dust suppression rather than being discharged once WYPDES permit conditions are met. Although these structures may cause some reduction in water yield to the Deadman Wash drainage, the reduction is probably very small due to the small size of watersheds within the mine permit boundaries.

Limited peak flow data from 1982 to 1986 are presented in the Leucite Hills Mine Permit (2020) for the stations that were evaluated for baseline hydrologic conditions in Section 3.1.1.1 (SW-1 through SW-6). Flows for 15 events were variable across the stations, ranging from 0.001 to 13.1 cfs.

In 1986, the Leucite Hills Mine changed the surface water monitoring program to include three stations (SW-7, SW-8, and SW-9) on small ephemeral drainages within the permit boundary (**Figure 13**; **Table 6**). Each station was equipped with a v-notch weir, crest gage, and single stage sediment sampler. Drainage areas on the stations range from approximately 0.22 to 3.86 mi^2. A fourth station (SW-10, 3.26 mi^2) (**Figure 13**; **Table 6**) was also installed in 1986 for monitoring of headcut advancement on the channel. Headcut monitoring also takes place at SW-7 and SW-8. From July through December 1986, only three events occurred at three of the stations: one 0.09 cfs event at SW-8 and two 0.02 cfs events at SW-9 (Leucite Hills Mine Permit, 2020).

Instantaneous flow data are available from 2002 to 2019 in the WDEQ/LQD Hydrology Database for the three stations at the Leucite Hills Mine. Since 2002, flow been less than 0.6 cfs during runoff events at the three stations (SW-7, SW-8, and SW-9). The headcut monitoring showed that from 1986 to 2018, the headcuts advanced 12.4, 33.5, and 34.1 feet at SW-7, SW-8, and SW-10, respectively. The advance of the headcuts is presumably due to natural fluvial processes and not exacerbated by any land use activity at the mine. These stations provide data to estimate the natural rate of erosion in native channels; the average rate of advancement ranges from 0.4 to 1.2 feet/year (Leucite Hills Mine Permit, 2020).

In summary, data from stations in the Deadman Wash watershed within the Jim Bridger and Leucite Hills mines indicate that the during-mining impacts to surface water quantity have been minimal. As was noted for the baseline period, runoff in the Deadman Wash watershed is very sparse due to limited precipitation. Flow-duration curves show little difference in frequency of flows between disturbed and undisturbed drainages at the Jim Bridger Mine. Nonetheless, it is reasonable to expect some amount of short-term reduction in water yield in the drainage due to retention in mining pits, sediment ponds, and ASCMs. These structures are necessary to control erosion and protect downstream water quality. Some temporary reductions in flows in Tenmile Draw may also occur due to mine-induced drawdown in the alluvium, which affects discharge from a local spring. It is unlikely that any reduction in water quantity would be detectable at the point of accumulation for the Bitter Creek CIA at USGS Station No. 09216550 near Point of Rocks, and no surface water rights exist in the Deadman Wash drainage other than those held by the coal mines and the Jim Bridger Power Plant. The routing of impacts downstream is further complicated by the Jim Bridger Power Plant surge pond, which contributes perennial flow to lower Deadman Wash. Underground mining impacts to surface water quantity have not been detected to date, but monitoring will continue to evaluate any potential impacts caused by subsidence.

6.1.1.1.2 Water Quality

As previously mentioned, ASCMs are used extensively for sediment control at the Jim Bridger Mine. Several sediment ponds are also used where ASCMs are not cost effective or where WYPDES point discharges may occur (Jim Bridger Mine Permit, 2020). ASCMs consist mostly of rock check dams. ASCM effectiveness is evaluated by the mine using runoff and sediment yield data from the SEDCO stations installed on disturbed and undisturbed drainages. The mine used data from undisturbed (receiving) watersheds over 1984 to 2019 to construct a regression relationship between unit-area sediment yield and storm runoff (**Figure 36**). A total of 184 samples yielded a strong predictive relationship with a R^2 of 0.85. There were no data collected in 2019 at disturbed watersheds, while 2019 data collected at undisturbed watersheds plotted below the regression line (**Figure 36**). Data from previous years at disturbed watersheds have generally plotted within the 95 percent prediction interval (Jim Bridger Mine Permit, 2020). This indicates that there is not a substantial difference between the sediment yields carried between undisturbed and disturbed drainages, implying that ASCMs are effective in reducing sediment loads from drainages disturbed by surface mining activities.

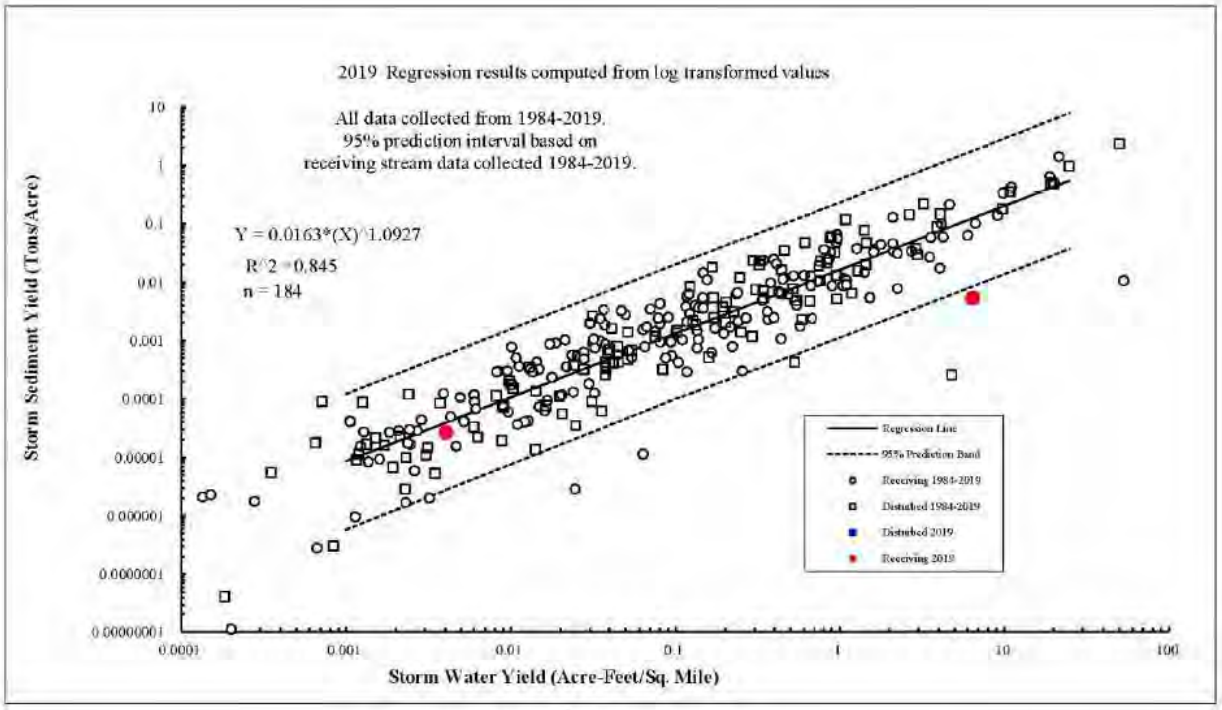


Figure 36. Relationship between storm water yield and storm sediment yield from undisturbed (receiving) watersheds at the Jim Bridger Mine, 1984-2019. Red circles are 2019 data from receiving watersheds. Image scanned from Figure VIII-C-2a in the Jim Bridger Mine 2019 Annual Report.

An analysis of during-mining period water quality data from the SEDCO stations was conducted using data from 1996 through 2019, since this period was available in the WDEQ/LQD Hydrology Database. Although TSS has been a parameter of emphasis given the ASCM evaluation as described above, several ions and dissolved metals have also been monitored. Summary statistics for selected water quality parameters at each SEDCO station are presented in **Table 22**, **Table 24**, and **Table 25**. The tables show the frequency of water quality standard exceedances, including the frequency of exceedances for the last three years of sampling.

Over the 1996 to 2019 period on Tenmile Draw, approximately 33 samples were collected upstream of mining at SWPS-13 and approximately 30 samples were collected downstream of mining at SWPS-14 (**Table 22**). Sodium chloride was the dominant water type at both SWPS-13 and SWPS-14, occurring in 38 and 62 percent of the samples, respectively (RockWare, Inc., 2015) (**Figure 37a, Figure 37b**). Sodium was also the dominant cation noted during the 1979-1980 baseline period, although sulfate was the dominant anion at SWPS-13 and bicarbonate was the dominant anion at SWPS-14. TDS from 1996-2019 at SWPS-13 ranged from 118 to 5,040 mg/L, with a median of 1,440 mg/L. At SWPS-14, TDS was lower, ranging from 168 to 2,660 mg/L, with a median of 1,225 mg/L. As was noted for the baseline period in the Deadman Wash drainage, TSS concentrations were highly variable. At SWPS-13, 419 TSS samples were collected, with concentrations ranging from <5 to 121,000 mg/L with a median of 3,840 mg/L. At SWPS-14, 175 TSS samples were collected, with concentrations ranging from 10 to 308,000 mg/L with a median of 11,300 mg/L. Only one field pH sample was reported at either station, and the value (9.09) at SWPS-13 slightly exceeded WDEQ/WQD Class 3B standards (**Table 22**).

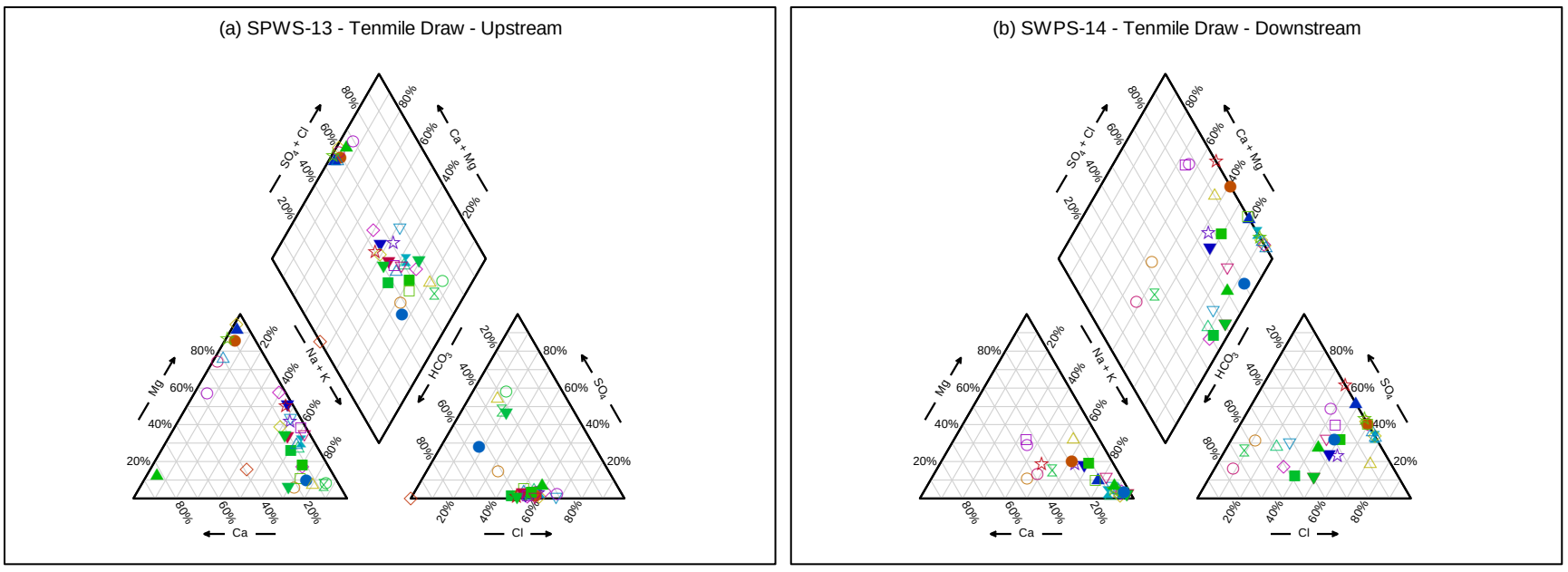


Figure 37. Piper diagrams for samples collected at (a) SWPS-13, (b) SWPS-14, (c) SWPS-10, (d) SWPS-8, (e) SWPS-3, and (f) SWPS-9 at the Jim Bridger Mine, 1996-2019. Each symbol represents a sample. The piper diagram in (g) provides a legend to assist in interpreting water types.

Table 22. During-mining water quality statistics and WDEQ/WQD class of use exceedances for selected constituents on Tenmile Draw at Jim Bridger Mine stations SWPS-13 (upstream) and SWPS-14 (downstream), 1996-2019.

Constituent	Units	Tenmile Draw (SWPS-13) (upstream-undisturbed) (1996-2019)							Tenmile Draw (SWPS-14) (downstream-disturbed) (1996-2019)						
		Number of samples	Min	Max	Median	Number of exceedances	Number of exceedances over last three years	Exceedances in at least two separate years of last three years?	Number of samples	Min	Max	Median	Number of exceedances	Number of exceedances over last three years	Exceedances in at least two separate years of last three years?
Aluminum (dissolved)	mg/L	23	<0.1	4.7	0.08	4	1	No	21	<0.1	3.5	0.25	4	0	No
Ammonia as N (total) [1]	mg/L	33	<0.1	11.41	0.2	NA	NA	NA	30	<0.1	10.9	0.4	NA	NA	NA
Arsenic (dissolved)	mg/L	29	<0.005	0.014	93% <0.01	0	0	No	25	<0.005	0.008	92% <0.01	0	0	No
Barium (dissolved)	mg/L	23	<0.5	0.043	96% <5	NA	NA	NA	21	<0.5	<1.0	100% <1.0	NA	NA	NA
Cadmium (dissolved)	mg/L	29	<0.001	<0.005	100% <0.005	0	0	No	25	<0.001	<0.005	100% <0.005	0	0	No
Chloride (dissolved)	mg/L	33	<10	410	130	NA	NA	NA	30	6	680	240	NA	NA	NA
Chromium (dissolved)	mg/L	29	<0.01	<0.05	100% <0.05	0	0	No	25	<0.01	<0.05	100% <0.05	0	0	No
Copper (dissolved)	mg/L	23	<0.01	0.02	83% <0.01	1	0	No	21	<0.01	0.04	*	3	0	No
Dissolved oxygen (field)	mg/L	0	-	-	-	NA	NA	NA	0	-	-	-	NA	NA	NA
Iron (dissolved)	mg/L	29	<0.05	2.63	0.17	2	0	No	25	<0.05	1.38	0.09	1	0	No
Lead (dissolved)	mg/L	23	<0.002	<0.02	100% <0.02	0	0	No	21	<0.002	<0.02	100% <0.02	0	0	No
Manganese (dissolved)	mg/L	23	<0.02	0.71	0.05	0	0	No	21	<0.02	0.79	0.03	0	0	No
Mercury (dissolved)	µg/L	23	<1	<1	100% <1	0	0	No	21	<1	<1	100% <1	0	0	No
Nickel (dissolved)	mg/L	23	<0.01	0.01	96% <0.01	0	0	No	21	<0.01	0.02	*	0	0	No
Nitrite plus nitrate as N (total)[1]	mg/L	28	<0.01	2.55	0.05	NA	NA	NA	24	<0.05	5.78	0.25	NA	NA	NA
pH (field)	S.U.	1	9.09	9.09	-	1	0	No	0	-	-	-	-	-	No
Selenium (dissolved)	mg/L	29	<0.001	0.007	87% <0.025	4	0	No	26	<0.005	0.025	0.003	12	1	No
Temperature (field)	°C	1	15.2	15.2	-	NA	NA	NA	0	-	-	-	NA	NA	NA
Turbidity	NTU	31	2.7	17,000	419	NA	NA	NA	28	75	49,000	1,290	NA	NA	NA
Zinc (dissolved)	mg/L	29	<0.01	0.01	93% <0.01	0	0	No	25	<0.01	0.7	80% <1	1	0	No
Boron (dissolved)	mg/L	27	<0.5	0.67	0.18	NA	NA	NA	26	<0.5	1.0	0.44	NA	NA	NA
Fluoride (dissolved)	mg/L	27	<0.5	3.03	0.5	NA	NA	NA	25	<0.5	4.10	0.8	NA	NA	NA
Sodium (dissolved)	mg/L	32	5	1,460	347	NA	NA	NA	29	18	883	302	NA	NA	NA
Sulfate (dissolved)	mg/L	32	<20	2,490	476	NA	NA	NA	29	15	544	183	NA	NA	NA
TDS dried at 180 °C	mg/L	33	118	5,040	1,440	NA	NA	NA	30	168	2,660	1,225	NA	NA	NA
Total suspended solids	mg/L	419	<5	121,000	3,840	NA	NA	NA	175	10	308,000	11,300	NA	NA	NA

[1]Presented as dissolved value. Summary statistics for constituents with non-detect values were calculated using methods recommended by Helsel (2005). Medians were not calculated for constituents having ≥ 80% non-detect values. Minimum and maximum concentrations shown in red exceed WDEQ/WQD Class 3B surface water quality standards. NA=no numeric standard established for stream classification. *A median could not be determined by the statistical software for unknown reasons.

Dissolved metal concentrations at both stations on Tenmile Draw were mostly low over the 1996-2019 period, with numerous values below detection limits. The maximum concentrations of aluminum (4.7 mg/L), copper (0.02 mg/L), iron (2.63 mg/L), and selenium (0.007 mg/L) at SWPS-13 exceeded WDEQ/WQD Class 3B water quality standards (**Table 22**). Over the last three years of sampling at SWPS-14, there was one exceedance of aluminum. The baseline (1979-1980) sampling on upper Tenmile Draw also showed exceedances of aluminum and copper, along with additional exceedances of nickel and zinc (**Table 13**). Over 1996-2019 at SWPS-14 downstream of mining, the maximum concentrations of aluminum (3.5 mg/L), copper (0.04 mg/L), iron (1.38 mg/L), selenium (0.025 mg/L), and zinc (0.7 mg/L) exceeded Class 3B standards (**Table 22**). Over the last three years of sampling at SWPS-14, there was one exceedance of selenium, occurring in August 2016. Two samples collected during the baseline period (1979-1980) on lower Tenmile Draw also showed exceedances of aluminum, copper, and iron, but no exceedances of selenium (**Table 13**).

Since selenium showed exceedances in the last three years of sampling at SWPS-14 and not at SWPS-13, and since no exceedances were observed in limited baseline sampling, a more in-depth analysis was conducted. As mentioned in Section 4-*Hydrologic Concerns*, selenium has been identified as a constituent of concern in backfill groundwater quality at coal mines in the Powder River Basin (Martin et al., 1988; Dreher and Finkelman, 1992; Reddy et al., 1995). **Figure 38** shows selenium concentrations over the 2001 to 2019 period at SWPS-13 and SWPS-14 on Tenmile Draw. The WDEQ/WQD Class 3B selenium standard of 0.0046 mg/L for aquatic life is shown in the figure for reference. The time series show periodic selenium exceedances over time at both stations, although SWPS-14 has more frequent exceedances. Since exceedances occasionally occur at SWPS-13 upstream of mining, natural sources of selenium appear to exist in the Tenmile Draw watershed.

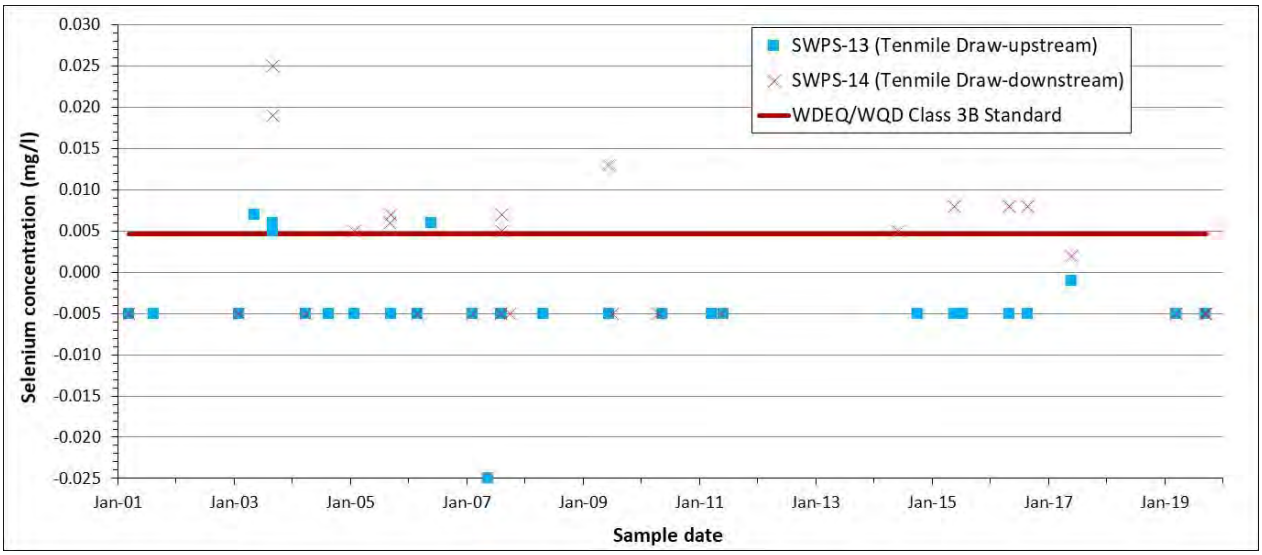


Figure 38. Selenium concentrations at Jim Bridger Mine stations SWPS-13 and SWPS-14 on Tenmile Draw, 2001 to 2019. The WDEQ/WQD Class 3B standard is shown for reference. Concentrations plotted below 0 mg/L as negative values are non-detect concentrations.

A statistical test was conducted to compare selenium concentrations between SWPS-13 and SWPS-14. The non-parametric generalized Wilcoxon test was used, as this is one method to use for comparing censored data with multiple detection limits among two groups. Minitab software (Minitab, Inc., 2017) was used to run the test using macros available from Practical Stats (2019). Significance levels (p-values) less than 0.05 were assumed to indicate significant differences in selenium concentrations among monitoring sites. A comparison of the 2001-2019 data indicated a

significant difference in selenium concentrations between SWPS-13 and SWPS-14 (p=0.005). This indicates selenium concentrations downstream of the Jim Bridger Mine permit boundary on Tenmile Draw are higher than those further upstream.

The Jim Bridger Mine Permit (2020) contains commitments for sampling regraded spoils to identify unsuitable materials, including selenium. Suitability requirements are set forth by WDEQ/LQD Guideline No. 1 – Topsoil and Overburden (Wyoming Department of Environmental Quality, 1996). For each reclamation unit at the Jim Bridger Mine, samples are collected on a 400-foot grid to a depth of four feet in two-foot increments. Drainage bottoms are sampled to a depth of eight feet. Sample results are submitted to the WDEQ/LQD for review and approval prior to proceeding with additional reclamation in the unit. Unsuitable materials are mitigated to ensure that a minimum of four feet of suitable material is provided on all reclaimed areas. The commitment is increased to eight feet in ephemeral drainages (Jim Bridger Mine Permit, 2020).

A review was conducted of the regraded spoils packages approved by the WDEQ/LQD from 2000 to 2017 for reclamation units in the Tenmile Draw watershed. A total of 27 reclamation units were evaluated comprising a total of 1,649.18 acres. Selenium was found to be suitable (<0.3 parts per million (ppm)) for all samples collected in 26 of the 27 reclamation units. One unit contained one sample from 49 cores that was classified as marginal suitability (0.36 ppm) (Jim Bridger Mine Permit, 2020). Overall, these results demonstrate that selenium has not been identified as a constituent of concern in the regraded spoils in the Tenmile Draw watershed, as WDEQ/LQD suitability requirements have been consistently met. Because of this, it is not possible to conclusively identify mining as the cause for higher selenium concentrations on Tenmile Draw downstream of the Jim Bridger Mine. The limited number of samples collected in the baseline period also makes it difficult to determine the extent selenium exceeded standards prior to mining.

A review was also conducted of the recent discharge monitoring reports (DMRs) submitted by the Jim Bridger Mine as part of the mine's WYPDES permit with WDEQ/WQD (Wyoming Department of Environmental Quality, 2020c). The mine has six active permitted outfalls that potentially discharge to Tenmile Draw. The 2002-2019 DMRs showed numerous discharges from some of the outfalls. However, only iron, field pH, manganese, TSS, and TDS are monitored under the WYPDES permit, so it is not possible to determine how the discharges might affect selenium concentrations in Tenmile Draw.

In order to better understand selenium concentrations and possible sources in the Tenmile Draw watershed, in March 2019 the Jim Bridger Mine agreed to conduct additional sampling at four locations on Tenmile Draw in between the SWPS-13 and SWPS-14 stations (**Figure 13**; **Table 6**). Selenium would also be sampled at six WYPDES outfalls to help determine the effect that permitted discharges may have on selenium in Tenmile Draw. In September 2019, selenium samples were collected at each of the four stream stations and concentrations were all below the laboratory detection limit of 0.005.

Since 2004, the SWCCD and BKWAG have monitored Tenmile Draw near the confluence with Deadman Wash (TM-1) (**Figure 13**; **Table 6**). Only select ions and bacteria (*E. coli* and fecal coliform) are monitored, making it difficult to compare to the other Class 3B criteria collected upstream at the Jim Bridger Mine stations. The data from TM-1 were obtained from the WDEQ/WQD Surface Water Monitoring (SWM) database. From 2004 to 2015, eight ion samples were collected. Chloride ranged from 180 to 490 mg/L, with a median of 230 mg/L (**Table 23**). For comparison, a median of 134 and 240 mg/L were recorded upstream at SWPS-13 and SWPS-14,

respectively. TDS ranged from 3,000 to 7,844, with a median of 5,850 mg/L (**Table 23**). The site was not sampled from 2016 through 2019. Bacteria results will not be discussed in the CHIA since the sources are typically human and animal wastes that are not associated with coal mining activities.

Table 23. During-mining water quality statistics and WDEQ/WQD class of use exceedances for selected constituents on Tenmile Draw at SWCCD station TM-1 on Tenmile Draw, 2004-2015.

Constituent	Units	Tenmile Draw (TM-1) (2004-2015)					
		Number of samples	Min	Max	Median	Number of exceedances	Number of exceedances over last three years
Calcium (total)	mg/L	8	130	660	405	NA	NA
Chloride (total)	mg/L	8	180	490	230	NA	NA
Magnesium (total)	mg/L	8	170	770	460	NA	NA
Sodium (total)	mg/L	8	440	760	580	NA	NA
Sulfate (total)	mg/L	8	1,200	5,000	3,450	NA	NA
TDS dried at 180 °C	mg/L	8	3,000	7,844	5,850	NA	NA
NA=no numeric standard established for stream classification.							

Over the 1996 to 2019 period on Ninemile Wash, approximately 42 samples were collected at SWPS-10 (**Table 24**). Magnesium chloride was the dominant water type, occurring in 42 percent of the samples (RockWare, Inc., 2015) (**Figure 37**). No baseline water quality data are available for Ninemile Wash, precluding a comparison to an older dataset. TDS from 1996-2019 ranged from 230 to 7,080 mg/L, with a median of 1,620 mg/L. TSS concentrations were highly variable; from 738 samples TSS ranged from 34 to 112,000 mg/L, with a median of 6,900 mg/L. The maximum concentrations of aluminum (11.9 mg/L), cadmium (0.002 mg/L), copper (0.06 mg/L), iron (7.33 mg/L), lead (0.04 mg/L), and selenium (0.072 mg/L) exceeded WDEQ/WQD Class 3B standards. Over the last three years of sampling, there was one exceedance of selenium (**Table 24**). These constituents have also shown periodic exceedances at other stations in the Deadman Wash drainage, both in the baseline and during-mining periods. However, the dissolved metal data from SWPS-10 indicate Ninemile Wash may have the poorest water quality among the Deadman Wash tributaries near the Jim Bridger Mine, as metal concentrations are often the highest.

On the Deadman Wash Tributary at SWPS-8, approximately 31 samples were collected over the 1996 to 2019 period (**Table 24**). Calcium sulfate was the dominant water type, occurring in 30 percent of the samples (RockWare, Inc., 2015) (**Figure 37**). No baseline water quality data are available for SWPS-8, precluding a comparison to an older dataset. TDS from 1996-2019 ranged from 148 to 4,690 mg/L, with a median of 820 mg/L. TSS concentrations were highly variable; from 254 samples TSS ranged from <5 to 170,000 mg/L, with a median of 11,100 mg/L. The maximum concentrations of aluminum (2.1 mg/L) and selenium (0.043 mg/L) exceeded WDEQ/WQD Class 3B standards. Selenium exceeded standards in 42 percent of the samples collected. Neither aluminum nor selenium showed exceedances over the last three years of sampling (**Table 24**).

Over the 1996 to 2019 period on Deadman Wash, approximately 19 samples were collected upstream of mining at SWPS-3 and approximately 37 samples were collected downstream of mining at SWPS-9 (**Table 25**). Calcium bicarbonate was the dominant water type at SWPS-3, occurring in 68 percent of the samples (RockWare, Inc., 2015) (**Figure 37**). At SWPS-9, water type

was more variable; magnesium chloride occurred in 25 percent of the samples, while calcium sulfate occurred in 19 percent of the samples (**Figure 37**). Sodium sulfate water was the dominant water type noted during the 1979-1980 baseline period on Deadman Wash. TDS at SWPS-3 from 1996-2019 ranged from 60 to 868 mg/L, with a median of 300 mg/L. At SWPS-9, TDS was several times higher, ranging from 118 to 4,730 mg/L, with a median of 1,060 mg/L. As was noted for the baseline period in the Deadman Wash drainage, TSS concentrations were highly variable. At SWPS-3, 117 TSS samples were collected, with concentrations ranging from 41 to 31,300 mg/L with a median of 5,320 mg/L. At SWPS-9, 612 TSS samples were collected, with concentrations ranging from 40 to 125,000 mg/L with a median of 9,300 mg/L (**Table 25**).

Dissolved metal concentrations at both stations on Deadman Wash were mostly low over the 1996-2019 period, with numerous values below detection limits. The maximum concentrations of aluminum (6.0 mg/L), copper (0.02 mg/L), iron (2.96 mg/L), and selenium (0.006 mg/L) at SWPS-3 exceeded Class 3B water quality standards (**Table 25**). There have been no exceedances of these parameters over the last three years of sampling. At SWPS-9 downstream of mining, the maximum concentrations of aluminum (30.7 mg/L), iron (9.44 mg/L), and selenium (0.075 mg/L) exceeded Class 3B standards (**Table 25**). There have been no exceedances of these parameters over the last three years of sampling. The same constituents also showed exceedances at SWPS-10 on Ninemile Wash, which is enters Deadman Wash in between SWPS-3 and SWPS-9. Only one iron sample was available for the baseline (1974-1976) period on Deadman Wash, and the sample did not exceed standards (**Table 12**); baseline aluminum and selenium data are not available.

Since 2004, the SWCCD and BKWAG have monitored Deadman Wash, just upstream of the confluence with Tenmile Draw (DM-1) (**Figure 13**; **Table 6**). Deadman Wash is a Class 2AB(ww) stream at this location. Similar to TM-1, only select ions and bacteria are monitored. From 2004 to 2010, seven ion samples were collected. The data from DM-1 were obtained from the WDEQ/WQD SWM database. Chloride ranged from 49 to 200 mg/L, with a median of 160 mg/L (**Table 26**). This median is lower than the median of 221 mg/L measured upstream at SWPS-9. No chloride samples at DM-1 exceeded the WDEQ/WQD Class 2AB(ww) standard of 230 mg/L. TDS ranged from 1,978 to 7,604, with a median of 4,345 mg/L (**Table 26**). The site was dry during checks in 2015 and 2016 and was not sampled from 2017 to 2019.

The underground portion of the Jim Bridger Mine is expected to have minimal impacts on surface water quality. Dewatering of the underground mine is not expected to affect surface water quality, as the mine has installed a pumping and clarifying system to send water for use at the Jim Bridger Power Plant (Jim Bridger Mine Permit, 2020). The mine also holds a WYPDES permit to discharge groundwater dewatered from the underground workings, if necessary. Therefore, potential impacts to surface water quality from underground mining activity should be minimal.

Table 24. During-mining water quality statistics and WDEQ/WQD class of use exceedances for selected constituents on Ninemile Wash at Jim Bridger Mine station SWPS-10 (downstream) and on Deadman Wash Tributary at Jim Bridger Mine station SWPS-8 (downstream), 1996-2019.

Constituent	Units	Ninemile Wash (SWPS-10) (downstream-disturbed) (1996-2019)							Deadman Wash Tributary (SWPS-8) (downstream-disturbed) (1996-2019)						
		Number of samples	Min	Max	Median	Number of exceedances	Number of exceedances over last three years	Exceedances in at least two separate years of last three years?	Number of samples	Min	Max	Median	Number of exceedances	Number of exceedances over last three years	Exceedances in at least two separate years of last three years?
Aluminum (dissolved)	mg/L	33	<0.1	11.9	0.01	3	0	No	23	<0.1	2.1	0.01	2	0	No
Ammonia as N (total) [1]	mg/L	42	<0.1	4.77	0.5	NA	NA	NA	31	<0.1	6.61	0.31	NA	NA	NA
Arsenic (dissolved)	mg/L	38	<0.005	0.054	0.001	0	0	No	26	<0.005	0.01	88% <0.005	0	0	No
Barium (dissolved)	mg/L	33	<0.5	0.14	97% <1	NA	NA	NA	23	<0.1	<0.5	100% <0.5	NA	NA	NA
Cadmium (dissolved)	mg/L	38	<0.001	0.002	95% <0.005	2	0	No	26	<0.001	<0.002	100% <0.002	0	0	No
Chloride (dissolved)	mg/L	42	10	2,190	378	NA	NA	NA	31	6	1,160	179	NA	NA	NA
Chromium (dissolved)	mg/L	38	<0.01	0.01	97% <0.05	0	0	No	26	<0.01	<0.01	100% <0.01	0	0	No
Copper (dissolved)	mg/L	33	<0.005	0.06	82% <0.01	3	0	No	23	<0.01	0.01	91% <0.01	0	0	No
Dissolved oxygen (field)	mg/L	0	-	-	-	NA	NA	NA	0	-	-	-	NA	NA	NA
Iron (dissolved)	mg/L	38	<0.05	7.33	0.03	2	0	No	26	<0.05	0.65	0.02	0	0	No
Lead (dissolved)	mg/L	33	<0.01	0.04	97% <0.02	1	0	No	23	<0.02	<0.02	100% <0.02	0	0	No
Manganese (dissolved)	mg/L	33	<0.02	2.08	0.05	0	0	No	23	<0.02	1.44	0.06	0	0	No
Mercury (dissolved)	µg/L	33	<1	<1	100% <1	0	0	No	23	<1	<1	100% <1	0	0	No
Nickel (dissolved)	mg/L	33	<0.01	0.12	0.01	0	0	No	23	<0.01	0.06	0.01	0	0	No
Nitrite plus nitrate as N (total)[1]	mg/L	37	<0.01	22.4	3.12	NA	NA	NA	25	<0.05	8.26	1.48	NA	NA	NA
pH (field)	S.U.	3	7.52	7.90	7.80	0	0	No	3	7.55	8.00	7.60	0	0	No
Selenium (dissolved)	mg/L	38	<0.001	0.072	0.01	25	1	No	26	<0.001	0.043	0.003	11	0	No
Temperature (field)	°C	3	13.3	14.1	13.9	NA	NA	NA	3	13.3	22.6	21.2	NA	NA	NA
Turbidity	NTU	40	<0.1	100,000	3,100	NA	NA	NA	28	8	100,000	1,650	NA	NA	NA
Zinc (dissolved)	mg/L	38	<0.01	0.18	*	0	0	No	26	<0.01	0.15	*	0	0	No
Boron (dissolved)	mg/L	37	<0.5	4.5	0.9	NA	NA	NA	28	0.1	3.0	0.63	NA	NA	NA
Fluoride (dissolved)	mg/L	35	<0.5	2.60	0.5	NA	NA	NA	27	<0.5	2.25	0.3	NA	NA	NA
Sodium (dissolved)	mg/L	41	12	410	158	NA	NA	NA	30	5.2	486	45	NA	NA	NA
Sulfate (dissolved)	mg/L	41	41	1,470	460	NA	NA	NA	30	17.8	1,490	200	NA	NA	NA
TDS dried at 180 °C	mg/L	42	230	7,080	1,620	NA	NA	NA	31	148	4,690	820	NA	NA	NA
Total suspended solids	mg/L	768	34	112,000	6,900	NA	NA	NA	256	<5	170,000	11,100	NA	NA	NA

[1]Presented as dissolved value. Summary statistics for constituents with non-detect values were calculated using methods recommended by Helsel (2005). Medians were not calculated for constituents having ≥ 80% non-detect values. Minimum and maximum concentrations shown in red exceed WDEQ/WQD Class 3B surface water quality standards. NA=no numeric standard established for stream classification. *A median could not be determined by the statistical software for unknown reasons.

Table 25. During-mining water quality statistics and WDEQ/WQD class of use exceedances for selected constituents on Deadman Wash at Jim Bridger Mine station SWPS-3 (upstream) and SWPS-9 (downstream), 1996-2019.

Constituent	Units	Deadman Wash (SWPS-3) (upstream-undisturbed) (1996-2019)							Deadman Wash (SWPS-9) (downstream-disturbed) (1996-2019)						
		Number of samples	Min	Max	Median	Number of exceedances	Number of exceedances over last three years	Exceedances in at least two separate years of last three years?	Number of samples	Min	Max	Median	Number of exceedances	Number of exceedances over last three years	Exceedances in at least two separate years of last three years?
Aluminum (dissolved)	mg/L	12	<0.1	6.0	0.2	3	0	No	26	<0.1	30.7	0.02	3	0	No
Ammonia as N (total) [1]	mg/L	19	<0.1	4.8	0.23	NA	NA	NA	37	<0.1	3.14	0.5	NA	NA	NA
Arsenic (dissolved)	mg/L	14	<0.005	0.005	93% <0.01	0	0	No	32	<0.005	0.01	0.004	0	0	No
Barium (dissolved)	mg/L	12	<0.5	<1	100% <1	NA	NA	NA	26	<0.5	<1	100% <1	NA	NA	NA
Cadmium (dissolved)	mg/L	14	<0.002	<0.005	100% <0.005	0	0	No	32	<0.001	<0.005	100% <0.005	0	0	No
Chloride (dissolved)	mg/L	19	1	47	3	NA	NA	NA	37	<10	1,480	221	NA	NA	NA
Chromium (dissolved)	mg/L	14	<0.01	0.01	92% <0.05	0	0	No	32	<0.01	0.03	97% <0.01	0	0	No
Copper (dissolved)	mg/L	12	<0.01	0.02	83% <0.01	1	0	No	26	<0.01	0.026	81% <0.01	0	0	No
Dissolved oxygen (field)	mg/L	0	-	-	-	NA	NA	NA	0	-	-	-	NA	NA	NA
Iron (dissolved)	mg/L	14	0.07	2.96	0.18	3	0	No	32	<0.05	9.44	0.02	2	0	No
Lead (dissolved)	mg/L	12	<0.002	<0.02	100% <0.02	0	0	No	26	<0.002	0.002	96% <0.02	0	0	No
Manganese (dissolved)	mg/L	12	<0.02	0.2	0.03	0	0	No	26	<0.02	1.94	0.07	0	0	No
Mercury (dissolved)	µg/L	12	<1	<1	100% <1	0	0	No	26	<1	<1	100% <1	0	0	No
Nickel (dissolved)	mg/L	12	<0.01	0.01	92% <0.1	0	0	No	26	<0.01	0.08	0.02	0	0	No
Nitrite plus nitrate as N (total)[1]	mg/L	14	<0.05	0.43	0.06	NA	NA	NA	31	<0.05	11.3	1.55	NA	NA	NA
pH (field)	S.U.	0	-	-	-	-	-	No	2	7.49	8.00	7.75	0	0	No
Selenium (dissolved)	mg/L	14	<0.005	0.006	93% <0.005	1	0	No	32	<0.005	0.075	0.006	16	0	No
Temperature (field)	°C	0	-	-	-	NA	NA	NA	2	13.0	17.2	15.1	NA	NA	NA
Turbidity	NTU	18	120	74,500	2,490	NA	NA	NA	36	19.4	100,000	3,585	NA	NA	NA
Zinc (dissolved)	mg/L	14	<0.01	0.05	86% <0.01	0	0	No	32	<0.01	0.08	*	0	0	No
Boron (dissolved)	mg/L	17	<0.03	0.9	0.06	NA	NA	NA	31	<0.5	2.88	0.96	NA	NA	NA
Fluoride (dissolved)	mg/L	16	<0.1	0.33	0.17	NA	NA	NA	31	<0.5	1.64	0.4	NA	NA	NA
Sodium (dissolved)	mg/L	19	1	202	8.0	NA	NA	NA	36	10.2	873	114	NA	NA	NA
Sulfate (dissolved)	mg/L	19	<20	172	10	NA	NA	NA	36	18.7	1,400	330	NA	NA	NA
TDS dried at 180 °C	mg/L	19	60	868	300	NA	NA	NA	37	118	4,730	1,060	NA	NA	NA
Total suspended solids	mg/L	117	41	31,300	5,320	NA	NA	NA	612	40	125,000	9,300	NA	NA	NA

[1]Presented as dissolved value. Summary statistics for constituents with non-detect values were calculated using methods recommended by Helsel (2005). Medians were not calculated for constituents having ≥ 80% non-detect values. Minimum and maximum concentrations shown in red exceed WDEQ/WQD Class 3B surface water quality standards. NA=no numeric standard established for stream classification. *A median could not be determined by the statistical software for unknown reasons.

Table 26. During-mining water quality statistics and WDEQ/WQD class of use exceedances for selected constituents on Deadman Wash at SWCCD station DM-1, 2004-2010.

Constituent	Units	Deadman Wash (DM-1) (2004-2010)					
		Number of samples	Min	Max	Median	Number of exceedances	Number of exceedances over last three years
Calcium (total)	mg/L	7	250	680	280	NA	NA
Chloride (total)	mg/L	7	49	200	160	0	0
Magnesium (total)	mg/L	7	180	640	380	NA	NA
Sodium (total)	mg/L	7	110	510	320	NA	NA
Sulfate (total)	mg/L	7	5,440	18,400	7,880	NA	NA
TDS dried at 180 °C	mg/L	7	1,978	7,604	4,345	NA	NA

NA=no numeric standard established for stream classification.

At the Leucite Hills Mine, limited water quality data from 1982 to 1986 are presented in the Leucite Hills Mine Permit (2020) for the stations that were evaluated for baseline hydrologic conditions in Section 3.1.1.1 (SW-1 through SW-6). The permit presents field water quality data (pH, alkalinity as calcium carbonate, temperature, and conductivity) for two samples each at SW-1, SW-3, and SW-6, three samples at SW-4, and six samples at SW-6. Conductivity ranged from 110 to 390 umhos/cm and field pH ranged from 6.98 to 8.31. There were no exceedances of Class 3B standards for pH.

As previously discussed, in 1986, the Leucite Hills Mine changed the surface water monitoring program to include three stations (SW-7, SW-8, and SW-9) on small ephemeral drainages within the permit boundary. From July through December 1986, only one TSS sample was collected from one of the events at SW-9 (3,040 mg/L) (Leucite Hills Mine Permit, 2020).

Limited water quality data are available from 2002 to 2017 in the WDEQ/LQD Hydrology Database for the three stations at the Leucite Hills Mine. TDS concentrations from seven samples collected from 2005 to 2014 at SW-7, SW-8, and SW-9 ranged from 150 to 1,130 mg/L. Eighteen TSS samples collected from 2005 to 2017 ranged from <5 to 22,300 mg/L. The high TSS concentrations are similar to those measured during the baseline period at the mine in 1979 and 1980. Given the limited data available, it is not possible to evaluate how the during-mining surface water quality data from the Leucite Hills Mine compare to WQD/WDEQ Class 3B standards.

In summary, data from stations in the Deadman Wash watershed within the Jim Bridger and Leucite Hills mines indicate TSS concentrations are highly variable and can become very high during runoff events, exceeding 100,000 mg/L. An evaluation of recent data from the Jim Bridger Mine shows that ASCMs are effective in reducing sediment yields from disturbed watersheds. Ninemile Wash appears to have slightly elevated dissolved metal concentrations compared to other stations at the Jim Bridger Mine. Water quality standards for WDEQ/WQD Class 3B waters were occasionally exceeded for dissolved metals at the Jim Bridger Mine, particularly aluminum, copper, iron, and selenium. Mining does not appear to be a controlling factor in the cause of the exceedances, since many of the exceedances were also noted at stations upstream of the mining disturbance and during the limited baseline sampling period. The during-mining water quality data appear to be within the range of variability for the watershed, although additional sampling on Deadman Wash near the confluence with Bitter Creek would allow a more thorough evaluation of water quality conditions.

6.1.1.2 BITTER CREEK

6.1.1.2.1 Water Quantity

During-mining hydrologic conditions on Bitter Creek were evaluated from the SBC1 and SBC2 stations at the Black Butte Mine and water quality sampling stations operated by the SWCCD BKWAG, and the WDEQ/WQD. The WDEQ/LQD also funded water quality sampling at the USGS station on Bitter Creek near Point of Rocks in 2015 and 2018 to 2020. The WDEQ/LQD is funding sampling at the USGS station at least through 2Q 2020 for CHIA purposes.

As discussed in Section 3.1.1.2.1, operational problems with the Parshall flumes and continuous recorders at SBC1 and SBC2 caused the Black Butte Mine to switch to the use of crest gages to monitor instantaneous flows. Instantaneous flows measured from 1987 to 2019 at SBC1 on Bitter Creek above the Black Butte Mine ranged from 0 cfs on several dates to a maximum of 315 cfs on February 21, 2017. At SBC2 below the mine permit boundary, instantaneous discharges during the same time period ranged from 0 cfs on several dates to a maximum of 234 cfs on February 21, 2017. Without a continuous recording device, it is unclear whether these maximums truly represent the highest flow that occurred at the sites from 1987 to 2019. The maximum discharges are approximately 10 percent lower than the maximum peak observed during the baseline period at USGS Station No. 09216545 on upper Bitter Creek, and approximately 80 percent lower than the highest peak observed at USGS Station No. 09216560 on Bitter Creek at Point of Rocks.

Although the Black Butte Mine has left a 200 foot buffer on either side of Bitter Creek to minimize surface disturbance to the channel, concerns were raised about the potential impact of operations at Pits 2 and 3 because mining either directly or indirectly intercepted the Bitter Creek alluvial aquifer. Once the pits were opened and drawdown was observed in the alluvial aquifer, the Black Butte Mine conducted several seepage runs on Bitter Creek in 1993-1994, measuring the flow with a current meter at different locations. The results showed there was no decline in flows through the entire reach within the mine boundaries (Black Butte Mine Permit, 2020). This finding is also supported from monitoring data taken above and below the mine permit boundaries at SBC1 and SBC2. A comparison of 281 paired instantaneous flow measurements taken from 1987 to 2019 showed that discharge at the upstream station explained 95 percent of the variation in discharge at the downstream station (**Figure 39**). The Black Butte Mine has found no notable gaining or losing reaches on Bitter Creek within the mine permit boundary, indicating there is no connection between surface water and groundwater between the two stations (Black Butte Mine Permit, 2020).

The data in **Figure 39** also indicate that water detention features such as ponds and mining pits are properly functioning to retain runoff from disturbed areas. These features are presumably negating any increase in flows that would be expected to be observed at SBC2 due to the larger drainage area. However, the Black Butte Mine estimates that there is only approximately a four percent temporary reduction in contributing area at SBC2 due to containment structures (Black Butte Mine Permit, 2020).

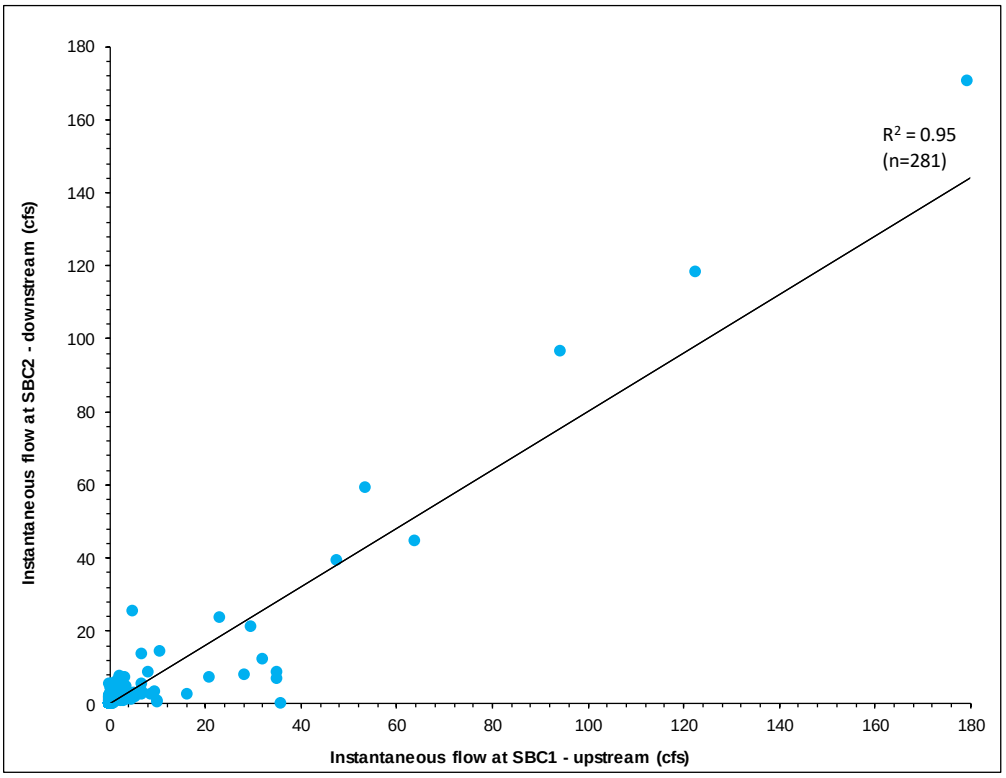


Figure 39. Relationship between 281 paired instantaneous discharge measurements on Bitter Creek at SBC1 (upstream) and SBC2 (downstream) at the Black Butte Mine, 1987 to 2019.

Since average annual precipitation for the Bitter Creek CIA is approximately six to eight inches, there is a limited supply of surface water available for industrial use. Therefore, much of the water stored in ponds or the mining pits is used for dust suppression rather than being discharged downstream at a later date. At the Black Butte Mine, this water use is generally not offset by additions through dewatering operations. The volume of water produced through dewatering of the coal and overburden aquifers is generally small because of the low transmissivity values associated with the local aquifers. Even where mining in Pit 3 partially intercepted the Bitter Creek alluvial aquifer, pumping was not required to sustain mining operations. Heavy rainfall in the area of the Black Butte Mine in September 2013 was the first time pumped water reached Bitter Creek in several years (Brian Wood, WDEQ/LQD, personal communication, October 2013).

In summary, data from the two stations on Bitter Creek at the Black Butte Mine indicate that the during-mining impacts to surface water quantity have been minimal. By maintaining a buffer to the channel, the Black Butte Mine has caused minimal disturbance to the Bitter Creek channel flowing through the permit boundary. Several years of crest gage monitoring indicates there is very little change in streamflow on Bitter Creek throughout the mine permit boundary. It is unlikely that any reduction in water quantity would be detectable at the point of accumulation for the Bitter Creek CIA at USGS Station No. 09216550 near Point of Rocks, and no surface water rights exist on Bitter Creek downstream of the Black Butte Mine to the point of accumulation for the CIA.

6.1.1.2.2 Water Quality

The Black Butte Mine monitored a full suite of constituents at SBC1 and SBC2 until 1986. From 1987 until 2013, only TDS and TSS were monitored monthly at both stations. The reason for changing to a reduced set of constituents was presumably because TDS and TSS were the primary constituents of concern. Bitter Creek was classified by the WDEQ/WQD as a Class 2C stream in

2001, meaning nongame fish and aquatic life were designated uses and thus water quality criteria became more stringent. In 2013, the WDEQ/LQD informed the Black Butte Mine of the stream classification and requested that the mine sample for additional water quality constituents so an evaluation to Class 2C standards could be made. Thus, in September 2013, a water quality sample was collected at both SBC1 and SBC2 that analyzed for additional constituents beyond TDS and TSS. From 2015 to 2017, a full-suite water quality sample was collected at both stations annually. A change to the mine plan in 2019 required both stations to have a full-suite sample collected biannually.

From 1982 to 2019, TDS ranged from 32 to 7,820 mg/L upstream of the mine at SBC1 (**Figure 40**). Downstream of the mine at SBC2, TDS ranged from 24 to 3,240 mg/L over the same time period (**Figure 40**). The median TDS from 203 samples collected at SBC1 was 1,100 mg/L. At SBC2, the median TDS from 188 samples was slightly lower at 979 mg/L. A Mann-Whitney test conducted using Minitab, Inc., (2017) software showed these medians were not significantly different (p=0.475). TDS at each station was relatively consistent over time, showing no obvious trends of increases or decreases (**Figure 41**). TDS generally decreased with increasing discharge, although the coefficient of determination for the relationship was low for both stations ($R^2 \leq 0.31$) (**Figure 41**).

At SBC1, TSS from 202 samples collected from 1982 to 2019 ranged from 6 to 15,640 mg/L (**Figure 42**), with a median of 118 mg/L. At SBC2, TSS from 192 samples ranged from <5 to 17,980 mg/L (**Figure 42**), with a median of 88 mg/L. Unlike TDS, there was a significant difference (p=0.06) in the distribution of TSS concentrations between the upstream and downstream stations, indicating TSS was higher upstream of mining. There was no obvious trend in TSS over time at each station, and TSS generally increased with discharge, although the relationship was quite variable with low predictive value ($R^2 \leq 0.21$) (**Figure 43**).

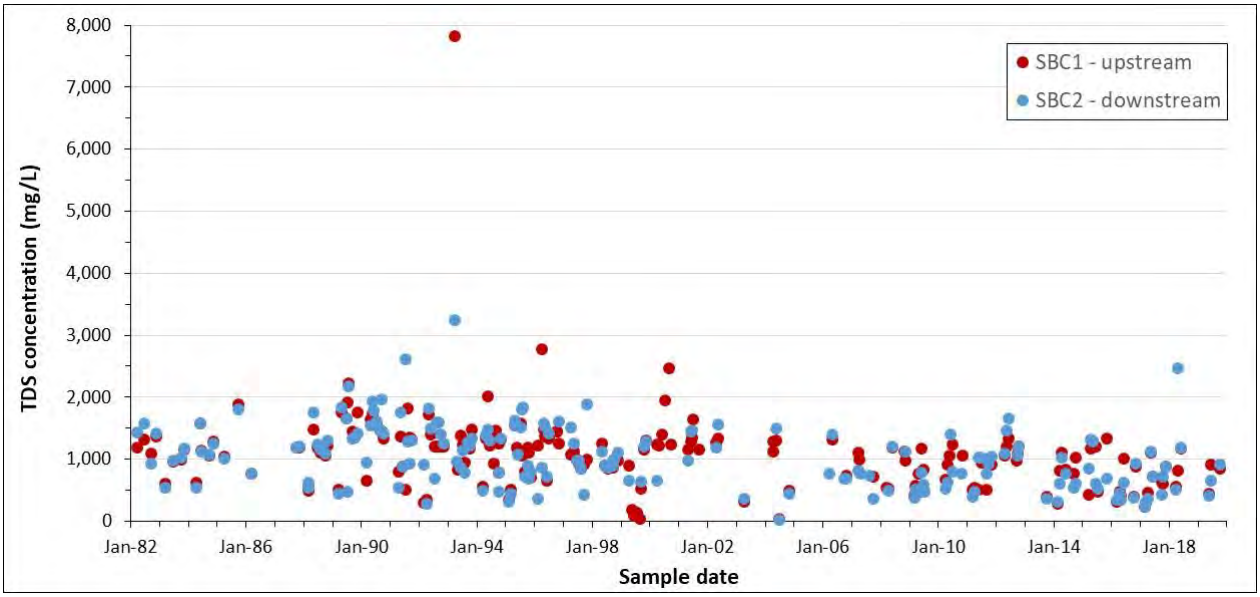


Figure 40. Total dissolved solids concentrations measured from 1987 to 2019 on Bitter Creek, upstream (SBC1) and downstream (SBC2) of the Black Butte Mine permit boundary.

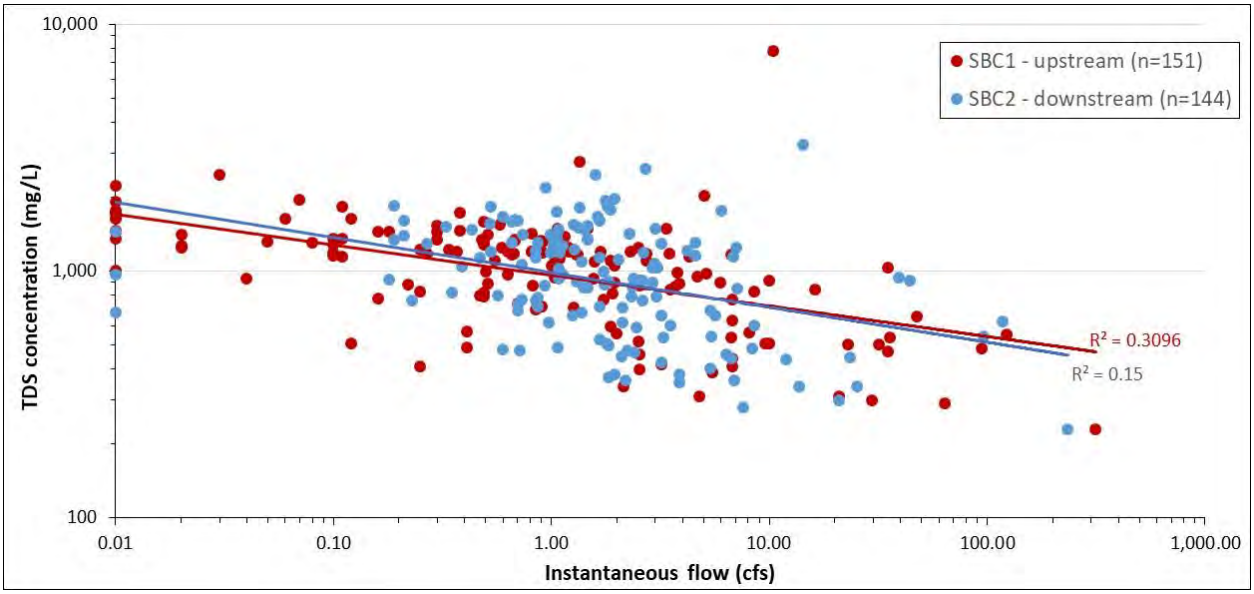


Figure 41. Relationship between instantaneous flow and TDS measured from 1987 to 2019 on Bitter Creek, upstream (SBC1) and downstream (SBC2) of the Black Butte Mine permit boundary.

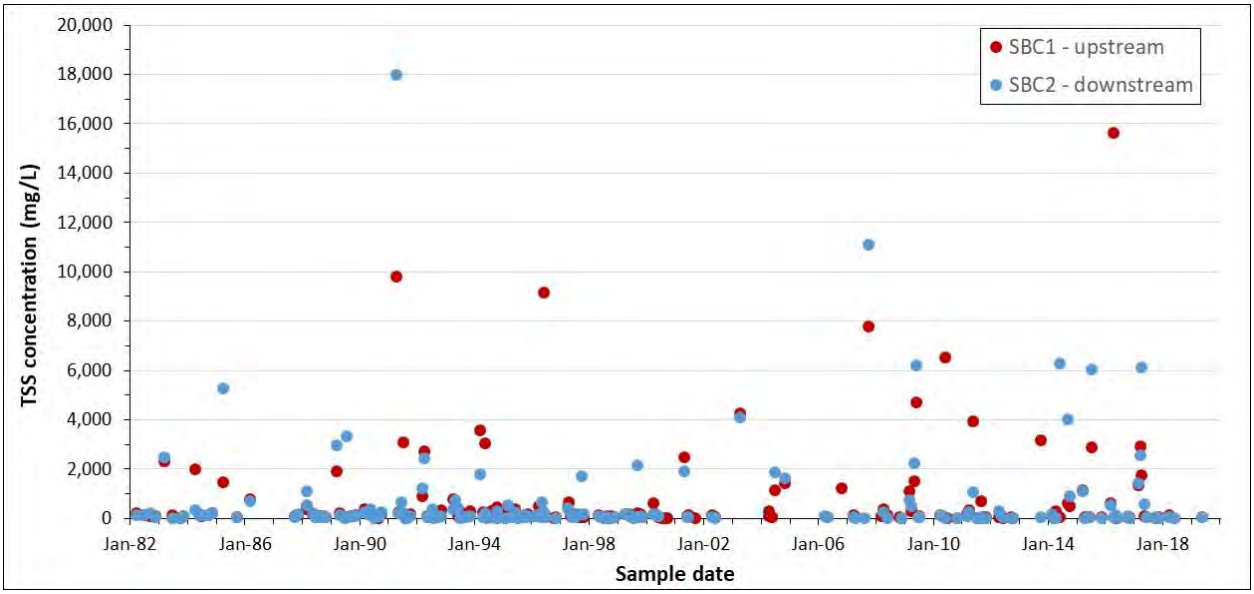


Figure 42. TSS concentrations measured from 1987 to 2019 on Bitter Creek, upstream (SBC1) and downstream (SBC2) of the Black Butte Mine permit boundary.

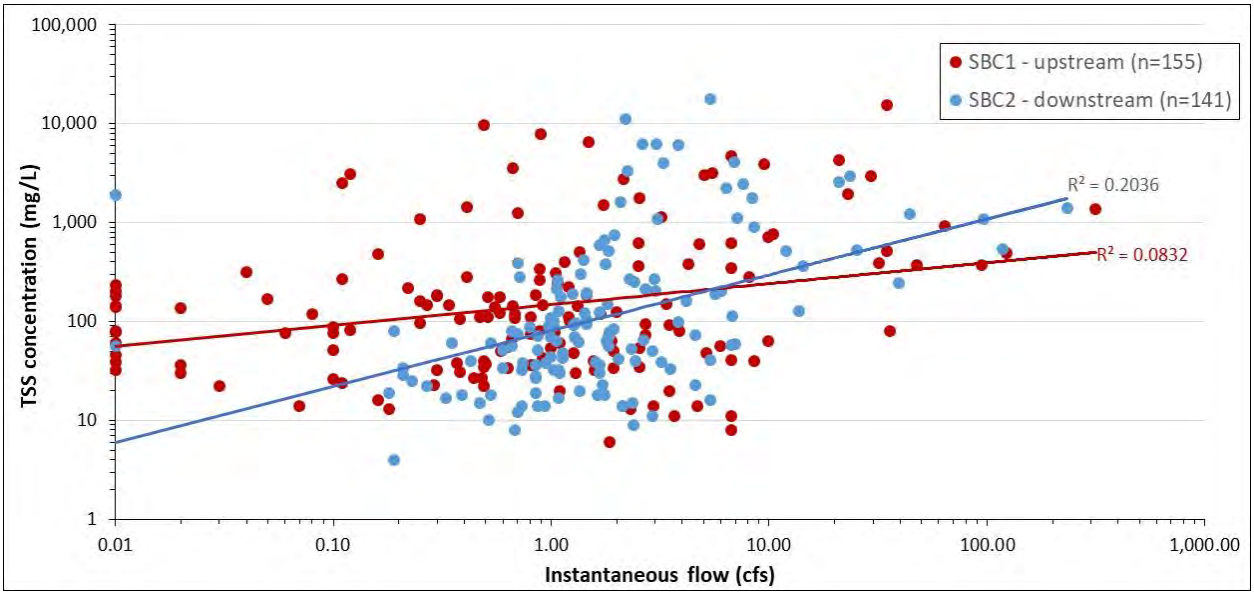


Figure 43. Relationship between instantaneous flow and TSS measured from 1987 to 2019 on Bitter Creek, upstream (SBC1) and downstream (SBC2) of the Black Butte Mine permit boundary.

A statistical summary of other water quality constituents sampled on Bitter Creek in relation to WDEQ/WQD Class 2C standards is presented in **Table 27**. Dissolved metals and major ions were analyzed in approximately 16 samples collected from 1982 to 1986, and in six samples collected from 2013 to 2019. Over 1982 to 2019, sodium sulfate was the dominant water type noted in 86 percent of the samples collected at both SBC1 and SBC2 (RockWare, Inc., 2015) (**Figure 44a,b**). Sodium sulfate was also the dominant water type noted during baseline sampling at the stations as well as the USGS station on upper Bitter Creek.

The data in **Table 27** indicate similar water quality between SBC1 and SBC2. At SBC1, the maximum concentrations of aluminum (7.8 mg/L), cadmium (0.003 mg/L), copper (0.05 mg/L),

iron (17.2 mg/L), lead (1.56 mg/L), and mercury (1 µg/L) exceeded Class 2C water quality standards (**Table 27**). The minimum dissolved oxygen value also exceeded standards. At SBC2 downstream of the Black Butte Mine, many of the same constituents showed exceedances. The maximum concentrations of aluminum (5.1 mg/L), cadmium (0.006 mg/L), copper (0.03 mg/L), iron (12.2 mg/L), and lead (0.12 mg/L) exceeded Class 2C water quality standards (**Table 27**). The minimum dissolved oxygen value and maximum field pH also exceeded standards. Since no constituents showed exceedances at SBC2 and not at SBC1 in the last three years of sampling, a more detailed analysis was not conducted. Furthermore, exceedances for similar constituents were noted during 1981 baseline sampling at SBC1 and SBC2, as well as Bitter Creek upstream of the Black Butte Mine at USGS Station No. 09216545.

In summary, the during-mining water quality data indicate that there is little difference in water quality conditions on Bitter Creek above and below the Black Butte Mine permit boundary. Although recent sample data are sparse, the during-mining water quality appears to be in the range of variability noted during the baseline period. The water quality results on Bitter Creek above and below the Black Butte Mine are not surprising since the mine has not disturbed the channel and seldom discharges from the sediment control ponds due to dust suppression needs. When discharges are necessary, they are monitored under the mine's WYPDES permit. From January 2013 to December 2019, 60 discharges were reported from 13 outfalls. All of the discharges were to small ephemeral streams that are tributary to Bitter Creek. The WYPDES permit shows there were infrequent discharges of TSS that exceeded conditions of the permit (Wyoming Department of Environmental Quality, 2020d).

Since 2004, the SWCCD and BKWAG has monitored Bitter Creek upstream of the Black Butte Mine (BC-7) near former USGS Station No. 09216545 (**Figure 13**; **Table 6**). The WDEQ/WQD has monitored Bitter Creek below Patrick Draw (BC-14), just upstream of the SBC1 station at the Black Butte Mine (**Figure 13**; **Table 6**). Select ions and bacteria are monitored at BC-7 and select ions are monitored at BC-14. The data from BC-7 and BC-14 were either obtained from the WDEQ/WQD SWM database or requested directly from the WDEQ/WQD. At BC-7, 11 ion samples were collected from 2004 to 2015. Chloride ranged from 4 to 82 mg/L, with a median of 24 mg/L (**Table 28**). TDS ranged from 340 to 2,921 mg/L, with a median of 1,057 mg/L (**Table 28**). Nineteen samples were collected over the 2009-2019 period at BC-14, and water quality was similar to BC-7. Chloride ranged from 7.5 to 39 mg/L, with a median of 25 mg/L (**Table 28**). TDS ranged from 271 to 1,720, with a median of 976 mg/L (**Table 28**).

Since 2004, the SWCCD, BKWAG, and WDEQ/WQD have monitored Bitter Creek near Point of Rocks (BC-6) (**Figure 13**; **Table 6**). The WDEQ/LQD also funded water quality sampling in 2015 and 2018 to present at USGS Station No. 09216560 – *Bitter Creek near Point of Rocks, WY* (**Figure 13**; **Table 6**). The two sample sites are in the same location. Only select ions and bacteria are monitored at BC-6 while ions, dissolved metals, and nutrients are monitored at the USGS station. The data from BC-6 were obtained from the WDEQ/WQD. At BC-6, 40 ion samples were collected from 2004 to 2019. TDS ranged from 780 to 5,996, with a median of 2,272 mg/L. The minimum field pH and dissolved oxygen exceeded Class 2C standards. Chloride ranged from 43 to 1,200 mg/L, with a median of 316 mg/L (**Table 29**). Twenty five of the samples exceeded the Class 2C criterion of 230 mg/L. Thirteen exceedances occurred over the last three years of sampling and there have been exceedances in at least two separate years of the last three years of sampling (**Table 29**).

At USGS Station No. 09216560, eight samples were collected from June 2015 to January 2020. Sodium sulfate was the water type noted in 50 percent of the samples, while magnesium sulfate and sodium chloride water was noted in 25 percent of the samples, respectively (RockWare, Inc., 2015) (**Figure 44c**). TDS ranged from 1,030 to 4,850 mg/L, with a median of 2,260 mg/L (**Table 29**). Chloride and iron exceeded Class 2C standards. For chloride, five exceedances occurred over the last two years of sampling. Three iron exceedances occurred over the last year of sampling (**Table 29**).

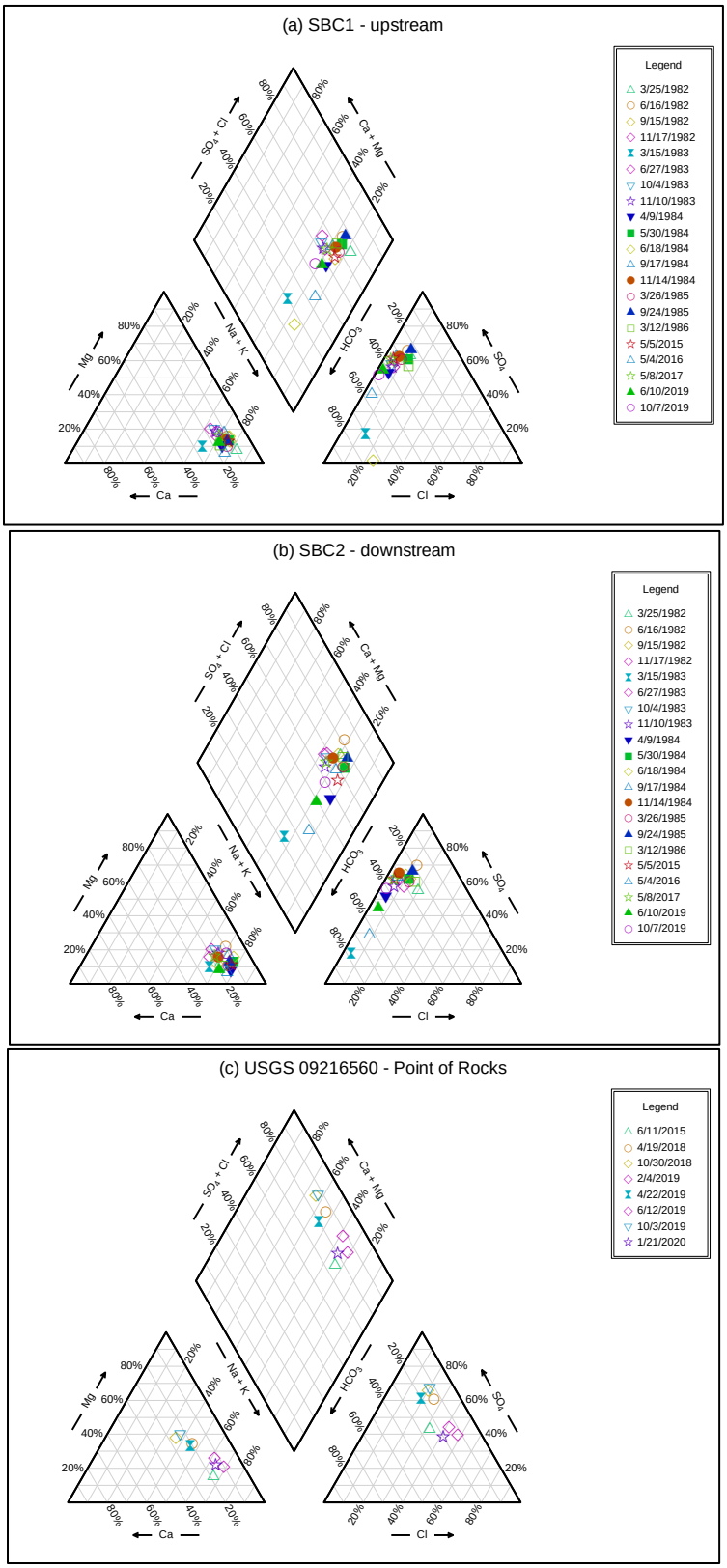


Figure 44. Piper diagrams for samples collected at (a) SBC1 and (b) SBC2 on Bitter Creek at the Black Butte Mine (1982-2019), and (c) USGS Station No. 09216560 on Bitter Creek at Point of Rocks. Each symbol represents a sample.

Table 27. During-mining water quality statistics and WDEQ/WQD class of use exceedances for selected constituents on Bitter Creek near the Black Butte Mine, 1982-2019.

Constituent	Units	SBC1 – Bitter Creek upstream Black Butte Mine permit boundary (1982-2019)							SBC2 – Bitter Creek downstream Black Butte Mine permit boundary (1982-2017)						
		Number of samples	Min	Max	Median	Number of exceedances	Number of exceedances over last three years	Exceedances in at least two separate years of last three years?	Number of samples	Min	Max	Median	Number of exceedances	Number of exceedances over last three years	Exceedances in at least two separate years of last three years?
Aluminum (dissolved)	mg/L	21	<0.1	7.8	0.25	4	0	No	21	<0.1	5.1	0.3	3	0	No
Ammonia as N (dissolved) [1]	mg/L	22	<0.01	0.21	86% <0.1	0	0	No	22	<0.01	0.24	0.01	0	0	No
Arsenic (dissolved)	mg/L	22	<0.002	0.009	91% <0.005	0	0	No	22	<0.002	0.003	95% <0.005	0	0	No
Barium (dissolved)	mg/L	21	<0.05	<0.5	100% <0.5	NA	NA	NA	21	<0.5	0.002	95% <0.5	NA	NA	NA
Cadmium (dissolved)	mg/L	22	<0.002	0.003	95% <0.005	1	0	No	22	<0.002	0.006	86% <0.002	3	0	No
Chloride (dissolved)	mg/L	22	9	110	37	0	0	No	22	5	149	40	0	0	No
Chromium (dissolved)	mg/L	22	<0.01	0.02	95% <0.02	0	0	No	22	<0.01	0.03	95% <0.02	0	0	No
Copper (dissolved)	mg/L	21	<0.01	0.05	*	5	0	No	21	<0.01	0.03	86% <0.1	2	0	No
Dissolved oxygen (field)	mg/L	4	0.03	20.0	12.7	1	0	No	4	0.5	17.3	12.6	1	0	No
Iron (dissolved)	mg/L	22	<0.05	17.2	0.4	6	0	No	22	<0.05	12.2	0.35	4	0	No
Lead (dissolved)	mg/L	21	<0.01	1.56	90% <0.05	2	0	No	22	<0.02	0.12	90% <0.05	2	0	No
Manganese (dissolved)	mg/L	21	<0.01	1.08	0.004	0	0	No	21	<0.01	1.03	0.004	0	0	No
Mercury (dissolved)	µg/L	21	<1	1	95% <2	1	0	No	21	<1	1	95% <1	1	0	No
Nickel (dissolved)	mg/L	21	<0.01	0.03	86% <0.01	0	0	No	22	<0.01	0.02	86% <0.01	0	0	No
Nitrite plus nitrate as N (diss.)[1]	mg/L	5	<0.05	0.36	80% <0.1	NA	NA	NA	5	<0.05	0.4	*	NA	NA	NA
pH (field)	S.U.	31	6.72	8.70	8.37	0	0	No	26	7.10	9.20	8.12	1	0	No
Selenium (dissolved)	mg/L	22	<0.002	0.002	95% <0.005	0	0	No	22	<0.002	0.003	95% <0.005	0	0	No
Temperature (field)	°C	31	0.1	23.7	8.0	0	0	No	31	0.1	21.8	8.0	0	0	No
Turbidity	NTU	7	62.9	6,770	175	-	-	NA	7	72	2,940	508	-	-	NA
Zinc (dissolved)	mg/L	22	<0.01	0.11	0.001	0	0	No	22	<0.01	0.012	91% <0.02	0	0	No
Boron (dissolved)	mg/L	21	<0.05	0.61	0.17	NA	NA	NA	21	<0.01	1.16	0.15	NA	NA	NA
Fluoride (dissolved)	mg/L	21	0.35	1.26	0.62	NA	NA	NA	21	0.29	1.13	0.51	NA	NA	NA
Sodium (dissolved)	mg/L	21	41.4	490	272	NA	NA	NA	21	48.3	483	252	NA	NA	NA
Sulfate (dissolved)	mg/L	21	6.3	874	460	NA	NA	NA	21	30	927	481	NA	NA	NA
TDS dried at 180 °C	mg/L	203	32	7,820	1,100	NA	NA	NA	188	24	3,240	979	NA	NA	NA
Total suspended solids	mg/L	202	<5	15,640	118	NA	NA	NA	192	<5	17,980	88	NA	NA	NA

[1]Class 2C standard expressed as total but only dissolved data were available. Summary statistics for constituents with non-detect values were calculated using methods recommended by Helsel (2005). Medians were not calculated for constituents having ≥ 80% non-detect values. Minimum and maximum concentrations shown in red exceed WDEQ/WQD Class 2C surface water quality standards. NA=no numeric standard established for stream classification. *A median could not be determined by the statistical software for unknown reasons.

Table 28. During-mining water quality statistics and WDEQ/WQD class of use exceedances for selected constituents on Bitter Creek at SWCCD station BC-7 and WDEQ/WQD station BC-14, 2004-2019.

Constituent	Units	BC-7 – Bitter Creek downstream of Road 4410 south of Bitter Creek town site (2004-2015)							BC-14 – Bitter Creek below Patrick Draw (2009-2019)						
		Number of samples	Min	Max	Median	Number of exceedances	Number of exceedances over last three years	Exceedances in at least two separate years of last three years?	Number of samples	Min	Max	Median	Number of exceedances	Number of exceedances over last three years	Exceedances in at least two separate years of last three years?
Calcium (total)	mg/L	11	15	98	36	NA	NA	NA	19	7.8	70	36	NA	NA	NA
Chloride (total)	mg/L	11	4	82	24	0	0	No	19	7.5	39	25	0	0	No
Dissolved oxygen (field)	mg/L	6	4.98	7.70	5.83	0	0	No	17	6.93	11.56	8.76	0	0	No
Magnesium (total)	mg/L	11	5.4	59	29	NA	NA	NA	15	2	63	34	NA	NA	NA
Nitrite plus nitrate as N (total)	mg/L	5	<0.05	<0.05	100% <0.05	NA	NA	NA	0	-	-	-	NA	NA	NA
pH (field)	S.U.	7	7.28	9.53	8.96	2	0	No	17	5.40	8.59	8.02	1	1	No
Potassium (dissolved)	mg/L	5	1.7	2.3	1.8	NA	NA	NA	17	0.5	7	5	NA	NA	NA
Temperature (field)	°C	7	11.7	19.9	15.8	0	0	No	17	0.04	20.68	12.17	0	0	No
Turbidity (field)	NTU	6	52.9	650	165	-	-	-	17	18	463	57	-	-	-
Sodium (dissolved)	mg/L	11	75	890	300	NA	NA	NA	19	17	471	271	NA	NA	NA
Sulfate (dissolved)	mg/L	11	95	1,430	510	NA	NA	NA	19	81	767	428	NA	NA	NA
TDS dried at 180 °C	mg/L	11	340	2,921	1,057	NA	NA	NA	19	271	1,720	976	NA	NA	NA

Minimum and maximum concentrations shown in red exceed WDEQ/WQD Class 2C surface water quality standards. NA=no numeric standard established for stream classification.

Table 29. During-mining water quality statistics and WDEQ/WQD class of use exceedances for selected constituents on Bitter Creek at Point of Rocks, 2004-2020.

Constituent	Units	BC-6 – Bitter Creek at Point of Rocks (2004-2019)							USGS Station No. 09216560 – Bitter Creek near Point of Rocks (2015-2020)						
		Number of samples	Min	Max	Median	Number of exceedances	Number of exceedances over last three years	Exceedances in at least two separate years of last three years?	Number of samples	Min	Max	Median	Number of exceedances	Number of exceedances over last three years	Exceedances in at least two separate years of last three years?
Aluminum (dissolved)	mg/L	0	-	-	-	-	-	No	7	<0.018	0.542	0.0316	0	0	No
Ammonia as N (total)	mg/L	1	0.2	0.2	-	0	0	No	8	<0.01[1]	0.75[1]	0.05	0	0	No
Arsenic (dissolved)	mg/L	0	-	-	-	-	-	No	8	0.0011	0.0029	0.002	0	0	No
Barium (dissolved)	mg/L	0	-	-	-	NA	NA	NA	7	0.0266	0.0872	0.075	NA	NA	NA
Cadmium (dissolved)	mg/L	0	-	-	-	-	-	No	6	<0.00009	<0.003	100% <0.003	0	0	No
Chloride (total)	mg/L	40	43	1,200	316	25	13	Yes	8	141[1]	1,290[1]	380	5	5	Yes
Chromium (dissolved)	mg/L	0	-	-	-	-	-	No	6	<0.005	<0.0015	100% <0.0015	0	0	No
Copper (dissolved)	mg/L	0	-	-	-	-	-	No	6	<0.004	0.0016	83% <0.004	0	0	No
Dissolved oxygen (field)	mg/L	23	1.45	15.11	9.14	1	0	No	8	5.5	12.0	8.7	0	0	No
Iron (dissolved)	mg/L	0	-	-	-	-	-	No	8	<0.02	4.36	0.247	3	3	No
Lead (dissolved)	mg/L	0	-	-	-	-	-	No	7	<0.0001	0.0014	0.000025	0	0	No
Manganese (dissolved)	mg/L	0	-	-	-	-	-	No	8	0.0363	1.46	0.264	0	0	No
Mercury (dissolved)	µg/L	0	-	-	-	-	-	No	7	<0.000005	0.000037	*	0	0	No
Nickel (dissolved)	mg/L	0	-	-	-	-	-	No	7	0.0043	0.0217	0.0058	0	0	No
Nitrite plus nitrate as N (total)	mg/L	0	-	-	-	NA	NA	NA	8	<0.04[1]	1.91[1]	*	NA	NA	NA
pH (field)	S.U.	27	6.20	9.42	7.65	2	1	No	8	7.50	8.80	8.10	0	0	No
Selenium (dissolved)	mg/L	0	-	-	-	-	-	No	8	<0.0003	0.0022	0.00035	0	0	No
Temperature (field)	°C	27	0.34	26.0	11.2	0	0	No	8	<0.2	27.3	5.5	0	0	No
Turbidity	NTU	26	11	960	48	-	-	NA	0	-	-	-	-	-	NA
Zinc (dissolved)	mg/L	0	-	-	-	-	-	No	7	<0.01	0.0645	0.011	0	0	No
Boron (dissolved)	mg/L	0	-	-	-	NA	NA	NA	7	0.21	0.422	0.339	NA	NA	NA
Fluoride (dissolved)	mg/L	0	-	-	-	NA	NA	NA	8	0.42	0.81	0.65	NA	NA	NA
Sodium (dissolved)	mg/L	40	88[2]	1,220[2]	435[2]	NA	NA	NA	8	209	1,030	417	NA	NA	NA
Sulfate (dissolved)	mg/L	40	298[2]	2,400[2]	996[2]	NA	NA	NA	8	303	1,910	953	NA	NA	NA
TDS dried at 180 °C	mg/L	35	780	5,996	2,272	NA	NA	NA	8	1,030	4,850	2,260	NA	NA	NA
Total suspended solids	mg/L	0	-	-	-	NA	NA	NA	3	123	7,810	353	NA	NA	NA

[1]Presented as dissolved value. [2]Presented as total value. Minimum and maximum concentrations shown in red exceed WDEQ/WQD Class 2C surface water quality standards. NA=no numeric standard established for stream classification. *A median could not be determined by the statistical software for unknown reasons.

A more in-depth analysis was conducted for chloride given the exceedances noted on Bitter Creek at Point of Rocks. A summary of the chloride results from the mainstem of Bitter Creek and the Deadman Wash watershed stations is presented in **Table 30**. The table includes available data through 2019 with the exception of the January 2020 sample from USGS Station No. 09216560. The number and proportion of samples that exceed the WDEQ/WQD aquatic life chronic value standard of 230 mg/L are provided for each station. Note that the 230 mg/L standard does not apply to several of the stations in the Deadman Wash watershed at the Jim Bridger Mine, as Class 3B streams do not have a chloride standard.

As shown in **Table 30**, 63 percent of the samples collected at Bitter Creek at Point of Rocks exceeded 230 mg/L over the 2001-2020 period. This is the highest proportion of samples exceeding 230 mg/L out of the 13 stations evaluated. The Deadman Wash drainage appears to be a higher source of chloride to Bitter Creek at Point of Rocks rather than the mainstem of the Bitter Creek watershed upstream of the confluence with Deadman Wash. For example, chloride did not exceed 230 mg/L at the other four stations on Bitter Creek upstream from Point of Rocks (**Table 30**). Each of the stations in the Deadman Wash watershed with the exception of SPWS-3 on upper Deadman Wash showed chloride concentrations that exceeded 230 mg/L. The stations with greater than 50 percent of samples exceeding 230 mg/L included SWPS-14 on lower Tenmile Draw and SWPS-10 on Ninemile Wash. Interestingly, the SWCCD DM-1 station located on Deadman Wash just upstream of the confluence with Tenmile Draw has shown no chloride values exceeding 230 mg/L, although this station only has seven samples available over the 2001-2010 period. More intensive chloride monitoring at this station, as well as further downstream on Deadman Wash prior to the confluence with Bitter Creek, would provide for a better evaluation of the effect of Deadman Wash on chloride concentrations in Bitter Creek.

Although the Deadman Wash watershed appears to have elevated chloride values at some stations, it is difficult to determine the effect that coal mining activities have on chloride concentrations. As shown in **Table 30**, the two stations upstream of mining activity (SPWS-3 on Deadman Wash and SWPS-13 on Tenmile Draw) have lower chloride concentrations compared to downstream stations. Chloride at SWPS-13 was greater than 230 mg/L in 24 percent of the samples, compared to 62 percent of the samples downstream at SWPS-14. The elevated chloride concentrations upstream of mining disturbance suggest that chloride may be naturally elevated in parts of the drainage. In addition, as shown in **Table 12** and **Table 13**, some of the baseline data at the stations in the Deadman Wash watershed showed maximum values of chloride that exceeded 230 mg/L.

Chloride is not required to be monitored under the Jim Bridger WYPDES permit so it is unclear the effect that mine discharges may have on chloride. The Jim Bridger Mine does occasionally use magnesium chloride as a dust suppressant on unpaved roads, and a study in Colorado suggested that this practice can increase chloride concentrations in streams (Goodrich et al., 2009). From the available information, it is not possible to determine the extent that this practice may be increasing chloride concentrations in the Deadman Wash watershed relative to background sources. The WDEQ/WQD is planning to prepare a TMDL for chloride in Bitter Creek (Ron Steg, WDEQ/WQD personal communication, September 2018), and this analysis will provide a more in-depth evaluation of possible chloride sources in the Bitter Creek watershed.

Table 30. Summary of chloride data collected from 2001 to 2020 at select stations on Bitter Creek and the Deadman Wash watershed.

Station	Drainage area (mi^2)	Years Evaluated	Number of samples	Minimum chloride concentration (mg/L)	Maximum chloride concentration (mg/L)	Median chloride concentration (mg/L)	Number of samples >230 mg/L	Proportion of samples >230 mg/L
SWPS-3 (Jim Bridger Mine – Upper Deadman Wash)	14.6	2001-2019	12	1.1	10	2.5	0*	0*
SWPS-8 (Jim Bridger Mine – Tributary to Deadman Wash)	0.88	2001-2019	22	9.5	1,160	220	10*	45*
SWPS-10 (Jim Bridger Mine – Ninemile Wash)	3.1	2001-2019	30	13	2,190	490	18*	60*
SWPS-9 (Jim Bridger Mine – Lower Deadman Wash)	42	2001-2019	26	<10	1,140	261	12*	46*
SWPS-13 (Jim Bridger Mine – Upper Tenmile Draw)	6.1	2001-2019	25	<10	410	139	6*	24*
SWPS-14 (Jim Bridger Mine – Lower Tenmile Draw)	36.9	2001-2019	21	6	680	265	13*	62*
TM-1 (SWCCD – Tenmile Draw upstream of confluence with Deadman Wash)	40.3	2004-2010	8	180	490	230	4*	50*
DM-1 (SWCCD – Deadman Wash downstream of BLM wetland ponds near Point of Rocks)	112	2004-2010	7	49	200	160	0	0
BC-14 (Bitter Creek below Patrick Draw)	476.5	2009-2019	19	7.5	39	25	0	0
SBC1 (Bitter Creek at upstream Black Butte Mine permit boundary)	494	2013-2019	6	9	29	12	0	0
BC-7 (Bitter Creek south of Bitter Creek town site)	317	2004-2012	11	4	82	24	0	0
SBC2 (Bitter Creek at downstream Black Butte Mine permit boundary)	596	2013-2019	6	15	51	21	0	0
USGS 09216560/BC-6 (Bitter Creek at Point of Rocks)	758	2004-2020	48	43	1,290	316	30	63

*Numeric chloride criteria do not apply but results are included for comparison purposes.

6.2 GROUNDWATER

The objectives of this section are to provide:

- A description of the existing groundwater hydrologic conditions within the CIA before the approval of the proposed Pit 15/Pit 10 South Amendment at Black Butte Mine.

- An evaluation of the cumulative impacts on groundwater as a result of existing mining at the Jim Bridger, Leucite Hills, and Black Butte mines. This evaluation focused on the groundwater hydrologic concerns identified in Section 4.2.2. that included: (1) reduced yield from existing wells in the CIA, (2) alteration of groundwater flow gradients and directions, (3) alterations to the recharge and discharge mechanisms, (4) backfill aquifer properties, (5) quality of groundwater migrating from the backfill aquifer to the undisturbed native aquifers outside the permit boundary, and (6) groundwater quality of the backfill aquifer within the permit boundary and its ability to support the approved post-mining land use.

A review of each annual report indicates that over the 4Q 2018 to 1Q 2020 period, the life-of-mine disturbed acreage at the three mines totals approximately 26,481 acres. Of this total, approximately 26 percent is being actively mined, 19 percent is in long-term mining or reclamation facilities, and 55 percent has been backfilled and graded. Of the 14,603 acres that have been backfilled and graded, approximately 91 percent of the area has been topsoiled and seeded and 63 percent has been planted for at least ten years. The extent of the backfilled acreage across the three mines is shown in **Figure 11**. The evaluation of the observed impacts caused by existing mining will be used in a qualitative manner to evaluate the impacts on groundwater that will be caused by the proposed amendment at Black Butte Mine.

One of the key limitations in this analysis is that there is a time lapse between existing mining and reclamation and the observed impacts on groundwater. In addition, not all groundwater impacts caused by mining will be realized with the current available monitoring data. These transient observed groundwater impacts will vary depending on the mining and reclamation methods and sequence, the aquifer of interest, and the distance of the location of interest from the disturbed or reclaimed area.

6.2.1 COAL MINE GROUNDWATER USE

Coal mine groundwater use will cause a decline in water levels in some of the aquifers of concern within the CIA. It is important to understand the volume of water that is being used by the mines. The volume of coal mine groundwater use is determined by four main factors: 1) the tons of coal mined per year, 2) the depth of the coal, 3) the permeability of the overburden and coal aquifers mined, and 4) pumpage from the mine water supply wells. Coal mine dewatering wells are regulated and permitted by the WSEO and disposal of pumped water is regulated by the WDEQ/WQD via WYPDES permits.

Water pumped for dewatering by the coal mines in the GGRB is: 1) used in the processing of coal, 2) used for dust control on haul roads, 3) used for cooling water by the Jim Bridger Power

Plant, or 4) released to surface waters through WYPDES permits. WYPDES permits establish effluent standards for the discharged water in order to protect designated uses on streams.

The reported groundwater use from 2006 to 2016 at the Jim Bridger Mine was obtained from the WSEO database (**Table 31**) (Wyoming State Engineer's Office, 2020b). Water use data were not available for 2017 through 2019. The data in **Table 31** include water produced from mine pit sumps and dewatering wells and does not include the Bridger No. 1 facility well completed in the Ericson Sandstone. As shown in **Table 31**, groundwater pumped by the Jim Bridger Mine in 2006 and 2007 was less than 300 ac-ft annually. Water was primarily used in these years for dust control on haul roads or was discharged under WYPDES permits. Starting in 2008, water use increased to 2,179.4 ac-ft due to increased pumping rates at Turbine Well No. 1 to control inflows to the underground mine. In 2008 and 2009, water from this well was stored in the Pit Lake at the mine. In 2010, a second underground mine pumping well, Turbine Well No. 2, was put into service to handle increased inflows to the underground mine. Beginning in January 2010, the majority of the water produced from the two Turbine Wells has been conveyed to the Jim Bridger Power Plant to be used as cooling water, while a portion of the water is still stored in the Pit Lake (Wyoming State Engineer's Office, 2020b). Use of underground mine water at the power plant reduces the amount of cooling water needed from the Green River and allows the mine to handle underground water without additional TDS treatment to meet the requirements of the Colorado River Salinity Control Program (N. Hargis, Bridger Coal Company, personal communication, September 2013). Water use at the mine decreased in 2016 to similar levels reported in 2011 (**Table 31**).

Table 31. Groundwater use at the Jim Bridger Mine, 2006 to 2016 (Wyoming State Engineer's Office, 2020b). Data are for mine pit sumps and dewatering wells and do not include the Bridger No. 1 facility well completed in the Ericson Sandstone.

Year	Acre-Feet
2006	298.7
2007	264.8
2008	2,179.4
2009	3,315.3
2010	4,622.9
2011	4,931.6
2012	5,759.3
2013	6,043.8
2014	6,168.7
2015	6,394.5
2016	4,978.2

Recent groundwater usage data for the Leucite Hills and Black Butte mines are not available in WSEO records. The Leucite Hills Mine Permit (2020) estimates that around year 2000, Well No. 4 in the Ericson Sandstone produced approximately 19.6 ac-ft that was used exclusively for dust control. The Black Butte Mine Permit (2020) contains usage data from mid-1997 to mid-1998 for three wells completed in the Ericson Sandstone that were used for either facility water supply, dust suppression, or coal processing. During this time period, the three wells collectively produced 149.6 ac-ft. (Black Butte Mine Permit, 2020). Given the current (2019) state of coal production at these two mines (see Section 1.4), it is reasonable to assume that coal mine groundwater use has decreased at the Leucite Hills Mine and increased at the Black Butte Mine compared to the older data presented in the mine permits.

6.2.2 CONTEMPORANEOUS RECLAMATION

It is beneficial for the environment, the State, and the mines to implement contemporaneous reclamation to include backfilling, grading, topsoil replacement, and revegetation on all areas affected by the mining operations. W.S. §35-11-402(a)(iii) requires "*A time schedule encouraging the earliest possible reclamation program consistent with the orderly and economic development of the mining property*."

The WDEQ/LQD coal rules can be condensed into the following fundamental concepts and requirements on reclamation (Wyoming Department of Environmental Quality, 1998):

1. Reclamation progression is tied to mining progression and is to be conducted concurrently.

2. The permits must contain a time schedule for rough backfilling, grading, contouring, topsoil replacement and seeding (and soon road reclamation).

3. The permits must contain a map showing the progression of mining and reclamation.

This emphasis on contemporaneous reclamation provides a good opportunity to evaluate the effectiveness of current reclamation practices on groundwater resource conservation and management, including the establishment of the backfill aquifer. In addition, if needed, timely corrective measures can be implemented.

6.2.3 BACKFILL AQUIFER

When coal mines are reclaimed, the overburden is returned to the mined-out portion of the pit as backfill, and the mined area is reclaimed to the approved post-mining topography. The backfill material gradually saturates with groundwater entering through surface infiltration and from the adjacent aquifers and becomes a shallow backfill aquifer with unique aquifer properties and water chemistry. The hydraulic properties of the backfill aquifer are presented in this Section; the water levels and water quality are presented later in Sections 6.2.6.6 and 6.2.7.6, respectively.

There were seven aquifer tests conducted by the mines in the backfill aquifer (**Figure 45**). Four of these tests were at the Black Butte Mine and three were at the Jim Bridger Mine. Saturated thicknesses from the aquifer tests ranged from 5.1 feet at well SW-1-W at the Jim Bridger Mine to 95 feet at well 90-02-SP at the Jim Bridger Mine. The median saturated thickness from all tests was 60 feet. The median hydraulic conductivity was 94 feet/day (**Figure 46**). A maximum of 2,271 feet/day was observed at well 510086 at the Black Butte Mine and a minimum of 0.1 feet/day was observed at 90-02-SP at the Jim Bridger Mine (**Figure 45**). Only one storage coefficient was reported from the backfill well tests: 0.07 for well 520387 at the Black Butte Mine. This storage coefficient indicates confined conditions.

Figure 46 shows the comparison of the hydraulic conductivity between the backfill aquifer and the other native aquifers of interest within the mine permit boundaries. Units that had less than five aquifer tests (overburden-AF, coal-LF, and underburden-AF) are not shown in the figure. The median hydraulic conductivity of the backfill aquifer is several times higher than the median hydraulic conductivity of the other native aquifers (**Figure 46**). Based on these limited data, it

appears that the backfill aquifer will have sufficient permeability to yield sufficient quantities of water to meet the post-mining land use of livestock.

It is important to note that the backfill aquifer is not fully saturated and there are sparse data on the aquifer properties. Therefore, it is difficult to make conclusive predictions on the future backfill aquifer characteristics. The backfill aquifer will likely have hydraulic conductivities at least that of the overburden and possibly greater than the fractured coal, particularly at the base of the backfill or between the lifts of backfill material (Rahn, 1976; Van Voast et al., 1976; Van Voast et al., 1978). It is expected that there will be some loss of permeability with time in the backfill aquifer as compaction and other physiochemical changes occur.

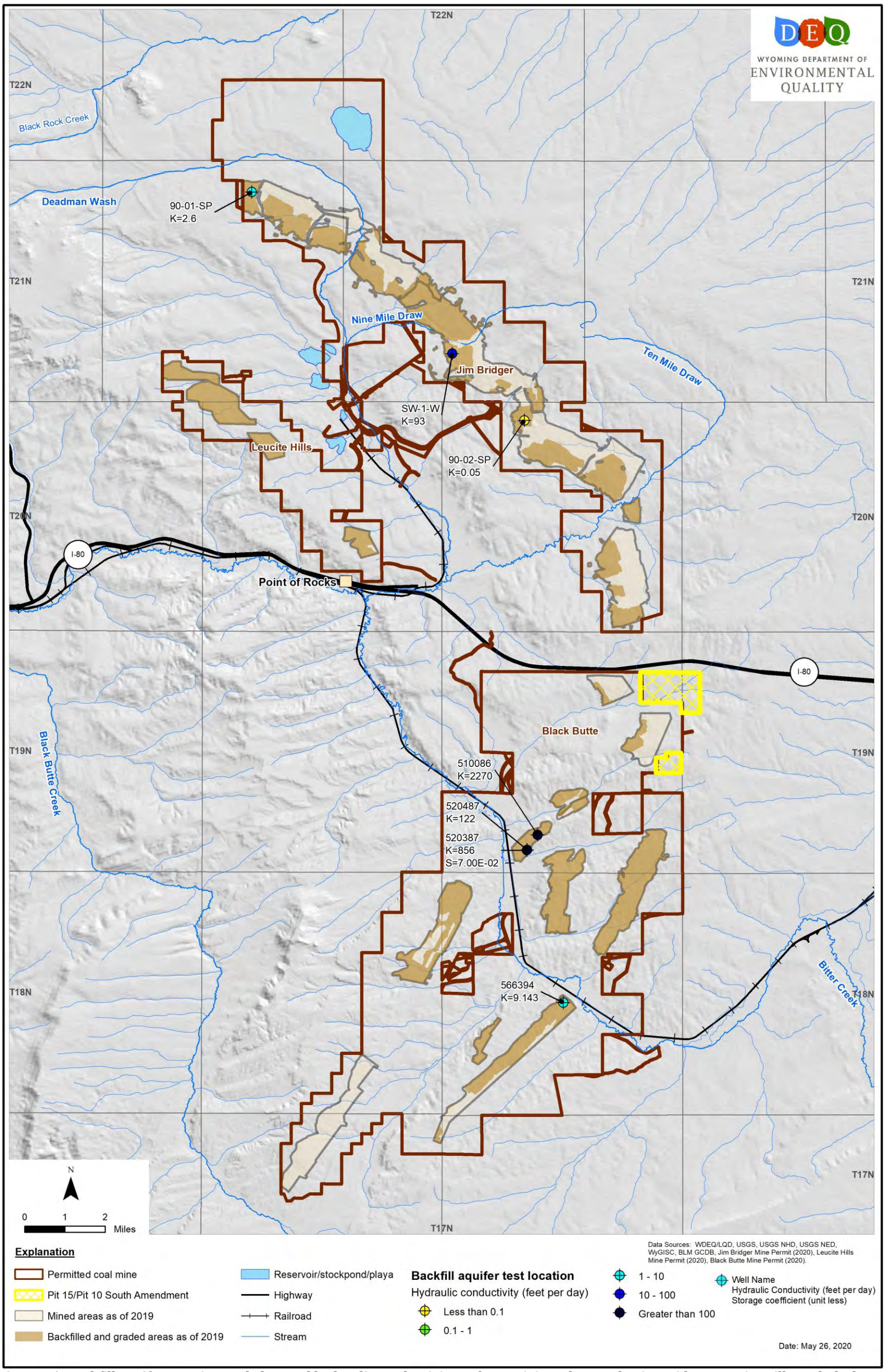
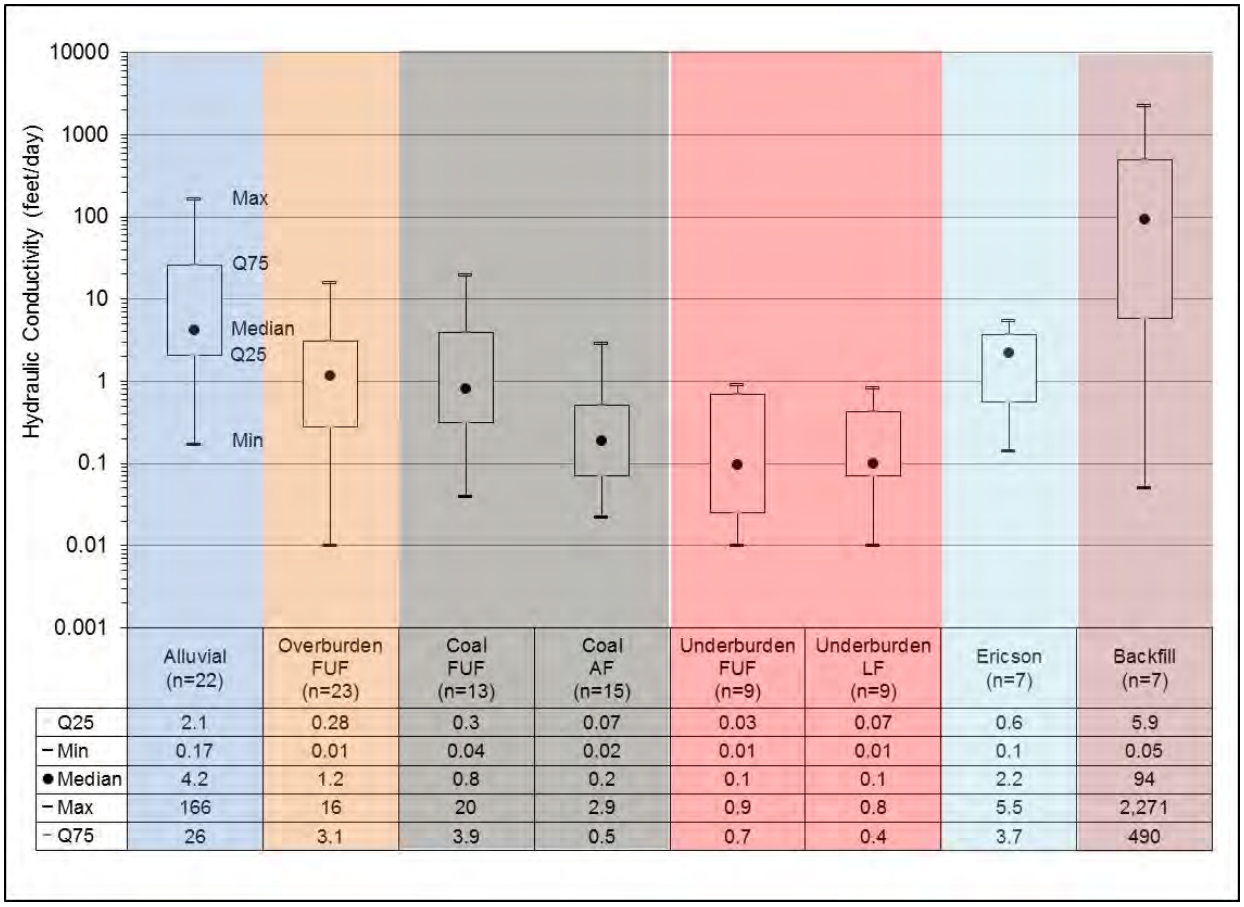


Figure 45. Backfill aquifer test sites and observed hydraulic conductivity and storativity values at the Jim Bridger, Leucite Hills, and Black Butte mines.



	Alluvial (n=22)	Overburden FUF (n=23)	Coal FUF (n=13)	Coal AF (n=15)	Underburden FUF (n=9)	Underburden LF (n=9)	Ericson (n=7)	Backfill (n=7)
Q25	2.1	0.28	0.3	0.07	0.03	0.07	0.6	5.9
Min	0.17	0.01	0.04	0.02	0.01	0.01	0.1	0.05
Median	4.2	1.2	0.8	0.2	0.1	0.1	2.2	94
Max	166	16	20	2.9	0.9	0.8	5.5	2,271
Q75	26	3.1	3.9	0.5	0.7	0.4	3.7	490

Figure 46. Boxplots comparing the hydraulic conductivity of the backfill to the other aquifers of interest at the Jim Bridger, Leucite Hills, and Black Butte mines.

6.2.4 TIME PERIODS SELECTED FOR GROUNDWATER LEVELS AND GROUNDWATER QUALITY

The 2017 to 2019 time period was selected to represent current conditions within the CIA. This approach was selected with the intent of characterizing the impacts on groundwater caused by the existing mining operations prior to the approval of the proposed revision at the Jim Bridger Mine. Annual precipitation from 2017 to 2019 at Rock Springs was below the long term average (**Figure 9**). The WDEQ/LQD Hydrology Database was the source of groundwater level and groundwater quality data used to characterize current conditions.

6.2.5 GROUNDWATER MONITORING NETWORK

A detailed description of the current monitoring network was described in Section 2.2.2. **Table 7** and **Figure 15** through **Figure 20** in Section 2.2.2 show the status, location, and number of active monitoring wells (as of February 2020) for the aquifer units of concern in the CIA. If a well was active for at least one year from 2017 through 2019, that well was used in the maps and analyses presented in Sections 6.2.6 and 6.2.7.

6.2.6 GROUNDWATER LEVELS

The available groundwater level data from the three mines were obtained from the WDEQ/LQD Hydrology Database for 2017 through 2019. If there were multiple water level data points for a well, a median was calculated to represent the current groundwater level. Some of the monitor wells have been discontinued or mined through. This presents a significant challenge in comparing groundwater levels over time or calculating drawdowns using the observed data without interpolating or estimating missing data.

Hydrographs at select wells were shown in each water level map as insets to represent the observed trend in groundwater levels. Any relevant analyses presented by the mines in their annual reports submitted to the WDEQ/LQD were also summarized in the below sections. Mined areas as of 2019 were shown in the maps to represent the proximity of the monitor wells to the mined areas.

6.2.6.1 ALLUVIAL AQUIFER

Water levels from 21 monitor wells were used to characterize current (2017-2019) groundwater levels in the alluvial aquifer (**Figure 47**). Five of the wells were dry. The highest median 2017-2019 water level elevation of 6,795 feet was observed at the Randor Springs well on Black Rock Creek. The lowest median 2017-2019 water level elevation of 6,538 feet was observed at Black Butte Mine well 567794 on Bitter Creek (**Figure 47**). Two wells were continuously active from the baseline to the current period. The difference between the median baseline and current groundwater levels at these select wells ranged from a drawdown of 1.9 feet (well ST-26-W, Jim Bridger) to 3.4 feet (well 284680, Black Butte Mine). The Black Rock Springs and Randor Springs wells might also be screened in a potential perched overburden aquifer (Amy Boyle, WDEQ/LQD, personal communication, November 2014).

Hydrograph insets are shown in **Figure 47** for alluvial wells ST-26-W on Tenmile Draw at the Jim Bridger Mine, and well 567794 and 566594 on Bitter Creek at the Black Butte Mine. Seasonal fluctuations of three to five feet, which are likely the result of precipitation and runoff events, are embedded in the long-term trends. Both wells along Bitter Creek showed a slight decreasing trend in water levels beginning in the early 2000s. The Black Butte Mine attributes this decline to mining in Pit 3 and lesser than average precipitation to recharge the alluvium (Black Butte Mine Permit, 2020). The distance of well 567794 from the pit would normally preclude any likelihood of impacts caused by mining at Pit 3. However, because the lower alluvium is confined, drawdown caused by mining at Pit 3 might be expected far from the pit. Water levels at well ST-26 (Tenmile Draw, Jim Bridger Mine) shows fluctuations of about five feet and it is difficult to associate any of these fluctuations to mining at the Jim Bridger Mine.

There is a small area along Pit 2 at Black Butte Mine where the backfill materials are in direct contact with the undisturbed Bitter Creek alluvium (Black Butte Mine Permit, 2020). Inflow from the Bitter Creek alluvium to the backfill aquifer has caused a drawdown cone in this area of the Bitter Creek alluvial aquifer. Although not in direct contact with the alluvial material, a similar effect is seen in the area of Pit 3. At this location, a very transmissive sandstone within the FUF subcrops under the Bitter Creek alluvium. Seepage from the Bitter Creek alluvial aquifer is conveyed through this lower sandstone into the pit. After Pit 3 is completely backfilled, only a slight drawdown of the Bitter Creek alluvial aquifers surface is predicted by Black Butte Coal Mine Permit (2020) at this location.

Similar to the baseline period, the general direction of groundwater flow in the alluvial aquifer currently follows the topography towards the downstream or down valley direction (**Figure 47**). During mining, sections of the alluvial aquifer in the vicinity of the Black Butte and Jim Bridger mines will be affected by removal and replacement of alluvial sediments, drawdown due to the influences of pit de-watering, temporary diversion of streams, or increased water levels due to the infiltration of pit and pond discharges. In general, these effects are local and do not extend large distances beyond the permit area. Cumulative effects to the alluvial aquifer are mitigated by the distribution of the alluvial sediments only along drainages and the spatial distribution of the mines over small segments of the alluvial aquifer. Therefore, although there may be some impact to the alluvial aquifer caused by the individual mines, few to none of the impacts to the alluvial aquifer are cumulative in nature as the individual mines tend to impact different sections of discrete alluvial sediments.

The Jim Bridger Mine Permit (2020) discusses recent observed drawdowns at the Randor Springs monitoring well. From 2007 to 2011, water levels at the well were constant, but then started to decline in 2012. Water levels in 2017 were 16 feet lower than levels measured in 2011. The water level declines are likely due to mining at the underground mine, although natural recharge conditions may also play a role. Water levels at the well have remained consistent since 2018. Water rights on Randor Springs have been held by the Rock Springs Grazing Association since the early 1930s. The Jim Bridger Mine Permit (2020) states that the need for mitigation plans will be evaluated for the declining water levels.

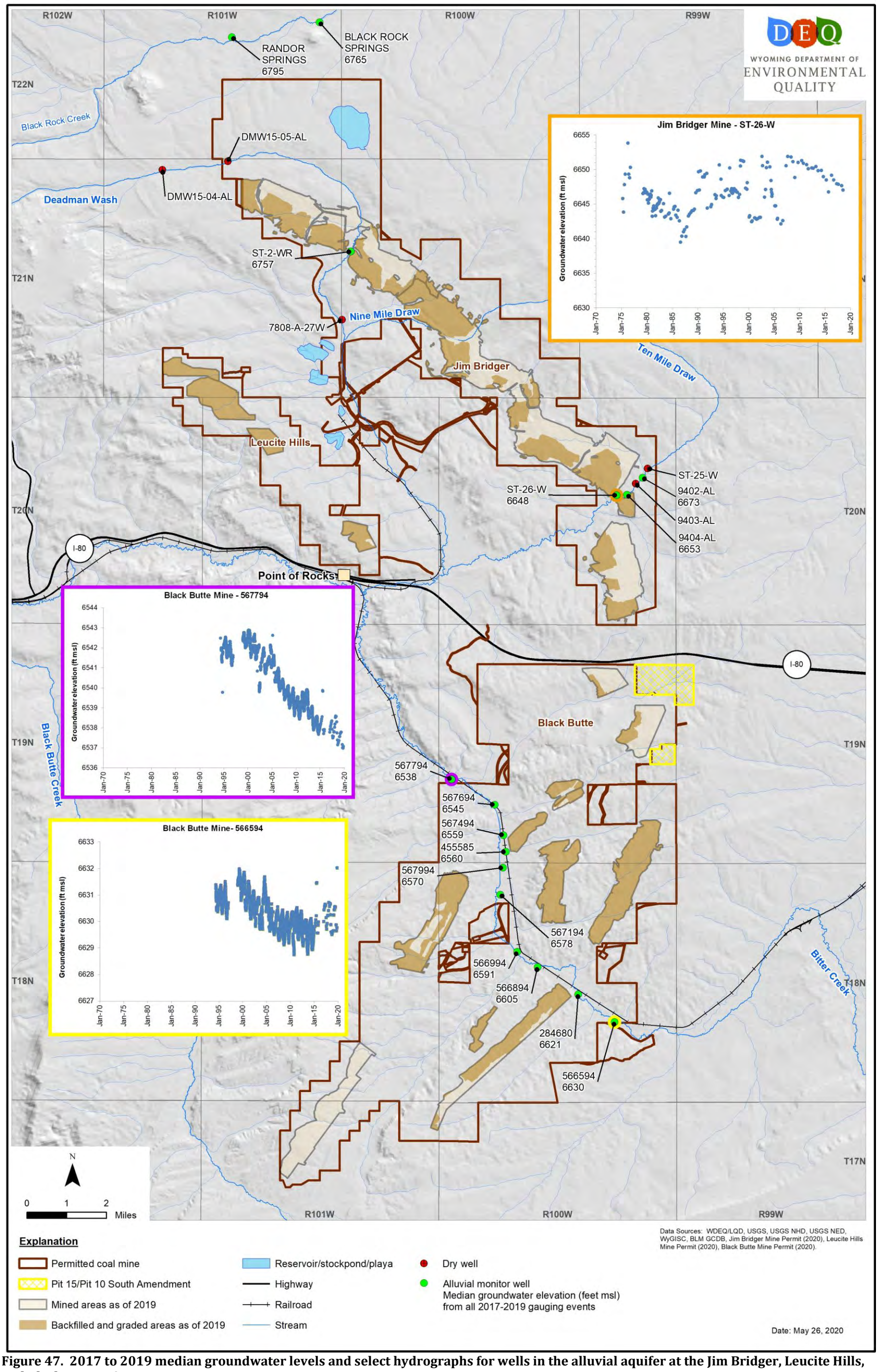


Figure 47. 2017 to 2019 median groundwater levels and select hydrographs for wells in the alluvial aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines.

6.2.6.2 OVERBURDEN AQUIFER

Water levels from 37 monitor wells were used to characterize current (2017-2019) groundwater levels in the overburden aquifer (**Figure 48**). Two of the wells were under artesian conditions and two wells were dry. No overburden aquifer monitor wells in the WDEQ/LQD Hydrology Database had continuous data from the baseline to the current period (Section 3.2.2).

The highest median 2017-2019 overburden water level elevation of 6,995.3 feet was observed at Black Butte Mine well SW3-OB in the AF. The lowest median 2017-2019 water level elevation of 6,624.6 feet was observed at Jim Bridger Mine well 81-03-OB in the FUF (**Figure 48**). Hydrograph insets are shown in **Figure 48** for overburden wells BCX-48-OB (FUF) and 81-06-OB (FUF) at the Jim Bridger Mine and well SW1-OB (AF) at the Black Butte Mine. The water levels at BCX-48-OB showed a continuous decline of about 91 feet since 2005. Well 81-06-OB had a steady decline until 2005. A decrease in water level of over 30 feet occurred abruptly in 2005 and this well was dry from 2006 to 2009. There was drastic increase in water levels in 2010. Slope work on this well resulted in a new top of casing elevation that has been factored in the water level measurements since 2011. From 2010 to 2018, water levels dropped seven feet. The water levels at the AF overburden well at Black Butte Mine dropped almost by eight feet from 2005 to 2015.

Predicted drawdowns by the individual mines in the overburden aquifer do not overlap with each other. In addition, cumulative effects of mining on the overburden appear limited as the sandstone units are discontinuous, and interbedded with claystone and siltstone. Based on current available data, the model predictions by the mines, and the area geology, it is expected that the cumulative impacts caused by mining on the overburden aquifer will be minimal.

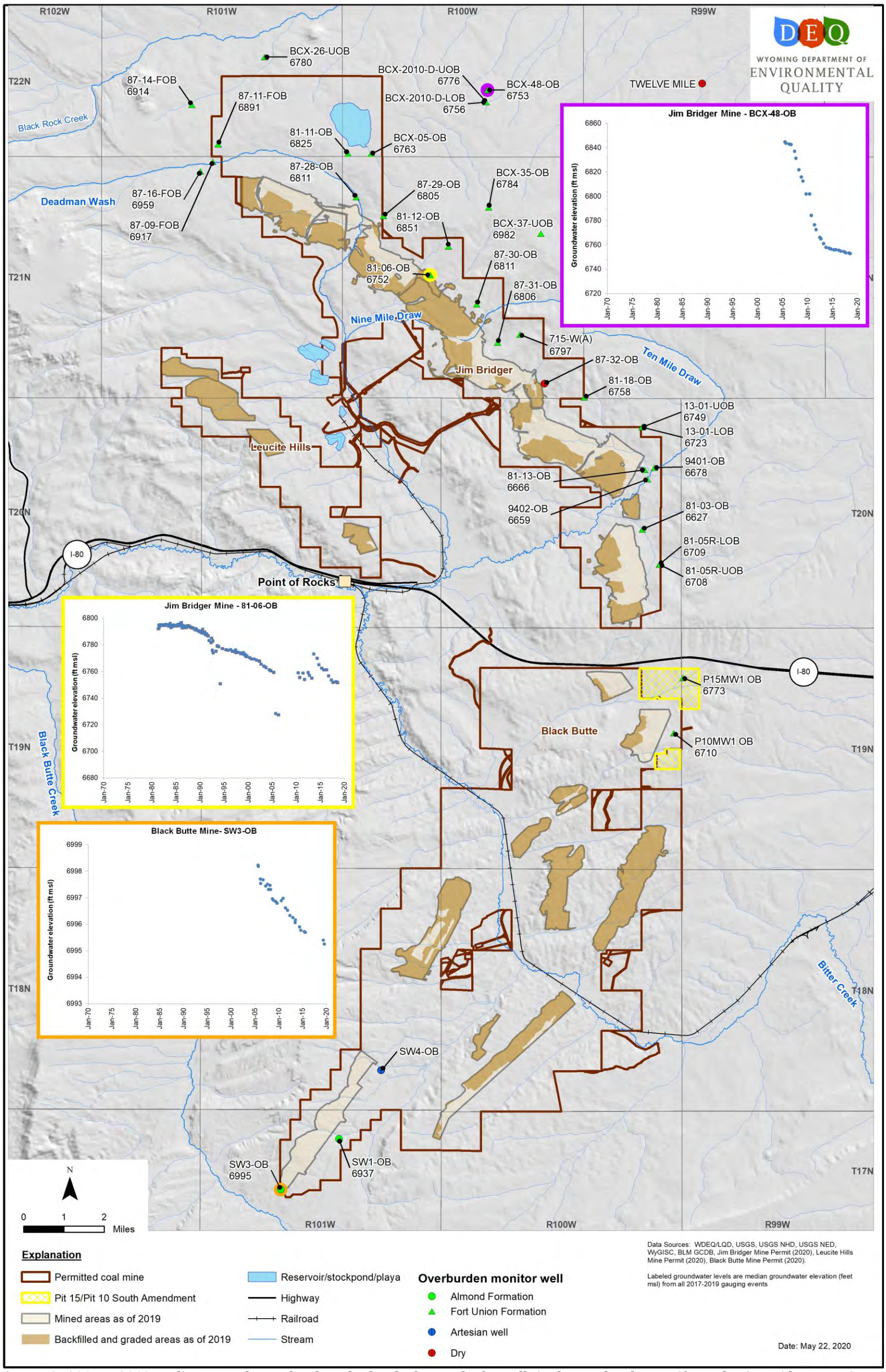


Figure 48. 2017 to 2019 median groundwater levels and select hydrographs for wells in the overburden aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines.

6.2.6.3 COAL AQUIFER

Water levels from 18 monitor wells were used to characterize current (2017-2019) groundwater levels in the coal seams of the FUF, AF, and LF (**Figure 49**). AF coal well SW4-CZ at the Black Butte Mine was under artesian conditions.

The highest median 2017-2019 coal water level elevation of 6,972.5 feet was observed at Black Butte Mine well SW3-CZ in the AF. The lowest median 2017-2019 water level elevation of 6,545.6 feet was observed at well 534990 near Pit 1 of the Black Butte Mine (**Figure 49**). Eight out of the 18 existing wells were continuously active from the baseline to the current period. The difference between the median baseline and current groundwater levels at these select wells ranged from an increase of 17 feet (well 59374, Black Butte Mine) to a drawdown of 44 feet (well LHM06, Leucite Hills Mine).

Hydrograph insets are shown on **Figure 49** for Leucite Hills Mine AF well LHM-06, Black Butte Mine FUF well 59374, and Black Butte Mine LF well 305181. LHM-06 showed the maximum drawdown among all the coal wells that were active. The water levels at LHM-06 began to decline in 1989 and continued to decline at a relatively rapid rate through 1992. During that time, the Pit 22N excavation was at its closest distance from LHM-06. The abrupt and temporary spikes in water levels after 1992 may reflect direct groundwater recharge into the coal seam from precipitation runoff water collected and temporarily held within open Pit 1. Although Pit 22N was nearly backfilled by 1995, Pit 21 remained open and prevented recharge at LHM-06 (Leucite Hills Mine Permit, 2020). However, since 2014 there has been a water level increase of approximately 32 feet (**Figure 49**).

Black Butte Mine FUF well 59374 is located east and down dip of Pit 4 (**Figure 49**). The increase in water levels at this well since 1992 resulted from increased recharge to the FUF from the open pit. After backfilling Pit 4 in 2009, water levels in this well increased 38 feet in 2011. From 2011 to 2016, water levels decreased 42 feet. However, the last measurement taken in 2019 remains approximately 16 feet higher than early measurements from baseline (Black Butte Mine Permit, 2020). The hydrograph at Black Butte Mine LF well 305181 is generally stable. Measured water levels showed few spikes of about 15 feet in 1993 and 1994. These spikes may be attributed to temporary recharge to this area from Pit 6 (Black Butte Mine Permit, 2020).

Compared to the Ericson Sandstone aquifer, mining impacts to groundwater levels in the coal seams are limited. Predicted drawdowns by the individual mines in the coal seams do not overlap with each other. Therefore, the cumulative effects of mining on the coals seams appear limited as these seams are generally less than 20 to 30 feet thick. Based on current available data, the model predictions by the mines, and the area geology, it is expected that the cumulative impacts caused by mining on the coal seams will be minimal.

6.2.6.4 UNDERBURDEN AQUIFER

Water levels from 25 monitor wells were used to characterize current (2017-2019) groundwater levels in the underburden aquifer (**Figure 50**). Two AF wells at the Black Butte Mine were under artesian conditions. The highest median 2017-2019 underburden water level elevation of 7,042.1 feet was observed at Jim Bridger Mine LF well 87-04-LOB. The lowest median 2017-2019 water level elevation of 6,622.8 feet was observed at LF well P10MW1 UB to the west of the Jim Bridger Mine (**Figure 50**). No underburden aquifer monitor wells in the WDEQ/LQD Hydrology Database had continuous data from the baseline to the current period (Section 3.2.2).

Hydrograph insets are shown on **Figure 50** for wells BCX-37-LA (LF) and 81-03-UB (FUF) at the Jim Bridger Mine, and well SW3-UB (AF) at the Black Butte Mine. The hydrograph of LF well BCX-37-LA has shown a steady decline of about 16 feet between 2005 and 2018. Water levels at FUF well 81-03-UB have decreased by approximately 23 feet over the past 12 years. Prior to 2000, water levels showed a steady decline, with an increased rate of decline in water levels from 2000 through 2005. The water level at this well has declined 48 feet since monitoring began in 1981 (Jim Bridger Mine Permit, 2020). The water levels at underburden AF well SW3-UB were relatively stable from 2007 to 2013, but measurements between 2014 and 2019 dropped by about three feet (**Figure 50**).

Compared to the Ericson Sandstone aquifer, mining impacts to groundwater levels in the underburden aquifer are limited. Predicted drawdowns by the individual mines in the underburden aquifer do not overlap with each other. The relatively lower hydraulic conductivity and the discontinuous nature of the underburden supports that coal mining would have limited cumulative effects on the underburden groundwater system.

6.2.6.5 ERICSON SANDSTONE AQUIFER

One well (LHM09) had current (2017-2019) groundwater level data available in the WDEQ/LQD Hydrology Database for the Ericson Sandstone aquifer. LHM09 is located at the Leucite Hills Mine (**Figure 51**). The Black Butte Mine also has an active Ericson Sandstone well that is artesian. A hydrograph inset is shown on **Figure 51** for well LHM09. Data are only available for the 2004-2019 period. From 2004 to 2013 there was a water level decline of two feet. Since 2013, water levels have increased by a maximum of about one foot with minor fluctuations (**Figure 51**).

With limited data and lack of readily available pumping records, it was difficult to interpret the drawdown caused by the current pumping of the mine facility wells in the Ericson Sandstone aquifer. However, all three mines used groundwater modeling to estimate the drawdown caused by the pumping at mine facility wells on the Ericson Sandstone aquifer (Section 2.2.1.2; **Figure 14**). The Leucite Hills Mine Permit (2020) model predicted a limited extent of drawdown caused by industrial supply well (Well No. 4) located in the Ericson Sandstone.

Stratigraphically, the Ericson Sandstone underlies the Almond Formation and therefore will not be physically disturbed by the mining operations. Given, that the Ericson formation is up to 700 feet thick, the effect of estimated drawdown caused by mining is expected to be minimal and would not affect the ability of the existing Ericson wells outside the mine permit boundaries to supply their intended use.

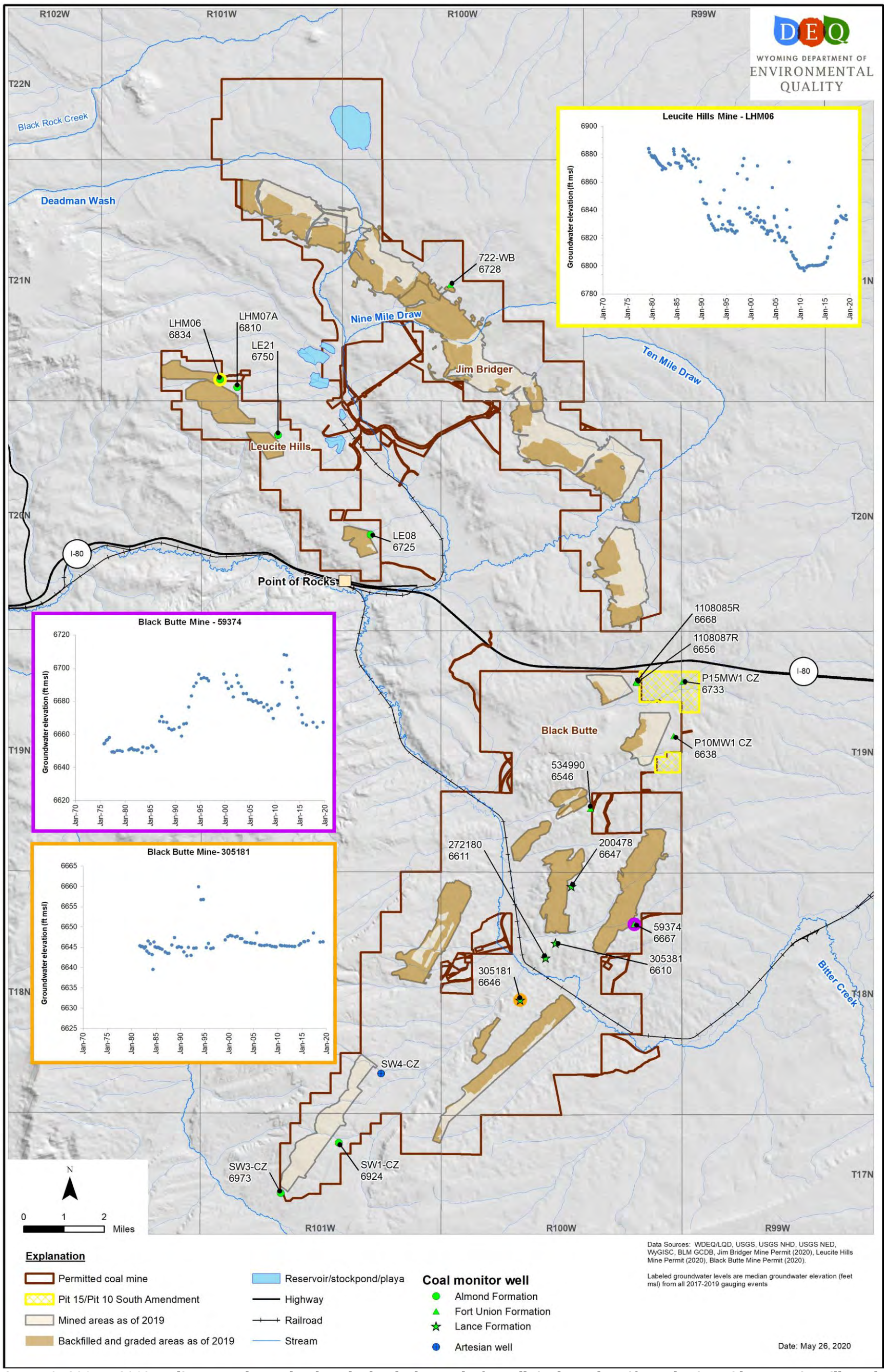


Figure 49. 2017 to 2019 median groundwater levels and select hydrographs for wells in the coal aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines.

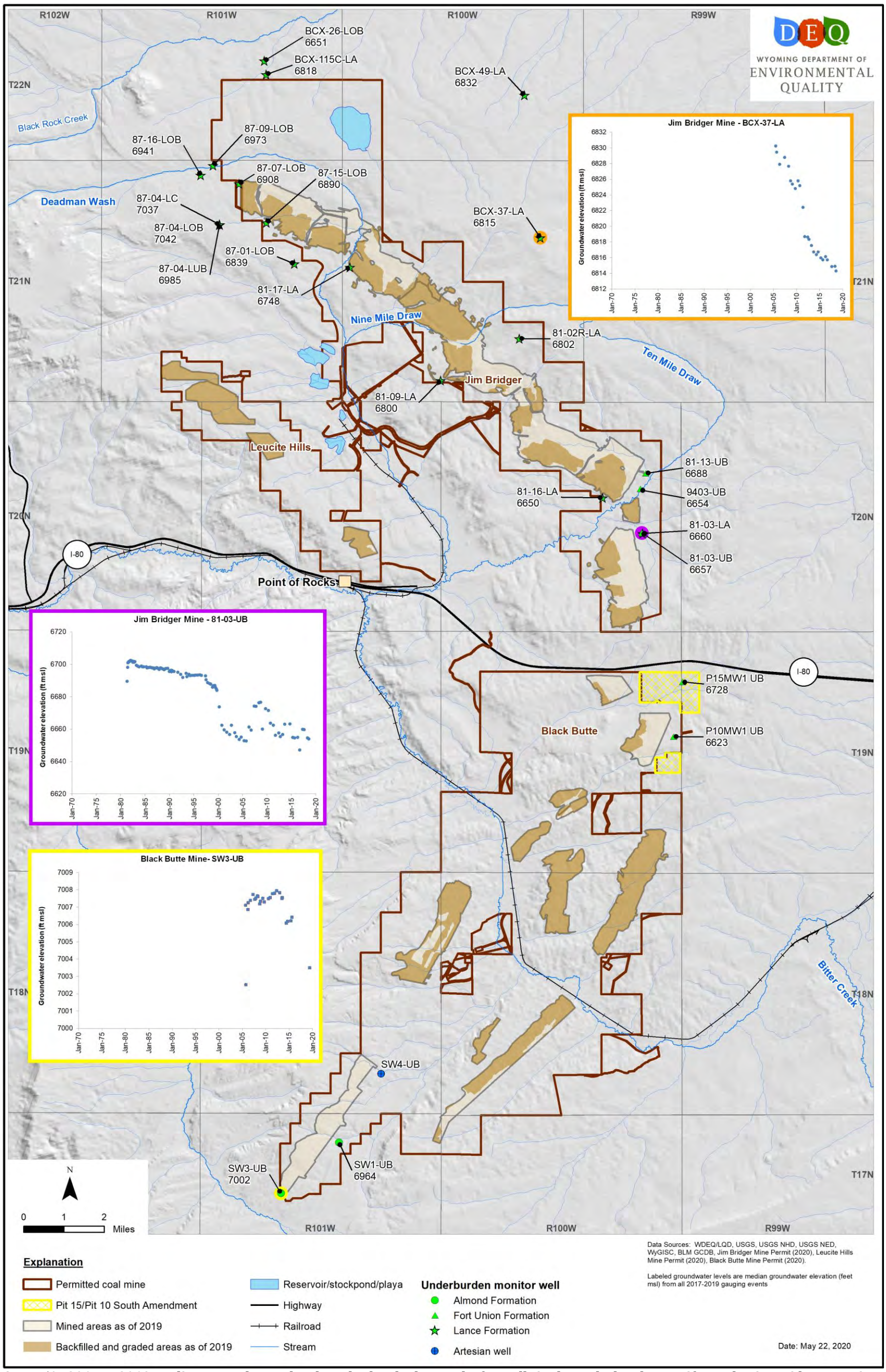


Figure 50. 2017 to 2019 median groundwater levels and select hydrographs for wells in the underburden aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines.

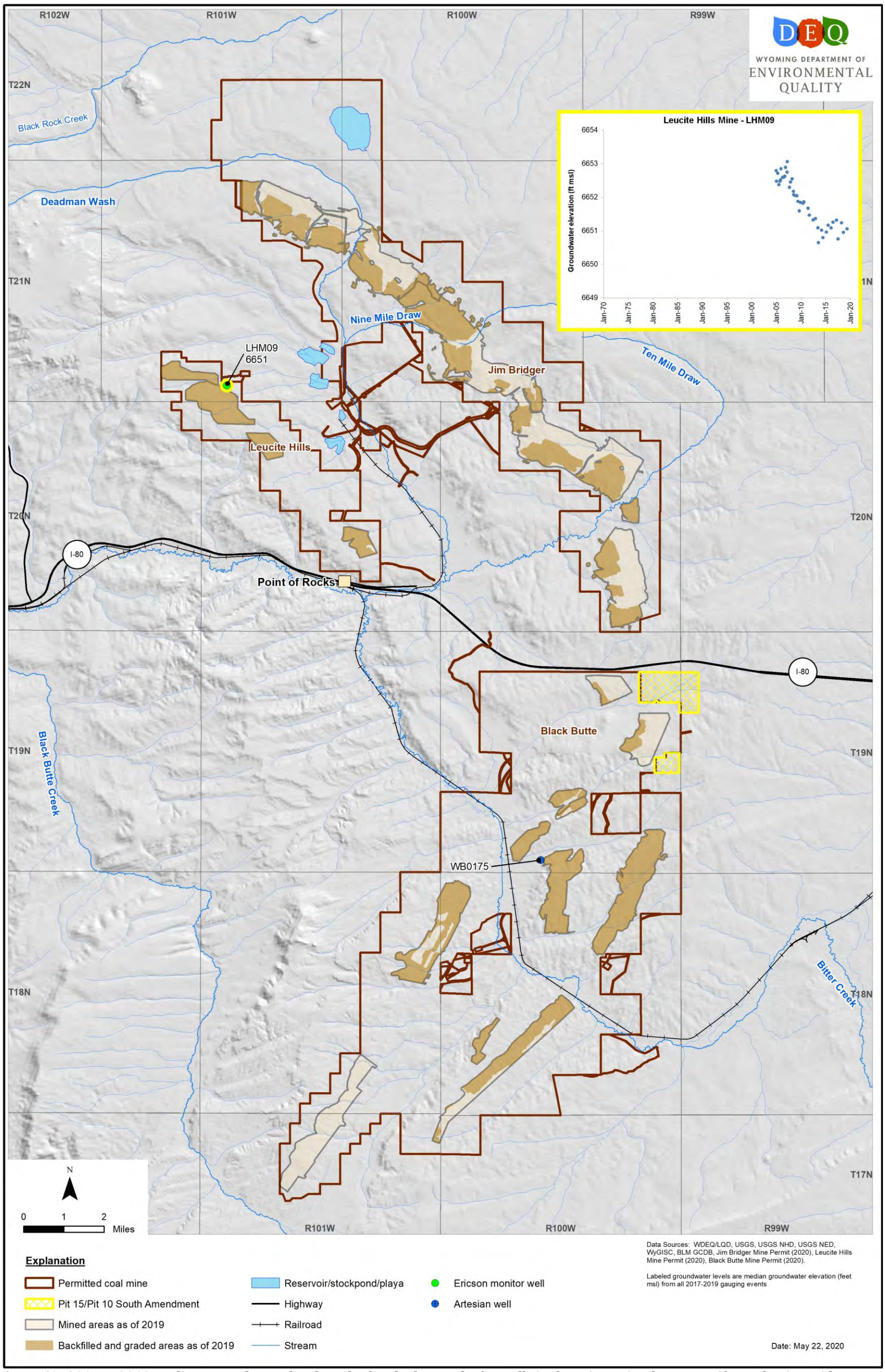


Figure 51. 2017 to 2019 median groundwater levels and select hydrographs for wells in the Ericson Sandstone aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines.

6.2.6.6 BACKFILL AQUIFER

The backfill aquifer is a new aquifer created by replacing overburden materials into the mining pit after the coal is removed. Water levels from 20 monitor wells were used to characterize current (2017-2019) groundwater levels in the backfill aquifer (**Figure 52**). Five of the wells were dry. It is important to note that these wells were in a transient recovery.

The earliest completed well is Jim Bridger Mine well SW-1-W (1985, shown as a hydrograph inset in **Figure 52**) and the latest completed wells were 17-01-SP and 17-02-SP (July 2017) at the Jim Bridger Mine. The water levels presented in **Figure 52** is a snapshot of the existing groundwater levels and it can be expected that the water levels will be rising for the next several years. The highest median 2017-2019 backfill water level elevation of 6,825.5 feet was observed at Jim Bridger Mine well SW-1-W. The lowest median 2017-2019 water level elevation of 6,561 feet was observed at Black Butte Mine well 568298 (**Figure 52**).

The backfill monitor wells and the baseline coal aquifer monitor wells were not located at the same exact location. Therefore, estimating the recovery of the backfill aquifer to baseline groundwater levels in the coal aquifer is difficult. The water level at Jim Bridger mine well SW-1-W (**Figure 52**) is relatively constant. A minor decline of about one foot in the last 12 years was observed and no specific reasons were attributed to this decline (Jim Bridger Mine Permit, 2020). The Leucite Hills Mine currently has two monitor wells completed in the backfill aquifer. The LHM22 well was completed in 1998 and the water levels at this well has increased over 27 feet between 1998 and 2019. Black Butte Mine well 566394 is completed in reclaimed spoils near the northeastern end of Pit 3. The hydrograph at Black Butte Mine well 566394 is relatively stable, and the most recent measurement in May 2019 is the highest on the period of record. However, analyzing the data after Pit 3 is completely backfilled would give a conclusive trend on the saturation at this well (Black Butte Mine Permit, 2020).

In general, the current conditions are representative of the early stages of reclamation of the mined areas. The available data show and support that the cumulative effects of mining on groundwater levels are being reduced as reclamation progresses and the backfill aquifer saturates. However, the viability of the backfill aquifer as a water supply source to support livestock use should be evaluated together with the groundwater quality of the backfill aquifer (Section 6.2.7.7).

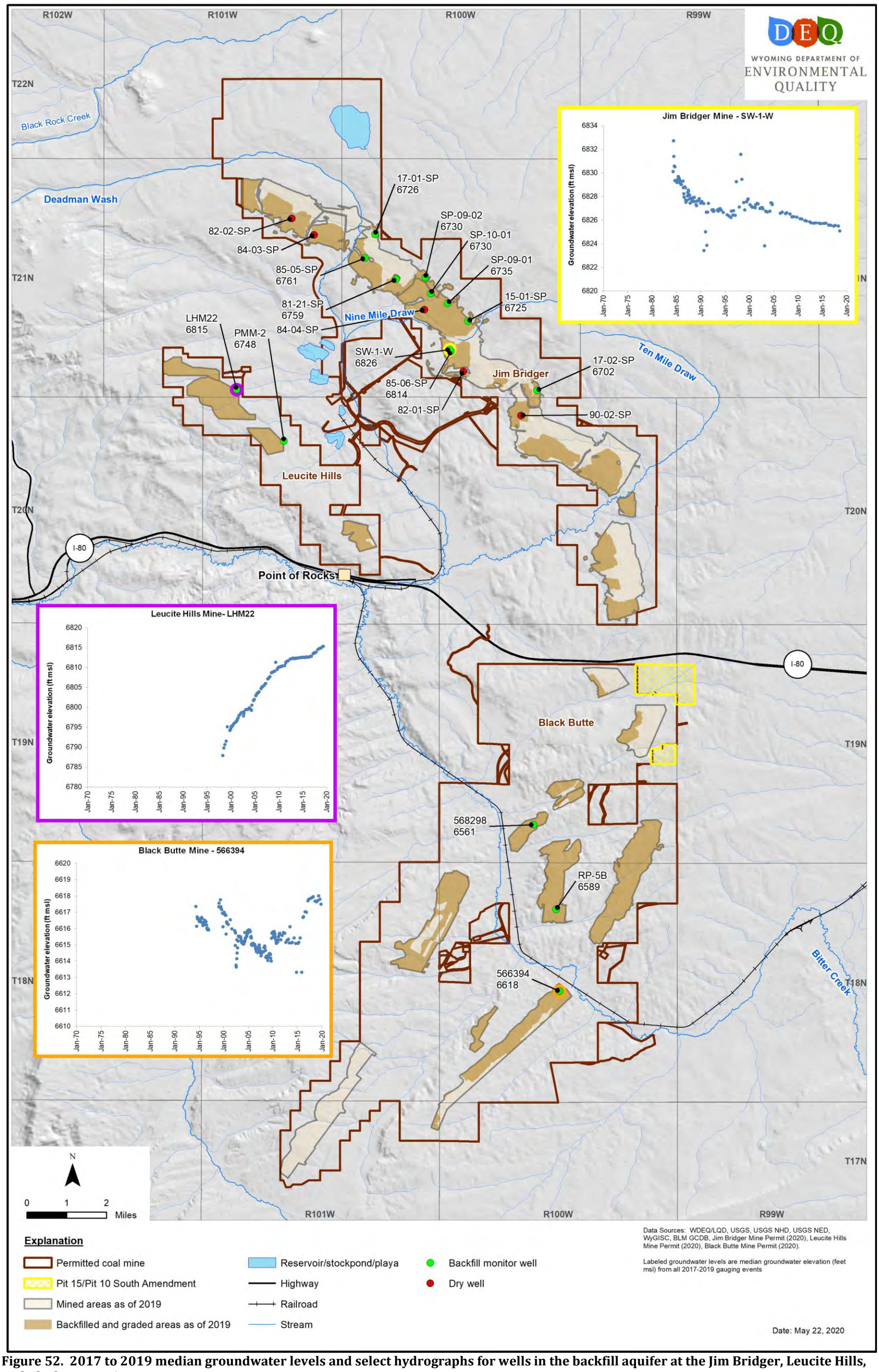


Figure 52. 2017 to 2019 median groundwater levels and select hydrographs for wells in the backfill aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines.

6.2.7 GROUNDWATER QUALITY

The evaluation of the effects of existing mining on groundwater quality is more challenging than the evaluation of groundwater levels. Groundwater quality is more heterogeneous and varies between the aquifers and within the aquifers. Unless a well has a continuous groundwater quality record for the baseline and the entire period of mining, it can be difficult to evaluate the effects of mining. Typically, the mines set up a groundwater monitoring network only in the area they are applying for a permit to mine from the WDEQ/LQD. The monitoring network expands as the mines apply for permit amendments to mine additional areas. Also, some of the monitor wells are mined through as the mines progress. This dynamic and transient monitoring network poses a significant challenge to characterize and quantify the effects of mining on groundwater quality.

Current groundwater quality in this section is evaluated primarily by comparing data against the WDEQ/WQD Class III livestock groundwater quality standards (**Table 20**) (WDEQ Water Quality Rules, Ch. 8, § 5). There are fewer wells with water quality data compared to the number of wells with water level data (**Figure 21**), and in general the spatial distribution of the well monitor network is too sparse to conduct a robust analysis of the impacts of mining on water quality. All data used for water quality analyses of current conditions were obtained from the WDEQ/LQD Hydrology Database.

One of the key parameters of interest in this CHIA is TDS, a measure of the combined content of all dissolved inorganic and organic substances in groundwater. The dissolved solids include carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium organic ions, and other ions. The use of the term TDS in the CHIA refers to TDS dried at 180° Celsius (C). The statistical analyses and discussions presented in this section are limited to these spatial extents and should not be extrapolated to other areas that do not have monitor wells.

Summary statistics for current conditions were compiled for each aquifer for several parameters of interest. Summary statistics were calculated using the total number of water quality samples available for all the wells in a given aquifer. Selection of parameters was based on what the mines commonly monitor as prescribed by WDEQ/LQD Guideline No. 8 (Wyoming Department of Environmental Quality, 2015). Summary statistics were calculated for both the entire available data set excluding the baseline time period (presented under the column "During Mining – All Data") and for the past three years of sampling (presented under the column "Past 3 Years of Sampling (2017 to 2019)"). The medians for constituents with non-detect concentrations were calculated using methods recommended by Helsel (2005), as previously discussed in Section 3.1.1.2. Comparisons against the WDEQ/WQD Class III livestock standards were also made by highlighting in red the minimum or maximum parameter values that exceed standards. The intent of these tables is to show major trends that might show that water quality is deteriorating or improving with time. For example, if the median TDS of the past three years for a certain aquifer is higher than the median TDS of the entire record, then a detailed analysis of TDS may be warranted. It is important to note the sampled wells were not always the same set of wells evaluated between the entire record data set and the past three years. Therefore, some of the changes in groundwater quality parameter statistics between these two data sets can be an artifact of the spatial heterogeneity within an aquifer.

Maps were created to show the median current TDS concentrations by well location in order to provide a spatial representation of groundwater quality in each aquifer. If there were

multiple TDS data for a well during this period, a median was calculated to represent the current TDS in the maps. A piper diagram was also used to show dominant water types in the aquifers of interest. The groundwater quality summary statistics and discussions presented in this section are limited to the spatial extents presented for each aquifer in **Figure 53** through **Figure 57** and should not be extrapolated to other areas that do not have monitor wells.

6.2.7.1 ALLUVIAL AQUIFER

For 2017 to 2019, groundwater quality data were collected from 13 alluvial wells shown in **Figure 53**. The minimum median TDS was observed at Black Rock Springs north of the Jim Bridger Mine (1,090 mg/L) and the maximum median TDS was observed at Black Butte Mine well 567494 along Bitter Creek (21,200 mg/L). Eight additional wells had a median TDS greater than 5,000 mg/L, all located along Bitter Creek at the Black Butte Mine (**Figure 53**). Under pre-mine conditions, water quality in most of the wells in the alluvial aquifer of Bitter Creek was poor and did not meet WDEQ/WQD Class III livestock standards (Black Butte Mine Permit, 2020).

The alluvial wells selected for time-series plots showed variability in TDS over time. TDS at well ST-26-W on Tenmile Draw at the Jim Bridger Mine was initially around 2,500 mg/L in 1980 and then increased to 3,060 mg/L in 2002. TDS then decreased to 2,280 mg/L in 2018 (**Figure 53**). Well 567794 on Bitter Creek near the downstream Black Butte Mine permit boundary showed a marked increase in TDS concentrations from around 2,340 mg/L in 1999 to 14,300 mg/L in 2018. TDS concentrations at well 566594 on Bitter Creek near the upstream Black Butte Mine permit boundary have always been above the WDEQ/WQD Class III livestock standard of 5,000 mg/L. Although there have been some drops in TDS over time, TDS at this well have generally been greater than 10,000 mg/L for several years (**Figure 53**).

Based on piper diagram shown in **Figure 58a**, the predominant 2017-2019 water quality type at seven of the 13 alluvial wells was sodium chloride (RockWare, Inc., 2015). Sodium sulfate type water was at three wells, sodium bicarbonate water was at two wells, and calcium sulfate water was at one well.

A comparison of the entire during-mining period of record (1992-2019) and current (2017-2019) water quality summary statistics for select parameters against WDEQ/WQD Class III livestock standards is shown in **Table 32**. Approximately 19 wells were evaluated during each time period. For the entire during-mining period, Class III exceedances were noted for aluminum (one well), boron (one well), chloride (eleven wells), chromium (one well), copper (two wells), nitrite+nitrate as N (two wells), selenium (seven wells), sulfate (ten wells), TDS (14 wells), and field pH (seven wells). For the 2017-2019 period, exceedances were observed for chloride (seven wells), sulfate (seven wells), TDS (nine wells), and field pH (one well). TDS over the 2017-2019 period ranged from 1,040 to 21,800 mg/L, with a median of 10,300 mg/L (**Table 32**). The minimum TDS was observed at the Black Rock Springs well north of the Jim Bridger Mine and the maximum TDS was observed at well 567494 along Bitter Creek at the Black Butte Mine. The overall results indicate that several wells in the alluvial aquifer exceed WDEQ/WQD Class III livestock standards for several constituents, particularly along Bitter Creek. The alluvial aquifer has poorest water quality among the aquifers of concern in the CIA.

6.2.7.2 OVERBURDEN AQUIFER

For 2017 to 2019, groundwater quality data were collected from 21 overburden wells shown in **Figure 54**. Seventeen of the overburden wells are in the FUF at the Jim Bridger Mine. At

Black Butte Mine, there are two wells are in the AF and two wells in the FUF. The minimum median TDS was observed at Jim Bridger Mine well BCX-26-UOB (630 mg/L) and the maximum median TDS was observed at Jim Bridger Mine well P15MW1 OB (1,820 mg/L) (**Figure 54**).

The time series plots of TDS for selected overburden wells showed minimal variation over the period evaluated (**Figure 54**). At well BCX-48-OB at the Jim Bridger Mine, TDS has been stable from 2005 to 2019 at around 1,700 mg/L. Similarly, at well 81-03-OB at the Jim Bridger Mine, TDS has been stable from 1995 to 2019 at around 1,600 mg/L. At well SW1-OB at the Black Butte Mine, TDS has been less than 1,000 mg/L for most of the period of record although there have been a few spikes in some years where concentrations exceeded 1,000 mg/L (**Figure 54**).

Based on piper diagram shown in **Figure 58b**, the predominant 2017-2019 water quality type at 14 of the 19 FUF overburden wells was sodium bicarbonate (RockWare, Inc., 2015). Calcium bicarbonate type water occurred at one well and sodium sulfate water occurred at four wells. In the AF overburden, sodium bicarbonate type water was noted at one of the two wells; magnesium bicarbonate water was noted at the other well (**Figure 58c**).

A comparison of the entire during-mining period of record and current (2017-2019) water quality summary statistics for select parameters against WDEQ/WQD Class III livestock standards is shown in **Table 33** (FUF overburden) and **Table 34** (AF overburden). For the entire during-mining period (2001-2017) in the FUF overburden, Class III exceedances were noted for field pH (20 wells). For the 2017-2019 period, field pH showed exceedances at ten wells. TDS over 2017-2019 ranged from 400 to 1,980 mg/L, with a median of 1,140 mg/L (**Table 33**). For the entire during-mining period (2005-2019) in the AF overburden, Class III exceedances were noted for field pH (one well) and selenium (one well). For the 2017-2019 period, there were no exceedances. TDS over 2017-2019 ranged from 710 to 1,620 mg/L, with a median of 1,145 mg/L (**Table 34**). The overall results from the overburden monitoring wells in both the FUF and AF indicate good water quality that generally meets WDEQ/WQD Class III livestock standards. Periodic exceedances of field pH occur in both formations, and for selenium in the AF overburden. Water quality in the overburden formations is better than quality in the alluvial and backfill monitoring wells.

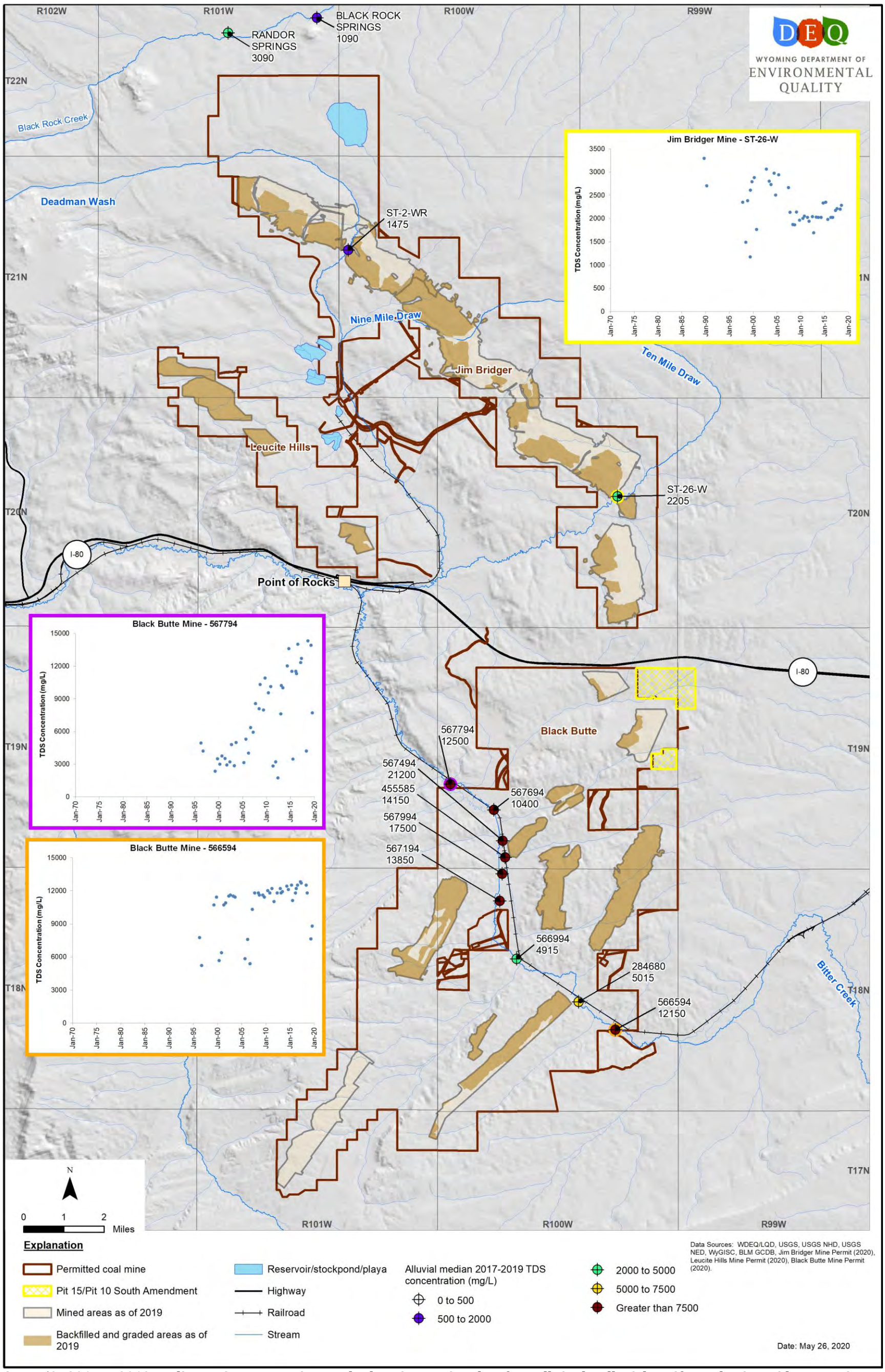


Figure 53. 2017 to 2019 median TDS concentrations and select time-series plots for wells in the alluvial aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines.

Table 32. During-mining water quality statistics in relation to WDEQ/WQD Class III standards for selected constituents in the alluvial aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines.

			Alluvial Aquifer													
			During Mining - All Data (1992 to 2019)							Past 3 Years of Sampling (2017 to 2019)						
Constituent	Units	Class III Livestock Standard	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances
Aluminum	mg/L	5.0	19	650	<0.05	8.6	0.01	1	1	12	67	<0.1	3.2	0.06	0	0
Ammonia as N	mg/L	---	19	632	<0.05	9.96	1.2	---	---	13	71	<0.1	5.1	1.0	---	---
Arsenic	mg/L	0.2	19	664	<0.005	0.139	0.002	0	0	13	71	<0.005	0.012	86% <0.005	0	0
Barium	mg/L	---	19	640	<0.1	3.3	99% <0.5	---	---	12	67	<0.1	0.1	96% <0.5	---	---
Boron	mg/L	5.0	19	646	<0.03	5.35	1.09	2	1	13	67	0.1	2.9	1.41	0	0
Cadmium	mg/L	0.05	19	664	<0.001	0.018	94% <0.002	0	0	13	71	<0.001	0.005	82% <0.001	0	0
Chloride	mg/L	2,000	19	664	<1	13,800	2,370	326	11	13	71	13	7,300	1,550	34	7
Chromium	mg/L	0.05	19	662	<0.01	0.06	96% <0.02	1	1	13	71	<0.01	0.03	89% <0.01	0	0
Copper	mg/L	0.5	19	652	<0.01	0.95	*	2	2	13	67	<0.01	0.04	94% <0.01	0	0
Fluoride	mg/L	---	19	654	<0.08	9.05	1.2	---	---	13	61	0.3	4.6	1.3	---	---
Iron	mg/L	---	19	664	<0.05	65.6	0.21	---	---	13	71	<0.05	33.2	0.28	---	---
Lead	mg/L	0.1	19	652	<0.02	<0.02	100% <0.02	0	0	12	67	<0.02	<0.02	100% <0.02	0	0
Manganese	mg/L	---	19	625	<0.02	4.77	0.51	---	---	9	54	<0.02	4.77	0.93	---	---
Mercury	mg/L	0.00005	19	640	<0.001	<0.001	100% <0.001	0	0	12	67	<0.001	<0.001	100% <0.001	0	0
Nickel	mg/L	---	19	638	<0.01	0.22	0.003	---	---	12	67	<0.01	0.04	*	---	---
Nitrate as N	mg/L	---	14	85	<0.01	41.8	0.22	---	---	0	---	---	---	---	---	---
Nitrite as N	mg/L	10.0	1	3	<0.01	0.13	*	0	0	0	---	---	---	---	---	---
Nitrite plus nitrate as N	mg/L	100	19	629	<0.01	1,590	0.04	2	2	13	71	<0.1	27.6	0.04	0	0
Selenium	mg/L	0.05	19	638	<0.001	2.02	0.001	28	7	13	71	<0.001	0.003	87% <0.005	0	0
Sulfate	mg/L	3,000	19	663	<1	26,500	2,600	314	10	13	71	136	9,950	3,150	38	7
TDS dried at 180 °C	mg/L	5,000	19	636	610	49,100	9,470	460	14	13	71	1,040	21,800	10,300	47	9
Zinc	mg/L	25.0	19	662	<0.01	0.29	*	0	0	13	71	<0.01	0.09	87% <0.01	0	0
pH (field)	S.U.	6.5-8.5	20	615	6.30	9.00	7.50	12	7	20	67	6.85	8.70	7.40	1	1
Bicarbonate	mg/L	---	19	615	114	3,940	988	---	---	13	71	129	1,370	973	---	---
Calcium	mg/L	---	19	664	7	747	146	---	---	13	71	8	737	248	---	---
Magnesium	mg/L	---	19	664	4.4	3,620	211	---	---	13	71	5	2,170	281	---	---
Potassium	mg/L	---	19	664	<0.2	60.3	9	---	---	13	71	2	48	12	---	---
Sodium	mg/L	---	19	664	139	11,700	2,385	---	---	13	71	270	6,630	2,160	---	---

Medians for constituents with non-detect values were calculated using methods recommended by Helsel (2005). Medians were not calculated for constituents having ≥ 80% non-detect values. Minimum and maximum concentrations shown in red exceed WDEQ/WQD Class III groundwater quality standards. *A median could not be calculated using the statistical software for unknown reasons.

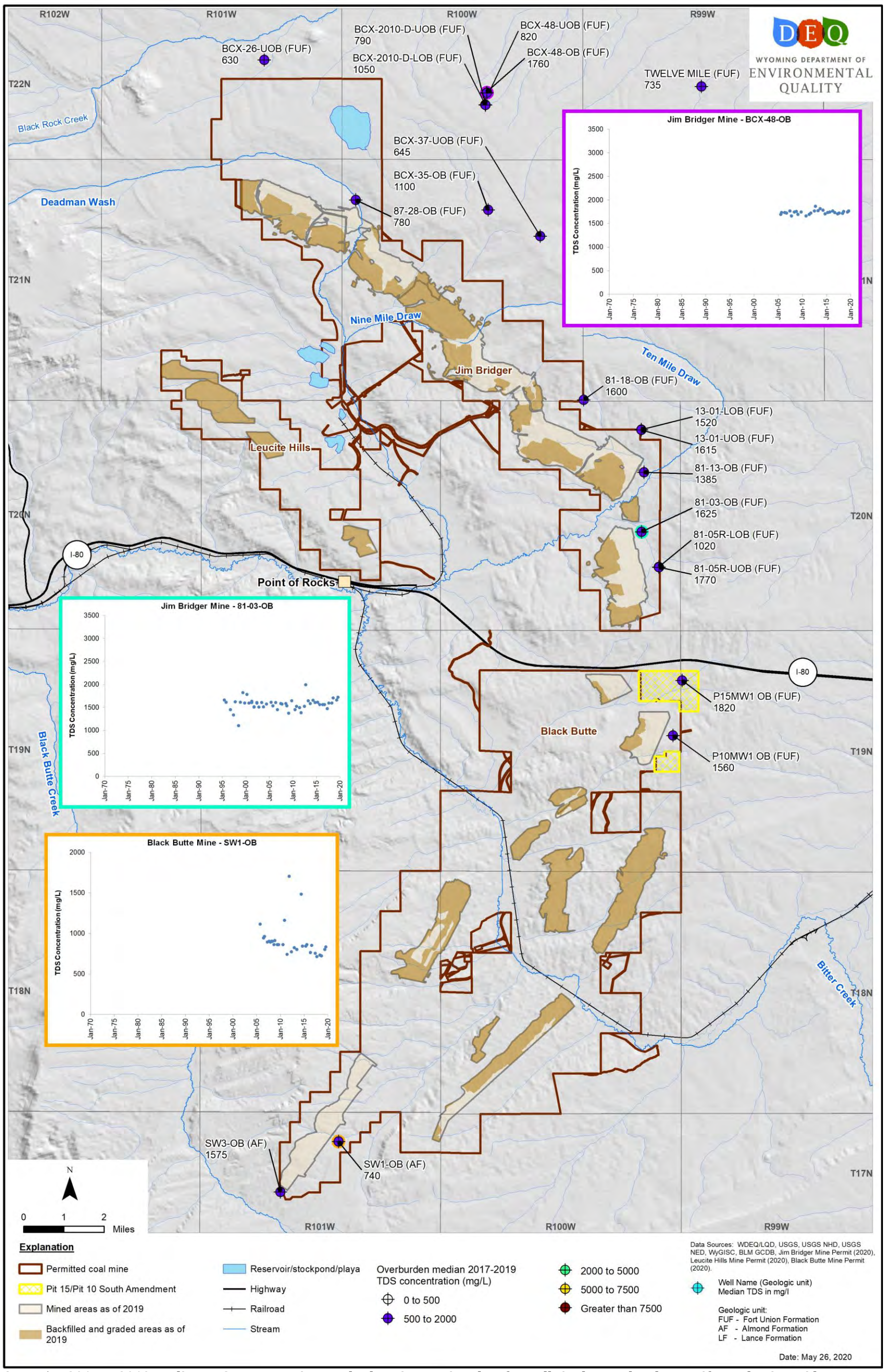


Figure 54. 2017 to 2019 median TDS concentrations and select time-series plots for wells in the overburden aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines.

Table 33. During-mining water quality statistics in relation to WDEQ/WQD Class III standards for selected constituents in the overburden aquifer (FUF) at the Jim Bridger, Leucite Hills, and Black Butte mines.

			Overburden Aquifer – Fort Union Formation													
			During Mining - All Data (2001 to 2019)							Past 3 Years of Sampling (2017 to 2019)						
Constituent	Units	Class III Livestock Standard	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances
Aluminum	mg/L	5.0	29	376	<0.1	1.1	95% <0.1	0	0	19	89	<0.1	0.4	96% <0.1	0	0
Ammonia as N	mg/L	---	29	428	<0.05	2.1	0.5	---	---	19	106	<0.1	1.3	0.6	---	---
Arsenic	mg/L	0.2	29	428	<0.005	0.044	96% <0.005	0	0	19	106	<0.005	0.019	94% <0.005	0	0
Barium	mg/L	---	29	337	<0.5	0.5	95% <0.5	---	---	19	89	<0.5	0.5	0.05	---	---
Boron	mg/L	5.0	29	359	<0.1	1.11	0.28	0	0	19	76	<0.1	0.5	0.3	0	0
Cadmium	mg/L	0.05	29	428	<0.001	<0.002	100% <0.002	0	0	19	106	<0.001	<0.002	100% <0.002	0	0
Chloride	mg/L	2,000	29	428	<1	486	15	0	0	19	106	6	387	17	0	0
Chromium	mg/L	0.05	29	428	<0.01	0.04	99% <0.01	0	0	19	106	<0.01	<0.01	100% <0.01	0	0
Copper	mg/L	0.5	29	376	<0.01	0.08	92% <0.01	0	0	19	89	<0.01	<0.01	100% <0.01	0	0
Fluoride	mg/L	---	19	246	<0.1	7.1	0.7	---	---	2	10	0.1	1.9	1.7	---	---
Iron	mg/L	---	29	428	<0.05	21.2	0.01	---	---	19	106	<0.05	0.48	90% <0.05	---	---
Lead	mg/L	0.1	29	376	<0.02	0.03	99% <0.02	0	0	19	89	<0.02	<0.02	100% <0.02	0	0
Manganese	mg/L	---	22	258	<0.02	0.47	*	---	---	2	10	<0.02	0.04	*	---	---
Mercury	mg/L	0.00005	29	337	<0.001	<0.001	100% <0.001	0	0	19	89	<0.001	<0.001	100% <0.001	0	0
Nickel	mg/L	---	29	337	<0.01	0.02	98% <0.01	---	---	19	89	<0.01	<0.01	100% <0.01	---	---
Nitrate as N	mg/L	---	6	18	<0.01	1.72	0.06	---	---	0	0	---	---	---	---	---
Nitrite as N	mg/L	10.0	6	18	<0.01	0.23	83% <0.01	---	---	0	0	---	---	---	---	---
Nitrite plus nitrate as N	mg/L	100	29	416	<0.01	11.4	0.008	0	0	19	106	<0.1	<0.1	100% <0.1	0	0
Selenium	mg/L	0.05	29	428	<0.001	0.007	99% <0.005	0	0	19	106	<0.001	0.001	99% <0.005	0	0
Sulfate	mg/L	3,000	29	428	<0.05	1,710	177	0	0	19	106	<1	793	187	0	0
TDS dried at 180 °C	mg/L	5,000	29	425	400	3,260	1,150	0	0	19	106	400	1,980	1,140	0	0
Zinc	mg/L	25.0	29	428	<0.01	2.94	*	0	0	19	106	<0.01	0.39	*	0	0
pH (field)	S.U.	6.5-8.5	28	279	6.39	9.51	8.20	82	20	19	71	7.01	9.38	8.20	21	10
Bicarbonate	mg/L	---	29	427	292	1,360	685	---	---	19	105	325	1,350	693	---	---
Calcium	mg/L	---	29	421	1	367	12.0	---	---	19	106	1	129	6.0	---	---
Magnesium	mg/L	---	29	428	<1	313		---	---	19	106	<1	73	3.0	---	---
Potassium	mg/L	---	29	428	1	71	4.0	---	---	19	106	1	10	3.5	---	---
Sodium	mg/L	---	29	428	29.1	932	424	---	---	19	106	33	753	429	---	---

Medians for constituents with non-detect values were calculated using methods recommended by Helsel (2005). Medians were not calculated for constituents having ≥ 80% non-detect values. Minimum and maximum concentrations shown in red exceed WDEQ/WQD Class III groundwater quality standards. *A median could not be calculated using the statistical software for unknown reasons.

Table 34. During-mining water quality statistics in relation to WDEQ/WQD Class III standards for selected constituents in the overburden aquifer (AF) at the Jim Bridger, Leucite Hills, and Black Butte mines.

			Overburden Aquifer – Almond Formation													
			During Mining - All Data (2005 to 2019)							Past 3 Years of Sampling (2017 to 2019)						
Constituent	Units	Class III Livestock Standard	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances
Aluminum	mg/L	5.0	3	79	<0.1	2.0	92% <0.1	0	0	2	12	<0.1	<0.1	100% <0.1	0	0
Ammonia as N	mg/L	---	3	78	<0.1	2.9	1.2	---	---	2	12	1.1	1.7	1.3	---	---
Arsenic	mg/L	0.2	3	79	<0.005	0.008	99% <0.005	0	0	2	12	<0.005	<0.005	100% <0.005	0	0
Barium	mg/L	---	3	79	<0.5	<0.5	100% <0.5	---	---	2	12	<0.5	<0.5	100% <0.5	---	---
Boron	mg/L	5.0	3	79	0.07	1.16	0.74	0	0	2	12	0.69	0.83	0.74	0	0
Cadmium	mg/L	0.05	3	79	<0.002	<0.002	100% <0.002	0	0	2	12	<0.002	<0.002	100% <0.002	0	0
Chloride	mg/L	2,000	3	79	9	124	16	0	0	2	12	11	19	16	0	0
Chromium	mg/L	0.05	3	79	<0.01	<0.01	100% <0.01	0	0	2	12	<0.01	<0.01	100% <0.01	0	0
Copper	mg/L	0.5	3	79	<0.01	0.1	94% <0.01	0	0	2	12	<0.01	<0.01	100% <0.01	0	0
Fluoride	mg/L	---	3	79	<0.1	4.8	0.5	---	---	2	12	0.2	0.7	0.4	---	---
Iron	mg/L	---	3	79	<0.05	1.27	0.13	---	---	2	12	0.17	0.84	0.33	---	---
Lead	mg/L	0.1	3	79	<0.02	<0.02	100% <0.02	0	0	2	12	<0.02	<0.02	100% <0.02	0	0
Manganese	mg/L	---	3	78	<0.02	0.49	0.06	---	---	2	12	0.05	0.06	0.06	---	---
Mercury	mg/L	0.00005	3	79	<0.001	<0.001	100% <0.001	0	0	2	12	<0.001	<0.001	100% <0.001	0	0
Nickel	mg/L	---	3	79	<0.01	0.06	98% <0.01	---	---	2	12	<0.01	<0.01	100% <0.01	---	---
Nitrate as N	mg/L	---	0	0	---	---	---	---	---	0	0	---	---	---	---	---
Nitrite as N	mg/L	10.0	0	0	---	---	---	---	---	0	0	---	---	---	---	---
Nitrite plus nitrate as N	mg/L	100	3	79	<0.05	0.9	0.03	0	0	2	12	<0.1	0.2	0.05	0	0
Selenium	mg/L	0.05	3	79	<0.005	0.179	82% <0.005	3	1	2	12	<0.005	<0.005	100% <0.005	0	0
Sulfate	mg/L	3,000	3	79	<1	476	207	0	0	2	12	57	357	218	0	0
TDS dried at 180 °C	mg/L	5,000	3	79	710	2,200	1,300	0	0	2	12	710	1,620	1,145	0	0
Zinc	mg/L	25.0	3	79	<0.01	0.51	*	0	0	2	12	<0.01	<0.01	100% <0.01	0	0
pH (field)	S.U.	6.5-8.5	3	76	6.80	8.70	7.70	3	1	2	12	7.10	8.10	7.45	0	0
Bicarbonate	mg/L	---	3	58	793	1,270	956	---	---	2	12	838	1,120	944	---	---
Calcium	mg/L	---	3	79	2	81	25	---	---	2	12	17	81	44	---	---
Magnesium	mg/L	---	3	79	1	118	26	---	---	2	12	14	98	52	---	---
Potassium	mg/L	---	3	79	6	42	25	---	---	2	12	21	33	25	---	---
Sodium	mg/L	---	3	79	83	1,000	459	---	---	2	12	84	583	300	---	---

Medians for constituents with non-detect values were calculated using methods recommended by Helsel (2005). Medians were not calculated for constituents having ≥ 80% non-detect values. Minimum and maximum concentrations shown in red exceed WDEQ/WQD Class III groundwater quality standards. *A median could not be calculated using the statistical software for unknown reasons.

6.2.7.3 COAL AQUIFER

For 2017 to 2019, groundwater quality data were collected from 10 coal aquifer wells shown in **Figure 55**. Three of the coal wells are in the AF at the Leucite Hills Mine, one of the wells are in the AF at the Black Butte Mine, four of the wells are in the FUF at the Black Butte Mine, and two of the wells are in the LF at the Black Butte Mine. The minimum median TDS was observed at Leucite Hills Mine AF well LE21 (780 mg/L) and the maximum median TDS was observed at Black Butte Mine LF well 305381 (10,100 mg/L) (**Figure 55**).

The three wells selected for TDS time-series plots showed varying trends over time (**Figure 55**). At well LHM06 in the AF at the Leucite Hills Mine, TDS was consistent from 2002 through 2007 at around 1,400 mg/L; from 2008 to 2019 TDS was more variable, ranging from 1,240 to 2,240 mg/L. The Leucite Hills Mine Permit (2020) attributes changing water quality conditions at the well due to open pit conditions at Pit 21. At well 59374 in the FUF at the Black Butte Mine, TDS increased over time from 1,060 mg/L in 1996 to 1,580 mg/L in 2010. From 2010 to 2012, TDS dropped to 280 mg/L. Since 2012, TDS has increased to 1,520 mg/L in 2019. At well 305181 in the LF at the Black Butte Mine, TDS showed upward and downward changes over the 1996 to 2006 period. From 2006 to 2015, TDS decreased in the well from 7,600 to 4,320 mg/L (**Figure 55**). The measurement in 2017 was the highest TDS on record at the well at 8,540 mg/L. The most recent TDS level measured in 2019 was 7490 mg/L. The Black Butte Mine Permit (2020) attributes changing water quality conditions at this well due to either completion problems or subsurface recharge from a sediment pond for Pit 6, upslope from the well.

The water quality type in the coal is dependent on several factors, including the proximity of a coal well to the alluvial and backfill aquifers, depth of the well, and the local geochemistry. Based on piper diagram shown in **Figure 58d**, the 2017-2019 water quality type at three of the four FUF coal wells was sodium bicarbonate (RockWare, Inc., 2015). Sodium sulfate type water occurred at the other FUF coal well. In the AF coal, sodium bicarbonate type water was noted at one of the four wells; magnesium bicarbonate, sodium sulfate, and calcium sulfate were noted at one well each (**Figure 58e**). In the LF coal, sodium sulfate type water was the dominant water type at three of the four wells; sodium chloride was noted at one well (**Figure 58f**).

A comparison of the entire during-mining period of record and current (2017-2019) water quality summary statistics for select parameters against WDEQ/WQD Class III livestock standards is shown in **Table 35** (FUF coal), **Table 36** (AF coal), and **Table 37** (LF coal). For the entire during-mining period (1992-2017) in the FUF coal, Class III exceedances were noted for selenium (one well), sulfate (one well), TDS (one well), and field pH (five wells). For the 2017-2019 period, field pH showed exceedances in one well. TDS over 2017-2019 ranged from 1,370 to 1,570 mg/L, with a median of 1,410 mg/L (**Table 35**). For the entire during-mining period in the AF coal (1986-2019), Class III exceedances were noted for chromium (one well), selenium (one well), and field pH (three wells). For the 2017-2019 period, there were no Class III exceedances at any wells. TDS over 2017-2019 ranged from 680 to 1,860 mg/L, with a median of 965 mg/L (**Table 36**). For the entire during-mining period in the LF coal (1992-2019), Class III exceedances were noted for chloride (one well), selenium (three wells), sulfate (one well), TDS (two wells), and field pH (three wells). For the 2017-2019 period, exceedances were noted for chloride (one well), sulfate (one well), and TDS (two wells). TDS over 2017-2019 ranged from 7,490 to 10,300 mg/L, with a median of 10,000 mg/L (**Table 37**). The overall results from the coal monitoring wells indicate water quality is slightly poorer in the Lance Formation coal, although much of this is driven by high dissolved ions

at one well at the Black Butte Mine (well 305381). The LF coal wells also contain higher concentrations of selenium compared to the FUF and AF coal wells.

6.2.7.4 UNDERBURDEN AQUIFER

For 2017 to 2019, groundwater quality data were collected from 15 underburden wells shown in **Figure 56**. Twelve of the underburden wells are in the LF at the Jim Bridger Mine, two of the wells is in the FUF at the Black Butte Mine, and one of the wells are in the AF at the Black Butte Mine. The minimum median TDS was observed at well BCX-26-LOB in the LF at the Jim Bridger Mine (715 mg/L) and the maximum median TDS was observed at Jim Bridger Mine well 87-04-LOB in the LF (2,490 mg/L) (**Figure 56**). The measured TDS was less than 5,000 mg/L at all the underburden monitor wells over the 2017-2019 period.

The TDS time-series plots for Jim Bridger Mine well BCX-37-LA showed that TDS ranged from 960 to 1,740 mg/L over the 2005 to 2019 period (**Figure 56**). Black Butte Mine well P10MW1 UB has been active since 2014 and TDS has been on a steady decline from 1,830 mg/L in 2015 to 1,320 mg/L in 2019. At Black Butte Mine well SW1-UB, TDS has been consistent at around 1,500 to 1,700 mg/L, with the exception of one measurement of 3,110 mg/L in 2012 (**Figure 56**).

Based on piper diagram shown in **Figure 59a**, the 2017-2019 water quality type at one of the FUF underburden wells was sodium sulfate; water quality type at the other FUF underburden well was sodium bicarbonate (RockWare, Inc., 2015). Based on piper diagram shown in **Figure 59b**, the 2017-2019 water quality type at the AF underburden well was sodium bicarbonate (RockWare, Inc., 2015). Based on piper diagram shown in **Figure 59c**, the 2017-2019 water quality type at nine of the 12 of the LF underburden wells was sodium bicarbonate; magnesium sulfate, sodium sulfate, and sodium chloride were the water types observed in the other three wells (RockWare, Inc., 2015).

A comparison of the entire during-mining period of record and current (2017-2019) water quality summary statistics for select parameters against WDEQ/WQD Class III livestock standards is shown in **Table 38** (FUF underburden), **Table 39** (AF underburden), and **Table 40** (LF underburden). For the entire during-mining period (2001-2019) in the FUF underburden, Class III exceedances were noted for mercury (one well) and field pH (two wells). For the 2017-2019 period, there were no exceedances. TDS over 2017-2019 ranged from 1,320 to 2,080 mg/L, with a median of 1,680 mg/L (**Table 38**). For the entire during-mining period in the AF underburden (2005-2019), Class III exceedances were noted for selenium (one well) and field pH (two wells). For the 2010-2019 period, field pH showed three exceedances at one well. TDS over 2017-2019 ranged from 1,490 to 1,670 mg/L, with a median of 1,610 mg/L (**Table 39**). For the entire during-mining period in the LF underburden (2001-2019), Class III exceedances were noted for aluminum (one well) and field pH (11 wells). For the 2017-2019 period, 12 exceedances were noted for field pH at six wells. TDS over 2017-2019 ranged from 690 to 2,640 mg/L, with a median of 1,520 mg/L (**Table 40**). The overall results from the underburden monitoring wells indicate water quality is high and generally meets WDEQ/WQD Class III livestock standards. Some wells in each underburden formation show slight exceedances of field pH, and one AF well at the Black Butte Mine (SW1-UB) has shown recent exceedances of the Class III selenium criterion.

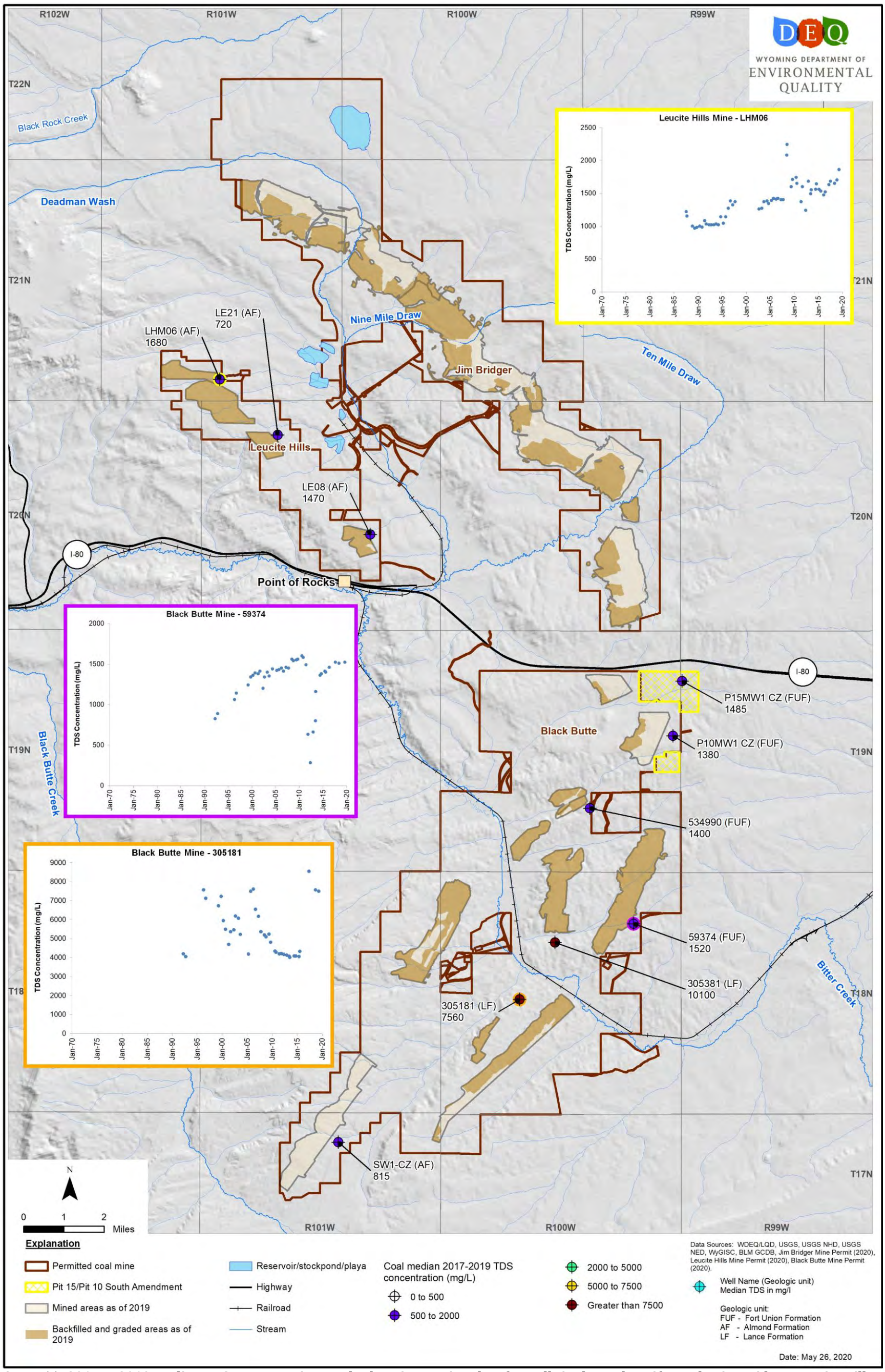


Figure 55. 2017 to 2019 median TDS concentrations and select time-series plots for wells in the coal aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines.

Table 35. During-mining water quality statistics in relation to WDEQ/WQD Class III standards for selected constituents in the coal aquifer (FUF) at the Jim Bridger, Leucite Hills, and Black Butte mines.

			Coal Aquifer – Fort Union Formation													
			During Mining - All Data (1992 to 2019)							Past 3 Years of Sampling (2017 to 2019)						
Constituent	Units	Class III Livestock Standard	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances
Aluminum	mg/L	5.0	9	148	<0.1	2.9	90% <0.1	0	0	3	16	<0.1	<0.1	100% <0.1	0	0
Ammonia as N	mg/L	---	9	133	<0.05	13.6	0.5	---	---	3	16	0.4	2.0	0.5	---	---
Arsenic	mg/L	0.2	9	148	<0.005	0.141	83% <0.01	0	0	3	16	<0.005	0.029	*	0	0
Barium	mg/L	---	9	146	<0.5	0.101	99% <0.5	---	---	3	16	<0.5	<0.5	100% <0.5	---	---
Boron	mg/L	5.0	9	146	0.05	0.85	0.38	0	0	3	16	0.23	0.44	0.37	0	0
Cadmium	mg/L	0.05	9	148	<0.002	<0.005	100% <0.005	0	0	3	16	<0.002	<0.002	100% <0.002	0	0
Chloride	mg/L	2,000	9	148	8	411	164	0	0	3	16	14	340	304	0	0
Chromium	mg/L	0.05	9	148	<0.01	<0.02	100% <0.02	0	0	3	16	<0.01	<0.01	100% <0.01	0	0
Copper	mg/L	0.5	9	148	<0.01	0.03	97% <0.01	0	0	3	16	<0.01	<0.01	100% <0.01	0	0
Fluoride	mg/L	---	8	144	0.1	6.0	2.3	---	---	3	16	0.4	4.5	2.4	---	---
Iron	mg/L	---	9	148	<0.05	3.95	0.08	---	---	3	16	<0.05	0.47	0.1	---	---
Lead	mg/L	0.1	9	148	<0.01	0.17	95% <0.02	0	0	3	16	<0.02	<0.02	100% <0.02	0	0
Manganese	mg/L	---	9	146	<0.02	0.4	0.03	---	---	3	16	<0.02	0.21	0.04	---	---
Mercury	mg/L	0.00005	9	145	<0.001	<0.001	100% <0.001	0	0	3	16	<0.001	<0.001	100% <0.001	0	0
Nickel	mg/L	---	9	146	<0.01	0.02	98% <0.03	---	---	3	16	<0.01	<0.01	100% <0.01	---	---
Nitrate as N	mg/L	---	4	29	<0.04	4.78	0.05	---	---	0	0	---	---	---	---	---
Nitrite as N	mg/L	10.0	0	0	---	---	---	---	---	0	0	---	---	---	---	---
Nitrite plus nitrate as N	mg/L	100	9	133	<0.01	1.24	0.03	0	0	3	16	<0.1	<0.1	100% <0.1	0	0
Selenium	mg/L	0.05	9	142	<0.005	0.054	92% <0.025	2	1	3	16	<0.005	<0.005	100% <0.005	0	0
Sulfate	mg/L	3,000	9	148	<1	4,580	137	12	1	3	16	4	764	44	0	0
TDS dried at 180 °C	mg/L	5,000	9	141	280	7,920	1,420	11	1	3	16	1,370	1,570	1,410	0	0
Zinc	mg/L	25.0	9	148	<0.01	1.33	*	0	0	3	16	<0.01	<0.01	100% <0.01	0	0
pH (field)	S.U.	6.5-8.5	9	147	6.70	9.41	8.23	52	5	3	16	7.50	8.80	8.20	3	1
Bicarbonate	mg/L	---	9	133	159	1,830	930	---	---	3	16	426	1,080	816	---	---
Calcium	mg/L	---	9	148	2	141	9.5	---	---	3	16	3	51	5.0	---	---
Magnesium	mg/L	---	9	148	1	103	6.0	---	---	3	16	2	28	3.0	---	---
Potassium	mg/L	---	9	148	1.5	22.4	4.5	---	---	3	16	3	10	4.0	---	---
Sodium	mg/L	---	9	148	63	2,340	551	---	---	3	16	421	644	561	---	---

Medians for constituents with non-detect values were calculated using methods recommended by Helsel (2005). Medians were not calculated for constituents having ≥ 80% non-detect values. Minimum and maximum concentrations shown in red exceed WDEQ/WQD Class III groundwater quality standards. *A median could not be calculated using the statistical software for unknown reasons.

Table 36. During-mining water quality statistics in relation to WDEQ/WQD Class III standards for selected constituents in the coal aquifer (AF) at the Jim Bridger, Leucite Hills, and Black Butte mines.

			Coal Aquifer – Almond Formation													
			During Mining - All Data (1986 to 2019)							Past 3 Years of Sampling (2017 to 2019)						
Constituent	Units	Class III Livestock Standard	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances
Aluminum	mg/L	5.0	11	243	<0.01	2.0	92% <0.1	0	0	4	18	<0.1	0.2	83% <0.1	0	0
Ammonia as N	mg/L	---	10	242	<0.01	3.2	1.2	---	---	4	18	<0.1	2.6	1.5	---	---
Arsenic	mg/L	0.2	11	243	<0.002	0.006	99% <0.005	0	0	4	18	<0.005	<0.005	100% <0.005	0	0
Barium	mg/L	---	11	244	<0.05	1.0	94% <0.5	---	---	4	18	<0.5	0.9	0.38	---	---
Boron	mg/L	5.0	11	248	0.41	2.4	0.86	0	0	4	18	0.51	1.2	0.74	0	0
Cadmium	mg/L	0.05	11	244	<0.002	0.007	99% <0.002	0	0	4	18	<0.002	<0.002	100% <0.002	0	0
Chloride	mg/L	2,000	11	248	<1	263	20	0	0	4	18	10	212	17.5	0	0
Chromium	mg/L	0.05	11	242	<0.01	0.07	97% <0.02	1	1	4	18	<0.01	<0.01	100% <0.01	0	0
Copper	mg/L	0.5	11	242	<0.01	0.12	97% <0.02	0	0	4	18	<0.01	<0.01	100% <0.01	0	0
Fluoride	mg/L	---	11	246	0.2	5.2	0.8	---	---	4	18	0.4	4.0	1.05	---	---
Iron	mg/L	---	11	247	<0.05	18.6	0.06	---	---	4	18	<0.05	1.1	0.08	---	---
Lead	mg/L	0.1	11	243	<0.01	0.01	99% <0.02	0	0	4	18	<0.02	<0.02	100% <0.02	0	0
Manganese	mg/L	---	11	246	<0.01	0.75	0.04	---	---	4	18	<0.02	0.75	0.04	---	---
Mercury	mg/L	0.00005	11	243	<0.001	<0.001	100% <0.001	0	0	4	18	<0.001	<0.001	100% <0.001	0	0
Nickel	mg/L	---	11	243	<0.01	0.06	90% <0.01	---	---	4	18	<0.01	<0.01	100% <0.01	---	---
Nitrate as N	mg/L	---	3	7	<0.04	2.1	0.02	---	---	0	---	---	---	---	---	---
Nitrite as N	mg/L	10.0	0	0	---	---	---	---	---	0	---	---	---	---	---	---
Nitrite plus nitrate as N	mg/L	100	10	195	<0.01	1.0	0.02	0	0	4	18	<0.1	0.5	0.03	0	0
Selenium	mg/L	0.05	11	242	<0.002	0.154	90% <0.005	4	1	4	18	<0.005	<0.005	100% <0.005	0	0
Sulfate	mg/L	3,000	11	246	<1	1,450	39	0	0	4	18	<1	764	26	0	0
TDS dried at 180 °C	mg/L	5,000	11	242	400	3,020	1,025	0	0	4	18	680	1,860	965	0	0
Zinc	mg/L	25.0	11	243	<0.01	1.2	*	0	0	4	18	<0.01	0.01	94% <0.01	0	0
pH (field)	S.U.	6.5-8.5	11	225	6.50	9.10	7.60	10	3	4	18	6.80	8.00	7.60	0	0
Bicarbonate	mg/L	---	10	245	338	1,710	926	---	---	4	18	409	1,550	932	---	---
Calcium	mg/L	---	11	247	2	341	49	---	---	4	18	10	285	49	---	---
Magnesium	mg/L	---	11	246	1	234	80	---	---	4	18	10	137	85	---	---
Potassium	mg/L	---	11	246	6	45	27	---	---	4	18	19	42	28	---	---
Sodium	mg/L	---	11	246	25	1,020	123	---	---	4	18	37	605	126	---	---

Medians for constituents with non-detect values were calculated using methods recommended by Helsel (2005). Medians were not calculated for constituents having ≥ 80% non-detect values. Minimum and maximum concentrations shown in red exceed WDEQ/WQD Class III groundwater quality standards. *A median could not be calculated using the statistical software for unknown reasons.

Table 37. During-mining water quality statistics in relation to WDEQ/WQD Class III standards for selected constituents in the coal aquifer (LF) at the Jim Bridger, Leucite Hills, and Black Butte mines.

			Coal Aquifer – Lance Formation													
			During Mining - All Data (1992 to 2019)							Past 3 Years of Sampling (2017 to 2019)						
Constituent	Units	Class III Livestock Standard	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances
Aluminum	mg/L	5.0	4	163	<0.1	1.9	91% <0.1	0	0	2	9	<0.1	<0.1	100% <0.1	0	0
Ammonia as N	mg/L	---	4	147	<0.05	7.6	1.3	---	---	2	9	<0.1	7.5	6.7	---	---
Arsenic	mg/L	0.2	4	163	<0.005	0.023	93% <0.01	0	0	2	9	<0.005	<0.005	100% <0.005	0	0
Barium	mg/L	---	4	163	<0.5	3.9	2.65	---	---	2	9	<0.5	3.2	3.1	---	---
Boron	mg/L	5.0	4	163	0.64	3.0	1.05	0	0	2	9	1.5	2.7	2.0	0	0
Cadmium	mg/L	0.05	4	163	<0.002	<0.005	100% <0.005	0	0	2	9	<0.002	<0.002	100% <0.002	0	0
Chloride	mg/L	2,000	4	163	8	5,760	62	42	1	2	9	76	4,940	4,700	6	1
Chromium	mg/L	0.05	4	163	<0.01	0.02	98% <0.02	0	0	2	9	<0.01	<0.01	100% <0.01	0	0
Copper	mg/L	0.5	4	163	<0.005	0.09	92% <0.01	0	0	2	9	<0.01	0.05	89% <0.01	0	0
Fluoride	mg/L	---	4	163	0.67	5.1	2.9	---	---	2	9	1.5	2.7	1.6	---	---
Iron	mg/L	---	4	163	<0.05	1.9	0.05	---	---	2	9	<0.05	0.59	0.09	---	---
Lead	mg/L	0.1	4	163	<0.02	0.03	99% <0.02	0	0	2	9	<0.02	<0.02	100% <0.02	0	0
Manganese	mg/L	---	4	163	<0.02	1.3	*	---	---	2	9	<0.02	1.3	0.02	---	---
Mercury	mg/L	0.00005	4	163	<0.001	<0.001	100% <0.001	0	0	2	9	<0.001	<0.001	100% <0.001	0	0
Nickel	mg/L	---	4	163	<0.01	0.19	95% <0.03	---	---	2	9	<0.01	0.02	*	---	---
Nitrate as N	mg/L	---	4	32	<0.04	35.2	0.01	---	---	0	---	---	---	---	---	---
Nitrite as N	mg/L	10.0	0	0	---	---	---	---	---	0	---	---	---	---	---	---
Nitrite plus nitrate as N	mg/L	100	4	147	<0.01	8.8	0.01	0	0	2	9	<0.1	8.8	0.01	0	0
Selenium	mg/L	0.05	4	155	<0.005	0.247	0.001	10	3	2	9	<0.005	<0.005	100% <0.005	0	0
Sulfate	mg/L	3,000	4	162	<1	4,440	326	12	1	2	8	<1	4,440	32	1	1
TDS dried at 180 °C	mg/L	5,000	4	154	1,420	12,400	4,075	65	2	2	9	7,490	10,300	10,000	9	2
Zinc	mg/L	25.0	4	163	<0.01	0.66	*	0	0	2	9	<0.01	<0.01	100% <0.01	0	0
pH (field)	S.U.	6.5-8.5	4	163	6.70	9.10	8.00	37	3	2	9	7.40	8.20	7.90	0	0
Bicarbonate	mg/L	---	4	147	742	3,440	2,440	---	---	2	9	1,680	3,190	3,090	---	---
Calcium	mg/L	---	4	163	<1	140	11	---	---	2	9	13	140	17	---	---
Magnesium	mg/L	---	4	163	<1	267	11	---	---	2	9	11	267	16	---	---
Potassium	mg/L	---	4	163	1.1	38	8.0	---	---	2	9	15	25	17	---	---
Sodium	mg/L	---	4	163	478	5,280	1,490	---	---	2	9	1,840	4,960	3,940	---	---

Medians for constituents with non-detect values were calculated using methods recommended by Helsel (2005). Medians were not calculated for constituents having ≥ 80% non-detect values. Minimum and maximum concentrations shown in red exceed WDEQ/WQD Class III groundwater quality standards. *A median could not be calculated using the statistical software for unknown reasons.

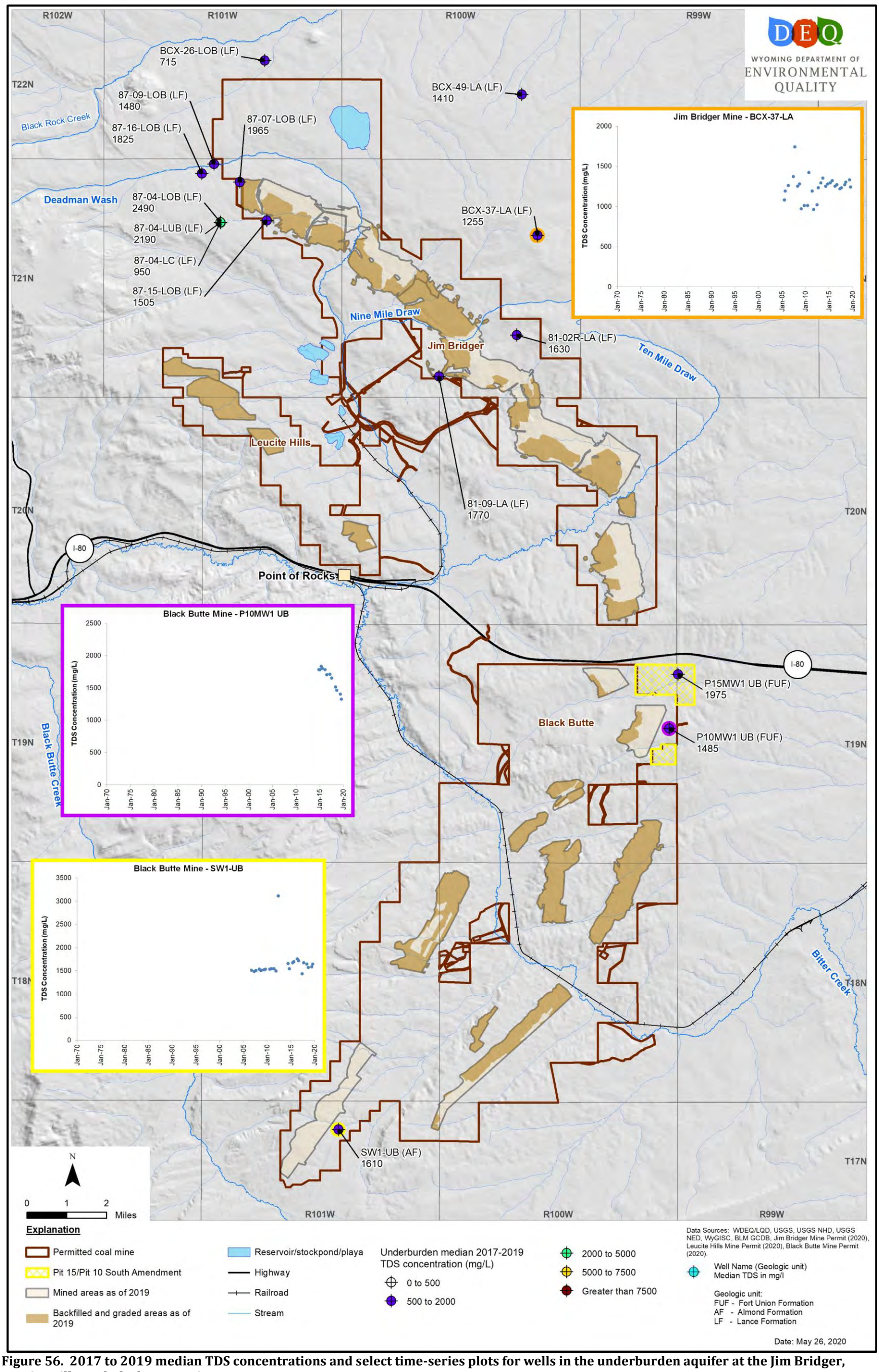


Figure 56. 2017 to 2019 median TDS concentrations and select time-series plots for wells in the underburden aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines.

Table 38. During-mining water quality statistics in relation to WDEQ/WQD Class III standards for selected constituents in the underburden aquifer (FUF) at the Jim Bridger, Leucite Hills, and Black Butte mines.

			Underburden Aquifer – Fort Union Formation													
			During Mining - All Data (2001 to 2019)							Past 3 Years of Sampling (2017 to 2019)						
Constituent	Units	Class III Livestock Standard	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances
Aluminum	mg/L	5.0	5	62	<0.1	0.4	87% <0.1	0	0	2	10	<0.1	<0.1	100% <0.1	0	0
Ammonia as N	mg/L	---	5	62	<0.05	3.7	0.5	---	---	2	10	0.3	0.5	0.4	---	---
Arsenic	mg/L	0.2	5	62	<0.005	0.044	0.006	0	0	2	10	<0.005	0.014	0.008	0	0
Barium	mg/L	---	5	62	<0.5	1.9	82% <0.5	---	---	2	10	<0.5	<0.5	100% <0.5	---	---
Boron	mg/L	5.0	5	62	0.27	1.33	0.52	0	0	2	10	0.29	0.35	0.32	0	0
Cadmium	mg/L	0.05	5	62	<0.002	0.003	98% <0.002	0	0	2	10	<0.002	<0.002	100% <0.002	0	0
Chloride	mg/L	2,000	5	62	12	1,910	26.5	0	0	2	10	24	90	27	0	0
Chromium	mg/L	0.05	5	62	<0.01	0.01	98% <0.01	0	0	2	10	<0.01	<0.01	100% <0.01	0	0
Copper	mg/L	0.5	5	62	<0.01	0.03	98% <0.01	0	0	2	10	<0.01	<0.01	100% <0.01	0	0
Fluoride	mg/L	---	5	62	0.1	6.5	2.0	---	---	2	10	0.9	2.4	2.0	---	---
Iron	mg/L	---	5	62	<0.05	0.66	0.04	---	---	2	10	<0.05	0.21	0.09	---	---
Lead	mg/L	0.1	5	62	<0.02	<0.02	100% <0.02	0	0	2	10	<0.02	<0.02	100% <0.02	0	0
Manganese	mg/L	---	5	62	<0.02	0.21	*	---	---	2	10	0.04	0.21	0.05	---	---
Mercury	mg/L	0.00005	5	62	<0.001	0.006	98% <0.001	1	1	2	10	<0.001	<0.001	100% <0.001	0	0
Nickel	mg/L	---	5	62	<0.01	0.02	95% <0.01	---	---	2	10	<0.01	<0.01	100% <0.01	---	---
Nitrate as N	mg/L	---	2	6	<0.01	0.8	0.63	---	---	0	---	---	---	---	---	---
Nitrite as N	mg/L	10.0	0	---	---	---	---	---	---	0	---	---	---	---	---	---
Nitrite plus nitrate as N	mg/L	100	5	58	<0.01	3.94	0.07	0	0	2	10	<0.1	<0.1	100% <0.1	0	0
Selenium	mg/L	0.05	5	62	<0.005	0.017	*	0	0	2	10	<0.005	<0.005	100% <0.005	0	0
Sulfate	mg/L	3,000	5	62	<1	955	456	0	0	2	10	363	778	588	0	0
TDS dried at 180 °C	mg/L	5,000	5	62	1,000	4,330	1,690	0	0	2	10	1,320	2,080	1,680	0	0
Zinc	mg/L	25.0	5	62	<0.01	0.18	*	0	0	2	10	<0.01	<0.01	100% <0.01	0	0
pH (field)	S.U.	6.5-8.5	5	50	7.19	9.40	8.00	12	2	2	10	7.30	8.20	8.00	0	0
Bicarbonate	mg/L	---	5	50	685	1,420	764	---	---	2	10	703	832	735	---	---
Calcium	mg/L	---	5	62	2	95	8	---	---	2	10	4	19	6	---	---
Magnesium	mg/L	---	5	62	<1	122	4.5	---	---	2	10	1	11	2	---	---
Potassium	mg/L	---	5	62	2.1	21	4.3	---	---	2	10	3	4	4	---	---
Sodium	mg/L	---	5	62	254	1,740	621	---	---	2	10	518	681	608	---	---

Medians for constituents with non-detect values were calculated using methods recommended by Helsel (2005). Medians were not calculated for constituents having ≥ 80% non-detect values. Minimum and maximum concentrations shown in red exceed WDEQ/WQD Class III groundwater quality standards. *A median could not be calculated using the statistical software for unknown reasons.

Table 39. During-mining water quality statistics in relation to WDEQ/WQD Class III standards for selected constituents in the underburden aquifer (AF) at the Jim Bridger, Leucite Hills, and Black Butte mines.

			Underburden Aquifer – Almond Formation													
			During Mining - All Data (2005 to 2019)							Past 3 Years of Sampling (2017 to 2019)						
Constituent	Units	Class III Livestock Standard	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances
Aluminum	mg/L	5.0	3	58	<0.1	0.8	81% <0.1	0	0	1	6	<0.1	<0.1	100% <0.1	0	0
Ammonia as N	mg/L	---	3	59	<0.1	1.5	0.6	---	---	1	6	0.7	0.9	0.75	---	---
Arsenic	mg/L	0.2	3	57	<0.005	0.019	97% <0.005	0	0	1	6	<0.005	<0.005	100% <0.005	0	0
Barium	mg/L	---	3	57	<0.5	<0.5	100% <0.5	---	---	1	6	<0.5	<0.5	100% <0.5	---	---
Boron	mg/L	5.0	3	57	0.05	1.38	0.74	0	0	1	6	0.70	0.78	0.73	0	0
Cadmium	mg/L	0.05	3	59	<0.002	<0.002	100% <0.002	0	0	1	6	<0.002	<0.002	100% <0.002	0	0
Chloride	mg/L	2,000	3	59	17	110	40	0	0	1	6	48	55	51	0	0
Chromium	mg/L	0.05	3	57	<0.01	0.02	97% <0.01	0	0	1	6	<0.01	<0.01	100% <0.01	0	0
Copper	mg/L	0.5	3	59	<0.01	0.17	93% <0.01	0	0	1	6	<0.01	<0.01	100% <0.01	0	0
Fluoride	mg/L	---	3	56	0.4	5.5	1.0	---	---	1	6	3.8	4.4	4.2	---	---
Iron	mg/L	---	3	58	<0.05	2.02	0.06	---	---	1	6	<0.05	0.1	0.05	---	---
Lead	mg/L	0.1	3	57	<0.02	<0.02	100% <0.02	0	0	1	6	<0.02	<0.02	100% <0.02	0	0
Manganese	mg/L	---	3	59	<0.02	0.11	0.03	---	---	1	6	<0.02	<0.02	100% <0.02	---	---
Mercury	mg/L	0.00005	3	57	<0.001	<0.001	100% <0.001	0	0	1	6	<0.001	<0.001	100% <0.001	0	0
Nickel	mg/L	---	3	57	<0.01	0.06	93% <0.01	---	---	1	6	<0.01	<0.01	100% <0.01	---	---
Nitrate as N	mg/L	---	0	0	---	---	---	---	---	0	0	---	---	---	---	---
Nitrite as N	mg/L	10.0	0	0	---	---	---	---	---	0	0	---	---	---	---	---
Nitrite plus nitrate as N	mg/L	100	3	57	<0.05	0.32	95% <0.1	0	0	1	6	<0.1	<0.1	100% <0.1	0	0
Selenium	mg/L	0.05	3	59	<0.005	0.52	*	9	1	1	6	<0.005	<0.005	100% <0.005	0	0
Sulfate	mg/L	3,000	3	58	<1	1,110	315	0	0	1	6	<1	2	*	0	0
TDS dried at 180 °C	mg/L	5,000	3	57	1,430	3,140	1,820	0	0	1	6	1,430	1,670	1,610	0	0
Zinc	mg/L	25.0	3	59	<0.01	0.32	*	0	0	1	6	<0.01	<0.01	100% <0.01	0	0
pH (field)	S.U.	6.5-8.5	3	58	7.00	8.90	8.40	19	2	1	6	8.40	8.70	8.55	3	1
Bicarbonate	mg/L	---	3	57	1,060	1,720	1,330	---	---	1	6	1,490	1,650	1,580	---	---
Calcium	mg/L	---	3	58	2	19	5	---	---	1	6	3	5	3.5	---	---
Magnesium	mg/L	---	3	58	1	25	5	---	---	1	6	2	4	2	---	---
Potassium	mg/L	---	3	57	15	40	20	---	---	1	6	15	18	17.5	---	---
Sodium	mg/L	---	3	57	559	1,100	692	---	---	1	6	640	696	692	---	---

Medians for constituents with non-detect values were calculated using methods recommended by Helsel (2005). Medians were not calculated for constituents having ≥ 80% non-detect values. Minimum and maximum concentrations shown in red exceed WDEQ/WQD Class III groundwater quality standards. *A median could not be calculated using the statistical software for unknown reasons.

Table 40. During-mining water quality statistics in relation to WDEQ/WQD Class III standards for selected constituents in the underburden aquifer (LF) at the Jim Bridger, Leucite Hills, and Black Butte mines.

			Underburden Aquifer – Lance Formation													
			During Mining - All Data (2001 to 2019)							Past 3 Years of Sampling (2017 to 2019)						
Constituent	Units	Class III Livestock Standard	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances
Aluminum	mg/L	5.0	18	241	<0.1	5.9	96% <0.1	1	1	12	50	<0.1	<0.1	100% <0.1	0	0
Ammonia as N	mg/L	---	18	280	<0.1	9.4	0.6	---	---	12	61	<0.1	3.0	0.8	---	---
Arsenic	mg/L	0.2	18	278	<0.005	0.02	99% <0.005	0	0	12	61	<0.005	<0.005	100% <0.005	0	0
Barium	mg/L	---	17	214	<0.1	0.3	95% <0.5	---	---	12	50	<0.1	0.3	0.16	---	---
Boron	mg/L	5.0	17	237	0.2	2.2	0.6	0	0	12	47	0.2	2.2	0.6	0	0
Cadmium	mg/L	0.05	18	280	<0.001	<0.002	100% <0.002	0	0	12	61	<0.001	<0.001	100% <0.001	0	0
Chloride	mg/L	2,000	18	280	<1	653	42	0	0	12	61	<1	410	28	0	0
Chromium	mg/L	0.05	18	280	<0.01	<0.01	100% <0.01	0	0	12	61	<0.01	<0.01	100% <0.01	0	0
Copper	mg/L	0.5	18	243	<0.01	0.14	92% <0.01	0	0	12	50	<0.01	<0.01	100% <0.01	0	0
Fluoride	mg/L	---	13	158	0.7	8.4	3.59	---	---	0	---	---	---	---	---	---
Iron	mg/L	---	18	280	<0.05	2.1	90% <0.05	---	---	12	61	<0.05	0.92	97% <0.05	---	---
Lead	mg/L	0.1	18	243	<0.02	0.03	99% <0.02	0	0	12	50	<0.02	<0.02	100% <0.02	0	0
Manganese	mg/L	---	13	165	<0.02	0.07	89% <0.02	---	---	0	---	---	---	---	---	---
Mercury	mg/L	0.00005	17	215	<0.001	<0.001	100% <0.001	0	0	12	50	<0.001	<0.001	100% <0.001	0	0
Nickel	mg/L	---	17	215	<0.01	0.01	99% <0.01	---	---	12	50	<0.01	<0.01	100% <0.01	---	---
Nitrate as N	mg/L	---	3	9	<0.01	0.22	0.02	---	---	0	0	---	---	---	---	---
Nitrite as N	mg/L	10.0	0	0	---	---	---	---	---	0	0	---	---	---	---	---
Nitrite plus nitrate as N	mg/L	100	18	274	<0.01	4.8	0.005	0	0	12	61	<0.1	3.1	80% <0.1	0	0
Selenium	mg/L	0.05	18	280	<0.001	0.007	99% <0.005	0	0	12	61	<0.001	<0.001	100% <0.005	0	0
Sulfate	mg/L	3,000	18	280	<1	1,320	164	0	0	12	61	<1	1,320	203	0	0
TDS dried at 180 °C	mg/L	5,000	18	280	690	2,800	1,470	0	0	12	61	690	2,640	1,520	0	0
Zinc	mg/L	25.0	18	280	<0.01	0.98	*	0	0	12	61	<0.01	0.98	*	0	0
pH (field)	S.U.	6.5-8.5	16	123	6.60	10.10	8.54	64	11	12	37	6.63	8.90	7.95	12	6
Bicarbonate	mg/L	---	17	246	439	1,950	1,090	---	---	12	61	439	1,860	1,030	---	---
Calcium	mg/L	---	18	278	<1	260	3	---	---	12	61	2	260	11	---	---
Magnesium	mg/L	---	18	280	<1	180	1	---	---	12	61	<1	180	5	---	---
Potassium	mg/L	---	18	280	1.5	27	4	---	---	12	61	2	27	4	---	---
Sodium	mg/L	---	18	280	113	881	570	---	---	12	50	<0.1	<0.1	100% <0.1	0	0

Medians for constituents with non-detect values were calculated using methods recommended by Helsel (2005). Medians were not calculated for constituents having ≥ 80% non-detect values. Minimum and maximum concentrations shown in red exceed WDEQ/WQD Class III groundwater quality standards. *A median could not be calculated using the statistical software for unknown reasons.

6.2.7.5 ERICSON SANDSTONE AQUIFER

Groundwater quality data have not been collected from the Ericson Sandstone wells at the mines since 2012. Because of this, a figure showing the wells, the selected time-series of TDS concentrations, and piper diagrams for current (2017-2019) conditions were not constructed. Analysis in a previous CHIA for the GGRB showed that TDS concentrations were less than 1,100 mg/L and showed little variability over time (Wyoming Department of Environmental Quality, 2014).

A comparison of the available during-mining period (1986-2012) of record water quality summary statistics for select parameters against WDEQ/WQD Class III livestock standards is shown in **Table 41**. For this period, Class III exceedances were noted for field pH (four wells). Although data since 2012 are not available, the overall results indicate water quality in the Ericson Sandstone is high and meets WDEQ/WQD Class III livestock standards, with the exception of periodic exceedances of field pH.

Table 41. During-mining water quality statistics in relation to WDEQ/WQD Class III standards for selected constituents in the Ericson aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines.

Constituent	Units	Class III Livestock Standard	Ericson Sandston Aquifer During Mining - All Data (1992 to 2012)						
			Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances
Aluminum	mg/L	5.0	9	64	<0.1	1.7	92% <0.1	0	0
Ammonia as N	mg/L	---	6	55	<0.01	2.97	0.2	---	---
Arsenic	mg/L	0.2	9	64	<0.002	0.013	94% <0.005	0	0
Barium	mg/L	---	9	64	<0.5	<0.5	100% <0.5	---	---
Boron	mg/L	5.0	9	64	0.05	1.55	0.11	0	0
Cadmium	mg/L	0.05	9	63	<0.002	<0.002	100% <0.002	0	0
Chloride	mg/L	2,000	9	64	5	273	7.7	0	0
Chromium	mg/L	0.05	9	63	<0.01	<0.02	100% <0.02	0	0
Copper	mg/L	0.5	9	64	<0.01	0.02	91% <0.01	0	0
Fluoride	mg/L	---	9	64	0.15	2.19	0.26	---	---
Iron	mg/L	---	9	64	<0.05	37.9	1.83	---	---
Lead	mg/L	0.1	9	64	<0.01	<0.02	100% <0.02	0	0
Manganese	mg/L	---	9	64	<0.02	1.36	0.44	---	---
Mercury	mg/L	0.00005	9	64	<0.001	<0.001	100% <0.001	0	0
Nickel	mg/L	---	9	64	<0.01	0.15	88% <0.1	---	---
Nitrate as N	mg/L	---	6	16	<0.04	0.88	0.03	---	---
Nitrite as N	mg/L	10.0	0	0	---	---	---	---	---
Nitrite plus nitrate as N	mg/L	100	3	45	<0.01	0.23	0.03	0	0
Selenium	mg/L	0.05	9	61	<0.002	0.027	95% <0.005	0	0
Sulfate	mg/L	3,000	9	64	123	1,070	483	0	0
TDS dried at 180 °C	mg/L	5,000	9	61	370	2,450	1,010	0	0
Zinc	mg/L	25.0	9	64	<0.01	1.28	0.01	0	0
pH (field)	S.U.	6.5-8.5	8	55	5.60	12.40	7.00	15	4
Bicarbonate	mg/L	---	6	55	<5	1,233	186	---	---
Calcium	mg/L	---	9	64	3	210	82	---	---
Magnesium	mg/L	---	9	64	1	92	44	---	---
Potassium	mg/L	---	9	64	2	50	13.2	---	---
Sodium	mg/L	---	9	64	13	696	22	---	---

Medians for constituents with non-detect values were calculated using methods recommended by Helsel (2005). Medians were not calculated for constituents having ≥ 80% non-detect values. Minimum and maximum concentrations shown in red exceed WDEQ/WQD Class III groundwater quality standards.

6.2.7.6 BACKFILL AQUIFER

Prior to mining, the WDEQ/LQD Coal Rules and Regulations require coal mine operators to document the physical and chemical properties of topsoil, subsoil, and overburden in order to identify areas that may be toxic or acid-forming (WDEQ Land Quality–Coal Rules, Ch. 2, § 4(a)(viii)(C)). If toxic or acid-forming areas are found, provisions of the Wyoming Environmental Quality Act and the WDEQ/LQD Coal Rules and Regulations require operators to address how the areas will be handled and/or disposed of prior to backfilling the mined pits (WDEQ Land Quality–Coal Rules, Ch. 2, § 6(b)(i); WDEQ Land Quality–Coal Rules, Ch. 4, § 2(xiii); W.S. § 35-11-406(b)(ix)). If the Probable Hydrologic Consequences (PHC) section of the mine permit indicates that toxic or acid-forming materials have the potential to result in groundwater contamination, operators must provide supplemental information to the WDEQ/LQD to evaluate and plan for remedial and reclamation activities (WDEQ Land Quality–Coal Rules, Ch. 2, § 4(xiv)). These measures are taken to ensure that the water quality of the reclaimed backfill aquifer will not be degraded such that post-mining land uses cannot be supported (WDEQ Land Quality–Coal Rules, Ch. 4, § 2 (c)(xi)(III)(6)).

WDEQ/LQD Guideline No. 1 – Topsoil and Overburden, provides sampling guidelines and topsoil and overburden suitability requirements for selected physical and chemical constituents of concern (Wyoming Department of Environmental Quality, 1996). With respect to overburden suitability requirements for aquifer restoration, unsuitable criteria include: pH (<5.0), nitrate/nitrogen (>50 ppm), and acid-base potential (<-5 tons $CaCO_3$ equivalent/1,000 tons). Unsuitable criteria for all other constituents of concern such as conductivity, sodium absorption ratio (SAR), selenium, boron, and arsenic depend on the premining groundwater quality and overburden quality specific to an area (Wyoming Department of Environmental Quality, 1996).

Each of the permits for the three coal mines provide specific overburden suitability criteria that generally include criteria for all the constituents listed in WDEQ/LQD Guideline No. 1 (Jim Bridger Mine Permit, 2020; Leucite Hills Mine Permit, 2020; Black Butte Mine Permit, 2020). The Black Butte and Leucite Hills mines use a higher boron unsuitability level than what is given in WDEQ/LQD Guideline No. 1, based on research conducted at the Black Butte Mine and the WDEQ/LQD (Leucite Hills Mine Permit, 2020). Each mining permit provides a detailed description of how overburden materials are sampled, characterized, handled, and identified as suitable or unsuitable. The permits also document how unsuitable materials would be mitigated in the backfilling process. Some of these mitigation measures include: blending unsuitable overburden with suitable material, using suitable material from adjacent spoil areas, and selective placement of material in between the predicted post-mine potentiometric surface and four feet below the graded backfill surface (Jim Bridger Mine Permit, 2020; Leucite Hills Mine Permit, 2020; Black Butte Mine Permit, 2020).

As part of the performance standards evaluated by the WDEQ/LQD in the coal mine annual reports, backfill material sampling data are reviewed. The data are used to indicate if the operator has properly handled and disposed of all overburden and spoil material that may be toxic or acid-forming. This performance standard provides an initial assurance that the water quality of the backfill aquifer would be able to support the post-mining land use. However, direct and ongoing monitoring of backfill aquifer water quality would ultimately be needed to confirm that post-mining land uses can be supported.

For 2017 to 2019, groundwater quality data were collected from 13 backfill aquifer wells shown in **Figure 57**. Six of the 13 wells have a 2017-2019 median TDS greater than 5,000 mg/L:

wells 17-02-SP, SW-1-W, and SP-10-01 at the Jim Bridger Mine, and wells 568298, 566394, and RP-5B at the Black Butte Mine (**Figure 57**).

The TDS time-series plots shown in **Figure 57** show mostly consistent trends between backfill wells. TDS at Jim Bridger Mine well SW-1-W has been typically been between 6,000 and 7,000 mg/L for 34 years. At Leucite Hills Mine well LHM22, TDS has been consistently around 4,000 mg/L for 17 years. TDS at Black Butte Mine well 566394 has been greater than 11,000 mg/L for 23 years, although recent data indicates there may be a slight decreasing trend (**Figure 57**). The Black Butte Mine Permit (2020) states that the poor water quality at wells 566394 and 568198 is due to recharge from the Bitter Creek alluvium. Groundwater level monitoring indicates the source of recharge to the backfill of Pits 2 and 3 is primarily the Bitter Creek alluvial aquifer, and the high TDS concentrations that occur naturally in the alluvial groundwater are also present in the backfill water quality (Black Butte Mine Permit, 2020).

Based on piper diagram shown in **Figure 59e**, the predominant 2017-2019 water quality type at seven of the 13 backfill wells was sodium sulfate (RockWare, Inc., 2015). Sodium chloride type water was at one well, magnesium sulfate water was at two wells, and sodium bicarbonate water was at three wells.

A comparison of the entire (1992-2019, 21 wells) during-mining period of record and current (2017-2019, 13 wells) water quality summary statistics for select parameters against WDEQ/WQD Class III livestock standards is shown in **Table 42**. For the entire during-mining period, Class III exceedances were noted for boron (three wells), chloride (five wells), chromium (two wells), lead (one well), nitrite+nitrate as nitrogen (one well), selenium (four wells), sulfate (11 wells), TDS (14 wells), and field pH (seven wells). For the 2017-2019 period, exceedances were observed for boron (two wells), chloride (one well), copper (one well), sulfate (five wells), TDS (six wells), and field pH (one well). TDS over 2017-2019 ranged from 1,560 to 17,100 mg/L, with a median of 4,380 mg/L (**Table 42**). The minimum TDS was observed at Jim Bridger Mine well 81-21-SP and the maximum TDS was observed at Black Butte Mine well RP-5D. The backfill aquifer currently has poorer water quality compared to the overburden-FUF, overburden-AF, coal-FUF, coal-AF, coal-LF, underburden-FUF, underburden-AF, underburden-LF, and Ericson Sandstone aquifers, but better quality than the alluvial aquifer.

From the available data, it is difficult to assess, interpret, and predict the groundwater quality of the backfill with a single hypothesis. Ogle (2004) found that higher TDS concentrations in the backfill aquifer of the coal mines in the PRB were associated with proximity to drainage channels and clinker outcrops. The backfill material has the potential to be very heterogeneous with respect to structure, permeability, and mineralogy. It is generally expected that over time the backfill will be flushed by groundwater flowing through the reclaimed material. Thus, the water quality in the backfill is expected to improve over time. The time to flush backfill and improve the water quality varies considerably based on the permeability of the backfill and groundwater flow rates in the aquifers. The data from the backfill aquifer need to be continuously evaluated and it is highly recommended that further research be conducted on this topic to gain more understanding on the behavior of the backfill aquifer over time. Additional discussion on predicted conditions in the backfill aquifer is provided in Section 7.2.7.

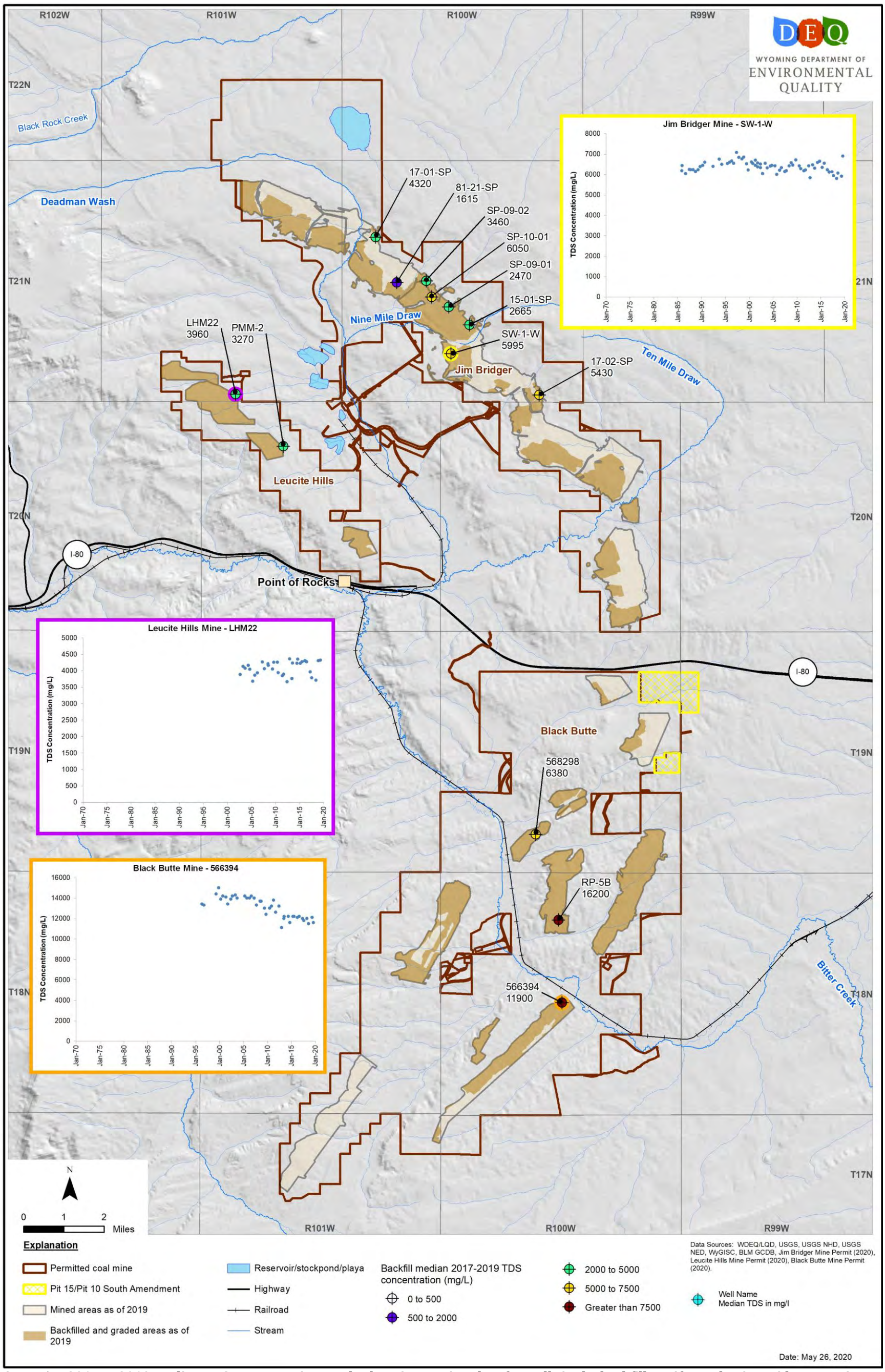


Figure 57. 2017 to 2019 median TDS concentrations and select time-series plots for wells in the backfill aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines.

Table 42. Water quality statistics in relation to WDEQ/WQD Class III standards for selected constituents in the backfill aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines.

			Backfill Aquifer												
			During Mining - All Data (1992 to 2019)							Past 3 Years of Sampling (2017 to 2019)						
Constituent	Units	Class III Livestock Standard	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances	Number of Wells Sampled	Number of Samples	Min	Max	Median	Number of Samples with Class III Exceedances	Number of Wells with Class III Exceedances
Aluminum	mg/L	5.0	21	276	<0.1	1.3	86% <0.1	0	0	13	63	<0.1	0.23	86% <0.1	0	0
Ammonia as N	mg/L	---	16	275	<0.1	26.5	2.3	---	---	13	69	<0.1	13.2	1.5	---	---
Arsenic	mg/L	0.2	21	290	<0.005	0.044	91% <0.006	0	0	13	69	<0.005	<0.005	100% <0.005	0	0
Barium	mg/L	---	21	265	<0.1	<0.5	100% <0.5	---	---	13	63	<0.1	<0.5	100% <0.5	---	---
Boron	mg/L	5.0	21	263	<0.03	103	1.14	43	3	13	53	0.7	16.2	1.4	10	2
Cadmium	mg/L	0.05	21	290	<0.001	0.01	96% <0.002	0	0	13	69	<0.001	0.005	94% <0.002	0	0
Chloride	mg/L	2,000	21	289	7.5	6,970	143	70	5	13	68	22	5,910	94	6	1
Chromium	mg/L	0.05	21	290	<0.01	0.19	97% <0.02	2	2	13	69	<0.01	0.03	99% <0.01	0	0
Copper	mg/L	0.5	21	276	<0.01	1.01	83% <0.01	1	1	13	63	<0.01	1.01	95% <0.01	1	1
Fluoride	mg/L	---	16	222	<0.1	5.5	0.3	---	---	5	23	0.2	5.5	0.9	---	---
Iron	mg/L	---	21	290	<0.05	9.06	0.08	---	---	13	69	<0.05	3.41	0.02	---	---
Lead	mg/L	0.1	21	276	<0.02	0.11	99% <0.02	1	1	13	63	<0.02	<0.02	100% <0.02	0	0
Manganese	mg/L	---	16	225	0.21	7.92	1.34	---	---	5	23	0.26	6.22	1.52	---	---
Mercury	mg/L	0.00005	21	265	<0.001	<0.001	100% <0.001	0	0	13	63	<0.001	<0.001	100% <0.001	0	0
Nickel	mg/L	---	21	265	<0.01	0.29	0.02	---	---	13	63	<0.01	0.29	0.02	---	---
Nitrate as N	mg/L	---	11	33	<0.04	11.2	0.31	---	---	0	0	---	---	---	---	---
Nitrite as N	mg/L	10.0	2	4	<0.01	0.04	*	0	0	0	0	---	---	---	---	---
Nitrite plus nitrate as N	mg/L	100	15	271	<0.01	836	0.04	1	1	13	69	<0.1	6.7	0.016	0	0
Selenium	mg/L	0.05	21	282	<0.001	0.718	81% <0.013	4	4	13	69	<0.001	0.015	93% <0.005	0	0
Sulfate	mg/L	3,000	21	290	163	15,200	2,433	118	11	13	69	416	10,400	1,830	20	5
TDS dried at 180 °C	mg/L	5,000	21	285	680	28,200	6,370	181	14	13	69	1,560	17,100	4.380	31	6
Zinc	mg/L	25.0	21	290	<0.01	2.88	*	0	0	13	69	<0.01	0.33	91% <0.01	0	0
pH (field)	S.U.	6.5-8.5	20	251	6.38	9.93	7.00	11	7	13	53	6.46	7.86	7.00	1	1
Bicarbonate	mg/L	---	16	270	279	2,050	1,240	---	---	13	69	929	1,810	1,440	---	---
Calcium	mg/L	---	21	290	20	641	249	---	---	13	69	20	641	132	---	---
Magnesium	mg/L	---	21	290	13	1,500	261	---	---	13	69	13	1,490	137	---	---
Potassium	mg/L	---	21	290	5	309	24	---	---	13	69	5	252	20	---	---
Sodium	mg/L	---	21	290	43.6	7,650	1,231	---	---	13	69	74	5,110	1,090	---	---

Medians for constituents with non-detect values were calculated using methods recommended by Helsel (2005). Medians were not calculated for constituents having ≥ 80% non-detect values. Minimum and maximum concentrations shown in red exceed WDEQ/WQD Class III groundwater quality standards. *A median could not be calculated using the statistical software for unknown reasons.

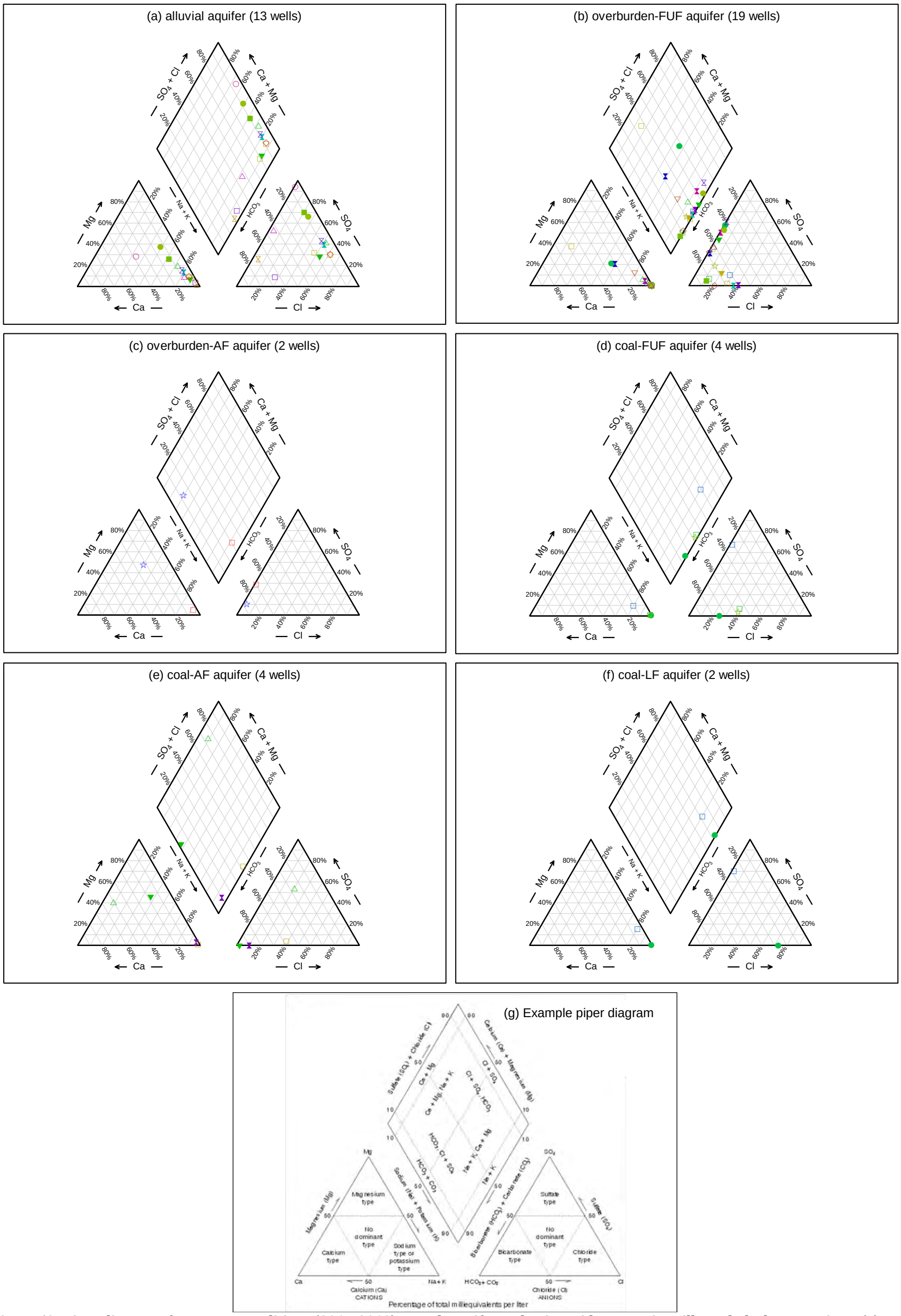


Figure 58. Piper diagrams for current conditions (2017-2019) at each aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines: (a) alluvial, (b) overburden-FUF, (c) overburden-AF, (d) coal-FUF, (e) coal-AF, and (f) coal-LF. Plotting positions were calculated using the median concentrations of the dominant ions at each well over the 2017-2019 period. The piper diagram in (g) provides a legend to assist in interpreting water types.

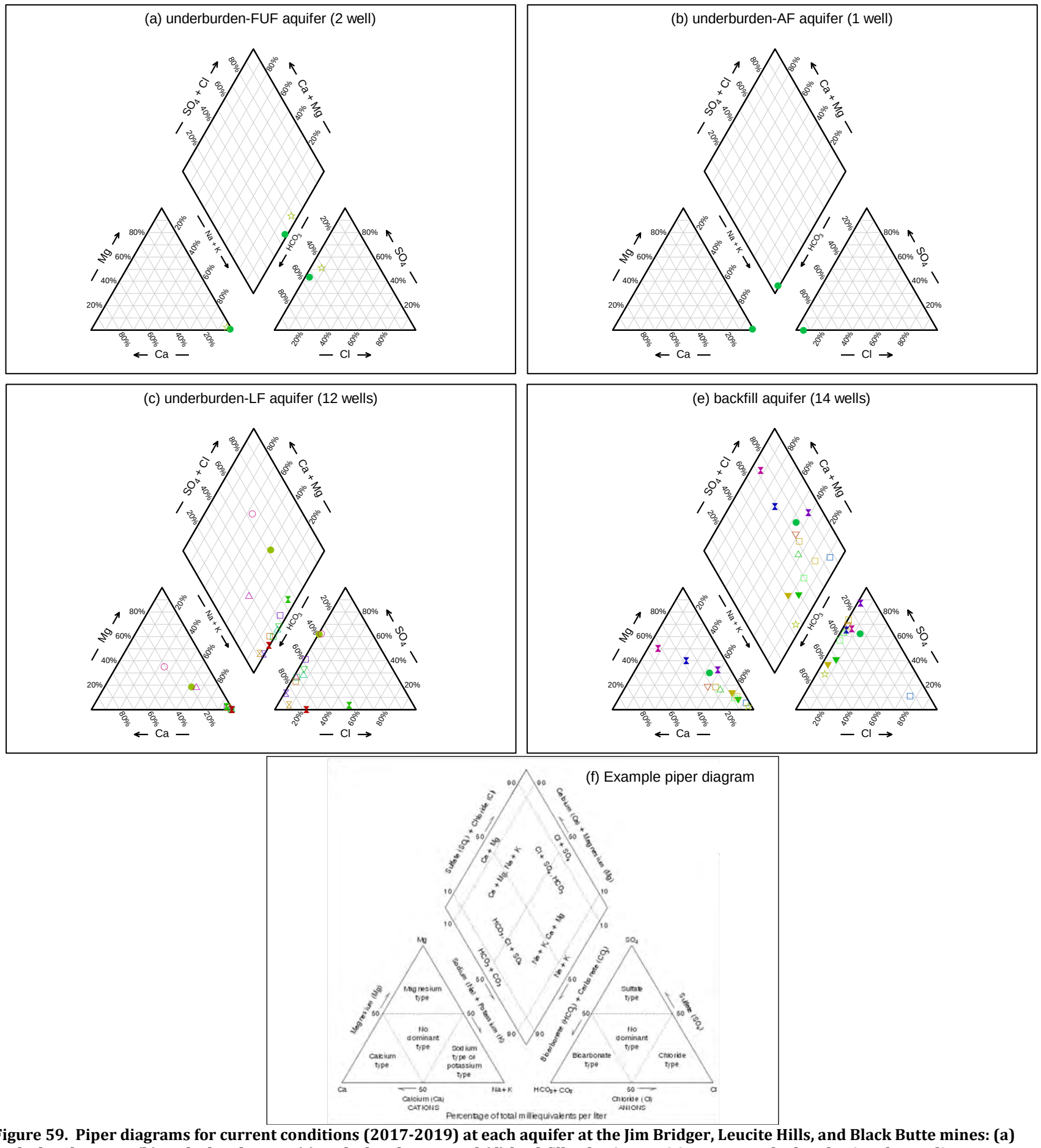


Figure 59. Piper diagrams for current conditions (2017-2019) at each aquifer at the Jim Bridger, Leucite Hills, and Black Butte mines: (a) underburden-FUF, (b) underburden-AF, (c) underburden-LF, and (d) backfill. Plotting positions were calculated using the median concentrations of the dominant ions at each well over the 2017-2019 period. The piper diagram in (e) provides a legend to assist in interpreting water types.

7. ANALYSIS OF PREDICTED POST-MINE HYDROLOGIC CONDITIONS

7.1 SURFACE WATER

The following section discusses predicted future hydrologic conditions and predicted cumulative hydrologic impacts to surface water and quality in the Bitter Creek CIA. Post-mining impacts are qualitatively discussed since none of the larger watersheds at the three active mines have been fully reclaimed.

7.1.1 POST-MINING WATER QUANTITY AND WATER QUALITY

The overall reclamation objective at the three coal mines is to restore the land to the approved post-mining land use which is livestock grazing and wildlife habitat. With respect to surface water quantity and quality, the goal is to minimize disturbance to the hydrologic balance inside the permit boundary, not cause material damage to the hydrologic balance outside the permit boundary, protect or replace water rights, and to support approved post-mining land uses. Proper reclamation will ensure that no material damage occurs to surface water quantity and quality as a result of mining.

At present, none of the mines in the Bitter Creek CIA have reclaimed an entire drainage basin upstream of a surface water monitoring station. This means there are no surface water quantity or quality data available to compare against pre-mining and during-mining data. Thus, a prediction concerning post-mining water quantity and quality is based on a qualitative analysis. The reader is also referred to Section 4.1, which provided a theoretical discussion of the expected post-mining surface water hydrologic conditions.

The three mines in the CIA are classified as approximate original contour (AOC) and border on being classified as thick overburden mines. A classification of AOC means that there is sufficient spoil available to construct a post-mine topography (PMT) that is similar to pre-mine conditions, conceding that there may be some overall reduction in elevation. A significant amount of pre-mine geomorphic data have been collected at each mine to design a PMT that reflects the pre-mine topography. Pre-mine basin characteristics such as relief, valley and channel profiles, drainage density, and slope histograms are used to develop post-mining reclamation design. Post-mining geomorphic parameters such as slope distribution, drainage area, drainage density, non-contributing drainage acreage, and stream sinuosity are designed to be similar to the pre-mining condition.

At the Jim Bridger Mine, average post-mine slopes are expected to be slightly higher than pre-mine slopes (7.5 versus 6.8 percent) (Jim Bridger Mine Permit, 2020). The increase in slope is predicted to result in an increase in hillslope erosion, as modeled by the higher slope length (LS) factor in the Revised Universal Soil Loss Equation (RUSLE) model. This is predicted to increase sediment yield by approximately 3.8 percent over pre-mine conditions (Jim Bridger Mine Permit, 2020). It is important to note that the baseline and during-mining monitoring data for the Deadman Wash drainage showed that TSS is highly variable, and concentrations can exceed 100,000 mg/L during runoff events (see Sections 3.1.1.1.2 and 6.1.1.1.2). Slope aspect at the Jim

Bridger Mine is also expected to change following reclamation. A rose diagram shows an increase in the number of south and west facing slopes (Jim Bridger Mine Permit, 2020). On a local scale, this may increase exposure to wind and sunlight, which could increase snowpack sublimation and decrease snowmelt runoff. Conversely, there may be a decrease in vegetation density because of drier soil conditions. With a decrease in vegetation density, there is a corresponding reduction in interception losses and evapotranspiration, which may increase runoff and erosion during intense rainstorms.

At the Leucite Hills Mine, post-mine slopes are predicted to be slightly flatter than pre-mining slopes, particularly for slopes greater than 20 percent (Leucite Hills Mine Permit, 2020). Flatter, less steep slopes will increase flow travel times, reducing peak flow magnitudes. Post-mine watershed aspect and hillslope lengths are not expected to change compared to pre-mine conditions. Infiltration rates will be compared on native and reclaimed lands with the goal of having reclaimed rates fall within the 80 percent confidence limits established from the native soils data (Leucite Hills Mine Permit, 2020).

At the Black Butte Mine, the average post-mine slopes are expected to be higher than pre-mine slopes in six of the reclaimed pits, while average post-mine slopes are predicted to be lower than pre-mine slopes in five of the reclaimed pits (Black Butte Mine Permit, 2020; Black Butte Mine Pit 15/Pit 10 South Amendment Application, 2020). No information on pre vs. post-mine slope was found for one of the pits (Pit 11). The proportion of lands steeper than 20 percent is also expected to decrease at several of the pits, which should help reduce overland flow velocities and travel times, promoting infiltration and reducing erosion. The pre and post-mining drainage basin characteristics are expected to be very similar, although there will be some changes in basin shape and stream lengths in the area of each pit. A slight decrease in drainage density is expected after reclamation since the area of the pits will typically have fewer constructed channels than what existed pre-mine (Black Butte Mine Permit, 2020; Black Butte Mine Pit 15/Pit 10 South Amendment Application, 2020).

Pre-mine stream morphology measurements have been used to design and evaluate reconstructed stream channels at each mine. Runoff modeling is used by the mines to evaluate hydraulic suitability and predict post-mine flows in reconstructed channels for varied recurrence intervals. The WDEQ/LQD requires that permanent reclaimed channels and associated floodplains be designed to pass, in a non-erosive manner, the 100-year, 6-hour precipitation event. Some bed and bank erosion is likely to occur, but the channel slope and cross-sectional dimensions should not change substantially during the design runoff event. Post-mine channels are generally wider and often flow at shallower gradients than corresponding pre-mine channels. This design results in greater cross-sectional area providing flow resistance and lower velocities while enhancing erosional stability.

At the Jim Bridger Mine, post-mine drainage density will increase approximately 3.8 percent over pre-mine conditions due to some reclaimed areas becoming steeper than the pre-mining surfaces (Jim Bridger Mine Permit, 2020). Channels will be reconstructed on several main streams, including Deadman Wash, Ninemile Wash, and Nine and One-Half Mile Wash. Other ephemeral channels draining less than 80 acres will be reestablished as graded swales. Traditional mine reclamation drainage design has used the maximum permissible velocity methodology. The Jim Bridger Mine has instead used the USACE HEC-2 and HEC-6 computer models to develop reconstructed channel designs using the moveable bed principal. The idea of this type of design is to balance sediment load through the stream system. A significant portion of the Fault Wash

tributary to Deadman Wash has been reconstructed using this approach (Jim Bridger Mine Permit, 2020).

At the Leucite Hills Mine, six channel designs have been prepared for watersheds draining greater than 80 acres in Pits 21, 22N, and 22S (Leucite Hills Mine Permit, 2020). All channels will be designed to convey the 100-year, 6-hour precipitation event of 1.7 inches. For channels draining less than 80 acres, which comprise most of the disturbed area, parabolic-shaped swales will be reconstructed to be 50 to 100 feet wide and two to five feet deep. Reclaimed and native channel transitions will be blended to similar slopes. Reclaimed channels will be visually and pictorially monitored to ensure erosional stability (Leucite Hills Mine Permit, 2020).

At the Black Butte Mine, first-order channels will be reconstructed as swales with wide bottoms of 20 to 50 feet (Black Butte Mine Permit, 2020). All reclaimed channels of second order or greater will be designed with a vegetated trapezoidal cross-section with floodplains to be stable for the 100-year, 6-hour peak runoff event. Transition sections of a minimum of 50 feet above and below the reclaimed channel will also be used to blend slopes between natural and reclaimed channels. Reclaimed channels will be visually monitored for erosion and stability problems. Diversions on channels will remain in place for approximately ten years to allow for vegetation reestablishment on reclaimed recontoured surfaces (Black Butte Mine Permit, 2020).

Permanent post-mining impoundments fall in two categories: small impoundments that are generally used as stockponds and major impoundments. Stockponds are defined by the WDEQ/LQD as impoundments that have a capacity of less than 20 ac-ft and a dam height of less than 20 feet. A major impoundment is an impoundment that provides a storage capacity of greater than 20 ac-ft and/or has an embankment height greater than 20 feet (Wyoming Department of Environmental Quality, 2019c). Both stockponds and major impoundments must have a designed spillway to provide through drainage, and WSEO approval must be obtained for a water right. The WSEO requires structures whose capacity exceeds 50 ac-ft or whose embankment exceeds 20 feet in height be in compliance with the Safety of Dams Act which includes approval of design plans, construction monitoring, and safety of dam inspection. Depending on the size and number of impoundments that remain after reclamation, there may be some decrease in water yield due to increased evaporative losses. However, permanent post-mining impoundments are beneficial in that they support the post-mine land use of livestock and wildlife. In many cases these permanent impoundments replace pre-mining impoundments.

No permanent post-mining impoundments are planned at the Jim Bridger Mine (Jim Bridger Mine Permit, 2020). However, construction of permanent impoundments upstream from the highwall may be considered for safety purposes. These would be less than 20 ac-ft in capacity and would support the post-mining land use of livestock and wildlife. At the Leucite Hills Mine, no permanent post-mining impoundments are planned, but the permit language is open to consideration of leaving permanent impoundments, contingent upon approval by the WDEQ/LQD (Leucite Hills Mine Permit, 2020). Some small depressions (<0.5 ac-ft) will exist in the reclaimed landscape at both the Jim Bridger and Leucite Hills mines to enhance vegetation establishment. These depressions are expected to have little or no measurable impact on runoff.

At the Black Butte Mine, there is currently one permanent post-mine impoundment, a 13.88 ac-ft stockpond at the reclaimed Pit 4 (Black Butte Mine Permit, 2020). The pond has a water right with the WSEO. A pond was also constructed in Pit 2 upon being reclaimed, but poor water quality forced the pond to be removed. Since the Black Butte Mine has no plans to construct additional

permanent post-mine impoundments, and since the current stockpond in the reclaimed landscape is small, it is unlikely that changes in water yield would be measurable at the point of accumulation for the Bitter Creek CIA at USGS Station No. 09216560 on Bitter Creek near Point of Rocks.

All disturbed jurisdictional wetlands in the Bitter Creek CIA are required to be replaced on a one-to-one area basis per regulatory statutes. At the Jim Bridger Mine, wetlands that will be potentially disturbed are associated with the Deadman Wash, Tenmile Draw, and E-11 channels (Jim Bridger Mine Permit, 2020). The Jim Bridger Mine identifies two types of wetland disturbances: (1) earthwork disturbance, which involves fill materials being placed into wetlands in the channels, and (2) aquifer drawdown disturbance, which is limited to upper Tenmile Draw where drawdown may reduce groundwater contributions to the wetland. The total wetland area projected to be disturbed from 1992 to 2007 is 10.95 acres, a majority of which is the Tenmile Draw wetland. A wetland mitigation plan has been approved that mitigates all earthwork disturbances to jurisdictional wetlands. All wetlands will be restored as passive wetlands that are self-supporting from natural water supply. Restored wetlands will exist as functioning hydrologic features that will preserve the hydrologic balance and support the post-mining land use. In the Tenmile Draw wetland, the monitoring of wells completed in separate geologic strata along the channel suggests that the wetland is mostly supported by surface runoff, channel storage, and channel recharge as opposed to deep alluvial groundwater. Since mining will not occur in the Tenmile Draw channel or floodplain, the wetland should continue to be supported despite the predicted drawdown in the alluvial aquifer. Therefore, the mitigation plan for the Tenmile Draw wetland consists of continued monitoring of alluvial water levels (Jim Bridger Mine Permit, 2020).

The Leucite Hills Mine will not disturb any jurisdictional wetlands within or adjacent to the permit boundary (Leucite Hills Mine Permit, 2020). At the Black Butte Mine, the USACE determined in March 2013 that no compensatory wetland mitigation measures were required since no wetland losses were attributed to mining activities (Black Butte Mine Permit, 2020).

Prior to replacing topsoil and contouring, the mines have committed to cover unsuitable spoil with a minimum of four feet of suitable material. In the vicinity of major reclaimed channels, this commitment is increased to eight feet. These commitments should provide an adequate rooting zone and minimize impairment concerning vegetation reestablishment. The increased burial depth within major drainages should assist in reducing the amount of unwanted salts or trace elements being wicked to the surface during dry periods and into surface water during runoff events.

Vegetative cover will be lower during the early stages of reclamation when compared to the pre-mine environment. To obtain final bond release, vegetative cover for each community type must be equal to or exceed pre-mine conditions. If post-mining vegetation cover meets these requirements, it is assumed that the level of soil surface protection closely resemble pre-mining conditions. Prior to the release of bond for any mined area, the WDEQ/LQD requires that the unit of permanently reclaimed land exhibit sufficient surficial stability and sufficient development of its post-mining vegetation. These conditions are used to demonstrate that drainage from the reclaimed unit does not need to pass through a sediment pond or ASCM structure.

Reclamation of surface disturbance at the underground mining area at the Jim Bridger Mine will consist of sealing and regrading of portals and shafts to the approved PMT (Jim Bridger Mine Permit, 2020). The Jim Bridger Mine expects no post-mining water discharge from the underground mine workings. Potential impacts to surface water quantity and quality in Deadman

Wash would be limited to impacts that occur as a result of subsidence. Surface expressions of subsidence would be addressed by the mine's mitigation program as discussed in Section 6.1.1.1.1.

The above analysis indicates that there will be little difference between pre-mine and post-mine topography, drainage patterns, infiltration rates, interception rates, and vegetation cover following reclamation at the mines in the Bitter Creek CIA. This suggests that runoff at the end of the bond release period is expected to be equal to or slightly less than pre-mining runoff. Frequency of lower gradient slopes (0 to 10 percent) is generally increased at each mine, decreasing the production and delivery of sediment to streams. Following several years of reclamation, sediment yield should approximate pre-mine conditions. Monitoring at other Wyoming coal mines that have shown that sediment yield from reclaimed lands is usually less than yields from adjacent native lands.

At the Leucite Hills Mine, runoff and water quality monitoring will continue at stations SW-7 through SW-9 up until final bond release (Leucite Hills Mine Permit, 2020). The Jim Bridger Mine will continue to monitor runoff and water quality on a quarterly basis at the SEDCO stations in the Deadman Wash watershed until post-reclamation trends are established (Jim Bridger Mine Permit, 2020). Sampling will continue as necessary until bond release is obtained. At the Black Butte Mine, monitoring will continue at SBC1 and SBC2 on Bitter Creek until the mine has demonstrated that the reclaimed area is hydrologically stable (Black Butte Mine Permit, 2020). The monitoring conducted by the mines will provide surface water quantity and quality data to compare to baseline conditions and evaluate reclamation practices.

7.2 GROUNDWATER

Coal mining operations within the groundwater CIA are expected to continue through 2038 with reclamation estimated to be completed approximately 15 years after coal removal as discussed in Section 1.5. Using this estimate, the Black Butte Mine will be the last mine to complete mine-wide reclamation in approximately 2053. The time period of predicted groundwater quantity and quality discussed in this section refers to the period after the completion of all mining and reclamation within the CIA. At the completion of reclamation: (1) all the mined areas will be backfilled and reclaimed, (2) the portions of the backfill aquifer that were contemporaneously reclaimed during mining will be under a transient groundwater level recovery, (3) the areas that underwent reclamation in the earlier years of mining and are closer to recharge sources like alluvial channels might even have reached a stable post-mining water level, and (4) a well delineated structural contact between the backfill aquifer and the undisturbed native aquifers would be established and this contact would be static over time.

The estimates of predicted groundwater levels and groundwater quality is discussed in a more qualitative manner in this section and is primarily based on the predictions and analysis presented in the individual mine permits (Sections 6.2.6 and 6.2.7).

7.2.1 ALLUVIAL AQUIFER

The analysis on the impacts of existing mining presented in Section 6.2.6.1 combined with the discussions presented in the individual mine permits indicate that no significant long term permanent changes in groundwater levels and groundwater quality are expected to the alluvial aquifer. This estimation is based on:

1. The general goal of the reclamation plans presented in the mine permits is to achieve post-mining hydrologic and geomorphic conditions that approximate pre-mine conditions following reclamation. If that goal is achieved, the post-mining alluvial aquifer groundwater gradients are expected to be similar to pre-mining gradients as groundwater gradients are expected to mimic the elevation gradient of the alluvial valleys.

2. As shown for baseline and current conditions, the general direction of groundwater flow in the alluvial aquifer currently follows the topography towards the downstream or down valley direction. Therefore, the effects of mining are expected to be minimal on the upstream undisturbed alluvial aquifer outside the mine permit boundaries to the west.

3. Although there may be some impact to the alluvial aquifer caused by the individual mines, few to none of the impacts to the alluvial aquifer are cumulative in nature as the individual mines tend to impact different sections of discrete alluvial sediments and the alluvial sediments are present only along drainages.

7.2.2 OVERBURDEN AQUIFER

The overburden aquifer would be removed from areas where the coal will be mined until approximately 2038. As reclamation progresses, the backfilled overburden material within the mined areas would create a backfill aquifer over time as the backfill saturates. Outside the mined areas, the native overburden aquifer would remain structurally undisturbed and would be in hydraulic connection with the backfill aquifer. Based on the current available data, the model predictions by the mines, and the area geology, it is expected that the cumulative impacts caused by mining on the native undisturbed overburden aquifer to the west of the mine permit boundaries will be minimal. This estimation is based on:

1. Predicted drawdowns by the individual mines in the overburden aquifer do not overlap with each other. Therefore, cumulative effects of mining appear to be minimal.

2. The overburden units at the different mines do not form a continuous overburden aquifer. Typically, these overburden units are discontinuous, and interbedded with claystone and siltstone. In some cases, they are present in different stratigraphic units (FUF, LF, or AF).

3. Away from the mine pits moving towards the east, similar to the baseline period, the current overburden aquifer groundwater gradients still follow the general dip of the stratigraphic units (**Figure 48**; Jim Bridger Mine Area). This suggests that the overburden units would not be significantly impacted on a regional scale outside the mine permit boundaries.

4. The impacts on groundwater levels and groundwater quality in the undisturbed native overburden units outside the mine permit boundaries would depend on the hydrologic connection with the backfill aquifer and on the quality of the groundwater migrating from the backfill aquifer (Section 7.2.7). However, given that the overburden aquifer is discontinuous and is of low permeability, the effects of groundwater migrating from the backfill aquifer to the overburden are expected to be local and not on a regional scale.

7.2.3 COAL AQUIFER

Where the coal is mined, the excavation will be backfilled creating the backfill aquifer. The native undisturbed coal seams outside the mined out areas would be in hydraulic connection with the backfill aquifer. It is expected that the impacts of mining on groundwater levels and groundwater quality are minimal. This estimation is based on:

1. The drawdowns predicted by the individual mines for the coal aquifer were much smaller than the drawdowns predicted by the mines for the Ericson aquifer (Section 2.2.1.2). Predicted drawdowns by the individual mines in the coal aquifer do not overlap with each other. Therefore, cumulative effects of mining within the CIA appear to be minimal.

2. The coal seams at the different mines do not form a continuous coal aquifer. Typically, these coal seams are discontinuous, and interbedded with sandstone, claystone and siltstone. In some cases, they are present in different stratigraphic units (FUF, LF, or AF)

3. The coal aquifer outside the mined area is expected to slowly recover as soon as mining stops by 2038 and would be on a recovery trend as reclamation would be completed by 2053. Therefore, the coal aquifer groundwater levels would be already recovering and hence displaying a declining cumulative effect caused by mining by the end of reclamation.

7.2.4 UNDERBURDEN AQUIFER

During mining, the underburden aquifer that is in close proximity to the mine pits will be impacted in various ways, including some fragmentation, drawdown due to the influences of pit dewatering, and exposure of the aquifer materials for a limited time to the atmosphere and direct precipitation events. During the initial stages of backfill aquifer saturation, there is expected to be some upward groundwater flow from the underburden to the backfill aquifer. As the backfill aquifer is established and the chemical equilibrium is reached, it is expected to improve over time (**Table 45**, Section 7.2.6). Therefore, in areas where the backfill aquifer will be recharging the underburden aquifer, it is expected to have minimal effects on the underburden aquifer groundwater quality.

Outside the mined out areas, the aquifers overlying the underburden aquifer would remain structurally undisturbed. Groundwater model predicted drawdowns by the individual mines in the underburden aquifer do not overlap with each other. In addition, the relatively lower hydraulic conductivity of the underburden aquifer supports that coal mining would have limited cumulative effects on the underburden groundwater system and these effects will be declining radially with increasing distance from the coal mine permit boundaries.

7.2.5 ERICSON SANDSTONE AQUIFER

The facility wells at the mines pump water from the Ericson Sandstone aquifer. In general, coal mining within the CIA has limited cumulative impacts with the pumping at the mine facility wells due to isolation of the Ericson Sandstone aquifer from the overlying units by the thick Lewis

Shale. Specifically, at locations where the mined coal seams are in the FUF or AF (**Table 1**), the Lewis Shale can be as thick as 1,000 feet. In locations where the mined coal seams are in the AF, the Ericson Sandstone aquifer is separated from the coal seams by a thick, low permeable interbedded sandstone, claystone, and siltstone AF underburden unit. Therefore, the groundwater quantity or quality impacts on the Ericson Sandstone aquifer would be minimal with no discernible effects that can be attributed to mining.

For all three mines combined, the model predicted drawdown for the Ericson Sandstone is the spatially extensive when compared to the other affected aquifers. However, given the general high permeability of the Ericson Sandstone aquifer, the aquifer is expected to be on a recovery trend between the time periods after the mining stops in 2038 and the completion of reclamation in 2053. The existing monitor wells (**Figure 51**) in the Ericson Sandstone aquifer do not show a significant drawdown. The maximum observed drawdown in this limited set of monitor wells is less than five feet and is consistent with the groundwater model predictions (Leucite Hills Mine Permit, 2020).

Given that the Ericson Formation is up to 700 feet thick, the effect of estimated drawdown caused by the pumping at the facility wells is expected to be minimal and would not affect the ability of the existing Ericson wells outside the mine permit boundaries to supply their intended use. In addition, if the existing wells with water rights are impaired due to coal mining operations, the mine(s) have committed to providing a replacement water source similar in quantity and quality to the water right user (Jim Bridger Mine Permit; Leucite Hills Mine Permit, 2020; Black Butte Mine Permit, 2020).

7.2.6 BACKFILL AQUIFER

The backfill aquifer is a new aquifer created by replacing overburden materials into the mined pit after the coal is removed. In general, the current conditions (Section 6.2.6.6) are representative of the early stages of reclamation of the mined areas. Apart from the existing backfill monitor wells shown in **Figure 20**, the coal mines have committed to expand the monitoring well network in the future as contemporaneous reclamation progresses (**Table 43**). There would be about 63 backfill monitor wells at the three mines towards the end of reclamation (20 existing active wells plus 43 future committed wells). The viability of the backfill aquifer as a water supply source will need to be continuously evaluated as more data become available in the future.

Table 43. Number of proposed backfill monitoring wells at the Jim Bridger, Leucite Hills, and Black Butte mines.

Mine	Number of Proposed Backfill Wells	Approximate Years of Completion	Source
Jim Bridger	15	2020-2050	Mine Plan, Table MP 5.4-12
Leucite Hills	0 (no additional wells planned)	NA	Permit 520, Reclamation Plan, Section 14.6.2
Black Butte	28	not listed	TFN 6 3/246, Reclamation Plan, Table RP-8

The time frame predicted for recovery is highly dependent on the hydrologic conditions including the proximity to outcrops and alluvial channels. The time predicted for complete recovery and stabilization varies among the individual mines and the individual pits at each mine. Underground longwall mining at Jim Bridger Mine will result in higher permeabilities after mining

as compared to pre-mining due to the collapse and subsidence of the strata overlying the coal seam (Jim Bridger Mine Permit, 2020). This will result in increased hydraulic conductivity and porosity due to the increased voids and greater interconnection of those voids. Aquifers above the mine void may be affected through subsidence. Preferential flow paths that did not previously exist may be created through subsidence. These preferential flow paths will have a significant impact on the backfill aquifer saturation rates near the Jim Bridger underground mine.

It appears that the backfill aquifer saturation is likely through a combination of inflow from adjacent aquifers and surface water infiltration from precipitation and stream flows. A summary of the backfill groundwater level recovery predictions by the individual mines is shown in **Table 44**. It is important to note that the recovery of groundwater levels is expected to be log-normal with both time and space. Therefore, the faster initial recovery in backfill groundwater levels will typically be followed by small water level changes over time until the system fully stabilizes. In addition, the backfill is at deepest part of the drawdown cone of depression, it is the last area to recover and recovery in the adjacent aquifers is expected to occur sooner. A recovery MODFLOW model run until year 2300 by the Jim Bridger Mine showed that groundwater levels in most areas and affected aquifers at the mine would be relatively stable at year 2300, or 261 years after the end of mine life year (2039) (Jim Bridger Mine Permit, 2020). Recovery of the lower overburden and coal/interburden aquifers is expected to take longer due to the larger effects of drawdown due to underground mining. The Leucite Hills Mine predicts that water level recovery will be relatively rapid at the four pits at the mine, ranging from six years at Pit 22S to 35 years at Pit 21 (Leucite Hills Mine Permit, 2020). The Black Butte Mine predicts that water level recovery will vary by pit, ranging from 38 to 75 years at Pits 10 and 15 to 240 years at Pits 3 and 7 (Black Butte Mine Pit 15/Pit 10 South Amendment Application, 2020). Note the mine currently has no plans to mine Pit 7 due to coal quality concerns.

Another important aspect to consider is that the backfill aquifer will be limited in extent within the mined areas inside the coal mine permit boundaries. From the material damage evaluation perspective, the area of interest is outside of the permit areas (W.S. § 35-11-406(n)(iii)). Outside the permit boundaries, the backfill aquifer will not be present and the native existing aquifers will remain structurally undisturbed. Groundwater modeling indicates that the effects of mining in these native aquifers are smaller than the effects observed at mined areas that were backfilled. Therefore, it is reasonable to expect that the recovery of these native aquifers outside the permit boundaries would be relatively faster than the backfill aquifer, and the existing wells in these native aquifers would remain viable to support the existing use.

The current data show variability on the groundwater quality in the backfill aquifer (Section 6.2.7.7). The individual mine permits also include a discussion on the prediction of the groundwater quality in the backfill aquifer. A summary of the backfill groundwater quality predictions is shown in **Table 45**. The mines base their predictions on three primary factors: (1) column leach test data, (2) time estimates based on exchange of pore volumes, and (3) data collected from the existing backfill monitoring wells.

The column leach test data generally indicate that the backfill aquifer groundwater quality will improve with time due to flushing of the aquifer. A good summary of the column leach tests appear in Van Voast and Reiten (1988) from their work at coal mines in the PRB of southeastern Montana:

> *"Trends of decreasing dissolved-solids concentrations are optimistic indications that soluble salts are being leached from the system and that long-term groundwater quality in mined and off-site lands will not be compromised. These trends can be simulated in the laboratory with column-leach tests and can be fitted to mathematical equations. Trends seen in the field resemble those found in the laboratory, but unfortunately at only a small percentage of sampling points. A longer time period is clearly necessary to establish geochemical equilibrium between groundwater and mine spoils."*

Out of the 13 backfill monitor wells with water quality data available during the 2017-2019 period, six wells had a median TDS concentration greater than 5,000 mg/L (wells 17-02-SP, SP-10-01, and SW-1-W at the Jim Bridger Mine, and wells 568298 , 566394, and RP-5B at the Black Butte Mine) (**Figure 57**). These wells will need to be closely monitored and analyzed for trends in the future that indicate improvements or degradation in the groundwater quality with time. When the backfill aquifer is under initial saturation conditions, high constituent concentrations are expected. This situation is exacerbated at two Black Butte Coal Mine wells where the Bitter Creek alluvial aquifer, which is known to have high dissolved constituent concentrations, is recharging the backfill aquifer. These wells occur in Pits 2 and 3 where the Bitter Creek alluvial aquifer was intercepted by the pit. The other pits at the Black Butte Mine are either not situated close enough to the Bitter Creek valley or have minimal potential for receiving alluvial groundwater recharge (Black Butte Mine Permit, 2020). Therefore, the backfill water quality at the other pits at the Black Butte Mine is expected to be better than Pits 2 and 3. The recovery of the water levels are in their initial stages (**Figure 52**).

From the material damage evaluation perspective, the area of interest is outside of the mine permit areas. Outside the permit boundaries, the backfill aquifer will not be present and the native existing aquifers will remain structurally undisturbed. It will take several years for the backfill aquifer to saturate and begin functioning as the recharge source to these native aquifers outside the mined areas. As the backfill aquifer groundwater levels are recovering, the water quality is expected to improve over time within the backfill aquifer. The groundwater migrating from the backfill aquifer is expected to migrate into different stratigraphic units (FUF, AF, or LF). Therefore, the potential for the cumulative mining impacts to cause material damage outside the permit areas is minimal.

Table 44. Summary of estimates on backfill aquifer water level recovery from each mine permit for the Jim Bridger, Leucite Hills, and Black Butte mines.

Mine Name	Select Excerpts from the Mine Permit on Estimated Backfill Aquifer Recovery	Reference in the Mine Permit
Jim Bridger	The Spoil aquifer is in direct contact with the UOB, LOB and Coal/IB aquifers. As such, the resaturation of the spoil aquifer will occur in conjunction with the recovery in the adjoining overburden and coal/IB aquifers. The majority of the recovery occurs by 2100 but measurable recovery continues for decades after 2100. Water levels in all aquifers are relatively stable at the end of the simulation in 2300.	Reclamation Plan, Section RP 7.4.2.1, Page RP 7.4-4; Section RP 7.4.7.2, Page RP 7.4-9
Leucite Hills	The time for postmining potentiometric elevations to recover in the mine backfill have been estimated for Pits 21, 22N, 22S and 24 by reference to the approximate volumes of saturated strata existing in each pit area prior to mining. In this analysis the highest potentiometric surface was used to conservatively define the approximate volume of saturated strata in a pit area, even though that surface may originate from sub-pit strata. This was done under the assumption that vertical seepage, no matter how small, will eventually saturate the spoils to the potentiometric surface of the seepage source. The highest potentiometric surface of each pit area was transcribed ono the geologic and hydrogeologic cross sections of Appendix D-6a to obtain cross-sectional, premining wetted areas and these in turn were applied along the long axes of pits between cross sections to obtain approximate, premining wetted volumes. Precipitation infiltration, assumed to average 0.01 ft/year, and a combined vertical seepage and lateral groundwater inflow rate of 15 gpm were used as the volumetric inflow rate values. In Pit 24, where lateral groundwater inflow is not expected during or after mining, the vertical seepage rate computed from the underlying 2 coal was used (3.6 gpm). Based on the assumptions above and not including any additional groundwater recharge provided by Bridger's water disposal irrigation system, the time for the Leucite spoils to resaturated after mining and reclamation is estimated to range from (six) to 35 years.	Reclamation Plan, Section 14.3, Pages 14.4a, 14.5
Black Butte	Using the rate of recharge calculations and the volume of spoil body to be recharged, time for spoil to be put back in equilibrium were computed. Time for establishing a new spoil aquifer will depend on pit location, size and formation…Recharge estimates range from a low of 60 years for Pit 2 (Fort Union) to a high of [240 years for Pit 3 (Fort Union) and Pit 7 (Lance Formation)].	Reclamation Plan, Hydrologic Restoration, Page RP-44; Addendum RP-A, RP-131, RP-149; TFN 6 3/246, Page RP-129

Table 45. Summary of estimates on backfill aquifer water quality from each mine permit for the Jim Bridger, Leucite Hills, and Black Butte coal mines.

Mine Name	Select Excerpts from the Mine Permit on Estimated Backfill Water Quality	Reference in the Mine Permit
Jim Bridger	The numerical modelling indicated that significant saturation will exist in most of the Spoil aquifer at the end of the first recovery simulation of 40 years. …an additional 63 years is needed for approximately 3 pore volumes of exchange in this area. The water quality in the Spoil aquifer is expected to be stabilizing after 3 pore volumes. Therefore, approximately 100 years of groundwater exchange after the start of resaturation may be required for the Spoil aquifer to reach the livestock standards.	Reclamation Plan, Section RP 7.4.3, Pages RP 7.4-7 to RP 7.4-8
Leucite Hills	The mean value of electric conductivity of the overburden is 3,200 micromhos/cm at 25 degrees C. This value [was] used to predict the mean concentration of dissolved solids in the reclaimed area using a method published by McWhorter (1980)…2,240 mg/L. However, taking into consideration the premining groundwater quality and experience in other coal mines in Wyoming, it is anticipated that the total dissolved solids concentration of ground water in the reclaimed pits could be higher than the calculated value. The potential increase in the concentration of total dissolved solids would probably be temporary until final geochemical equilibrium in the reclaimed spoils is reached. The anticipated change in water quality in the reclaimed pit would not change the present classification of ground water and its suitability for stock watering.	Reclamation Plan, Section 14.2, Pages 14.2 to 14.3
Black Butte	During the initial phase of recovery, water quality produced from wells in the spoil would probably not be suitable for stock watering use, primarily due to excessive levels of sulfate and boron. It would take many years even beyond the recharge time predictions before regional flow would dilute some of the higher concentrations. When recharge to spoils occurs laterally from adjacent aquifers, which in fact will be the primary and major component, degradation of water quality will be minimized. Shallow groundwater occurring in and around the Black Butte Mine area is of poor quality and high concentrations of ions already existed prior to mining. It is therefore doubtful that addition to these concentrations from available salts in the spoil materials will significantly detract from the existing water quality or its potential use. [The 1981 Black Butte Spoil Study] employed the leachate extract (or column leach testing) method to predict the quality of groundwater within the backfilled spoils [in Pits 2, 3, 5, 8, and 9]. The groundwater quality data for the resaturated Pit Two and Pit Three spoils is worse, with respect to dissolved chemical constituents, than the laboratory test predictions. High concentrations of certain inorganic chemicals that occur naturally in the alluvial groundwater are also present in the postmining spoil groundwater of Pits Two and Three, further evidence of a significant recharge contribution from the Bitter Creek alluvial groundwater. Even though these concentrations may be somewhat less than the alluvial recharge water, it is likely that the final postmine groundwater quality [in Pits Two and Three] will not be improved sufficiently to meet Class III standards.	TFN 6 3/246, Page RP-56o to RP-56p, Reclamation Plan, Hydrologic Restoration, Pages RP-66 to RP-67; Addendum RP-A

8. MATERIAL DAMAGE POTENTIAL

The potential for material damage to the hydrologic balance outside the coal mine permit areas was evaluated for the CIAs. This evaluation focused on surface water quantity and quality, and groundwater quantity and quality.

8.1 SURFACE WATER

8.1.1 WATER QUANTITY

Surface water quantity has been evaluated to determine if coal mining will cause cumulative impacts to downstream surface water rights. The available surface water quantity data have been evaluated for the baseline and during-mining periods in each of the major drainages within the Bitter Creek CIA. Specific data elements evaluated included mean daily flows, peak flows, and flow duration. In addition to this analysis, the assessment considered factors such as the proximity of downstream water rights, extent of dewatering, extent of surface disturbance, extent and capacity of water retention features, and changes to post-mine drainage basins. Material damage to surface water quantity is presumed to occur if the analysis demonstrates that coal mining has caused or will cause a decrease in surface water quantity such that downstream surface water rights will be affected, and the mine(s) have not committed to providing a replacement water source similar in quantity and quality.

Current mining and reclamation activities at the Jim Bridger, Leucite Hills, and Black Butte mines is not predicted to cause long-term or permanent damage to surface water quantity in the Bitter Creek CIA. The Pit 15/Pit 10 South Amendment at the Black Butte Mine is also not predicted to cause material damage to surface water quantity.

The baseline flow data for the former USGS stations and mine stations span a relatively short time period, making it difficult to completely characterize the pre-mine hydrology of the Bitter Creek CIA. Nonetheless, the available data suggest a reasonable understanding of flow characteristics in the CIA under normal or average conditions. Runoff is driven by snowmelt and short-duration, high intensity rainfall events. Available baseline data also illustrate the possibility for differences in timing of peak flows among sub-watersheds. This variability in precipitation inputs over space and time makes it difficult to detect changes in runoff that can be attributed to mining activities alone. Losses and inputs due to impoundments, permitted discharges, and leakage from the surge pond at the Jim Bridger Power Plant, further hamper the ability to detect changes in runoff due to mining.

Following coal removal, drainages are reconstructed to AOC. As a result of material removed, the topography will be lowered and hillslope gradients will be reduced, resulting in a potential reduction in peak flows. Pre-mine watershed characteristics and stream morphology have been characterized at each mine to ensure appropriate reconstruction and function in the PMT. A comparison of pre-mine and post-mine drainage basin characteristics at the mines indicate the two are mostly similar, suggesting little change in runoff potential. Each mine permit contains modeled runoff simulations for storms of varying intensity and duration; these models do not show significant changes in water quantity under the projected reclaimed conditions.

It is reasonable to expect a short-term reduction in water yield in the CIA during mining due to water retention in the mining pits and sediment ponds. These structures are necessary to protect downstream water quality. The three mines discharge to streams infrequently, as most of the impounded water is used for other purposes such as dust suppression and equipment wash down, and water use may increase in dry years.

Analysis of during-mining flow data from the Jim Bridger and Leucite Hills mines shows that runoff is very infrequent, similar to the pre-mine period. Flows on Deadman Wash further downstream near Point of Rocks are supplemented from leakage from the surge pond at the Jim Bridger Power Plant, and the absence of continuous streamflow monitoring on lower Deadman Wash and Bitter Creek further hampers the ability to detect during-mining changes in flow characteristics at the watershed scale.

The Jim Bridger Mine predicts that mine-induced drawdown will affect discharge to small springs along portions of upper Tenmile Draw (Jim Bridger Mine Permit, 2020). Dewatering will result in short-term reduction to spring flow until the backfill aquifer partially recharges. The Jim Bridger Mine has attempted to minimize its impact on the Tenmile Draw springs by not directly mining through the Tenmile Draw channel. The wetlands along Tenmile Draw are predicted to be impacted, but the springs are predicted to flow again after water level recovery. Monitoring of alluvial water levels will continue to assess conditions. There are no water rights associated with the Tenmile Draw springs, so the material damage potential with respect to water rights is non-existent.

Underground mining at the Jim Bridger Mine is not expected to cause significant subsidence features on the surface. A significant subsidence feature would be any feature that poses a hazard to human and animals and/or disrupts the pre-existing hydrologic regime, including changes in water quantity. Due to the longwall method of coal mining, any surface expression of subsidence should occur quickly. The land surface will be periodically monitored for subsidence features, and features will be mitigated accordingly. Small (<0.5 ac-ft) subsidence-induced impoundments have been documented in Deadman Wash, but these are not expected to significantly affect downstream surface flows and will not be permitted with the WSEO. Based upon the limited amount of area that may be potentially affected by subsidence and the commitment to mitigation, changes in water quantity in Deadman Wash are not expected. While surface water stations on Deadman Wash will help document changes in surface water quantity associated with subsidence, it should be noted that the inherent variability with the ephemeral system makes it difficult to positively identify changes to surface hydrology as a result of underground mining.

Analysis of data from Bitter Creek at the Black Butte Mine indicates that there have been no changes in surface water quantity during mining. Seepage runs, an investigative technique where surface water flows are measured and compared at several locations in a stream, have demonstrated that the Bitter Creek alluvial aquifer is not connected to the channel (Black Butte Mine Permit, 2020). Therefore, the amount of streamflow lost to aquifer recharge is essentially non-existent with the slight exception of some of the minor tributaries to Bitter Creek. The Black Butte Mine predicts that the mine operation will disturb a maximum of approximately four percent of the Bitter Creek drainage. Assuming an annual runoff of approximately 4,000 ac-ft, the mine predicts that the operation prevents 160 ac-ft of runoff from reaching Bitter Creek on an annual basis (Black Butte Mine Permit, 2020). The 160 ac-ft reduction in annual runoff has been accounted for as a depletion under the Recovery and Implementation Program for Endangered Fishes in the Upper Colorado River Basin (Kelly, 2003; Bureau of Land Management, 2006). A comparison of

paired instantaneous flow measurements taken from 1987 to 2019 on Bitter Creek above and below the mine permit boundaries shows that flows remain constant through the Black Butte Mine permit area (**Figure 39**).

The Jim Bridger and Leucite Hills mines have no plans to construct permanent post-mine impoundments, meaning that there will be no major net increase in water retention features in the post-mine environment. The single permanent impoundment constructed at the Black Butte Mine is relatively small, has been permitted with the WSEO, and should not significantly impact post-mining streamflows in Bitter Creek. Because of this no material damage to surface water rights is expected.

Approximately 6.7 percent of the 758 mi^2 Bitter Creek CIA is approved for coal mining-related disturbance at the three mines. Approval of the Pit 15/Pit 10 South Amendment at the Black Butte Mine would increase this value to 6.8 percent. However, the amount of disturbed area at any given point in time is much less, assuming the practice of contemporaneous reclamation. For example, the current (2019) disturbed area, which also includes areas that have been permanently reclaimed, totals approximately 5.5 percent of the Bitter Creek CIA. Considering the size of CIA, the chances of measuring water quantity changes that would be persistent and detectable at USGS Station No. 09216560 on Bitter Creek are small. Therefore, the potential for material damage to water quantity downstream of the mines is low.

Each of the three mine permits have identified all surface water rights within the permit area, within one half-mile radius of the permit boundary, and three miles downstream of the permit area. There are 18 surface water rights within the Bitter Creek CIA besides those owned by the three coal mines. Surface water rights in the Deadman Wash watershed are entirely held by the Jim Bridger Power Plant; these water rights are for the surge and evaporation ponds and are not dependent on securing water from the Deadman Wash watershed. Surface water rights in the Bitter Creek watershed (not including Deadman Wash) are held by the Union Pacific Railroad, BLM, and private individuals. There is one surface water right held for a stockpond at Point of Rocks. Upstream of the Black Butte Mine, surface water rights are held for stock, irrigation, railroad, and domestic use. Due to the limited impact area, there should be no impact to water rights further downstream of the Bitter Creek CIA. Mining proposed by the Pit 15/Pit 10 South Amendment is not predicted to impact downstream water rights due since the mining disturbance would occur in the headwaters of ephemeral tributaries to Bitter Creek. In the event that a non-mine water right is impacted by mining activities, the law and mine permits require water supply to be replaced by a source suitable in quantity and quality. The potential for material damage to water rights downstream of the mines is therefore minimal.

8.1.2 WATER QUALITY

Material damage to surface water quality was assessed by determining if coal mining has caused, or will cause, a significant long-term or permanent adverse change such that WDEQ/WQD surface water quality standards and classes of use are no longer met. The available sample data have been analyzed for the baseline and during-mining periods in each of the major drainages in the Bitter Creek CIA. Summary statistics have been compiled, and water quality differences between baseline and during-mining periods were discussed, as well as upstream and downstream of mining activity. The frequency of water quality standard exceedances has been examined, including over the last three years of sampling. The potential for material damage outside the mine permit areas is assessed by evaluating the frequency of surface water quality standard exceedances

over the last three years of sampling. If more than one exceedance for a given constituent is observed over the last three years of sampling, a more detailed analysis has been conducted to determine if coal mining activity is the cause of exceedance. Comparisons to data from the pre-mining period and stations upstream of mining activity have been used to indicate when coal mining may be the cause of exceedance.

Current mining at the Jim Bridger, Leucite Hills, and Black Butte mines is not predicted to cause material damage to surface water quality in the Bitter Creek CIA. The mining proposed by the Pit 15/Pit 10 South Amendment at the Black Butte Mine is also not predicted to cause material damage to surface water quality.

Water quality data collected during the baseline period at the Jim Bridger and Leucite Hills mines in the Deadman Wash watershed mostly focused on TDS and TSS, limiting an in-depth comparison to WDEQ/WQD standards for Class 3B and Class 2AB(ww) waters. The most noteworthy aspect of the baseline data collection was the extreme variability and high values for TSS concentrations; maximum TSS concentrations exceeded 100,000 mg/L at several of the stations in the drainage. The limited number of samples with a full suite of parameters showed that WDEQ/WQD standards were occasionally not met. Downstream of the Jim Bridger Power Plant, Deadman Wash holds a more stringent classification of 2AB(ww) and occasional exceedances were noted for lead and chloride. Deadman Wash upstream of the power plant is a Class 3B stream, as are the other major tributaries (Ninemile Wash, Nine and One Half Mile Wash, and Tenmile Draw) to Deadman Wash. During the baseline period, exceedances of WDEQ/WQD Class 3B standards occurred on Upper Tenmile Draw (aluminum, copper, nickel, zinc), Lower Tenmile Draw (aluminum, copper, iron), and Tenmile Draw Tributary (zinc) (**Table 13**).

The during-mining water quality data collected from 1996 to 2019 at the Jim Bridger Mine also showed that TSS concentrations are highly variable and can become very high during runoff events, exceeding 100,000 mg/L. Water quality standards for WDEQ/WQD Class 3B waters were occasionally exceeded for dissolved metals, particularly aluminum, copper, iron, and selenium. Mining does not appear to be a controlling factor in the cause of the exceedances, since many of the exceedances were also noted at stations upstream of the mining disturbance and during the limited baseline sampling period. The during-mining water quality data appear to be within the range of variability for the watershed, although additional sampling on Deadman Wash near the confluence with Bitter Creek would allow a more thorough evaluation of water quality conditions.

A more in-depth analysis was conducted for selenium on Tenmile Draw, since the downstream station (SWPS-14) showed one exceedance in the last three years of sampling while no exceedances were noted upstream at station SWPS-13. A time series of selenium over the entire period of record showed periodic exceedances at both stations, although SWPS-14 had more frequent exceedances. A statistical comparison of 2001-2019 selenium data also indicated selenium concentrations at the downstream Jim Bridger Mine permit boundary on Tenmile Draw are higher than those upstream.

It is not possible to conclusively determine that mining is the cause of the higher selenium concentrations on Tenmile Draw. In other coal mines in the Powder River Basin, higher selenium concentrations in shallow alluvial aquifers have been attributed to seleniferous alluvium and overburden materials used for stream channel reconstruction (Murphree, 2003; Murphree, 2007). However, the Jim Bridger Mine has and will not mine through and reconstruct the Tenmile Draw channel. Furthermore, a review of regraded spoils data from 27 reclamation units in the Tenmile

Draw watershed indicated WDEQ/LQD suitability requirements for selenium have consistently been met. Since selenium exceedances occasionally occur on Tenmile Draw upstream of mining, non-coal mine sources of selenium appear to exist in the Tenmile Draw watershed. The limited number of samples collected in the baseline period also makes it difficult to determine the extent selenium exceeded standards prior to mining in the drainage. In order to better understand selenium concentrations and possible sources, the Jim Bridger Mine has established four new monitoring stations in Tenmile Draw and has committed to selenium monitoring at WYPDES outfalls in the watershed. Although additional monitoring is needed, results from a single sample collected at each of the four new stream stations in September 2019 showed no selenium exceedances.

Potential increases in sediment yield during mining are being mitigated through sediment control ponds and ASCMs at all three mines, and point source discharges are monitored by the WYPDES program. Sediment control measures and diversions will help disconnect the disturbed areas from the stream network, helping to protect water quality. No sediment control structures will be removed until it has been demonstrated that the reclaimed lands are erosionally stable.

Water yield and sediment yield data at the Jim Bridger Mine show that there is not a substantial difference between the sediment loads carried between undisturbed and disturbed drainages, implying that ASCMs are effective in reducing sediment loads from drainages disturbed by surface mining. This implies that mining activities should not cause increase sedimentation in Deadman Wash downstream of the Jim Bridger Power Plant. Hydrologically, this part of Deadman Wash largely functions as the result of leakage from the power plant's surge pond, a condition that will not change due to mining.

The underground portion of the Jim Bridger Mine is expected to have minimal impacts on surface water quality due to the small amount of surface disturbance. Dewatering of the underground mine is not expected to affect surface water quality, as the mine has installed a pumping and clarifying system to send water for use at the Jim Bridger Power Plant. The mine also holds a WYPDES permit to discharge groundwater dewatered from the underground workings, if necessary. Subsidence features are not predicted to significantly disrupt stream morphology or alter the erosional stability of undermined channels. Any alterations in stream morphology will be detected through the subsidence monitoring plan and mitigated appropriately. Surface water stations located on Deadman Wash will serve to document changes in surface water quality associated with surface expressions of subsidence. Based upon a qualitative analysis it is predicted that post-mine sediment yields from the undermined area will reflect pre-mine yields. Any detection of minor changes in sediment delivery will most likely be masked by the variability inherent with sediment transport on ephemeral streams. Therefore, potential impacts to surface water quality from underground mining activity should be minimal.

Water quality data collected on Bitter Creek during the baseline period at the USGS stations and the stations at the Jim Bridger and Black Butte mines showed that WDEQ/WQD Class 2C surface water quality standards were occasionally not met due to exceedances of aluminum, ammonia as nitrogen, chloride, iron, lead, mercury, field pH, and zinc. Turbidity was also elevated due to natural factors, although TSS concentrations were much lower than those measured in the Deadman Wash watershed.

The during-mining water quality dataset for Bitter Creek is limited to the sampling conducted by the Black Butte Mine at the upstream and downstream mine permit boundaries, the

recent sampling at USGS Station No. 09216560 at Point of Rocks, and the ion and *E. coli* monitoring by the SWCCD, BKWAG, and WDEQ/WQD. The during-mining water quality data collected by the Black Butte Mine indicate that there is little difference in water quality conditions on Bitter Creek above and below the mine permit boundary. Data from 1982 to 2019 indicate no significant difference in TDS between upstream and downstream stations, while TSS was significantly higher at the upstream station. Limited data are available over the during-mining period for a larger suite of constituents, but periodic exceedances of Class 2C standards occurred prior to 1987 at both the upstream and downstream stations, particularly for aluminum, cadmium, copper, iron, lead, mercury, field pH, and dissolved oxygen. Recent full-suite sample data since 2013 show only one exceedance of iron at the upstream station. The available data demonstrate that the mining operation has not caused material damage to water quality in Bitter Creek.

A more in-depth analysis was conducted for chloride given the recent exceedances noted on Bitter Creek at Point of Rocks. Chloride at this location has exceeded the 230 mg/L standard in 63 percent of the samples collected over the 2001 to 2019 period. The Deadman Wash drainage appears to be a higher source of chloride to Bitter Creek at Point of Rocks rather than the mainstem of the Bitter Creek watershed upstream of the confluence with Deadman Wash. Although the Deadman Wash watershed appears to have elevated chloride values at some stations, it is difficult to determine the effect that coal mining activities have on chloride concentrations. From the available information, it is not possible to determine the extent that mining activities may be increasing chloride concentrations in the Deadman Wash watershed relative to background sources. The WDEQ/WQD is planning to prepare a TMDL for chloride in Bitter Creek, and this analysis will provide a more in-depth evaluation of possible chloride sources in the Bitter Creek watershed. The WDEQ/LQD also plans to continue funding water quality sampling on Bitter Creek near Point of Rocks at USGS Station No. 09216550 to allow for a better evaluation of cumulative hydrologic impacts and water quality conditions in relation to WDEQ/WQD Class 2C standards.

The Black Butte Mine has left a 200 foot buffer on the Bitter Creek channel throughout the mine permit boundary. Disturbances to the channel are limited to road and coal conveyor crossings. The mine seldom discharges from the sediment control ponds due to dust suppression needs. When discharges are necessary, they are monitored under the mine's WYPDES permit. These actions help prevent material damage to surface water quality.

Reclamation practices at each mine will help ensure that the post-mine surface water quality is similar to the pre-mine water quality. Some of the relevant reclamation practices include: (1) salvaging and replacing topsoil in a manner that prevents compaction, protects erosion, and conserves soil moisture, (2) covering all unsuitable spoils with a minimum of four feet of suitable material prior to replacing topsoil, with the thickness of suitable material increasing to eight feet in areas underlying major drainages, and (3) designing reconstructed landscapes to be erosionally stable, which will help minimize soil loss. The limited amount of data collected in various plot studies at other mines and previously reclaimed mines sites suggest that post-mine sediment yields should be similar to pre-mine levels.

Assuming the post-mine hydrologic and geomorphic conditions approximate pre-mine conditions following reclamation, the post-mining water quality in the Bitter Creek CIA should be similar to pre-mine water quality. With approval of the Pit 15/Pit 10 South Amendment at the Black Butte Mine, approximately 51.3 mi^2 or 6.8 percent of the Bitter Creek CIA would be approved to be affected by surface mining activities at the three mines, but not all the disturbance will occur at once due to the practice of contemporaneous reclamation. Based on the limited amount of

acreage affected relative to the size of the CIA, it unlikely that water quality changes would be detectable at the point of accumulation at USGS Station No. 09216560 on Bitter Creek near Point of Rocks. Dilution from water outside the permit areas also would help negate impacts to water quality. Therefore, the potential for the mines to cumulatively impact surface water quality in the Bitter Creek CIA is low. No material damage to surface water quality is expected.

8.2 GROUNDWATER

The potential for the Pit 15/Pit 10 South Amendment at the Black Butte Mine and the existing coal mining in the GGRB to cause material damage to groundwater in the aquifers of interest outside the coal mine permit boundaries was evaluated in this CHIA. The analyses for this evaluation included:

1. Delineation of the horizontal and vertical extents of the groundwater CIA (Section 2.2).

2. Baseline characterization of the pre-mining hydrologic conditions (Section 3.2).

3. Evaluation of the current hydrologic conditions and cumulative impacts on groundwater as a result of existing mining at the Jim Bridger, Leucite Hills, and Black Butte mines (Section 6.2).

4. Predicted future hydrologic conditions and predicted cumulative hydrologic impacts (Section 7.2).

Groundwater hydrologic concerns within the groundwater CIA were identified in Section 4.2 and the material damage criteria and material damage indictors were defined in Section 5.2. The approach used to evaluate the material damage criteria and material damage indicators was to use the information provided in the individual mine permits and the existing data available from the mine monitoring wells to compare the pre-mining and current conditions using statistical and spatial analyses.

8.2.1 MATERIAL DAMAGE INDICATORS

Contemporaneous reclamation has provided the opportunity to identify three material damage indicators that are related to the contemporaneously reclaimed backfill aquifer within the mine permit boundaries. A summary of the analyses conducted in the CHIA that are relevant to the material damage indicators is presented below.

8.2.1.1 PHYSICAL CHARACTERISTICS OF THE BACKFILL AQUIFER

Section 6.2.3 presented a detailed discussion and a comparison of the physical characteristics of the backfill aquifer to the pre-mining native aquifers. Some of the significant items of note are:

- The backfill aquifer reclamation is in the initial stages and is not fully saturated and there are sparse data available on the aquifer properties.

- The median hydraulic conductivity of the backfill aquifer is greater than the median hydraulic conductivity of the other native aquifers evaluated (alluvial, overburden-FUF, coal-FUF, coal-AF, underburden-FUF, underburden-LF, and Ericson Sandstone).

- It is expected that there will be some loss of permeability with time in the backfill aquifer as compaction and other physiochemical changes occur.

Continued monitoring of the backfill aquifer will be needed and additional analyses will be required as more data become available. Based on the limited data, it appears that the backfill aquifer will have sufficient permeability to allow interconnection between the outcrop recharge areas and the down dip to the discharge areas. It also appears that the backfill aquifer will have permeability to yield sufficient quantities of water to meet the WDEQ/LQD approved post-mining land use of livestock and wildlife.

8.2.1.2 GROUNDWATER LEVEL RECOVERY IN THE BACKFILL AQUIFER

Sections 6.2.6.6 and 7.2.6 presented detailed discussions and analyses on the ability of the backfill aquifer to recover to the water levels of the pre-mining coal aquifer. Some of the significant items of note are:

- The current observed groundwater level recovery rates are representative of the early stages of reclamation.

- The mines estimate that the time period of the backfill aquifer saturation to steady state conditions is about six to 280 years (**Table 44**). From the material damage evaluation perspective, the area of interest is outside of the permit areas (W.S. § 35-11-406(n)(iii)). It is important to note that these recovery time periods are for the backfill aquifer and the areas within the mine permit boundaries where the material damage assessment is not applicable. Therefore, it is more reasonable to evaluate the groundwater level recovery in the backfill aquifer as a material damage indicator than as a material damage criterion.

- The recovery rate at a specific location in the backfill aquifer is dependent on the proximity to recharge sources, the hydraulic conductivity, and storage coefficients of the backfill aquifer. The approved post mining livestock use can be supported even before the groundwater levels completely recover to the baseline. Therefore, viability of the backfill aquifers for the approved post mining use would likely be attained before the 280 years of full recovery estimate.

Continued monitoring of the backfill aquifer will be needed and additional analyses will be required as more data become available. Based on the model predictions and the observed data it is expected that the backfill aquifer would be a viable supply source to support the WDEQ/LQD approved post-mining land use of livestock and wildlife.

8.2.1.3 GROUNDWATER QUALITY IN THE BACKFILL AQUIFER

Sections 6.2.7.6 and 7.2.6 presented detailed discussions and analyses on the ability of the backfill aquifer to support the post-mining land use. The discussion and analyses indicate that the potential for the backfill groundwater to migrate to and affect the adjacent undisturbed native

aquifers outside the mine permit boundaries would be minimal and localized. Some of the significant items of note are:

- During removal and replacement of the overburden to backfill the mine pits, appropriate measures are taken to ensure that the water quality of the reclaimed backfill aquifer will not be degraded such that post-mining land uses cannot be supported (Section 6.2.7.6).

- Out of the 13 backfill monitor wells with water quality data available during the 2017-2019 period, six wells had a median TDS concentration greater than 5,000 mg/L (wells 17-02-SP, SP-10-01, and SW-1-W at the Jim Bridger Mine, and wells 568298, 566394, and RP-5B at the Black Butte Mine). The poor water quality at wells 566394 and 568198 is due to recharge from the Bitter Creek alluvial aquifer. Groundwater level monitoring indicates the source of recharge to the backfill of Pits 2 and 3 is primarily the Bitter Creek alluvial aquifer, and the high TDS concentrations that occur naturally in the alluvial groundwater are also present in the backfill water quality (Black Butte Mine Permit, 2020). Backfill wells will continue to be monitored by the mines to evaluate water quality trends and additional backfill wells will be installed as more areas are reclaimed.

- It is generally expected that over time, the backfill aquifer will be flushed by groundwater flowing through the reclaimed material to the downdip native undisturbed aquifers. Thus, the water quality in the backfill is expected to improve over time.

- The data from the backfill aquifer need to be continuously evaluated and it is highly recommended that further research be conducted on this topic to gain more understanding on the behavior of the backfill aquifer over time.

Groundwater migrating from the backfill aquifer to the native aquifers outside the mine permit boundaries is expected to have a minimal effect and would not affect the ability of the existing wells to supply for their intended use. The three material damage indicators suggest that there is limited potential for material damage to result to the native aquifers outside the coal mine permit boundaries from the addition of the Pit 15/Pit 10 South Amendment at the Black Butte Mine to the existing mining in the GGRB.

8.2.3 MATERIAL DAMAGE CRITERIA

The material damage criteria are examined for groundwater quantity and quality. The finding that the mining operations are designed to prevent material damage to the hydrologic balance outside the permit areas is supported by the evaluation conducted in this CHIA and is summarized in **Table 46** for the aquifers of interest within the CIA. Potential impact mitigation strategies are also presented in **Table 46**.

Impacts to water supplies are addressed on an individual basis either by the WSEO interference process or by W.S. § 35-11-415(b)(xii) and W.S. § 35-11-416 (b) which requires, within the constraints of the law, replacement of a water supply that has been affected by surface coal mine operations. The individual mine permits generally discuss the methods they would use to assure that this requirement can be met, if needed. Some common methods include lowering

pumps, extending the depth of the well in the current aquifer, or replacing the well with a new well completed in a deeper aquifer.

The observed and predicted groundwater effects were compiled, cumulated, and evaluated within the CIA. Although coal mining will have impacts, based on available data, information presented in the mine permits, and analysis in this CHIA, the potential for material damage to groundwater quantity and groundwater quality appear limited. The addition of the Pit 15/Pit 10 South Amendment to the Black Butte Mine is not expected to significantly change hydrologic conditions such that material damage to groundwater quantity and groundwater quality would occur. No material damage to groundwater is expected.

8.3 ALLUVIAL VALLEY FLOORS

The potential for coal mining to cause material damage to AVFs is nonexistent because no AVFs exist in the Bitter Creek CIA.

Table 46. Summary of groundwater material damage analyses in the CHIA and potential impact mitigation strategies.

Aquifer	Sections in the CHIA with Relevant Analyses	Primary Reasons for No Material Damage Finding	Impact Mitigation
Alluvial	3.2.3.1, 3.2.4.1, 6.2.6.1, 6.2.7.1, 7.2.1	Cumulative effects to the alluvial aquifer are limited by the distribution of the alluvial sediments only along drainages and the spatial distribution of the mines over small segments of the alluvial aquifer. Therefore, although there may be some impact to the alluvial aquifer caused by the individual mines, few to none of the impacts to the alluvial aquifer are cumulative in nature as the individual mines tend to impact different sections of discrete alluvial sediments. As shown for baseline and current conditions, the general direction of groundwater flow in the alluvial aquifer currently follows the topography towards the downstream or down valley direction. Therefore, the effects of mining are expected to be minimal on the undisturbed alluvial aquifer outside the mine permit boundaries.	The Jim Bridger Mine will not mine through Tenmile Draw and its floodplain. The Black Butte Mine has left a 200 foot buffer along Bitter Creek within the permit boundary.
Overburden	3.2.3.2, 3.2.4.2, 6.2.6.2, 6.2.7.2, 7.2.2	Predicted drawdowns by the individual mines in the overburden aquifer do not overlap with each other. This is primarily due to the lower hydraulic conductivity, storativity, and the discontinuous nature of the overburden aquifer. The overburden units at the different mines do not form a continuous overburden aquifer. Typically, these overburden units are discontinuous, and interbedded with claystone and siltstone. In some cases, they are present in different stratigraphic units (FUF, LF, or AF). Away from the mine pits moving outside the permit boundaries, similar to the baseline time period, the current overburden aquifer groundwater gradients still follow the general topography, which suggests that the overburden aquifer would not be significantly impacted on a regional scale outside the mine permit boundaries. The impacts on groundwater levels and groundwater quality in the undisturbed native overburden aquifer outside the mine permit boundaries would depend on the hydrologic connection with the backfill aquifer and on the quality of the groundwater migrating from the backfill aquifer. However, given that the overburden aquifer is discontinuous and is of low permeability, the effects of groundwater migrating from the backfill aquifer to the overburden are expected to be local and not on a regional scale.	Contemporaneous reclamation
Coal	3.2.3.3, 3.2.4.3, 6.2.6.3, 6.2.7.3, 7.2.3	From the material damage evaluation perspective, the area of interest is outside of the permit areas (W.S. § 35-11-406(n)(iii)). Outside the permit boundaries, the backfill aquifer will not be present and the native existing aquifers will remain structurally undisturbed. The magnitude of the decrease in the potentiometric surface is a log normal relation to both time and space, the drawdowns outside the permit boundaries in the native coal aquifers are expected to be less than the drawdowns adjacent to the coal mine pits. The coal seams at the different mines do not form a continuous coal aquifer. Typically, these coal seams are discontinuous, and interbedded with sandstone, claystone and siltstone. In some cases, they are present in different stratigraphic units (FUF, LF, or AF). Predicted drawdowns by the individual mines in the coal seams do not overlap with each other. Therefore, cumulative effects of mining on the coals seams appear limited, as these seams are generally less than 20 to 30 feet thick. Based on current available data, the model predictions by the mines, and the area geology, it is expected that the cumulative impacts caused by mining on the coal seams will be minimal.	Contemporaneous reclamation
Underburden	3.2.3.4, 3.2.4.4, 6.2.6.4, 6.2.7.4, 7.2.4	Outside the mined out areas, the aquifers overlying the underburden aquifer would remain structurally undisturbed. Groundwater model predicted drawdowns by the individual mines in the underburden aquifer do not overlap with each other. In addition, the relatively lower hydraulic conductivity of the underburden aquifer supports that coal mining would have limited cumulative effects on the underburden groundwater system and these effects will be declining radially with increasing distance from the coal mine permit boundaries.	Contemporaneous reclamation
Ericson	3.2.3.5, 3.2.4.5, 6.2.6.5, 6.2.7.5, 7.2.5	Coal mining within the CIA has limited cumulative impacts with the pumping at the mine facility wells due to isolation of the Ericson Sandstone aquifer from the overlying units by the thick Lewis Shale. Specifically, at locations where the mined coal seams are in the FUF or AF (**Table 1**), the Lewis Shale can be as thick as 1,000 feet. In locations where the mined coal seams are in the AF, the Ericson Sandstone aquifer is separated from the coal seams by a thick, low permeable interbedded sandstone, claystone, and siltstone AF underburden unit. Therefore, the groundwater quantity or quality impacts on the Ericson Sandstone aquifer would be minimal with no discernible effects that can be attributed to mining.	Contemporaneous reclamation

9. MATERIAL DAMAGE STATEMENT OF FINDINGS

Based on the information in the Black Butte Pit 15/Pit 10 South Amendment Application (TFN 6 3/246) and the analysis in this cumulative hydrologic impact assessment (CHIA), the WDEQ/LQD has determined that the proposed and existing coal mining and reclamation operations in the Greater Green River Basin have been designed to prevent material damage to the hydrologic balance outside the mine permit areas. Mining will also not materially damage the quantity and quality of water in surface or underground systems that supply alluvial valley floors (AVFs) not subject to statutory exclusions since there are no declared AVFs.

Todd Parfitt
Director
Wyoming Department of Environmental Quality

1-4-21
Date

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1.5.21
Date

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ADDENDUM A: AGENCY REVIEW COMMENTS ON CHIA-44

The following contains the agency concurrence letters and associated review comments on CHIA-44 for the Pit 15/Pit 10 South Amendment at the Black Butte Mine. The Wyoming State Engineer's Office (WSEO) reviews the surface and groundwater quantity aspects of the CHIA and the Wyoming Department of Environmental Quality Water Quality Division (WDEQ/WQD) reviews the surface and groundwater quality aspects of the CHIA. As part of the review, the WSEO provided minor grammatical edits for the draft document, and these were incorporated into the final document. Otherwise it was determined that a formal response to the WSEO review was not necessary. It was also determined that a response to the WDEQ/WQD reviews was not necessary.

State Engineer's Office

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MARK GORDON
GOVERNOR

GREG LANNING
STATE ENGINEER

December 4, 2020

Kyle Wendtland, Administrator
Wyoming Department of Environmental Quality/Land Quality Division
200 W. 17th St.
Cheyenne, WY 82002

RE: Review of the Pre-Decisional Draft of the Cumulative Hydrologic Impact Assessment of Coal Mining in the Greater Green River Basin, Southwestern Wyoming, Pit 15/Pit 10 South Amendment (TFN 6 3/246) to the Black Butte Mine (Permit 467), WDEQ-CHIA-44

Dear Mr. Wentland:

The Ground Water Division of the State Engineer's Office (SEO) reviewed the Wyoming Department of Environmental Quality/Land Quality Division's (WDEQ/LQD) Pre-decisional Draft of the Cumulative Hydrologic Impact Assessment of Coal Mining in the Greater Green River Basin, Southwestern Wyoming, Pit 15/Pit 10 South Amendment (TFN 6 3/246) to the Black Butte Mine (Permit 467), WDEQ-CHIA-44. Overall, the SEO is in agreement with the WDEQ/LQD's conclusions.

Please note, the Cumulative Impact Area identified under this CHIA is located within the Colorado River Drainage. If the amount of water to be used, or the quality of water to be discharged to the Colorado River Basin, changes during the permitting process, the WDEQ/LQD and/or the Black Butte Mine must contact the SEO/Interstate Stream Division regarding compliance with Wyoming's responsibilities under the Colorado River Compacts and Treaties.

Editorial comments will be forwarded under separate cover. Please let me know if you have any questions regarding our review.

Sincerely,

Lisa Lindemann
Administrator, SEO Ground Water Division

cc: Greg Lanning, State Engineer
Nathan Graves, Administrator, SEO Surface Water Division
Jeremy Manley, SEO Ground Water Division
Muthu Kuchanur, WDEQ/LQD Cheyenne
Matt Kunze, WDEQ/LQD Cheyenne
Steve Wolff, SEO/Interstate Streams, Cheyenne

Board of Control 307-777-6178 | Ground Water 307-777-6163 | Interstate Streams 307-777-1942 | Surface Water 307-777-6475

Mark Gordon, Governor

Department of Environmental Quality

To protect, conserve and enhance the quality of Wyoming's environment for the benefit of current and future generations.

DEQ

Todd Parfitt, Director

December 3, 2020

Mr. Kyle Wendtland, Administrator
Wyoming Department of Environmental Quality, Land Quality Division
200 W. 17th St., Suite 10
Cheyenne, WY 82002

RE: Review of Draft Cumulative Hydrologic Impact Assessment of Coal Mining in the Greater Green River Basin, Southwestern Amendment, Black Butte Mine, Southwestern Wyoming, Permit #467

Dear Mr. Wendtland:

The Watershed Protection Program and Groundwater Pollution Control Program of the Water Quality Division have reviewed the Department of Environmental Quality, Land Quality Division's Draft Cumulative Hydrologic Impact Assessment of Coal Mining in the Greater Green River Basin, Southwestern Amendment, Black Butte Mine, Southwestern Wyoming, Permit #467.

Based on our review of the data provided and the analysis conducted in the draft CHIA, both Programs are in agreement with the conclusions of the draft CHIA that the proposed operation has been designed to prevent material damage to the hydrologic balance outside the permit area.

Review comments on the draft document are included for your consideration.

Sincerely,

Kevin Frederick
Administrator, Water Quality Division

Attachments: Staff Reviews

cc: David Waterstreet, WQD Cheyenne
Lily Barkau, WQD Cheyenne
Muthu Kuchanur, LQD Cheyenne
Matt Kunze, LQD Cheyenne

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MEMORANDUM

To: Kevin Frederick, Administrator, WQD

Through: Lily Barkau, Groundwater Section Manager

From: Nicole Twing, P.G., Geology Supervisor, Groundwater Section

Date: December 2, 2020

Subject: WQD, GPC Review of Draft Cumulative Hydrologic Impact Assessment of Coal Mining in the Greater Green River Basin, Southwestern Amendment, Black Butte Mine, Southwestern Wyoming, Permit #467

I have reviewed the above-mentioned document and have the following comments:

1. The Southwestern Amendment is a n expansion to an existing mine permit proposed by Black Butte Mine (Permit #467) in the Greater Green River Basin of Wyoming, approximately 25 miles east of Rock Springs, in southwest Wyoming. The proposed mine permit expansion would cover 963.35 acres, with 331 of those acres proposed to be disturbed by mining. The groundwater cumulative impact area (CIA) is the area encompassed by the modeled five (5) foot drawdown contour. The 5-foot groundwater drawdown is limited in extent and does not cover the entire proposed permit boundary. To be conservative, the groundwater impact evaluation was extended to encompass potential impacts from overlapping mine drawdown impacts and included approximately 1,151 square miles. Six aquifer units were included in the evaluation: alluvial, Fort Union, Lance Formation, Almond Formation, Ericson sandstone and backfill.

   Largest groundwater elevation drawdowns modeled were within the backfill and Ericson Sandstone. Since the backfill is not continuous and does not extend outside the permit boundary, material impacts are not expected. Impacts to the Ericson Sandstone are estimated to be less than 5 feet across the combined impact area, with no expected material impacts to water well supply outside the permit boundary.

2. Based upon the data and assumptions presented in CHIA #44, the proposed expansion to Black Butte Mine will not result in material damage to aquifer yields.

3. Based upon the data and assumptions presented in CHIA #44 the potential for material damage to shallow groundwater quality as a result of the Black Butte Mine appears to be limited.

END OF MEMO

MEMORANDUM

TO: Kevin Frederick
THROUGH: David Waterstreet
FROM: Jeremy ZumBerge
DATE: December 1, 2020

RE: **Comments on CHIA-44, Cumulative Hydrologic Impact Assessment of Coal Mining in the Greater Green River Basin, Southwest Wyoming.**

The permitting action evaluated by this CHIA is Pit 15/Pit 10 South Amendment (TFN 6 3/246) to the Black Butte Mine (Permit 467). The Black Butte Mine is located in the Greater Green River Basin (GGRB) of southwest Wyoming, approximately 25 miles east of Rock Springs. The Pit 15/Pit 10 South Amendment proposes to extend existing Pit 10 to the south and mine a new pit (Pit 15) to the northeast of the existing permit. The amendment would add a total of 963.35 acres northeast of the existing Black Butte Mine permit boundary. The amendment proposes to disturb 331 acres. The amendment area is located within the headwaters of unnamed ephemeral tributaries to Bitter Creek.

It is unlikely that the proposed changes to the permit area will lead to material damage to surface water quality in the cumulative impact area (CIA). Monitoring of Bitter Creek at the upstream and downstream permit boundaries has shown negligible differences in water quality between the two sites. The permit amendment will add a relatively small amount of acreage to the Black Butte permit, thus the likelihood of material damage is low.

APPENDIX D –
PROBABLE HYDROLOGIC CONSEQUENCES

Mining Hydrology

Groundwater

Five foot drawdown maps for each aquifer affected are submitted for the term of permit and life of mine in Appendix D6-Hydrology as Exhibits D6-1 through D6-3. Although these exhibits and the drawdown predictions shown on them are obsolete, the drawings are retained in the appendix in the interest of preserving historic baseline data. The reader is referred to Exhibits MP-5a, MP-5b and MP-5c of this Mine Plan for updated (2006) projections of mine-life, five-foot, drawdown limits that include the affects of pit drainage, highwall mining and mine dewatering wells.

Pit Inflows

Pit inflow estimates to the advancing box cuts of selected pits were calculated using steady state volume balance equations. This technique has been used by Bear (1972) Polubarinowa-Kochina (1952) and Arawin Numerou (1953, 1965). A discussion of this method for various pit situations is presented by McWhorter (1980). McWhorter also reports that the method is, of course, an approximation but has the added dimension that mass continuity is accounted for exactly.

For a given instant in time, volume of water produced into the pit along a unit length is given by equations given below that utilize, together with others, the following variables:

S = aquifer storage coefficient

h = height of the water table above floor of aquifer

x = distance between a mine pit and point of negligible groundwater drawdown measured parallel to the groundwater flow path leading to the pit

d_u = extent of unconfined zone

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In the unconfined zone, flow is accounted for by:

$$q = Kh \frac{dh}{dx} \quad 0 \leq x \leq du$$

Where:

q = discharge to pit per unit length of pit
k = hydraulic conductivity

The equations written below account for groundwater inflow along an induced groundwater gradient and inflow from aquifer storage releases to yield the approximate volume of inflow per unit length of pit. Implicit in the solutions are the assumptions that: 1) the aquifer becomes unconfined when the box cut is opened; 2) the aquifer slice is normal to the cut, as is the case at Black Butte, and 3) groundwater drained from aquifer storage is equivalent to the specific yield of the aquifer (S_{yd}).

$$V_d = S_{ya} \int_0^{dx} s \, dx$$

Where:

S_{ya} = specific yield
s = drawdown at cut face

upon integration and assuming s_{01} will be constant for the first cut we arrive at:

$$Q_1 = 2R \left[\frac{S_{yd} T s_{01}^2}{12} \right]^{1/2} t^{1/2}, \; t = \frac{L_1}{R_1}$$

$$Q_1 = 2R \left[\frac{S_{yd} T s_{01}^2}{12} \right]^{1/2} \left[t^{1/2} - (t - L/R)^{1/2} \right], \; t = \frac{L_1}{R_1}$$

incremental discharge to the second cut would then be:

$$Q_2 = 2R \left[\frac{S_{yd} T s_{02}^2}{12} \right]^{1/2} (t-t_1)^{1/2}, \; t_1 \leq t \leq t_1 + t_2$$

$$Q_2 = 2R \left[\frac{S_{yd} T s_{02}^2}{12} \right]^{1/2} (t-t_1)^{1/2} - (t - t_1 - t_2)^{1/2}, \; t \geq t_1 + t_2$$

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Table MP-20 Pit Inflows Ft Union Pits

Pit No.	Year	Q_{Low} Ft^3/day	Q_{High} Ft^3/day	$Q_{Avg.}$ (Weighted) Ft^3/day	Q_{Total} Ac-Ft/ Year
3	1980	468	2,002	1,235	10.3
3	1981	1,637	5,258	3,448	28.9
3	1982	2,276	13,753	8,014	67.2
3	1983	95	814	454	3.8
3	1984	4,377	18,702	11,540	96.7
3	1985	75	371	223	1.9
3	1986	37	228	132	1.1
3	1987	3,295	16,279	9,787	27.1
3	1987	483	3,083	1,783	5.0
3	1987	100	1,108	604	1.7
					33.8
3	1988	Dry			
3	1989	10,193	31,592	20,892	87.5
3	1989	966	3,213	2,089	8.7
					96.2
3	1990	78	400	239	2.0
3	1991	Dry			
3	1992	6,885	23,253	15,069	31.6
3	1992	17,234	40,226	28,730	60.2
3	1992	540	2,200	1,370	2.8
3	1992	251	635	443	0.9
					95.5
10	1989	104	444	274	2.3
10	1990	1,116	1,839	1,477	12.4
10	1991	1,848	2,410	2,129	17.8
10	1992	2,357	2,375	2,366	19.8
10	1993	2,302	2,218	2,260	18.9
15 & 10	2018-2019			7,400	62.0
15 & 10	Future	80,438	210,425	148,005	1240

1. Dry pits and mined-out pits are not shown.

2. Pit 11 experienced approximately 228 Ac-Ft groundwater inflow in the first three months that the pit was open. This was equivalent to an inflow rate of about 721 gpm. Some 13 months later, the inflow rate had declined to 32 Ac-Ft over a three-month period, or to about 80 gpm. In 2013, the inflow rate to Pits 10 and 11 combined was about 66 gpm and it was about 47 gpm in 2014.

3. Inflow to Pits 15 and 10 will be commingled and treated together. The inflow rate shown for 2018-2019 is groundwater moving through the future Pit 15/Pit 10 expansion area; the flow is likely being captured by Pit 10. The inflow rate estimations were derived using hydraulic conductivity values applied with the Darcy equation. Total annual inflow volumes are based on average inflow rates.

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Table MP-21. Pit Inflows Lance Pits

Pit No.	Year	Q_{Low} Ft^3/day	Q_{High} Ft^3/day	Q_{Avg} Ft^3/day	Q_{Total} Ac-Ft/Year
5A	1981	640	1,729	1,184	9.9
	1982	1,595	1,750	1,672	14.0
	1983	1,704	1,753	1,728	14.5
5B	1984	164	445	304	2.5
	1985	250	562	406	3.4
5C	1986	223	1,351	787	6.6
6	1985	1,823	2,171	1,997	16.7
	1986	1,701	1,811	1,756	14.7
	1987	1,621	1,689	1,655	13.9
	1988	1,637	1,751	1,694	14.2
	1989	1,780	1,981	1,880	15.8
	1990	2,069	2,844	2,456	20.6
7	1991	81	349	215	1.8
	1992	485	1,129	807	6.8
	1993	1,121	1,384	1,252	10.5
	1994	1,433	2,021	1,727	14.5
	1995	1,689	1,878	1,783	14.9
12	1999	154	661	408	3.4
	2000	787	1,487	1,137	9.5
	2001	1,527	2,086	1,806	15.1
	2002	2,073	2,337	2,205	18.5
	2003	2,385	2,756	2,570	21.5
	2004	2,602	2,675	2,638	22.0
13	2000	123	527	325	8.9
	2001	712	1,604	1,158	9.7
	2002	1,691	2,549	2,120	17.8
	2003	2,511	2,731	2,529	21.2
	2004	2,153	2,548	2,350	19.7

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Table MP-22. Pit Inflows Almond Pits

Pit No.	Year	Q_{Low} Ft^3/day	Q_{High} Ft^3/day	Q_{Avg} Ft^3/day	Q_{Total} Ac-Ft/Year
8	1989	561	1,256	908	4.2
	1990	1,606	1,902	1,754	4.0
	1991	1,564	3,525	2,544	21.3
	1992	2,405	2,848	2,626	22.0
	1993	1,288	1,369	1,328	11.0
	1994	2,367	3,739	3,053	25.6
	1995	3,355	5,207	4,281	35.9
	1996	4,271	5,826	5,048	42.3
	1997	4,390	6,128	5,259	44.1
	1998	4,564	6,260	5,412	45.3
	1999	4,036	4,059	4,048	33.9
	2000	2,268	3,149	2,708	22.7
	2001	2,259	3,158	2,708	22.7
	2002	2,250	3,165	2,708	22.7
	2003	2,361	3,174	2,768	23.2
14[(1)]	All Years	1,770	5,310	3,540	29.7

Notes:

1) While only one groundwater inflow rate was computed as typical for all years of mining in Pit 14, the analytical solution employed allows estimation of a range in rates. As described in accompanying text, the range is 0.2 to 0.6 the single calculated rate. The factor 0.4 was applied to the single calculated rate in computing the average inflow rate and annual total values.

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Where: L = length of cut

R = advance of cut

T = transmissivity

s_0 = drawdown

This increment scheme would then follow for the rest of the cuts of a pit. The incremental drawdown s_0 can be calculated for the advancing pits by:

$s_x = W \tan \theta$

Where: W = width of cut

θ = dip angle of aquifer

Utilizing this method, pit inflows have been estimated for all pits except for Pits 11, 14 and the Pit 15/Pit 10 South amendment cuts. Inflows to Pit 14 are projected utilizing a similar analytical technique described in the following text section. Inflow rates to Pit 11 are evaluated in text section *Estimated and Observed Groundwater Inflow Rates at Pit 11* by reference to pit sump pumping data recorded in late 2006 through February 2008, and by reference to the predictive groundwater model described in section *Analysis of Potential Drawdown Caused by Dewatering Well Field Operations.* Inflow rates to the Pit 15/Pit 10 South mine pits are projected using a simplified flow net approach with the Darcy equation, as described below under *Groundwater Inflow Rates Predicted for Pit 15/Pit 10 South Amendment Mining.*

A summary of inflows calculated for each affected formation by the steady-state volume balance equations is presented as Tables MP-20 through MP-22. In Tables MP-20 through MP-22, Q average was determined using a method of weighted values. This was accomplished by: (1) noting the length of cut made for a given interval; (2) using the transmissivity value assigned to that specific interval being mined, and; (3) averaging those values for the total time to complete the cut. For example, Pit A, in 1978, intersected three zones of transmissivity. The three zones, called 1, 2 and 3, resulted in variable discharge to the pit. Zone 1, which accounted for 25% of the cut, had inflow of 200 ft^3/day for a high and 100 ft^3/day for a low. Zone 2, which accounted for 60% of the cut, had inflow of 100 ft^3/day for a high and 25 ft^3/day for a low. Zone 3, which was the remaining 15% of the cut, had inflow which ranged from 50 ft^3/day to 10

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ft^3/day. An average flow for the year was determined and multiplied by the relative percent for the resulting Q (weighted) average. Results are as follows:

Zone	Average ft^3/day		%		Q ft^3/day
1	150.0	x	0.25	=	37.5
2	62.5	x	0.60	=	37.5
3	30.0	x	0.15	=	4.5
					79.5 weighted average

The volumes of calculated inflow can only represent estimates based on the data at hand. The use of this method maximizes predicted inflows, but it must be remembered that actual inflow rates may vary from predicted inflow rates by several factors or even as much as an order of magnitude.

Pumping estimates from pit dewatering combined with site reconnaissance has indicated that pit inflows from 1979 to 1985 were on the order of one-half to one-third less than the calculated estimates.

Estimated Groundwater Inflow Rates At Pit 14

Data are provided in Addendum D6-G indicating that groundwater conditions in the Almond Formation at Pit 14 are similar to those found in the Almond at Pit 8. Aquifer transmissivities are typically low in both areas, averaging about 4 ft^2/day at Pit 8 and 10 ft^2/day at Pit 14. Monitor well yields average less than 0.1 gallons per minute per foot of drawdown in both pit areas. Groundwater inflow rates at Pit 14 can therefore be expected to be similar to those projected for Pit 8 on Table MP-22.

A reconnaissance assessment of potential groundwater inflow rates at Pit 14 was performed using a simple analytical solution recommended by Hanna et al. (1994) that estimates lateral, radial flow to a fully penetrating pit or well in an idealized confined aquifer. The solution is written as:

$$Q = \frac{4\pi T \Delta h}{Ln\left\{\frac{2.25Tt}{r_w^2 S}\right\}}$$

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Where:

Q = inflow rate, ft^3/day
T = transmissivity, ft^2/day
Δh = groundwater drawdown in well or pit face, ft
r^2_w = well or pit radius,ft
S = aquifer storativity
t = time since pit or well drawdown began, days

Hanna et al. (1994) caution that the above equation should only be applied when the dimensionless parameter, α, defined by

$$\alpha = \frac{Tt}{r_w^2 S}$$

is greater than about 0.01.

The dimensionless parameter equation was solved for a transmissivity (T) of 10 ft^2/day and a storativity of 0.0002, both taken from Addendum D6-G. Time since drainage began (t) was set at 180 days, which will be about half the duration of a typical pit at Pit 14. Because the pits at Pit 14 will be relatively straight, the pit/well radius variable (r^2_w) was replaced with the expression

$\left\{\frac{L}{2\pi}\right\}^2$ where L is the length of a typical proposed pit as measured from the pit progression drawing of this Mine Plan. This expression solves for the radius of a circle having a perimeter equivalent to the length of a typical proposed pit, thus replacing pit length with a circular well or pit radius value as required by the dimensionless parameter equation. Typical pit lengths (L) over the course of a mining year at Pit 14 will be about 11,600 feet after the first several years of mining. Solving the dimensionless parameter equation for the values of T, t, and S noted above and a pit length of 11,600 feet yields a value of 2.6, which meets the criterion stated above for the parameter to exceed 0.01.

The final step in predicting approximate inflow rates at Pit 14 was to solve for the variable Q of the first equation written in this text section. Exhibit D6-G-1, *Approximate Potentiometric Surface In Premining Overburden At Pit 14*, was superimposed on the coal pit sequence drawing and on a contour map of proposed pit floor elevations to derive a typical value for the variable Δh. A potential head decline of about 125 feet appears to be typical for the pit

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planned for year 2020. Solving for Q using this value and the values for the other equation variables cited above yields an approximate inflow rate of 8,850 ft^3/day, or about 46 gallons per minute (gpm). Hanna et al. (1994) compared predictions made by the inflow rate equation with those generated using a three-dimensional finite element model, finding that the inflow rate equation provides reasonable estimates of true inflow rates when results from the equation are multiplied by factors ranging from 0.2 to 0.6. Multiplying 8,850 ft^3/day by 0.4 yields a predicted inflow rate of 3,540 ft^3/day, which is equivalent to 18 gpm. This final value is probably nearly equivalent to the average of values listed on Table MP-22, and as shown on the table, inflow rates can be expected to vary widely, primarily as a result of changes in aquifer transmissivity and hydrostatic heads. Table MP-22 lists the range of approximate groundwater inflow rates computed using multiplication factors of 0.2 and 0.6 and the estimated average inflow rate computed with a factor of 0.4, all applied to the single, calculated, inflow value of 8,850 ft^3/day.

Estimated and Observed Groundwater Inflow Rates at Pit 11

Section *Analysis of Potential Drawdown Caused by Dewatering Well Field Operations* of this Mine Plan presents the results of a groundwater model that simulates four, hypothetical dewatering wells plus the initial pit sump pumping for a period of 180 days at Pit 11. The model does not include the additional effect of pit drainage on lowering potentiometric heads, but only simulates instead drawdown resultant from five dewatering sites. The total pumping rate of the five sites is 635 gpm. Model results shown on Table MP-24d indicate that the four wells and the pit sump could be pumped for 180 days at the rates assigned them (75 gpm to 200 gpm), with only one dewatering well going dry (well No. 1 at drawdown point No. 47). In fact, Table MP-24d also shows that the remaining four dewatering wells (well No. 3 is actually the simulated pit sump) have ample saturation remaining after 180 days to allow continued pumping, or conversely, to have been pumped at higher rates during the 180-day simulation period. Overall, the model results demonstrate that Pit 11 could be expected to initially experience somewhat more than 635 gpm of groundwater inflow, or conversely, the strata be dewatered in advance of mining by a well field producing at an equivalent flow rate.

Mining at Pit 11 was initiated in 2006 and sump pumping and dewatering well discharge records are available to assess actual trends in groundwater inflow rates from late 2006 through February 2008. Ultimately, only two dewatering wells were operated (Nos. 114 and 115 on

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Exhibit MP-5a), and then only during September and October 2006 before the wells became nearly dry and were impractical to operate as a result of pumping at large rates from the nearby pit sump. The sump has been relocated with successive pit cuts since the initial sump of 2006, but the original sump and the relocated sumps have all remained in the southwestern corner of the advancing mine pit. Tabulated below are the available discharge records from the dewatering wells and the pit sump. Pit sump volumes were computed using motor run-time records on the pumps. Pit sump pumping rates that were applied to the running times were computed by calculating the total dynamic heads on the pumps and applying these values to pump performance curves provided by the pump manufacturers.

Initial Pit Sump and Dewatering Well Pumping Records For Pit 11

Period [1]	Vol. Pumped From Sump (AF)	Vol. Pumped From Wells (AF)	Total Vol. Pumped (AF)	Avg. Pumping Rate in Sump (gpm)	Avg. Pumping Rate In Wells (gpm) [2]
Sep. through Nov. 2006	223	5.0	228	700	21
Jan. through May 2007	79	0	79	119	--
Dec. 07 through Feb. 08	32	0	32	80	--

Notes:

1. Records are unavailable for December 2006, June and July 2007, and October and November 2007. Sump pumping in August and September 2007 was significantly influenced by rainfall runoff, and these records are not used because they are unindicative of pumping groundwater alone.
2. The dewatering wells began operating on September 8, 2006. Discharges from the wells were initially much greater than 21 gpm but the wells, with their electronic float level switches, began operating for progressively smaller durations after the third week of September 2006 when the first pump, and then a second pump, were energized in the pit sump.

Averaging some 721 gpm in the above table, the initial pumping rate was in close agreement with the total pumping rate for the wells and pit sump simulated by the well field model. Recorded pumping rates declined more rapidly, however, than projected by the groundwater model. This disparity is probably indicative of the limited physical extent and,

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hence, substantial dewatering of the Pit 11 scoria aquifer that trends parallel to and west of the coal removal block.

All groundwater pumped from the two dewatering wells was conveyed to sedimentation pond SPA1 having WYPDES site No. 052. Discharge records from site No. 052 constitute the data source for the well pumping records tabulated above. Most of the water pumped from the pit sump was conveyed via closed pipeline to Pit 10, although some minor volumes were also conveyed to sedimentation pond SPA1 at Pit 11 and to sedimentation pond SPB1 at Pit 10.

Based on visual observations by mine employees, about half of the groundwater inflow, 80 gpm, was derived from backfill abutting scoria along the western side of the pit during the winter of 2007-2008. The other half was from strata that is not scoria lying east of the operating pit. Pool levels in the sump during the winter of 2007–2008 recovered over fairly consistent time periods after pumping, indicating that the overall groundwater inflow rate was consistent. Groundwater inflow rates, inclusive of inflow to the backfill, are expected to remain at about 80 gpm, although as stated in Section *Pit Inflows*, actual inflow rates may vary from those predicted by several factors or even an order of magnitude.

Pit 11 mining ended in first quarter 2018. The last pit pumpage records kept for Pits 10 and 11 date back to 2013 and 2014 when water in both pits were commingled for discharge via one metered pumping system. Based on metered hour records and pump performance curve, the groundwater inflow rate to both pits combined averaged about 66 gpm in 2013. The average inflow rate had declined to about 47 gpm in 2014.

Groundwater Inflow Rates Predicted for Pit 15/Pit 10 South Amendment Mining

Maximum groundwater inflow rates that may be experienced with the Pit 15/Pit 10 South amendment mining have been estimated applying the Darcy equation with hydraulic conductivity pump test results of monitor wells developed in mineable sequence sandstone reported in Table D6-2 (Volume 5). The results are shown on Exhibit MP-52. Testing results of Table D6-2 indicate that the coals to be mined are typically of much lower hydraulic conductivity than the sand/sandstone units that will be intercepted on the mine pit faces; hence, groundwater originating in the coal seams is expected to be a relatively minor inflow source. Table D6-2 presents aquifer test results for six monitor wells developed in sand/sandstone strata (wells Nos. 39, 40, 44, 45, 53 and 55). All but one of these wells were in the Pit 3 area. The

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pump tests were completed in 1981 at which time total saturated sand/sandstone thicknesses in the wells, usually divided into multiple strata layers, ranged from 23 feet to 66 feet. Calculated hydraulic conductivity values ranged from 0.2 ft/day to 84.5 ft/day. Completion logs for four of the wells noted yields ranging from 5 gpm to 50 gpm during completion; two of the six well logs do not note completion yields. Groundwater yields recorded in coal exploration borings completed within and near the Pit 15 mining block were up to about 50 gpm (see Exhibit D6-H-1 of Addendum D6-H). After discounting outliers in the set of six aquifer test results (hydraulic conductivities of 0.2 ft/day, 1.8 ft/day and 84.5 ft/day), the conductivities of the remaining three tests range from 12.5 ft/day to 32.7 ft/day with an average value of 23 ft/day. This information is shown on the table embedded in Exhibit MP-52.

The potentiometric contours shown on Exhibit MP-52 are those drawn for the overburden on Exhibit D6-H-3 of Addendum D6-H to which has been added saturated sand/sandstone thicknesses recorded in exploration holes during and after drilling completed mainly in 2012 and 2014. The saturated thicknesses include sands found in the overburden and in the interburden of the coal seams to be mined. Exhibit MP-52 also includes saturated sand thicknesses existing in August 2018 at the sites of three overburden monitor wells; 113, P10MW1_OB and P15MW1_OB. As explained in Addendum D6-H, the approximate dry zone shown for the overburden on Exhibit MP-52 is interpreted to be due to drawdown caused by mining in the northern Pit 10 area together with drawdown associated with resaturation of Pit 10 backfill. The potentiometric gradient of Exhibit MP-52 is indicative of topographically controlled groundwater movement in overburden, from uplands east of the mine westward toward the mine. Prior to mining at Pits 10 and 11, the prevailing direction of groundwater movement was likely downdip, generally toward the Washakie Basin, especially for the hydraulically confined coal seams and deeper strata. Note on Exhibit D6-H-2 of Addendum D6-H that groundwater elevations in coal well 65, positioned near the southern boundary of Pit 10, were about 40 feet higher than initial readings taken in coal well P15MW1-CZ, positioned downdip and east of proposed Pit 15.

The Darcy equation is employed to solve for the groundwater inflow rate that may currently (in 2018) be entering the Pit 15 and northern Pit 10 area and which is currently largely lost to Pit 10 and Pit 10 backfill, and to solve for future, maximum inflow rates. The current inflow rate, identified on the Exhibit MP-52 table under heading "Approximate Existing Conditions (2018),,, is based on the average hydraulic conductivity of 23 ft/day derived from

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historic testing results referenced above applied with a measured water table gradient of 0.001 ft/ft crossing the 6770-foot water table contour of Exhibit MP-52 and a saturated sand/sandstone thickness of 50 feet. The 6770-foot contour is interpreted as approximately defining the extent of the up-gradient zone of groundwater entering the Pit 15 and northern Pit 10 area south of the Pit 11 boundary fault. The computed current inflow rate, 38 gpm, agrees reasonably with the combined Pit 10 and Pit 11 inflow rate of 47 gpm estimated for 2014 (see section *Estimated and Observed Groundwater Inflow Rates at Pit 11*). This agreement supports use of the average hydraulic conductivity value and flow-path length employed with a net overburden/interburden saturated sand thickness of 50 feet, even though the Pit 11 portion of the 47-gpm inflow rate is hydraulically disconnected by fault displacement from groundwater found within the Pit 15 and Pit 10 areas.

Future maximum groundwater inflow rates are shown on the table of Exhibit MP-52 for the average and range of hydraulic conductivity values developed for the calculations as described above. The 6770-foot potentiometric contour was used again as the Darcy flow-path length under the assumption that some similar path configuration relocated to the east will likely persist south of the Pit 11 boundary fault as drawdown further develops during mining. The water table gradient used for future, maximum inflow projections was increased by a factor of 20 from the current inflow rate assessment (from 0.001 ft/ft to 0.02 ft/ft) under the assumption that the current potentiometric surface configuration will shift eastward but still support roughly 50 feet of permeable sand/sandstone saturation at the outer, up-gradient edges of mine-induced drawdown. Future inflow rates may be highly variable as individual aquifer layers dewater or mostly dewater at pit wall seepage faces in advance of new mine cuts being driven forward (eastward) up the water table gradient. As shown on the geologic cross sections of the Mine Plan, there also appears to be sufficient structural variability in the overburden and interburden strata so as to expect potential pit interception of anticlinal-like aquifer forms subject to relatively abrupt dewatering separated by synclinal-like forms that may locally act as pockets of groundwater unable to fully drain until mining progresses eastward (down dip) in to lower structural elevations.

Hydrologic Monitoring During Mining

Groundwater monitoring during mining will follow the schedule of and apply to the wells outlined in Table MP-23 *During Mining Groundwater Monitoring Network*. A similar table is

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Table MP-23 During Mining Groundwater Monitoring Network

SITE NO.	STATION & AQUIFER ID	LOCATION - MINE COORDINATES	GROUND ELEVATION	TOTAL DEPTH	CASING TYPE, DIAM.	COMPLETION, PERFORATION ZONE	PACKER DEPTH	PIT/AREA MONITORED	INITIAL WATER ELEV.	DATE COMPLETED	MONITORING INFORMATION
1	0534 74 KLD	346812.91N 520267.95E	6898.13	164	PVC 4"	LANCE 144 - 164	24	PIT 7	6757.63	11/22/74	Not Presently Monitored See Footnote *
2	0535.74 KLDE	353087.60N 514502.87E	6927.41	198	PVC 4"	LANCE 178 - 198	18	PIT 13	6748.41	11/22/74	Not Presently Monitored See Footnote *
4	0537.74 KLI	334000.00N 509000.00E	6660.00	150	PVC 4"	LANCE 130 - 150	126	PIT 12	6645.88	11/24/74	Not Presently Monitored See Footnote *
5	0547.74 KLAB	343099.63N 518425.31E	6924.93	205	PVC 4"	LANCE 184 - 204	24	PIT 7	DRY	10/20/74	Not Presently Monitored See Footnote *
9	0593.74 FU	323631.0N 529778.63E	6796.53	250	PVC 4"	FT. UNION 236 - 248	233	PIT 4	6589.53	11/23/74	Ground water performance criteria met per WDEQ/LQD findings letter of 4/17/15. Monitor annual water levels & qualtiy
21	2004.78 KLB	328589.71N 521514.10E	6910.80	400	PVC 5"	LANCE 364 - 374	362	PIT 5	6749.71	5/24/78	Casing partially collapsed; cannot bail well. Monitoring discontinued.
22	2005.78 KLE	322644.10N 521273.50E	6679.80	223	PVC 5"	LANCE 213 - 223	203-213	PIT 5	6493.16	5/24/78	Semi-annual water levels
33	2721.80 KLD	319213.50N 518135.70E	6709.80	130	PVC 5"	LANCE 118 - 130	-	PIT 5S	6619.73	8/5/80	Semi-annual water levels
35	2723.80 KLF	322256.40N 520153.50E	6667.00	63	PVC 5"	LANCE 56 - 60	-	PIT 5	6621.64	8/5/80	Monitoring is temporarily suspended and will commence one year prior to opening Pit 5S.
37	2842.80 FUASH	314255.30N 521205.00E	6634.10	130	PVC 5"	FT. UNION 80 - 90	-	PIT 3	6623.92	12/3/80	Semi-annual water levels and annual water quality samples
39	2844.80 FUCSS	311867.26N 523154.85E	6648.42	90	PVC 5"	FT. UNION 30 - 90	30	PIT 3	6611.82	12/4/80	Semi-annual water levels and annual water quality samples
40	2845.80 FUCSS	312614.90N 522341.00E	6639.10	130	PVC 5"	FT. UNION 30 - 130	30	PIT 3	6623.77	12/5/80	Semi-annual water levels
41	2846.80 QAL	312958.20N 522943.90E	6631.50	82	PVC 5"	ALLUVIUM 58 - 78	GRAVEL PACKED	PIT 3	6624.40	12/4/80	Semi-annual water levels and water quality samples
56	2861.80 KLCST	318439.20N 517244.20E	6729.60	180	PVC 5"	LANCE 160 - 180	158	PIT 5S	6604.47	12/4/80	Monitoring temporarily suspended, but will resume one year prior to opening Pit 5S.
57	2862.80 KLA	318872.60N 516505.30E	6755.10	180	PVC 5"	LANCE 160 - 180	-	PIT 5S	6596.03	12/5/80	Monitoring temporarily suspended, but will resume one year prior to opening Pit 5S.
58	2863.80 FUSS	313258.80N 522103.50E	6642.00	100	PVC 5"	FT. UNION 60 - 100	-	PIT3	6624.42	12/6/80	Semi-annual water levels and annual water quality samples

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Table MP-23 During Mining Groundwater Monitoring Network

SITE NO.	STATION & AQUIFER ID	LOCATION - MINE COORDINATES	GROUND ELEVATION	TOTAL DEPTH	CASING TYPE, DIAM.	COMPLETION, PERFORATION ZONE	PACKER DEPTH	PIT/AREA MONITORED	INITIAL WATER ELEV.	DATE COMPLETED	MONITORING INFORMATION
65	3050.81 FU	344462.20N 530553.30E	6919.10	165	PVC 5"	FT. UNION 130 - 160	109-129	PIT 10	6793.72	6/16/81	Not Presently Monitored (Dry) See Footnote**
66	3053.81 KL	321154.00N 519451.70E	6758.00	288	PVC 5"	LANCE 274 - 285	252-272	PIT 5S	6604.48	6/23/81	Semi-annual water levels and annual water quality samples
67	3052.81 KL	305478.50N 509762.70E	6870.30	167	PVC 5"	LANCE 153 - 162	128-148	PIT 6	6809.99	6/17/81	Monitoring suspended 2016. Leave for stock well.
68	3051.81 KL	313692.00N 514808.80E	6731.40	109	PVC 5"	LANCE 97 - 105	85-105	PIT 6	6645.30	6/16/81	Annual water levels and water quality samples
71	3306.82 AL	328165.80N 508793.90E	6665.30	201	PVC 5"	ALMOND 166 - 198	119	PIT 8	6661.47	4/28/82	Semi-annual water levels and water quality samples
72	3307.82 AL	314885.10N 501631.40E	6784.20	224	PVC 5"	ALMOND 200 - 220	170	PIT 8	6756.14	4/28/82	Semi-annual water levels and water quality samples
73	4555.85 QAL	331899.57N 513302.73E	6589.85	76	PVC 5"	ALLUVIUM 56 - 76	GRAVEL PACKED	PIT 2	6519.10	8/21/85	Semi-annual water levels and water quality samples
75	5059.86 FU	307061.80N 518183.00E	6790.30	402	PVC 5"	FT. UNION 302 - 382	39	PIT 3	6632.05	11/6/86	Semi-annual water levels and water quality samples
76	5060.86 FU	300308.80N 511319.50E	6903.60	362	PVC 5"	FT. UNION 292 - 352	45	PIT 3	6755.85	11/7/86	Semi-annual water levels and water quality samples
81	5025.86 FU	353566.60N 532695.60E	6803.70	280	PVC 5"	FT. UNION 171 - 255	170-238	PIT 10	6736.70	10/27/86	Semi-annual water levels and water quality samples
85R	11-08085R FU	355398.28N 530023.81E	6805.37	281	PVC 5"	FT. UNION 260 - 281	258	PIT 11	6716.87	7/9/08	Semi-annual water levels
86	5349.90 FU	338783.81N 524027.65E	6774.20	401	STEEL 5"	FT. UNION 364 - 389	359	PIT 9	6532.49	9/18/90	Annual water levels and water quality samples
87R	11-08087R KFU	355296.30N 530051.97E	6803.40	228	PVC 5"	FT. UNION 212 - 228	207	PIT 11	6591.75	7/8/08	Semi-annual water levels
89	5661.94 FUA	304621.52N 516909.65E	6819.47	372	PVC 5"	FT. UNION 362 - 372	SAND PACKED	PIT 3	6629.34	4/94	Semi-annual water levels
90	5662.94 FUC	311979.40N 523173.11E	6639.68	230	PVC 5"	FT. UNION 210 - 230	SAND PACKED	PIT 3	6605.93	4/94	Semi-annual water levels and annual water quality samples.
91	5663.94 SP	313387.20N 520372.40E	6643.70	90	PVC 5"	RECL. SPOIL 20 - 90	SAND PACKED	PIT 3	6617.33	4/94	Quarterly water levels and semi-annual water quality.
93	5665.94 QAL	309308.90N 527769.40E	6641.00	80	PVC 5"	ALLUVIUM 20 - 80	SAND PACKED	UP-GRADIENT	6631.38	5/94	Monthly water levels and semi-annual water quality.
96	5668.94	316570.60N	6619.90	80	PVC	ALLUVIUM	SAND	DOWN-	6606.28	5/94	Semi-annual water levels

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	QAL	517530.90E			6"	20 - 80	PACKED	GRADIENT			
97	5669.94 QAL	318614.40N 514816.70E	6614.30	84	PVC 5"	ALLUVIUM 24 - 84	SAND PACKED	DOWN- GRADIENT	6592.53	5/94	Semi-annual water levels and semi-annual water quality
99	5671.94 QAL	326201.20N 512594.50E	6596.20	80	PVC 5"	ALLUVIUM 20 - 80	SAND PACKED	MID- GRADIENT	6569.25	5/94	Quarterly water levels and semi-annual water quality.
102	5674.94 QAL	334096.80N 512986.80E	6583.00	85	PVC 5"	ALLUVIUM 25 - 85	SAND PACKED	MID- GRADIENT	6541.81	5/94	Discontinue monitoring. Water has become very rusty with high dissolved & total iron.
104	5676 94 QAL	338146.80N 511828.00E	6574.90	85	PVC 6"	ALLUVIUM 25 - 85	SAND PACKED	DOWN- GRADIENT	6551.12	5/94	Quarterly water levels and semi-annual water quality.
105	5677 94 QAL	341510.70N 506108.40E	6563.30	89	PVC 5"	ALLUVIUM 29 - 89	SAND PACKED	DOWN- GRADIENT	6542.47	5/94	Monthly water levels and semi-annual water quality.
107	5679 94 QAL	329777.40N 512923.60E	6589.90	84	PVC 6"	ALLUVIUM 24 - 84	SAND PACKED	MID- GRADIENT	6555.55	5/94	Semi-annual water levels and semi-annual water quality
108	5680 94 FUBC	335550.70N 521314.10E	6697.10	320	PVC 5"	FT. UNION 287 - 313	SAND PACKED	PIT 2	6543.57	5/94	Annual water levels and annual water quality
109	5681 98 SPOIL	332862.96N 515114.88E	6601.31	202	PVC 5"	SPOIL 77 - 202	SAND PACKED	PIT 2	6538.89	4/98	Discontinued monitoring 2016
110	5682 98 SPOIL	335457.00N 516926.93E	6626.38	142	PVC 5"	SPOIL 82 - 142	SAND PACKED	PIT 2	6539.42	4/98	Annual water levels and annual water quality
111	AL	322520.75 N 506509.30 E	6696.80	255	PVC 4"	ALMOND 227 -247	SAND PACKED	PIT 8	6689.00	7/05	Semi-annual water levels and semi-annual water quality
112	FU U.B	355161.32 N 530015.17 E	6803.00	315	PVC 4"	FT. UNION 290-310	SAND PACKED	PIT 11	6727.10	7/05	Semi-annual water levels.
113	FU O.B	355215.61 N 530050.73 E	6802.90	175	PVC 4"	FT. UNION 150-170	SAND PACKED	PIT 11	6713.10	7/05	Semi-annual water levels.
RP-5B	Pit 5 Spoils	324234.49 N 519905.27 E	6729.21	190	PVC 4"	Pit 5 Spoils 145-183	134-183	Pit 5	140.50	10/9/2015	Quarterly water levels and water quality for the 1st year, then semi-annual water levels & water quality samples.
SW1-OB	SW1-OB AL	294997.4N 491019.2E	6987.70	150	PVC 4"	Overburden 125 - 145	115-120	Pit 14	6969.45	8/05	Semi-annual water levels and semi-annual water quality
SW01-0370	SW1-CZ AL	294963.3N 490992.5E	6991.85	252	PVC 4"	Coal Zone 197 - 252	178-192	Pit 14	6973.76	9/01	Semi-annual water levels and water quality samples.
SW1-UB	SW1-UB AL	295022.4N 491039.5E	6988.03	290	PVC 4"	Underburden 265-285	255-260	Pit 14	>6990.6 Flowing	8/05	Semi-annual water levels and water quality samples.
SW3-OB	SW3-OB	288369.20N	7051.30	82	PVC	Overburden	47-52	Pit 14	6998.2	8/05	Semi-annual water levels

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	AL	483387.90E			4"	55 - 77					and water quality samples.
SW3-CZ	AL Coal	288370.20N 483398.82E	7051.80	112	PVC 4"	Coal Zone 92 - 112	85-90	Pit 14	6969.8	8/05	Semi-annual water levels
SW3-UB	AL U.B.	288370.23N 483409.70E	7052.00	150	PVC 4"	Underburden 125 - 145	115-120	Pit 14	6999.6	8/05	Semi-annual water levels
SW4-OB	AL O.B.	304033.58N 496569.97E	6844.30	165	PVC 4"	Overburden 140 - 160	130-135	Pit 14	FLOWING	8/05	Semi-annual water levels
SW4-CZ	AL Coal	304044.15N 496565.12E	6844.30	250	PVC 4"	Coal Zone 185 - 245	175-180	Pit 14	FLOWING	8/05	Semi-annual water levels
SW4-UB	AL U.B.	304055.70N 496557.85E	6844.00	300	PVC 4"	Underburden 270-290	260-265	Pit 14	FLOWING	8/05	Semi-annual water levels
WATER SUPPLY	WB01 75 ERIC	332073.00N 517596.00E	6600.00	1219	STEEL	ERICSON 930 - 1219	---	---		4/75	Semi-annual water levels (Head) Facilities Supply Bluebell #13 well. See Footnote***
P10MW1 UB	FU Underburden	348271.41N 534950.23E	6946.56	500	PVC 4"	Underburden 475 - 495	470- 495	PIT 10	248.54	9/24/2014	Semi-annual water levels and water quality samples
P10MW1 CZ	FU Coal Zone	348261.87N 534946.57E	6946.82	451	PVC 4"	Coal Zone 411 - 451	405- 451	PIT 10	390.5	10/2/2014	Semi-annual water levels and water quality samples
P10MW1 OB	FU Overburden	348252.26N 534943.22E	6946.78	365	PVC 4"	Overburden 325 - 365	320- 365	PIT 10	214.53	10/5/2014	Semi-annual water levels and water quality samples
P15MW1 UB	FU Underburden	355466.42N 536114.65E	6847.11	339	PVC 4"	Underburden 319-339	313.5- 339	PIT 15	118.88	01/26/15	Semi-annual water levels and water quality samples
P15MW1 CZ	FU Coal Zone	355472.30N 536122.50E	6847.18	296	PVC 4"	Coal Zone 256-296	251- 296	PIT 15	114.04	01/26/15	Semi-annual water levels and water quality samples
P15MW1 OB	FU Overburden	355478.46N 536130.40E	6847.56	184	PVC 4"	Overburden 144-184	138.5 184	PIT 15	75.96	01/26/15	Semi-annual water levels and water quality samples

Footnotes: * Wells 1, 2, 4 & 5 are not presently monitored. Annual water level monitoring will be resumed 1 year prior to any mining activities in Pit 7, 12 or 13.
** Well 65 is currently dry. Potentiometric water levels are expected to rise upon completion of backfill. At that time, semi-annual water level and water quality monitoring will resume.
*** Pressure guage on wellhead, convert to head (2.31' per lb psi)

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also included in the Hydrology section of Black Butte Coal Company's Annual Reports to the WDEQ/LQD. A detailed discussion of the on-going modifications that are made to the monitoring network as mining progresses is also outlined in the Hydrology section of the mine's Annual Reports.

The monitoring well network is in constant revision as mining progresses. Monitor wells are inevitably removed by mine advancement and new wells are installed as replacements, or for additional information. Whenever possible, a new well installed as a replacement for a well that will be removed by mining will be constructed at least one year prior to destruction of the original monitor well so that there is overlap of monitoring data. Circumstances beyond the control of Black Butte Mine, such as the availability of well drilling contractors and field conditions, may sometimes result in there not being a full year of monitoring overlap between a new well and the well being replaced.

Table D6-1 has been updated to lists those wells that were in the baseline monitoring network, inclusive of the Pit 15 amendment area revision of 2018. Exhibit MP-50 has been updated to show all current (2018) monitor well locations, and most wells that have been mined through or otherwise deleted from monitoring. As mining and backfilling proceed, spoil wells will continue to be installed as part of the active monitoring network. Tables MP-23, MP-24 and Exhibit MP-50 have been updated (2018) and will be kept updated to reflect the most current monitoring network. The tables will be updated via major permit revisions submitted for Mine Plan or Reclamation Plan changes. Table MP-24 lists all mining-related wells that have ever existed at Black Butte Mine. Wells listed on Table MP-24 that are not found on Exhibit MP-50 may be found on exhibits of the historic Appendix D6.

Postmining groundwater and surface water monitoring plans, inclusive of the placement and monitoring of backfill (spoil) wells, are described in the Reclamation Plan under section *Hydrologic Restoration*, subsection *Post Mining Monitoring Plan.*

New monitor wells constructed in native strata will be monitored for four consecutive quarters, and thereafter, on a semi-annual or lesser basis. The monitoring may or may not include sampling for chemical analyses, depending upon the location of each well and the database of historic groundwater quality data proximate to the well. All groundwater samples will be analyzed for the same constituent suite reported for the Pit 14 monitor wells in

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Table MP-24 Well Inventory During Mining

Well ID. [1]	Formation	Monitored Pit No.	Projected or Actual Installation Year	Projected or Actual Year Mined Out [2]
1	Lance	7	1974	UNK
2	Lance	13	1974	UNK
3***	Alluvium/Lance	Down-Gradient 12	1974	-
4	Lance	12	1974	-
5	Lance	7	1974	UNK
6	Fort Union	9	1974	1987
7	Fort Union	10	1974	1994
8	Almond	8	1974	2003
9	Fort Union	4	1974	-
10***	B.C. Alluvium	Up-Gradient 3	1974	-
11	Fort Union	3	1974	1984
12***	Fort Union	3	1974	-
13	Lance	6	1974	1985
14***	B.C. Alluvium	Near Pit 8	1975	-
15	Fort Union	2	1975	1980
16	Lance	5	1975	1983
17	Almond	8	1975	1991
18	Fort Union	2	1978	1984
19	Fort Union	2	1978	1984
20	Fort Union	2	1978	1984
21**	Lance	5	1978	-
22	Lance	5	1978	-
23	Fort Union	2	1974	1984
24	Lance	5	1974	-
25	Fort Union	11	1975	1979
26	Fort Union	3	1980	1984
27	Fort Union	3	1980	1983
28	Fort Union	3	1980	1983
29	B.C. Alluvium	3	1980	-
30	B.C. Alluvium	3	1980	-
31	B.C. Alluvium	3	1980	-
32	Lance	5S	1980	-
33	Lance	5S	1980	-
34**	—	—	1980	1980
35	Lance	5	1980	-
36	Lance	5	1980	1982
37	Fort Union	3	1980	-
38	B.C. Alluvium	3	1980	-
39	Fort Union	3	1980	-
40	Fort Union	3	1980	-
41	B.C. Alluvium	3	1980	-
42	B.C. Alluvium	3	1980	-
43	Fort Union	3	1980	1990
44	Fort Union	3	1980	1985
45	Fort Union	3	1980	1984
46	B.C. Alluvium	3	1980	-
47	B.C. Alluvium	3	1980	-
48	B.C. Alluvium	3	1980	-
49	B.C. Alluvium	3	1980	-
50	B.C. Alluvium	3	1980	-
51	B.C. Alluvium	3	1980	-
52	B.C. Alluvium	3	1980	-
53	Fort Union	4S	1980	-
54	Fort Union	4S	1980	-
55	Fort Union	3	1980	-
56	Lance	5S	1980	-
57	Lance	5S	1980	-
58	Fort Union	3	1980	-
59	Fort Union	3	1980	1984
60	Fort Union	3	1980	1983
61	Fort Union	3	1980	1984
62	Fort Union	3	1980	1984
63	Fort Union	3	1980	1984
64	Almond	8	1980	1992
65	Fort Union	10	1981	-
66	Lance	5S	1981	-
67	Lance	6	1981	-
68	Lance	6	1981	-
69	Fort Union	10	1981	2002
70	Almond	8	1982	-
71	Almond	8	1982	-
72	Almond	8	1982	-
73	B.C. Alluvium	Near Pit 2	1985	-
74	B.C. Alluvium	Near Pit 2	1985	-
75	Fort Union	3	1986	-
76	Fort Union	3	1986	-
77	Fort Union	2	1983	1992

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Table MP-24 Well Inventory During Mining

Well ID. [1]	Formation	Monitored Pit No.	Projected or Actual Installation Year	Projected or Actual Year Mined Out [2]
78	Red. Spoils	2	1986	1992
79	Recl. Spoils	2	1986	1995
80	Fort Union	4	1983	1988
81	Fort Union	10	1986	2026
82	Recl. Spoils	2	1987	1994
83	Recl. Spoiis	2	1987	1995
84	Recl. Spoils	2	1987	1995
85	Fort Union	11	1990	2011
86	Fort Union	9	1990	-
87	Fort Union	11	1991	2009
88	Recl. Spoils	5	1993	-
89	Fort Union	3	1994	-
90	Fort Union	3	1994	-
91	Recl. Spoils	3	1994	-
92	Recl. Spoils	3	1994	-
93	B.C. Alluvium	Up-Gradient 3	1994	-
94	B.C. Alluvium	Up-Gradient 3	1994	-
95	B.C. Alluvium	Down-Gradient 3	1994	-
96	B.C. Alluvium	Down-Gradient 3	1994	-
97	B.C. Alluvium	Down-Gradient 3	1994	-
98	B.C. Alluvium	Near Pit 8	1994	-
99	B.C. Alluvium	Near Pit 8	1994	-
100	B.C. Alluvium	Up-Gradient 2	1994	-
101	B.C. Alluvium	Near Pit 2	1994	-
102**	B.C. Alluvium	Near Pit 2	1994	-
103	B.C. Aliuvium	Down-Gradient 2	1994	-
104	B.C. Aliuvium	Down-Gradient 2	1994	-
105	B.C. Alluvium	Down-Strm. Mining	1994	-
106	B.C. Alluvium	Near Pit 2	1994	-
107	B.C. Alluvium	Up-Gradient 2	1994	-
108	Fort Union	2	1994	-
109	Recl. Spoils	2	1998	-
110	Recl. Spoils	2	1998	-
111	Almond	8	2005	-
112	Fort Union	11	2005	-
113	Fort Union	11	2005	-
114	Fort Union (Dewater)	11	2006	2007
115	Fort Union (Dewater)	11	2006	2007
116	Fort Union (Dewater)	11	2006	2007
117	Fort Union (Dewater)	11	2006	2007
Bluebell #13	Ericson	None	1975	-
C. Simpson #1	Ericson	None	1962	-
Darter #1	Ericson	None	1979	-
Darter #2	Ericson	None	1979	-
Squawfish #1	Ericson	None	1985	-
Squawfish #2	Ericson	None	1985	-
Red Hill #1	Fort Union (Dewater)	11	1991	-
Red Hill #2	Fort Union (Dewater)	11	1991	-
SW1-OB	Almond	14	2005	2023
SW1-CZ	Almond	14	2001	2023
SW1-UB	Almond	14	2005	2023
SW2	Almond	14	2001	-
SW3-OB	Almond	14	2005	-
SW3-CZ	Almond	14	2005	-
SW3-UB	Almond	14	2005	-
SW4-OB	Almond	14	2005	-
SW4-CZ	Almond	14	2005	-
SW4-UB	Almond	14	2005	-
P10MW1 UB	Fort Union	10	2014	-
P10MW1 CZ	Fort Union	10	2014	-
P10MW1 OB	Fort Union	10	2014	-
P15MW1 UB	Fort Union	15	2014	-
P15MW1 CZ	Fort Union	15	2014	-
P15MW1 OB	Fort Union	15	2014	-

NOTES:

1) ** Wells abandoned because of casing failures or similar problems
*** Wells dropped from monitoring due to poor completion
2) UNK indicates that the mine plan and future status of well are uncertain.
A dash indicates that no mine disturbance is anticipated at the well.

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Addendum D6-G of Appendix D6. This suite includes all criteria listed for determining classes of use in Chapter 8, Table 1, of WDEQ/WQD Rules and Regulations (2015) except for the constituents beryllium, cobalt, cyanide, hydrogen sulfide, lithium, oil and grease, phenol, silver, vanadium, and radionuclides. Groundwater depths/elevations will be monitored during each sampling event.

Mining Activities have not been initiated at proposed pits (Pits 7, 12 and 13) and Pit 4 has had and is scheduled to have (Table RP-8 of Reclamation Plan) relatively little groundwater monitoring because it has not intercepted groundwater. Four Lance Formation wells (Nos. 1, 2, 4 and 5) were monitored in the areas of proposed Pits 7, 12 and 13. Groundwater conditions in the Lance in these three proposed pit areas, inclusive of the saturation boundaries shown on Exhibit MP-5b, are only approximately understood. Groundwater monitoring would be initiated in these existing wells and in new wells planned in consultation with WDEQ/LQD at least one year prior to initiation of activities at Pits 7, 12 or 13. Monitoring existing and new wells constructed for Pits 7, 12 and 13 would follow criteria set forth above for "new wells,, except that each well would also be sampled quarterly, following practices normally applied in baseline (premining) groundwater investigations.

Surface water monitoring during mining will follow the same schedule as provided in the Hydrology section of the mine's Annual Reports. The monitoring plan for Bitter Creek was changed in 2019 per recommendation of Mr. Matt Kunze, LQD (memorandum from Matt Kunze to Gwen Robson, District 2; CHIA 42 File; October 9, 2018). Specifically, water quality samples and discharge measurements will continue to be taken at Bitter Creek monitoring sites SBC1-75 and SBC2-75 on a monthly basis during the ice-free period, which is typically March through October. No surface water installations will be disrupted by mining activity. The monthly monitoring of Bitter Creek will include collection of staff gage readings for instantaneous flow measurements, and recording of crest gage readings for computation of peak flow rates. The monthly monitoring will also include collecting grab samples from sites SBC1 and SBC2 when there is stream flow at the time of monitoring, with the samples analyzed for total suspended solids and total dissolved solids. On a semi-annual basis, the grab samples will be analyzed for the constituents recommended in Appendix 7, LQD Guideline No. 8 Hydrology (May 2015). Surface water monitoring efforts will continue until Black Butte Coal Company has demonstrated that a disturbed area which has been reclaimed is "hydrologically stable,,.

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will imply that the replaced channel does not easily erode causing "knick points" or "head cutting" unless desirable, and that, where deemed necessary, vegetation covers the sides of the channels.

Impacts of Mining on Water Resources

The impacts of mining in the Bitter Creek watershed should generally be comparable to those experienced at similar operations in other areas of the arid western coal-mining region, at least in kind if not degree. These probable hydrologic impacts during mining would include: removal of parts of aquifers and/or water-bearing strata causing changes in groundwater levels and supplies, interruption or redirection of pre-mining groundwater flow by replaced spoil materials, changes in groundwater quality caused by leaching of fresh mineral surfaces exposed in backfilled spoil material, effects of blasting (i.e., increased fracturing and permeability), and changes in surface water quantity and quality where any natural drainages are disturbed.

The following discussion on the impacts that mining has had on the groundwater regime is based on historic monitoring information recorded through calendar year 2005, and updated for the Fort Union formation in the areas of Pits 10, 11 and 15 through 2018. Areas are identified within and adjacent to the mine that are projected to experience five feet or more of potentiometric decline as a result of pit developments throughout the life of the mine. Black Butte Mine will continue to submit Annual Hydrology Reports to WDEQ/LQD providing updated monitoring information and interpretative analyses.

Groundwater Regime

Mining operations at Black Butte impact the local groundwater regime by the unavoidable removal of portions of certain aquifers or water-bearing strata within the pit areas, thus interrupting or altering the premining groundwater levels, flow patterns and availability. Changes to the premining groundwater quality can also be caused by the resaturation and leaching of the replaced spoil materials. Formations affected include the Fort Union, Lance, Almond and small sections of Bitter Creek-Quaternary alluvium. The approximate aerial extent of water-bearing strata within each formation that will be subjected to five feet or more of potentiometric decline is summarized below, based on developments presented in following text sections:

Formation	Area Subject To 5 Feet Or More Drawdown (mi^2)
Fort Union	17.9
Lance	12.4
Almond	14.7
Alluvium	<1.0

In defining the relative importance of a water-bearing strata as an aquifer (defined as "a zone, stratum or group of stratum that can store and transmit water in sufficient quantities for a specific use") in the general area, consideration must be given to the aerial extent of the lithologic zone. Consideration must also be given to water quality when defining the

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importance of a water-bearing strata as an aquifer. The premining water quality characteristics of the water-bearing formations in the general mine area are discussed in Appendix D6. In general, the premining quality of groundwater sampled from the affected water-bearing strata was of poor quality; having high concentrations of chemical constituents and typically unsuitable for domestic and agricultural uses. Some groundwater, especially that of the Bitter Creek alluvial wells, was identified as being unsuitable for livestock use. Changes observed during mining in groundwater quality are considered insignificant if the water's use suitability (i.e. stock watering) is not detrimentally affected. The coal seams within the Fort Union, Lance and Almond Formations and the Bitter Creek alluvium are the only lithologic units which are large in areal extent. The discontinuous water-bearing sandstones lenses that are present primarily in the Fort Union Formation can not be defined as regional aquifers and have only very localized hydrologic significance.

The groundwater inflow estimation tables (MP-20 through MP-22) and text section *Estimated Groundwater Inflow Rates At Pit 14* address which pits intercept groundwater, the predicted inflow rates and the respective formations mined at each pit. Groundwater levels can be expected to decline in the vicinity of each pit as pits are opened and the surrounding aquifer or water-bearing strata is dewatered by pit drainage. Following replacement of the spoil material, the original hydraulic gradient should be essentially reestablished and groundwater levels should return to approximately the premining state.

Fault Control On Groundwater Movement And Drawdown

In 1991 Black Butte Coal undertook a well drilling and aquifer testing program specifically for the purpose of determining groundwater availability along the Pit 11 south boundary fault in Section 11, T19N, R100W. The information obtained from this program identified not only the source and quantity of groundwater available to production wells but also the influence of the boundary fault on local groundwater movement.

The program began with the drilling of Red Hill wells Nos. 1 and 2 along the north (downthrown) side of the fault and monitor well No. 87 along the south (upthrown) side of the fault. Monitor well No. 85, lying about 1150 feet east of Red Hill No. 2 and about 674 feet east of Red Hill well No. 1, had already been constructed the year before and was available for aquifer testing purposes. Well 85 monitors potentiometric elevations in Fort Union coal. The locations of the wells and the surface trace of the fault plane are shown on Exhibit MP-

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5a, whose development is described more fully in following sections of this text. All three wells intercepted thick, friable sandstone units having large groundwater yields and the two Red Hill wells also intercepted coal seams up to about 26 feet thick. Red Hill well No. 1 was constructed to a depth of 170 feet and fitted with 40 feet of 8-inch diameter well screen. Red Hill well No. 2 was constructed to a depth of 190 feet and also fitted with 40 feet of 8-inch diameter well screen. Observation well No. 87 was constructed with 5-inch diameter casing to 180 feet with mill-slotted perforations from 100 to 160 feet below ground surface. Each of the Red Hill wells were air lifting over 300 gpm groundwater during development.

A step-drawdown test was performed on August 10, 1991 using Red Hill well No. 2 as the pumping well. Total pumping time was 810 minutes and the test was conducted with four pumping rates ranging from 44 to 90 gpm. At the end of pumping there was 47.2 feet of drawdown at the pumped well, 2.46 feet of drawdown at Red Hill No. 1 (472 feet from pump well) and 1.52 feet of drawdown at No. 85 (1,150 feet from pump well), all three wells being on the downthrown side of the fault. There was no drawdown at monitor well No. 87 on the south side of the fault 479 feet away from the pumping well. The groundwater did not recover to pretest elevations in a reasonable time period after the step-drawdown test, indicating that the aquifer is affected by a local barrier boundary.

A constant discharge test was initiated on August 11, 1991 with the objective of determining the aquifer's hydraulic coefficients and to confirm the hydrologic significance of the Pit 11 south boundary fault. Red Hill No. 1 well was pumped for 24 hours (1,440 minutes) at an average rate of 75.3 gpm. The pumping well experienced 64.5 feet of drawdown and was computed to be only 19 percent efficient. Constructed with efficient well screen packed with uniform, silica sand, the well's low efficiency was surprising and was credited to the well's proximity to the impermeable fault plane. The results of the aquifer test are summarized below.

Pump Well No.	Obs. Well No.	Distance From Pump Well (Ft),	Maximum Drawdown (Ft)	Specific Capacity (gpm/ft)	Transmissivity (gpm/ft)	Storage Coefficient
Red Hill #1	Pump Well	0	64.53	1.1	3,582	-
Red Hill #1	Red Hill #2	472	2.58	-	15,372	0.00036
Red Hill #1	Well No. 85	674	1.43	-	6,478	0.00160
Red Hill #1	Well No. 87	253	0	-	-	-

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The low storage coefficient of the aquifer was also unexpected because the stratigraphy penetrated by the wells does not contain an impervious confining layer. The low storativity was also ascribed to the proximity of the wells to the fault plane flow boundary.

A water quality sample was collected from Red Hill #1 well about 23 hours after the pump test began. The sample was collected for the purpose of determining whether or not groundwater might be ascending along the fault plane from deep sources in the Ericson formation. The potential for groundwater ascending into the Pit 11 area could have grave implications on the mine engineering. The results of the water analysis were, very typical of groundwater from the Fort Union formation. The principal solutes were sodium, bicarbonate and sulfate, the SAR was over 30 and the calcium and magnesium concentrations were low. Conversely, groundwater from the Ericson formation is enriched in calcium and sulfate and total dissolved solids concentrations are relatively low (500 to 1,000 mg/l).

The results of the aquifer pump test conducted on the Pit 11 south boundary fault clearly indicate that there is no potential for groundwater in strata that will be mined in Pits 10 and 11 to locally move across the fault plane. It is interesting to note that this particular fault does not cause a large lateral displacement of the Lance-Fort Union contact, as is shown southwest and west of Pit 11 on Exhibit MP-5a. This suggests that the fault's vertical displacement is small relative to other faults at Black Butte that cause large lateral displacements in geologic contacts. Based on these facts it is concluded that groundwater movement in all bedrock units at Black Butte Mine is parallel to and not across fault planes that strike through the mine permit area. All faults mapped as beginning in structurally elevated terrain west of Black Butte and striking through the mine into structurally lower areas east of the mine all appear to have vertical displacements at least as great or greater than the Pit 11 south boundary fault. Very likely, those faults mapped as being continuous through the mine act as nearly impermeable barrier boundaries to potential groundwater movement (and mining induced drawdown) across the fault planes. Potentiometric drawdown caused by mining the Fort Union, Lance and Almond formations at Black Butte will be confined within the fault blocks that are defined by the fault planes and will be most evident downdip (east and northeast) of operating mine pits.

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Potentiometric Declines Through Years 2005 and 2018 With Projections For Life-Of-Mine

Historic water level data from wells monitored in the Fort Union formation through year 2018 and monitored in the Lance and Almond formations through year 2005 were compiled for the purposes of evaluating distance (from mine pits) versus drawdown trends in each formation. With the exception of Almond formation well No. 8, data from monitoring wells that have been mined through or otherwise destroyed, while examined, were not included in this trend analysis under the logic that their recorded maximum drawdown would be less descriptive of final, steady-state drawdown distant from ultimate pit limits than are data from long-term wells that were monitored until either after mining in the area ceased or drawdown stabilized and head recovery began. Also excluded from the analysis are wells that have exhibited erratic groundwater level trends that are not clearly related to mining, some wells that have not been monitored for extended periods of time, and wells that have gone dry due to being positioned very near mine pits. In two cases where monitoring ceased (in 1985 at wells Nos. 53 and 54 located near Pit 3), recorded drawdown data were used in the distance-versus-drawdown analysis because the data shows stabilization and some recovery of heads over a year before monitoring ceased. The objective in the trend analysis was to determine distance-versus-drawdown trends using data from wells having reliable records as a means of projecting the ultimate extent of steady-state, five-foot drawdown away from reclaimed, idle and future mine pits in each respective formation.

Potentiometric drawdown compiled for wells monitored through years 2005 and 2018 are shown on Table MP 24c. The Fort Union formation is represented by 28 wells having up to 38 years of record. This includes wells having data that were examined, but for the reasons given above, not used for the drawdown-versus-distance graphical analysis described below. Potentiometric data for the Lance and Almond formations are available from monitoring wells having up to 31 years of data. Drawdown shown on table MP-24c for all three formations are considered conservatively large in that they were typically computed as the difference between the earliest or near earliest water level elevation at each site and the minimum water elevation subsequently recorded. In some cases, the potentiometric elevations increased substantially during times while mine pits proximate to wells were being developed, probably as a result of methane gas buoyancy in the well water columns but also potentially as a result of runoff water collected on pit floors acting as recharge sources for down-gradient wells. A number of factors were considered in evaluating and, in some cases selecting, the numerical drawdown values shown on Table MP 24c. These factors include: the position and age of each well with respect to active mine pits in the same respective formation; the position of each well with respect to potential hydrologic barriers such as structural faults, formation contacts and identified saturation boundaries; the position of each well with respect to potential recharge boundaries such as saturated alluvium of Bitter Creek; evidence of potentiometric changes being influence by methane gas and/or recharge caused by water collected on pit floors, and; the depth of each well relative to the approximate thickness of the respective formation and the depth of mining in the formation. The results of these analyses and the distance-versus-drawdown trends thus determined are explained more fully below for each geologic formation.

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Table MP-24c **Groundwater Drawdown Data For Fort Union, Lance And Almond Formations At Black Butte Mine**

Well No.	Initial SWL (Ft MSL)	(1) Initial SWL Date	Max. Drawdown SWL (Ft MSL)	Max. Drawdown SWL Date	Max. Drawdown (Ft)	(2) Approx. Distance From Mining At Pit No. (Ft)	(3)	(4) Ratio Drawdown/ Distance	(5) Monitor Well Data Years
FORT UNION FORMATION									
9	6589.5	Dec-74			0	1100	4	0.000	44
37	6623.9	Dec-80	6618.2	Sep-09	5.7	400	3	0.014	38
39	6611.8	Dec-80	6606.6	Sep-06	5.2	1200	3	0.004	38
40	6623.8	Dec-80	6615.1	Sep-08	8.7	100	3	0.087	38
53	6624.2	Feb-81	6620.5	Mar-84	3.7	4450	3	0.001	
54	6622.7	Dec-80	6619.9	Mar-84	2.8	4900	3	0.001	
55	6623.1	Dec-80	6619.3	Sep-08	3.8	5670	3	0.001	35
58	6624.4	Feb-81	6614.6	Sep-09	9.8	300	3	0.033	38
65	6793.7	Sep-81	6755.1	Jun-08	38.6	300	10	0.129	27
69 *	6762.8	Jul-81	6715.6	May-02	47.2	10	10	4.724	20
75	6660.0	From Ex.D6-4	6582.2	Jul-94	77.8	1500	3	0.052	32
76	6755.9	Dec-86	6746.4	Apr-92	9.5	1800	3	0.005	32
81	6736.7	May-87	6711.7	Aug-18	25.0	2200	10	0.011	31
85	6708.2	Jun-91	6667.6	May-09	40.6	1800	11	0.023	18
85R	6721.8	Sep-08	6666.7	Aug-18	55.1	1000	11	0.055	10
86	6600.0	From Ex.D6-4	6530.2	Jan-94	69.8	900	9	0.078	27
87	6727.4	Oct-91	6726.5	May-09	0.9 (6)	2700	10	0.000	18
87R	6609.6	Sep-08	6609.6	Sep-08	0	1100	11	0.000	10
89	6695.0	From Ex.D6-4	6629.4	May-94	65.6	1600	3	0.041	24
90	6610.0	From Ex.D6-4	6606.0	May-94	4.0	1350	3	0.003	24
108	6585.0	From Ex.D6-4	6543.6	May-94	41.4	2300	2	0.018	24
112	6726.8	Aug-05	6640.7	May-18	86.1	900	11	0.096	13
113	6712.8	Aug-05	6645.9	May-18	66.9	1000	11	0.067	13
P10MW1_OB	6733.0	Jan-15	6709.8	Aug-18	23.2	1750	10	0.013	3
P10MW1_CZ	6665.1	Jan-15	6637.7	Aug-18	27.4	1750	10	0.016	3
P10MW1_UB	6716.3	Jan-15	6621.0	Aug-18	95.4	1750	10	0.054	3
P15MW1_OB	6774.1	Jan-15	6772.9	Aug-18	1.2	3450	Fault Zone (7)	0.000	3
P15MW1_CZ	6735.6	Jan-15	6732.3	Aug-18	3.4	3800	Fault Zone (7)	0.001	3
P15MW1_UB	6730.7	Jan-15	6727.8	Aug-18	3.0	3800	Fault Zone (7)	0.001	3
								SUM	572
LANCE FORMATION									
1	6757.6	Dec-74			0.0	15000	5	0.000	31
2	6748.4	Dec-74			0.0	22000	5	0.000	31
4	6646.0	Jan-75	6604.3	Sep 05	41.7	4300	2	0.010	31
5	Dry	Feb-81	Dry		0.0	3300	1	0.000	24
21	6749.7	Jun-78	6677.4	Sep-02	72.3	880	5	0.082	27
22	6640.8	Feb-81	6617.7	Sep-02	23.1	1430	5	0.016	27
24	6619.7	Dec-74	6610.7	May-02	9.0	1210	5	0.007	31
33	6616.7	Feb-81	6610.6	Sep-87	6.1	4000	5	0.002	24
35	6621.6	Feb-81	6616.1	Apr-92	5.5	990	5	0.006	24
56	6605.2	Feb-81	6600.6	Mar-83	4.6	4870	5	0.001	25
57	6596.0	Feb-81	6590.1	Aug-84	5.9	4600	5	0.001	24
66	6604.5	Jul-81	6600.0	Jun-84	4.5	2130	5	0.002	24
67	6810.0	Jul-81	6788.3	May-91	21.7	2100	6	0.010	24
68	6645.3	Sep-81	6642.8	May-91	2.5	3300	6	0.001	24
								SUM	371
ALMOND FORMATION									
8 *	6734.8	Dec-74	6677	Apr-03	57.8	10	8	5.780	28
71	6661.5	Jun-82	6576.4	Sep-05	85.1	1100	8	0.000	23
72	6757.7	Aug-82	6744.3	Sep-03	13.4	1520	8	0.009	23
111	6689.0	Sep-05	First monitored September 2005			1250	8	--	
								SUM	74

Notes:

1) Wells Nos. 75, 86, 89, 90 and 108 were constructed relatively late in the history of adjacent mine pits after potentiometric elevations had potentially declined. For this reason initial (premining) water elevations at these sites were taken from Exhibit D6-4. Wells numbers having an asterisk (*) were removed by mining in years 2002 or 2003.

2,3) Distance from well to mine pit responsible for drawdown read as "Approximate Distance From Mining At Pit No. (Ft)". Distances were arbitrarily set at 10 feet for wells that have been mined through.

4) Linearized drawdown per foot distance from mine pit. These values are only a gross representation of distance versus drawdown because the relationship is exponential and not linear.

5) Time interval between first and most recent monitoring dates inclusive of periods of missing data. The monitoring data used in this table is updated through third quarter 2005 for the Almond and Lance Formations, and through third quarter 2018 for the Fort Union Formation.

6) The water level has recovered to above the initial SWL subsequent to September 2006.

7) Distance measured parallel and north of Pit 15 South Fault from well to east boundary of zero overburden or coal saturation believed caused by Pit 10 dewatering shown on Exhibit D6-H-3 of Addendum D6-H.

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Fort Union Formation

Drawdown in the Fort Union formation on Table MP 24c ranges from zero feet to about 95 feet around active mine pits through year 2018. The water level in well No. 9, located east of Pit 4 but separated from the pit by the formation's zero saturation boundary, has risen nearly 100 feet over its history, probably as a result of methane gas buoyancy, mine pit ponding or settling pond recharge, or all three. Potentiometric elevations in well No. 65 near Pit 10 rose from late 1983 to mid-2002 probably as a result of gas buoyancy, but then declined thereafter and the well became dry in 2008. Well No. 85, once located east of Pit 11 before being mined out in 2011 and within the same fault block as Pit 11, began showing head declines in September 2006 as a result of groundwater first being pumped from Pit 11 and from adjacent dewatering wells that began operating that same month. Located about 770 feet southwest of well 85, well No. 87, positioned just south of the Pit 11 boundary fault and less than 1500 feet from Pit 11 when the well was last measured in 2009, experienced essentially no head changes after Pit 11 opened. Well 87 was destroyed in 2011. The profound differences in head responses between wells 85 and 87 is evidence of the effect of the Pit 11 fault acting as a barrier to groundwater flow and drawdown between Pits 10 and 11, and with future Pit 15 mining, between Pit 15 and Pit 11.

Wells Nos. 53, 54 and 55, located across Bitter Creek valley floor from Pit 3 and separated from Pit 4 by the formation's saturation boundary, has experienced minor drawdown believed to be caused by Pit 3 partially dewatering alluvium of Bitter Creek. Drawdown in Bitter Creek alluvium near Pit 3 and the projected rate of water table recovery are examined in the Reclamation Plan under section *Projected Rate Of Recovery For Water Table In Alluvium Near Pit 3*. Wells 75, 86, 89, 90 and 108 on Table MP 24C were all constructed relatively late in the history of the adjacent mine pits and the initial potentiometric elevations used for computing drawdown at these sites were taken from historic permit Exhibit D6-4 of Appendix D6. The accuracy of the initial groundwater elevations taken from Exhibit D6-4 for these five wells cannot be verified by reference to actual groundwater depth measurements. Exhibit D6-4 does not include potentiometric elevation contours for the Pit 15/Pit 10 South amendment area; consequently six Fort Union monitor wells were constructed within the amendment area in early 2015 (see Addendum D6-H). Although methane gas buoyancy affected groundwater elevations at some wells during initial developments of proximate mine pits, such as at wells Nos. 21, 22 and 68 in the Lance Formation, gas buoyancy effects have not been detected through 2018 at the six wells constructed for the Pit 15/Pit 10 South amendment.

On Figure MP- 17g, most Fort Union monitor well drawdown values shown on Table MP 24c meeting the criteria described above are plotted against well distances from actual pits excavations. For wells P15MW1_Ob, P15MW1_CZ and P15MW1_UB, drawdown is plotted against the distance measured parallel along the Pit 15 South Fault from each well to the boundary of saturation drawn for coal and overburden aquifer zones on Exhibit D6-H-3 of Addendum D6-H. As explained in Addendum D6-H, the boundaries of

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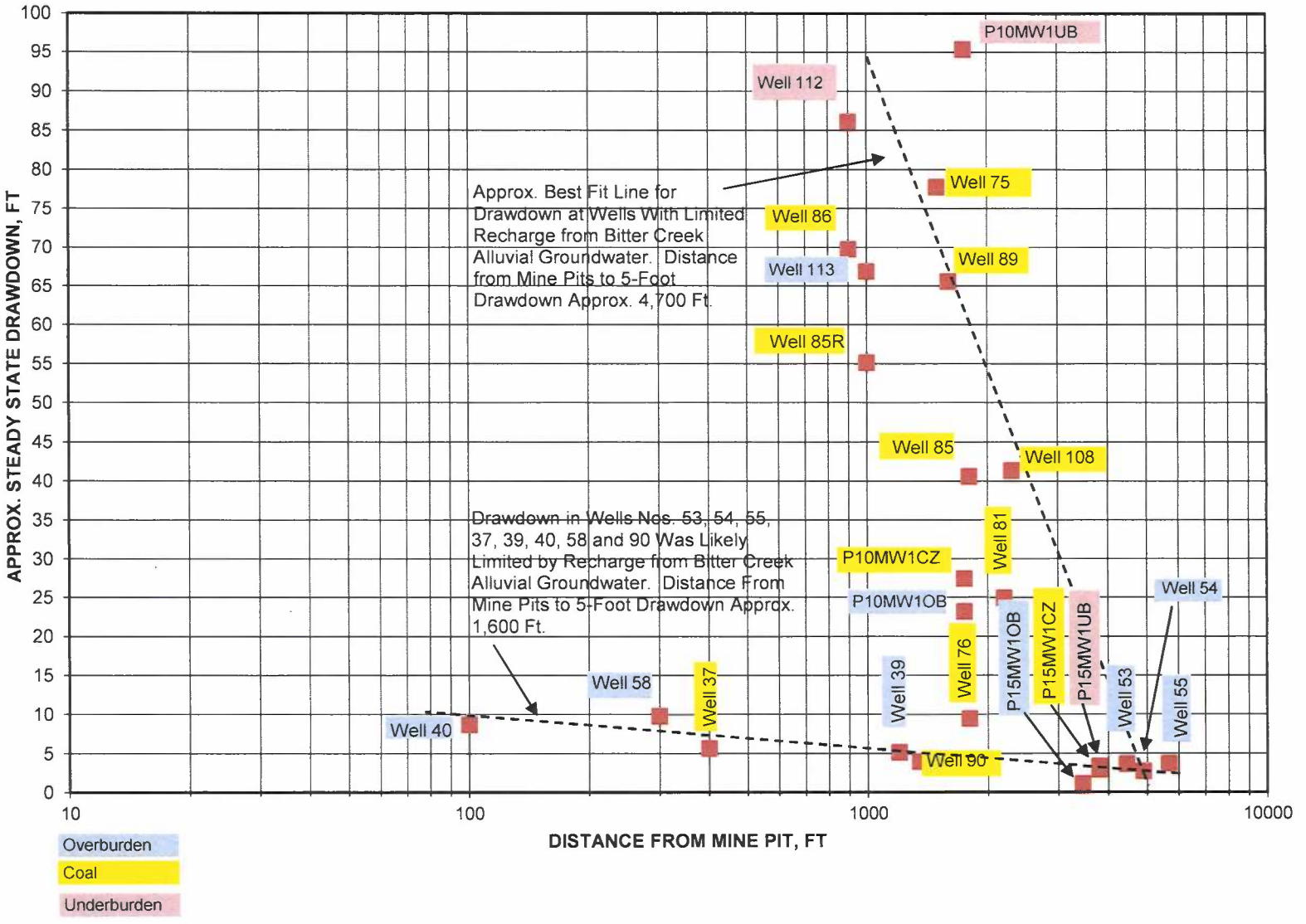
Figure MP-17g HISTORIC DRAWDOWN IN FORT UNION WELLS AT BLACK BUTTE MINE



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zero saturation in the overburden and coal sequence strata found in the Pit 15 area baseline groundwater study are believed to be strongly influenced by drawdown caused by Pit 10 dewatering. Figure MP-17g is the same type of semilog plot used for determining aquifer hydraulic coefficients in a multiwell aquifer test where observation well distances from a pumping well are plotted against their respective drawdown.

Figure MP-17g displays two best-fit drawdown-versus-distance trends; one for wells where drawdown was buffered or contained by recharge from Bitter Creek alluvial groundwater recharge, and one for wells exhibiting little influence of alluvial recharge. Figure MP-17g has been updated for the Pit 15/Pit 10 South amendment using groundwater monitoring records as recent as 2018. The trend drawn on the figure for the alluvial recharge influence depicts a distance from mine pits to 5-foot final, steady-state drawdown of about 1,600 feet. The trend line for aquifer conditions exhibiting negligible Bitter Creek alluvial recharge shows a distance between mine pits and 5-foot drawdown limit of approximately 4,700 feet. The distances from mine pits from where the two best fit lines of Figure MP-17g intercept the five-foot drawdown gridline were initially used for mapping the projected extent of five feet and greater drawdown for the life of Black Butte's mining in the Fort Union formation. The smaller distance-versus-drawdown value (1,600 feet) was used for portions of Pits 2, 3 and 4. The larger distance-versus-drawdown value (4,700 feet) was used for Pits 1, 9 and for areas south of Pit 3, and Pits 10, 11 and 15. Drawdown that will occur from Pit 10 and Pit 15 mining alone was not extrapolated across the Pit 11 boundary fault because the fault acts as an effective barrier to groundwater movement.

Coal faces exposed in the final open pits were mined by Black Butte Coal with a long wall machine, essentially a form of tunneling, in Pit 3 and in Pit 8 (Almond). The processes is explained in Section *Auger and Highwall Mining*. Additional auger mining may take place in a southern segment of Pit 3, and there is a high probability that auger mining will be undertaken within segments of the Pit 10 highwall and along a southeastern length of Pit 15 highwall. The hydrologic implications of the long wall mining together with an analysis of drawdown from dewatering wells in the Pit 11 area are more fully explained later in this section. The positions of the five-foot drawdown limits proximate to Pits 3, 10 and 15 derived from Figure MP-17g as described above were extended beyond the areas proposed for highwall tunneling an additional 1,600 feet, the planned maximum penetration lengths of the long wall tunnels. The results of the best-fit drawdown projection of Figure MP-17g, adjusted for the long wall mining penetration depths, are illustrated on Exhibit MP-5a.

Exhibit MP-5a shows that drawdown around Pit 10 coalesces with that remaining around Pits 1, 2 and 9. This is inferred because the southern-most boundary of the Pit 10 boxcut and the long wall tunnels that will follow after open-pit mining cross the Pit 10 south boundary fault. Moreover, the fault found immediately southwest of the Pit 10 south boundary fault that partially separates Pit 10 from Pits 1, 2 and 9 may not act as a complete hydrologic barrier to mine drawdown because the fault apparently terminates in the local area. Drawdown caused by Pit 4 mining will be relatively isolated because most of this historic pit was believed to be dry. Mining in Pit 3 has lowered the alluvial water table in Bitter Creek valley and this in turn has caused minor

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drawdown in the Fort Union near Pit 4 opposite the valley from Pit 3. Groundwater stored in the alluvium has buffered Pit 3 and Pit 4 impacts to the extent that the five-foot drawdown limits of the two pits are interpreted as not coalescing.

Drawdown from Pit 11 will not coalesce per se with that caused by Pit 10 because of the structural and hydraulic discontinuity of the Pit 11 south boundary fault. The effects of this fault on controlling groundwater movement and drawdown in the Pits 10 and 11 area is described by reference to an aquifer pumping test presented earlier in the subsection *Fault Control On Groundwater Movement And Drawdown*. Further evidence of the groundwater barrier effects associated with the Pit 11 boundary fault has been shown in the form of profound differences in drawdown observed between monitor wells 85 and 87, as described at the beginning of this section Fort Union Formation. Shown on Exhibit MP-5a, another fault (Pit 15 south fault) splits the planned coal recovery block of Pit 15 into roughly north and south halves. The groundwater baseline investigation conducted for Pit 15 and presented in Addendum D6-H concludes that drawdown from Pit 10 mining and/or backfill resaturation has progressed over or around the western segment of this fault where the displacement is small; consequently, drawdown from mining in Pit 15 will be cumulative with Pit 10 drawdown. Drawdown on Exhibit MP-5a is shown extending well west of Pit 11 within saturated clinker deposits that were intercepted by the initial dragline cut. The extent of the five-foot drawdown shown west of Pit 11 is drawn along the western boundary of the clinker as viewed on semi-infrared, color, aerial images.

Finally, the western five-foot drawdown limit for Pit 2 is drawn on top of the Lance-Fort Union contact at the base of the Fort Union in Bitter Creek valley. As described below, Pit 2 drawdown extended both vertically and horizontally into the Lance formation, causing over 40 feet of drawdown at well No. 4 in the proposed Pit 12 area.

Lance Formation

Drawdown in the Lance formation on Table MP-24C ranges from zero to 72 feet with this largest value estimated at well No. 21 where the potentiometric data were extremely erratic until October 1988, probably as a result of gas buoyancy. Similarly, potentiometric elevations in well No. 22 were erratic until February 1981; consequently, the maximum drawdown shown for wells 21 and 22 on Table MP- 24C are suspect. The records for well 67, located south of Pit 6 and indicating nearly 22 feet of drawdown, show no evidence of gas buoyancy and are considered reliable. Minimum water elevations in Lance wells 1 and 2 occurred 4 and 5 years, respectively, before mining began at Pit 5 and because of this and the great distances that these wells lie from Pit 5, both sites are assigned zero drawdown on Table MP-24C.

As stated in the previous text section, the nearly 42 feet of drawdown recorded at well No. 4 at proposed Pit 12 is considered reliable and a direct result of Pit 2 mining dewatering Bitter Creek alluvium. Comparing the potentiometric surface maps prepared for the Lance and Bitter Creek alluvium in the mid-1980s (Exhibits D6-5 and D6-6, respectively), it is apparent that groundwater in the Lance discharges to the valley floor in the

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vicinity of Pits 2 and 12. The head in the Lance at well No. 4 on Exhibit D6-5 is shown to be about 70 feet above the alluvial water table elevation near Pit 2; consequently, it can be expected that Lance potentiometric heads would be sensitive to water table drawdown in the alluvium. More information is presented below about the hydrologic effects of mining alluvium in Pit 2 in the subsection *Bitter Creek Alluvium*.

Figure MP-17h is a plot of distances of Lance wells from actual pit excavations versus drawdown at the wells. This figure was prepared in identical fashion to Figure MP-17g from Table MP- 24c data. An approximate best fit line drawn through the data points of Figure MP-17h essentially ignores the 72 feet of drawdown estimated at well 21 because potentiometric heads in the well were affected by gas buoyancy as described above. The distance of 4,900 feet to the five-foot drawdown gridline of Figure MP-17h was used to define the ultimate extent of five feet and greater drawdown in Lance on Exhibit MP-5b. The five-foot drawdown limits drawn on the exhibit follow formation saturation boundaries, and in the case of Pit 5, follow proximate to saturated alluvial boundaries of Bitter Creek.

Pit 5 will not intercept saturated alluvium and groundwater stored in the alluvium will likely prevent significant (> 5 feet) drawdown in Lance units beneath the valley floor. The saturation boundary in Pits 7 and 13 is only approximate, being extrapolated with data from only wells 1, 2 and 5. The five-foot drawdown limits of Exhibit MP-5b also conform to fault planes where the faults laterally displace the geologic formations, based on the results of an aquifer pumping test showing complete hydraulic discontinuity across the Pit 11 south boundary fault. Although Table MP-24c and Figure MP-17h have been updated to incorporate monitor well data through year 2005, the changes to both are very minor and do not affect drawdown limits projected on Exhibit MP-5b that were prepared using monitoring data collected through year 2000. For this reason, and because Lance Formation pits will not be subject to highwall mining, the drawdown projections shown on Exhibit MP-5b remain valid.

Exhibit MP-5b shows that areas subject to five feet and greater drawdown in Lance will not coalesce between Pits 5 and 6 but will coalesce in the Pits 7 and 13 areas because mining there will be through or on both sides of fault planes. Although Pit 12 will not intercept saturated Bitter Creek alluvium, potentiometric heads in the Lance through the proposed pit area and beneath the valley floor between Pits 12 and 2 remained depressed through year 2005 as a result of the alluvium, and hence Lance groundwater discharge to alluvium, recharging the Pit 2 spoils. Although the potentiometric head in well No. 4 within Pit 12 has nearly 42 feet to recover as of September 2005, water table elevations in adjacent Bitter Creek alluvium have recovered from about 12 feet to 32 feet in monitor wells Nos. 73, 74, 101, 102, and 106 since the early to mid-1990's.

Depending upon the ultimate scheduling of Pit 12 activities, drawdown exceeding five feet in the Lance may extend east from the pit across the valley floor and beneath the reclaimed Pit 2 area.

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Almond Formation

Three monitoring wells having long-term records are available to assess groundwater drawdown in the Almond Formation, which has been and will be mined within only one pit at Black Butte. Well No. 70, also completed in the Almond near Pit 8, has not been monitored since 1985 and is not included in the analysis. Drawdown in the three wells of Table MP-24c range from about 13 to 85 feet. Potentiometric records from well No. 8 appear to be consistent and reliable whereas the records from wells 71 and 72 are somewhat erratic and suggestive of gas buoyancy. The aquifer testing results of Appendix D6 mention difficulty in completing pumping tests in the Almond because of gas vapor-locking the submersible pumps.

Interestingly, potentiometric trends in the Almond wells excepting well No. 8 seem to be independent of the Pit 8 developments. This includes wells Nos. 17 and 64, which were mined through in late 1991 and late 1992, respectively, where potentiometric heads remained essentially unaffected by the pit advances up to the time when the wells were removed. Similarly, well 71 began flowing after June 1983 but heads in the well declined about 90 feet from mid-2002 through late 2005. Heads in well 72 were above baseline from October 1995 to September 2003, but have declined thereafter with an inconsistent trend.

While gas buoyancy has very likely affected the potentiometric records of all the Almond wells, the position of the mined coals in the stratigraphic sequence of the formation likely also accounts for potentiometric heads remaining high even in the immediate vicinity of the pit's advances. Specifically, in Appendix D5 the Almond is described as consisting of three distinct units: a bottom unit about 100 feet thick consisting of sandstone, shale and thin discontinuous coal; a middle unit 75 feet thick holding the principal coal seams and; an upper unit about 150 feet thick consisting of shale, sandstone and siltstone. These facts taken together, it is concluded that potentiometric heads in sandstone units beneath the Pit 8 mining horizon can be expected to be only indirectly affected by mining. The lower sandstone units are probably recharged at their outcrops/subcrops along the western (up dip) boundary of the formation near where it contacts the Ericson formation.

Drawdown data for the Almond from Table MP-24c were plotted on Figure MP-17i against respective well distance from Pit 8 to obtain the average distance to the five-feet or greater drawdown limit of approximately 4,300 feet. This drawdown limit was then extended an additional 1,600 feet beyond the proposed, underground, highwall mining limit following the same technique described above for defining the maximum extent of five-foot drawdown in the Fort Union Formation proximate to Pits 3 and 10. The results are illustrated on Exhibit MP-5c. The exhibit shows an edge of saturation boundary inferred in the formation west of Pit 8. This was drawn approximately one-third the distance down the outcrop breadth of the formation approximately along the top of the lower, 100-foot thick unit. Drawdown in the Almond illustrated on Exhibit

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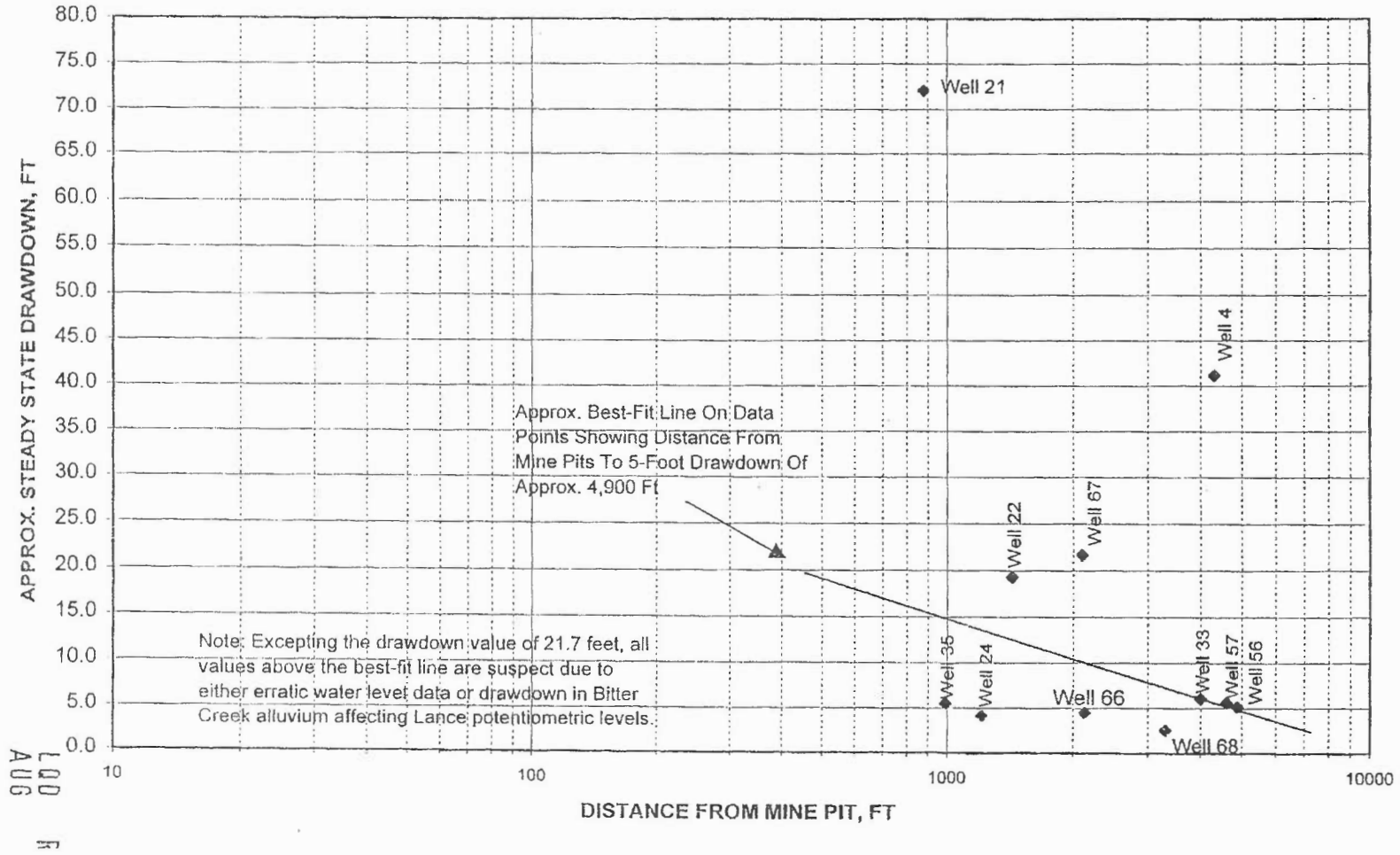
FIGURE MP-17h HISTORIC DRAWDOWN IN LANCE FORMATION WELLS AT BLACK BUTTE MINE



MP-5c is shown extending beneath saturated alluvium of Bitter Creek valley but water table elevations in the valley will not be affected by Pit 8 activities because shale of very low permeability in the Lewis Shale formation stratigraphically separate the alluvium from the Almond. As the exhibit illustrates, it is highly unlikely that potentiometric declines in the Almond will cross over the fault at the north pit boundary because the fault displacement positions the Almond against the Lance formation.

Hydrologic Implications of Highwall Mining

As stated earlier under subsection *Fort Union Formation,* coal in Pits 3, 10 and 8 will be mined for a distance of some 1,600 feet beyond the down-dip boundaries of the final open pit highwalls using an underground highwall mining machine. This type of mining began in year 2006 in Pit 3 and Pit 8 and occurred again in Pit 3 in 2022. The effect of this mining on increasing the geographic area subject to five feet or more drawdown nears these pits is accounted for in the drawdown projections illustrated on Exhibits MP-5a and MP-5c.

Groundwater inflows to the open mine pits from the highwall tunnels are expected to be insignificant because of the following reasons.

1) As shown in Appendix D6, transmissivities found for Fort Union and Almond (and Lance) coal seams are very low, ranging from only 1 ft^2/day to 7 ft^2/day.

2) The coal seams have never been observed to produce significant flows to the mine pits, whereas significant inflows have been observed from overburden and interburden sandstone units and from saturated clinker.

3) The highwall machine is designed to avoid penetrating through the coal roofs and floors so as to avoid contaminating the coal recovery stream with overburden/underburden clastics. If the tunnels do penetrate through the coal, the strata encountered will likely be shale of low permeability in that the coal seams mined are more often than not layered in sandy to clayey shales.

4) The highwall tunnels will penetrate tangentially to or directly down the geologic dip of the formations. Because the pits proposed for highwall mining have been existence for years, it is doubtful that sufficient hydrostatic pressure will be encountered in the highwall tunnels to force water up the tunnel inclines out to the open mine pits.

Black Butte Mine anticipates that groundwater inflows from the highwall tunnels will be sufficiently small so as to not require any special handling requirements in the pits beyond that already undertaken for pumping storm runoff and other groundwater (overburden/interburden sands and clinker) inflow sources. Black Butte is confident that the it has sufficient settling pond capacities in the ponds now treating water from Pits 3, 10 and 8 to treat all pit pumpage water to NPDES discharge criteria, inclusive of any groundwater emanating from the highwall tunnels. In the unlikely event that this is not the case during highwall mining operations, pit floor segments may be bermed off and used to preliminarily treat water prior to pumping the water to final treatment in an existing sedimentation pond. Note on Exhibit MP-5a that approximately the southwestern-most, one-fifth of the area slated for highwall mining in Pit 3 is naturally dry.

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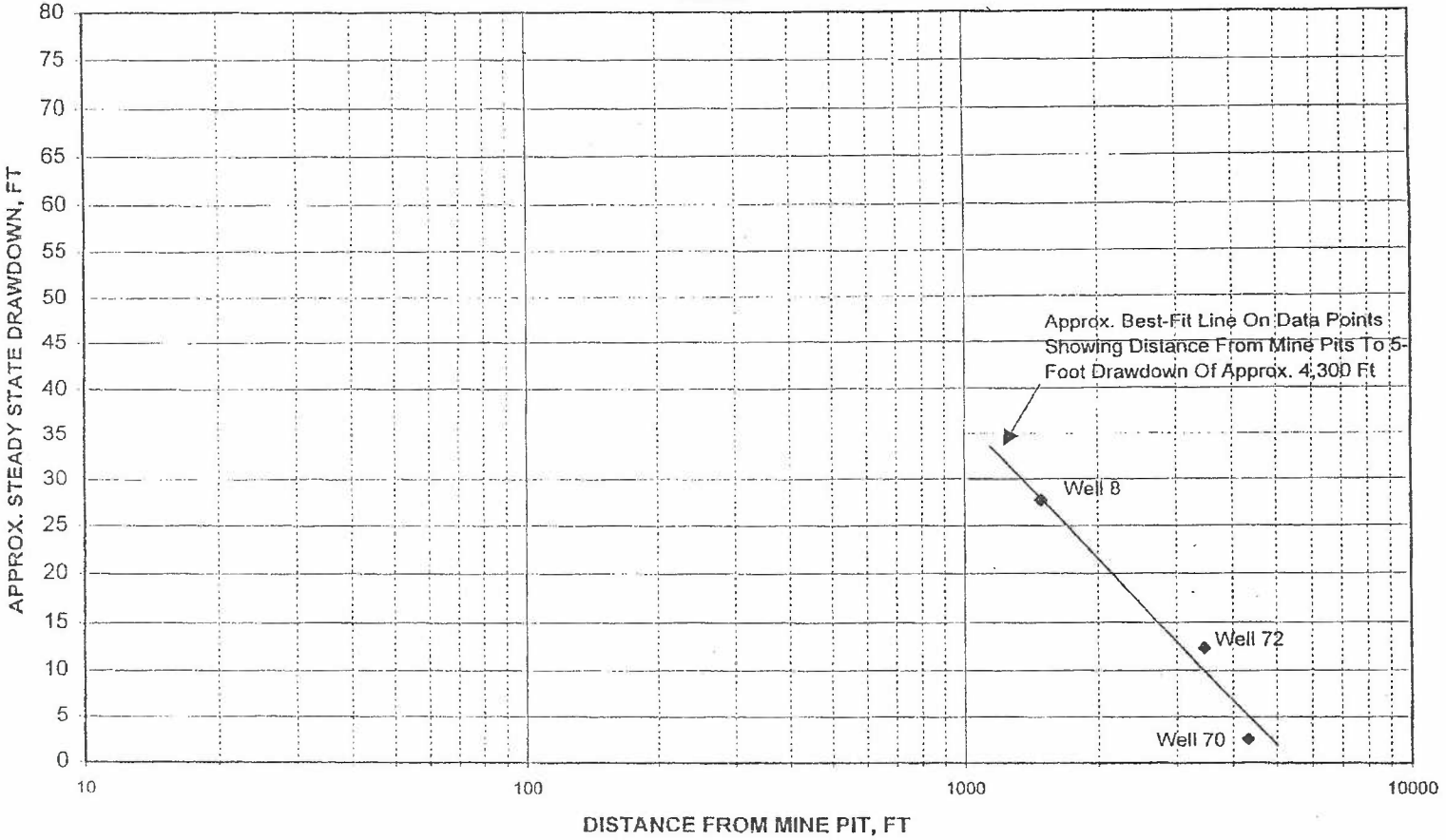
FIGURE MP-17i HISTORIC DRAWDOWN IN ALMOND FORMATION WELLS AT BLACK BUTTE MINE



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As mentioned in text *Highwall Mining Operation* of this Mine Plan, the highwall mining machine will utilize 24,000 gallons per day (gpd) water for dust suppression and cooling. This is equivalent to an average production rate of about 17 gallons per minute. Putting this water usage into perspective, the text entitled *Ground Water Supplies* of this Mine Plan states that daily water usage at the mine is estimated without regard to specific usage records to be about 50,000 gpd for truck wash, 50,000 gpd for dust abatement, 45,000 for the coal plant and 2,000 gpd for potable water supply, all provided by wells developed in the Ericson Formation. Text under the heading *1998 Update on Impacts of Groundwater Withdrawal on the Ericson Formation* states that water usage at Black Butte from mid-1997 to mid-1998 averaged about 151,700 gpd. A well field operations model described within that same text computes drawdown in the Ericson due to pumping for 40 years at rates of 105 gpm and 144 gpm. Since the highwall mining machine's projected use rate of 17 gpm is less than the difference between rates simulated by the impact modeling, no further analysis of impacts to the Ericson caused by the potential use of Ericson groundwater for highwall mining has been undertaken.

Replacement of Monitor Wells Removed by Highwall Mining

No monitoring wells will be reached with highwall mining activities in Pit 10. No further highwall mining activity is expected in either Pit 3 or Pit 8. Therefore, no replacement wells are anticipated at this time.

Hydrologic Implications of Mine Dewatering Wells

Four dewatering wells were drilled along the south boundary fault of Pit 11 in the first quarter of 2006. Geologic logs and completion details for these wells are provided in Appendix D6 (Addendum D6-B), and well locations are illustrated on Exhibit MP-5a. The two wells drilled north of the fault (wells 114 and 115) have estimated yields of 120 gpm each, and these two wells will definitely be used for dewatering beginning in year 2006. The two dewatering wells drilled south of the boundary fault, wells 116 and 117, have estimated yields of 15 gpm and 20 gpm, respectively. These wells will likely not be used for dewatering. Other, preexisting wells that will likely be used for dewatering include Red Hill #1 and Red Hill #2, which were the subject of aquifer pump testing described in section *Fault Control On Groundwater Movement And Drawdown* of this Mine Plan. In addition to the wells, a sump will be constructed in the southwest corner of Pit 11 as part of the initial pit excavation. The sump will operate in conjunction with dewatering wells Nos. 114 and 115 and the two Red Hill wells. All dewatering, inclusive of pit drainage, will occur in Fort Union age strata.

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Operation of the dewatering well field was necessary early in the development of Pit 11 because of the confirmed existence of a coarse-grained, poorly consolidated, highly permeable and saturated sand found with the overburden on the north (pit side and down-thrown) block of the south boundary fault. Well 114 was developed in saturated clinker deposits that are believed to be hydraulically connected to the permeable sands. Overburden removal occurred across the fault plane. The objective of the well field operation was to dewatering the permeable sands, thereby increasing the stability of the sands to withstand the mine pit highwall slopes without mass failure. Accomplishing this was particularly important during pit blasting when hydrostatic pore pressures in the saturated strata may instantaneously escalated to high levels.

Analysis of Potential Drawdown Caused by Dewatering Well Field Operations

The same well field operations model used to predict potential drawdown in the Ericson Formation caused by the mine's water supply wells was employed to predict potential drawdown in the Fort Union Formation caused by the Pit 11 sump and dewatering wells, inclusive of using the Red Hill wells as dewatering wells, for a total of five discharging sites. This model is described in the text of *1998 Update on Impacts of Groundwater Withdrawal on the Ericson Formation* of this Mine Plan. Although Pit 11 mining ended in early 2018, the description and results of the well field model presented below have been preserved in the interest of maintaining a record of groundwater drawdown once predicted to occur in areas surrounding the mine pit.

Table MP-24d provides the input data used for the Pit 11 well field model and also summarizes the drawdown calculation results. The first five well sites are simulated pumping wells and the remaining site numbers 6 through 15 are image wells employed to simulate no-flow boundaries caused by the local edge of saturation in the Fort Union and the Pit 11 south boundary fault. Placement of image wells followed standard image well theory described in most groundwater texts. Image well locations together with the actual pumping sites are shown on Exhibit MP-5a. The center of the model axis describing an orthogonal (N-S and E-W) coordinate system is placed over well No. 114. Groundwater production rates applied to each pumping site and to the image well sites are shown within the top header section of Table MP-24d. The total groundwater production of the real wells on the table is 635 gpm. The model simulated pumping 24 hours each day for a period of 180 days, the maximum estimated duration that the wells and sump will likely actually operate before drawdown associated with pit drainage causes most or all of the wells to become dry.

The results of the Pit 11 well field model are shown on Table MP-24d as drawdown computed at points of interest selected around the model's axis center. These same points and the drawdown

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computed at them are shown on Exhibit MP-5a where the extent of the five-foot drawdown boundary was drawn based on the interest point drawdown values. Importantly, the exhibit shows that drawdown caused by the dewatering well field alone was projected to not extend beyond the boundary of five-foot drawdown projected to eventually develop as a result of pit drainage alone without dewatering wells.

The area predicted to experience five feet or greater drawdown on Exhibit MP-5a extends nearly one-half mile west (up dip) of Pit 11 to the edge of saturation projected in the stratigraphic sequence to be mined. Formerly, the edge of saturation was believed to trend northwest-southeast approximately through the middle of premine Pit 11. Additional drilling west of Pit 11, most particularly dewatering well No. 114, revealed the presence of saturated scoria deposits west of Pit 11. These deposits are evident on high-resolution satellite images of the area and the edge of saturation was redrawn along the western boundary of the scoria. Groundwater in the scoria was believed to be hydraulically connected to groundwater along the Pit 11 south boundary fault, based on a groundwater gradient that ascended from west to east along the fault from well 114 to well 115 to well Red Hill #2 to well Red Hill #1 and finally, to monitor well No. 85 (see Exhibit MP-5a for well locations). The extent of five-foot drawdown was drawn on the edge of saturation in scoria west of Pit 11 because Pit 11 mining dewatered permeable strata hydraulically up gradient of the scoria, and the mining also physically intercepted and dewatered saturated scoria itself. The large yield of well No. 114 (see Addendum D6-B, Appendix D6) indicated that the scoria was highly permeable; meaning that it was expected to experience drawdown throughout the deposit.

Discharges from the Pit 11 well field dewatering wells, but not the pit sump, were conveyed via closed pipeline to NPDES outfall No. 052 located in the SESE Sec. 10, T19N, R100W on the natural tributary to Bitter Creek that flows from northeast to southwest along the southern boundary of Pit 11.

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Table MP-24d Well Field Model Results Projecting Drawdown From Pit 11 Dewatering Wells Operating In Combination With A Pit Sump

Model Parameters For Pumping Wells, Pit Sump And Hydrologic Boundary Image Wells

WELL NO. [1]	WELL COORDINATES [2] X	Y	TRANS. [3] (gpd/ft)	STOR. [4] COEF.	PUMP RATE (gpm)	AQUIFER THICK (ft)	INITIAL [5] THICK (ft)
1	0	0	10900	0.05	75	38	38
2	1393	331	10900	0.05	120	91	91
3	855	120	10900	0.05	200	90	90
4	3581	1207	10900	0.05	120	114	114
5	3121	1018	10900	0.05	120	141	141
6	85	-462	10900	0.05	75	38	38
7	1535	77	10900	0.05	120	91	91
8	937	-115	10900	0.05	200	90	90
9	3656	962	10900	0.05	120	114	114
10	3294	718	10900	0.05	120	141	141
11	-2102	0	10900	0.05	75	38	38
12	-2336	331	10900	0.05	120	91	91
13	-1656	-2149	10900	0.05	200	90	90
14	-4983	-1854	10900	0.05	120	141	141
15	-6414	-2377	10900	0.05	120	114	114

Summary Of Model Drawdown Calculations

POINT NO.	COORDINATES OF POINTS OF DRAWDOWN X	Y	TIME (days)	DRAW-DOWN (feet)
1	0	4095	180	4.1
2	0	6276	180	1.1
3	0	7388	180	0.5
4	0	8279	180	0.2
5	0	9124	180	0.1
6	0	10000	180	0
7	-1000	2000	180	10.7
8	-1000	4000	180	3.7
9	-2000	4000	180	2.9
10	-3000	4000	180	2.3
11	-1000	5000	180	2.1
12	-2000	6000	180	0.9
13	-4000	6000	180	0.5
14	-1000	7000	180	0.6
15	-3000	7000	180	0.3
16	-4000	7000	180	0.2
17	-2000	8000	180	0.2
18	-3000	8000	180	0.1
19	-1000	9000	180	0.1
20	0	-272	180	31.2

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Table MP-24d Well Field Model Results Projecting Drawdown From Pit 11 Dewatering Wells Operating In Combination With A Pit Sump

Summary Of Model Drawdown Calculations

POINT NO.	COORDINATES OF POINTS OF DRAWDOWN X	Y	TIME (days)	DRAW-DOWN (feet)
21	-773	-318	180	21.7
22	-1542	-383	180	18.5
23	-2482	-490	180	15.5
24	-3486	-661	180	10.4
25	-7980	-830	180	2.6
26	3000	2000	180	18.3
27	5000	2000	180	9.1
28	7000	3000	180	2
29	5000	3000	180	5.9
30	4000	3000	180	8.5
31	2000	3000	180	10.1
32	2000	4000	180	5.5
33	4000	4000	180	4.7
34	6000	4000	180	2.3
35	5000	5000	180	1.9
36	3000	5000	180	2.9
37	1000	5000	180	2.7
38	2000	6000	180	1.6
39	4000	6000	180	1.3
40	3000	7000	180	0.8
41	1000	7000	180	0.8
42	2000	8000	180	0.4
43	1159	8300	180	0.3
44	2000	9000	180	0.2
45	4000	9000	180	0.1
46	3000	10000	180	0.1
47	0	1	180	42.4
48	1393	332	180	55.9
49	855	121	180	77.5
50	3581	1208	180	45.6
51	3121	1019	180	46.9
52	85	-461	180	41.9
53	1535	78	180	55.2
54	937	-114	180	77.4
55	3656	963	180	46.2
56	3294	719	180	46.8
57	-2102	1	180	31.5
58	-2336	332	180	35.2
59	-1656	-2148	180	53.9
60	-4983	-1853	180	27.4
61	-6414	-2376	180	26

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Table MP-24d Well Field Model Results Projecting Drawdown From Pit 11 Dewatering Wells Operating In Combination With A Pit Sump

NOTES:

1. Model wells Nos. 1 through 5 are real pumping wells, inclusive of a proposed pit sump simulated as well No. 3. Model wells 6 through 15 are image wells that simulate the Pit 11 boundary fault and the edge of saturation barrier boundaries.
2. Distances in feet from the model axis shown on Exhibit MP-5a.
3. Arithmetic average of the transmissivities found for wells Red Hill #2 and No. 85 shown in the Mine Plan Section "Fault Control On Groundwater Movement and Drawdown".
4. Estimated storage coefficient applicable to an unconfined aquifer.
5. Initial saturated thickness expressed as the well depth minus depth to groundwater. The value shown for the proposed pit sump (well No. 3) is estimated. Setting the total aquifer thickness equivalent to the initial saturated thickness does not affect computational results for unconfined aquifers.

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Potential impacts associated with this discharge are described in Mine Plan section titled *Surface Water Regime*. Groundwater pumped from the initial pit sump, simulated in the well field model as 200 gpm, was discharged for treatment to sedimentation pond SPA1 constructed at Pit 11, and/or to Pit 10 sedimentation pond No. SPB1. Although not required with the water rights permit issued for the dewatering wells by the Wyoming State Engineer (permit No. 172986), a totalizing water meter was installed on the main pipeline conveying dewatering well water to outfall site No. 052. A motor usage meter was used to track water production from the Pit 11 sump. Data derived from the water totalizing and motor usage meters was submitted to DEQ/LQD in Black Butte's Annual Report. Black Butte Mine felt that it was impractical to attempt to meter the individual water flow from each dewatering well in terms of a maintenance item. Motor usage meters on wells would not provide data for accurate determination of well flow rates because operating heads will be extremely variable within each well; meaning that accurately tracking well production rates by using pump manufacturer's pump performance curves of production versus head was not practical.

Significance of Off-Site Impacts to the Hydrologic Balance and to Groundwater Rights

Exhibits MP-5a, MP-5b and MP-5c show that groundwater drawdown may extend outside the permit boundary proximate to mine pits in the Fort Union, Lance and Almond formations, respectively. The drawdown will not constitute "material damage to the hydrologic budget" ("a significant long-term or permanent adverse change to the hydrologic regime") because: 1) excepting some stratigraphically discontinuous sand aquifers found in the overburden and interburden, the aquifers of the affected formations are insignificant by virtue of their very low hydraulic conductivities or physical discontinuities, or both, and, hence, the impacts are insignificant, and 2) the formations being mined are collectively well over 1000 feet thick, and the depth of mining and, hence, potential drawdown, is small relative to the total strata interval. In terms of groundwater yield and physical continuity, the only significant aquifers identified at Black Butte are the alluvium of Bitter Creek and the Ericson Formation. Groundwater drawdown in the Fort Union proximate to Pits 3, 4, 10, 11 and 15 has been predicted to extend beyond the mine permit boundary. This is also true for Pit 14 mining of Almond Formation coal, and to a small extent for mining Lance coal at Pits 12 and 13, should that occur (Lance coal pits 7, 12 and 13 have never opened). There is no evidence that groundwater in the Ericson has been affected by any of the mine pits. There have been no known impacts to date (2018) to existing groundwater rights within or proximate to Black Butte.

Potential Groundwater Rights Impacts Caused by Open Pit Drainage and Highwall Mining

The extent of five-foot drawdown projected on Exhibits MP-5a and MP-5c for the life of the mine incorporate the effects of open pit drainage plus impacts that may occur as a result of highwall mining. Highwall mining is not proposed for Lance Formation coals and the extent of mine-life drawdown shown on Exhibit MP-5b is for open pit drainage only. Dewatering wells were used at Pit 11 to help dewater the Fort Union in advance of mining, but as shown above under section *Analysis of Potential Drawdown Caused by Dewatering Well Field Operations*, drawdown from these dewatering wells was predicted to not add to the geographic area subject to drawdown caused by pit drainage combined with highwall mining.

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Groundwater rights existing within the five-foot drawdown boundaries of Exhibits MP-5a, MP-5b and MP-5c were researched in April 2006 by reference to the Wyoming State Engineer's on-line database. The groundwater rights search was repeated for the Pit 15/Pit 10 South amendment in 2019, and results specific to the greater amendment area were examined. Potential drawdown impacts to groundwater rights were not re-examined for other areas of the mine because drawdown extents projected for those areas have not changed. The results, tabulated below, intentionally exclude coalbed methane wells and monitor wells, wells having abandoned or cancelled permits, and wells on surface estate controlled by Black Butte Coal.

PERMIT No.	TWN.	RNG.	SEC.	Qtr.-Qtr.	Sec.	WELL TYPE	PRIORITY DATE	TOTAL DEPTH (Ft)	YIELD (gpm)	TOP MAIN WATER ZONE (Ft)	BOT. MAIN WATER ZONE (Ft)	WITHIN MINE PERMIT BND.
WELLS POTENTIALLY AFFECTED BY MINE DRAWDOWN IN FORT UNION FORMATION (None Found Within Or Outside Mine Permit Area)												
WELLS POTENTIALLY AFFECTED BY MINE DRAWDOWN IN LANCE FORMATION												
P72114W	19N	100W	4	SWSW		Misc.	03/24/1986	80	80	10	80	Yes
P29064W	18N	100W	3	SENW		Domestic	02/06/1975	65	12.5	50	65	Yes
WELLS POTENTIALLY AFFECTED BY MINE DRAWDOWN IN ALMOND FORMATION												
P499C	18N	101W	12	SESE		Domestic	12/31/1916	400	250	8	400	Yes
P1029W	18N	100W	8	SWSW		Industrial	05/24/1963	4932	500	900	4932	Yes

No groundwater rights of record were found within or proximate to Pit 14. The U.S. Geological Survey has identified a spring on the Cooper Ridge NE quadrangle about 1.25 miles south of the Pit 14 permit boundary. The spring lies between parallel stream channels in the broad valley bottom of Black Butte Creek. The bedrock topography underlying any alluvium at the spring site is the Lewis Shale Formation, which overlies the Almond Formation. The up-dip edge of the Lewis Shale lies some one-quarter to one-half mile south and southeast of Pit 14 (see Exhibit MP-5a), and the formation will not be disturbed by any mine excavations in Pit 14. Appendix D6 of this permit document describes the Lewis Shale as a dark gray, partly silty shale with some thin coal, gray siltstone and green-gray mudstone. The text of that appendix further adds that the permeability of the formation is extremely low, with small volumes of water recharging the Lewis Shale. Based on the geologic dip of formations at Black Butte Mine (4 degrees to 8 degrees according to Appendix D6), the Almond Formation underlies the Lewis Shale about 275 feet to 550 feet beneath the aforementioned spring. Potentiometric head declines in the Almond outside of Pit 14 are projected to be less than five feet at the site of the spring (see Exhibit MP-5c). Because it is very unlikely that less than five feet of drawdown occurring in the Almond Formation would be transmitted through 275 feet to 550 feet of overlying Lewis Shale, it is predicted that the spring will be unaffected by the proposed mining.

Regarding the wells tabulated above, well P1029W is almost certainly developed in strata far deeper than the mining sequence at Black Butte Mine. Well P499C, penetrating Almond strata updip of Pit 8, is probably developed in strata underlying Pit 8. Well P72114W, developed in the Lance, lies approximately one-

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quarter to one-half mile from the northeastern boundary of proposed Pit 13. The yield of this well could be significantly affected by mine drawdown, particularly if the well lies on the same fault block that defines the Pit 13 area (see Exhibit MP-5b). Conversely, the well could be only marginally impacted, if impacted at all, by mine drawdown if the fault lies opposite (north of) the fault block of Pit 13. Well P29064W, also developed in the Lance, is located or was once located near monitor well No. 21 east of Pit 5. Per Table MP-24c, drawdown in well No. 21 has been over 72 feet; consequently, well P29064W has likely become dry or nearly dry by mine drawdown.

In light of the multiple agencies that may be regulating potential groundwater impacts in the vicinity of BBC and the dynamic nature of those impacts, BBC will protect groundwater rights by utilizing the water-rights permitting functions of the SEO. If an owner of a water supply well experiences drawdown that adversely impacts his water supply, BBC will investigate its monitoring records and determine whether its mining activities may have contributed to the reported impacts. BBC will expend every reasonable effort to determine any cause of the suspected impact and to develop a remedy for repair or replacement of the well related to the impacted groundwater right.

BBC will report to DEQ, the SEO, and the well owner any findings as to the potential cause of the impact. Long-term groundwater elevation and water quality records will be summarized to help establish the extent of impact as a result of mining. If the DEQ determines that mining operations contributed to any impact, BBC will formulate a mitigation plan and forward it to DEQ, the SEO, and the well owner for review. Mitigation plans will be formulated on a case-by-case basis to tailor the remedy to the specific water supply problem. Remedies may include deepening the well, replacing the well in a different aquifer, or replacing the well in an alternate location.

Bitter Creek Alluvium

Appendix D6 addresses the occurrence of groundwater within the Bitter Creek alluvium, its hydraulic characteristics and its importance as a source of recharge to permeable subcropping strata, particularly of the Fort Union Formation. Prior to, and during the early phase of mining at Black Butte, numerous monitoring wells were installed for the purpose of studying and identifying the hydraulic characteristics, groundwater levels and water quality of the Bitter Creek alluvium. The majority of these baseline alluvial wells were installed in the Bitter Creek valley near the north end of Pit Three. As the geologic map (Exhibit D5-1) and the Fort Union Formation Potentiometric Surface Map (Exhibit D6-4) illustrate, the Fort Union Formation subcrops under the Bitter Creek valley immediately north of and adjacent to Pit Three; the same area where the baseline alluvial wells were installed. The "premining" Bitter Creek alluvial groundwater monitoring network was scrutinized and evaluated in 1993. This involved a thorough review of every monitoring well's litholog and completion description, its historical records and trends, and the importance of its location relative to mined and/or reclaimed areas.

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and the Bitter Creek Alluvial Aquifer. It was determined that an insufficient number and distribution of wells along the Bitter Creek valley length through the permit area existed to adequately monitor and describe the alluvial groundwater regime. In addition, because some of the existing wells were improperly designed, constructed or located, there has been information recorded which may not necessarily be a true representation of the alluvial aquifer's properties and conditions. As a result, Black Butte Coal Company implemented numerous revisions to the alluvial groundwater monitoring network in 1993 and 1994. These changes are reflected in Tables MP-23 and MP-24 and Exhibit MP-50. The 1993 and 1994 Annual Hydrology Reports contain detailed discussions on the reasons why certain changes were made to the overall groundwater monitoring network. Copies of the lithologs and completion descriptions for the new monitoring wells installed in 1994 are included in the 1994 Annual Hydrology Report. A total of 15 new Bitter Creek alluvial aquifer monitoring wells (site numbers 93 through 107) were installed throughout the Bitter Creek valley, from the upstream permit boundary to the downstream permit boundary, to replace those wells being discontinued and to provide information where none existed previously.

The hydraulic characteristics of each shallow water-bearing strata in the Black Butte Mine area are identified in Appendix D6. The results of all aquifer pumping tests which were conducted through 1986 as baseline investigation are presented in Table D6-2 and Addendum D6-C. Within the Aquifer Characteristics Summary section (page D6-32), it is stated that, "Bitter Creek alluvium exhibits consistently high transmissivity values since the deposits are fairly uniform" and "the average transmissivity is approximately 2,200 ft2/day based on the results of two multiple well tests". The General Hydrogeology section in Appendix D6 includes a physical description of each of the potentially affected aquifers, including Bitter Creek alluvium, and it states, "the major system for unconfined water is the Bitter Creek alluvium" and "isolated areas within the valley may give a confined appearance due to fine silts and clays overlying coarser-grained material".

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Four pumping tests were conducted on the Bitter Creek alluvial aquifer in 1994 at the newly installed alluvial groundwater monitoring sites. Two of the tests were single-well (site number 93 and site number 105), and two of the tests were multiple-well (site numbers 100 and 107, and site numbers 103 and 104). These tests were conducted to provide a more complete description of the Bitter Creek alluvial aquifer's hydraulic properties throughout the mine permit area. The data, graphs and interpretation of these four alluvial aquifer pumping tests are included in the 1994 Annual Hydrology Report. Table MP-24a summarizes the Bitter Creek alluvial aquifer's hydraulic parameters as determined by all pumping tests conducted through 1994.

A transmissivity value of 469 ft2/day was calculated from the test performed at site number 93; the alluvial observation well located farthest upgradient/upstream, at the mine's permit boundary. As mentioned above, the transmissivity values calculated from the two multiple-well tests that were conducted at those observation well clusters located near the northern end of Pit Three (included in Appendix D6) are relatively high at 2,200 ft2 /day. A transmissivity of 130 ft2/day was calculated from the multiple-well test conducted at site numbers 100 and 107. These two wells are situated near, and upgradient of, Pit Two. The test conducted on the two wells downgradient of Pit Two, site numbers 103 and 104, indicate the alluvial aquifer has a similar transmissivity of roughly 100 ft2/day. The test on site number 105, the well located farthest downgradient/downstream of all the alluvial observation wells, resulted in a transmissivity value of 130 ft2/day. Based upon the results of the 1994 pumping tests, the Bitter Creek alluvium does not exhibit consistently high transmissivity values throughout its length within the Black Butte Mine's permit area, as it is stated in Appendix D6. The alluvium appears to be most transmissive in

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Table MP-24a. Bitter Creek Alluvial Aquifer Pumping Tests --Parameter Results

Site Number	Type of Test	Discharge (gpm)	Transmissivity (ft2/day)	Storage Coefficient	Comments
93	Jacob Time Recovery	38.7	469		Single-well test. Pumped 6.5 hours. Specific capacity 2.54 gpm/ft.
51	Jacob Time Drawdown	40.3	2,903	—	Multiple-well test. Pumped well.
	Jacob Time Recovery		2,736		Pumped 10.7 hours. Specific capacity = 4.76 gpm/ft.
			3,309	2x10^4	Observation well to #51. Excellent
50	Jacob Time Drawdown		3,167	2x10^4	non-leaky artesian type curve fit for the Theis method.
	Theis Time Drawdown		2,371	4)(10^4	Observation well to #51. Excellent
			2,287	4x10^4	non-leaky artesian type curve fit for the Theis method.
52	Jacob Time Drawdown				
	Theis Time Drawdown				
38	Jacob Time Recovery	22.2	1,703		Multiple-well test. Pumped well. Pumped 6.0 hours. Specific capacity = 2.01 gpm/ft.
			1,866	5x10^4	Observation well to #38. Excellent
41	Jacob Time Drawdown		1,599		non-leaky artesian type curve fit for
	Jacob Time Recovery		1,839	5x10^4	the Theis method.
	Theis Time Drawdown		1,866	5x10^4	Observation well to #38. Excellent
			1,760		non-leaky artesian type curve fit for
42	Jacob Time Drawdown		1,890	5x10^4	the Theis method.
	Jacob Time Recovery				
	Theis Time Drawdown				
107	Jacob Time Drawdown	15	132	—	Multiple-well test. Pumped well.
	Jacob Time Recovery		139		Pumped 9.0 hours. Specific capacity = 1.05 gpm/ft.
			123	5x10^4	Observation well to #107. Excellent
			115		non-leaky artesian type curve fit for
100	Jacob Time Drawdown		129	5x10^4	the Theis method.
	Jacob Time Recovery				
	Theis Time Drawdown				
104	--		13	--	Multiple-well test. Pumped well. Pumped 2.2 hours. Specific capacity = 0.45 gpm/ft. Insufficient data for curve fitting.
103	Jacob Time Drawdown	–	97	1x10^4	Observation well to #104. Excellent
	Jacob Time Recovery		99		non-leaky artesian type curve fit for
	Theis Time Drawdown		111	1x10^4	the Theis method.
105	Jacob Time Drawdown	17.1	132	---	Single-well test. Pumped 6.8 hours.
	Jacob Time Recovery		126		Specific capacity = 1.07 gpm/ft.

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the area immediately north of Pit Three, although there may in fact be localized variations in transmissivity due to the discontinuous nature of the unconsolidated deposit's grain size, sorting and stratification.

Typically, confined aquifers have storage coefficients that range between 0.001 to 0.00001. The storage coefficient values determined from all of the Bitter Creek alluvial aquifer pumping tests ranged between 0.002 and 0.0005 (Table MP- 24a). These values indicate that the Bitter Creek alluvium is 'a confined aquifer. Therefore, groundwater occurs within a permeable zone of coarser-grained materials which are overlain by finer-grained, impermeable or relatively impermeable materials.

The lithologs of the alluvial monitoring wells installed in 1994 (1994 Annual Hydrology Report) accurately describe the lithology of the alluvium at every location. The Quaternary alluvial deposit has a maximum thickness of approximately 80 to 85 feet and typically consists of beds of very fine-grained silts and clays overlying a coarse-grained basal zone that is roughly 5 to 10 feet thick. The coarser materials at or near the base of the valley fill are comprised of medium- to coarse- grained sand and small pebble-sized gravels of local origin (i.e., clasts of weathered sandstones and siltstones) within a matrix of silt and clay. These are overlain by nearly 70 feet of fine to very fine-grained silts and clays and discontinuous interbedded lenses of sands and small gravels, all of which are locally derived from nearby Tertiary and Cretaceous age rocks.

During the alluvial well drilling operation, at a few select locations, only a thin or no basal zone of coarser-grained materials was encountered. Wells completed at these sites yield very little or no groundwater. On the other hand, those wells completed wherever a significant thickness of basal gravels, was encountered are capable of yields in the 10 to 50 gallons per minute range. Based upon this

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physical evidence and the aquifer pumping test analyses, it can now be concluded that within the study area, Bitter Creek alluvial groundwater is confined in the coarse-grained basal zone beneath the overlying silts and clays. The basal sands and gravels are the primary transmitter of groundwater in the alluvial deposits. The upper fine-grained alluvial deposits are impervious and sufficiently thick within this general section of Bitter Creek's length to isolate surface flow in Bitter Creek from the alluvial groundwater system. Recharge to the alluvium from Bitter Creek or vertical leakage occurs primarily upstream of the study area where the relatively impervious unit of the alluvium is not continuous and as it thins and changes in lithologic character the alluvial aquifer becomes unconfined.

Using the hydrostatic levels measured in October 1994 at all of the Bitter Creek alluvial monitoring wells, an analysis of the alluvial groundwater flow pattern throughout the Black Butte Mine area was complete. The potentiometric surface map (Exhibit MP-51) of the alluvial aquifer shows the groundwater movement at that time. As this map illustrates, the flow pattern trends from upstream to downstream at a relatively uniform gradient, although it is being affected in the vicinities of Pit Two and Pit Three.

During the mining of Pit Two the entire thickness of Bitter Creek alluvial deposits, and consequently alluvial groundwater, were directly intersected for a distance of approximately 1,500 feet along the western edge of the excavation. The Pit Two operation mined the Fort Union Formation and backsloping caused the physical removal of a portion of Bitter Creek alluvium. Alluvial deposits were not salvaged and selectively replaced. Therefore, undisturbed in-situ saturated Bitter Creek alluvium is now in direct contact with the backfilled spoils of Pit Two, providing a significant source of groundwater recharge to the backfilled spoils. The historical hydrographs of the two monitoring wells completed in the Bitter Creek alluvium contiguous with the Pit Two spoils, Site Numbers 73 and 74, are included in

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the 1993 Annual Hydrology Report. These two wells were installed coincident with the backfilling of Pit Two in 1985. These hydrographs illustrate that the alluvium was nearly dewatered in this particular area prior to 1992. At that time, the alluvial groundwater levels began to increase dramatically in the vicinity of Pit Two as the saturation level in the backfilled spoils began to reach equilibrium with the premining potentiometric surface elevation of the contiguous Bitter Creek alluvial aquifer. The installation and subsequent monitoring of additional alluvial wells in the near vicinity of Pit Two in 1994 verified that the movement of alluvial groundwater into the Pit Two backfilled spoils created,a depression in the Bitter Creek alluvial aquifer's potentiometric surface (Exhibit MP-51). When hydrostatic equilibrium is reached between the potential saturation level of the spoils and the contiguous alluvium, only a slight drawdown of the Bitter Creek alluvial aquifer's potentiometric surface should be evident. Data from the ongoing monitoring of Bitter Creek alluvial groundwater levels and Pit Two backfilled spoils groundwater levels will continue to be included in the Annual Hydrology Reports.

The Pit Three operation is mining the Fort Union Formation and even though the excavation does not directly intersect or disturb Bitter Creek alluvium, it does indirectly intercept alluvial groundwater via the subcropping permeable strata that are exposed in the pit. The coal seams, and more importantly the sandstone strata which have much higher transmissivities, are providing conduits for the movement of Bitter Creek alluvial groundwater toward and into the open excavation and the backfilled spoils. As illustrated by Exhibit MP-51, the alluvial aquifer's potentiometric surface was slightly depressed along the edge of the Bitter Creek valley adjacent to the northern end of the Pit Three excavation in October 1994. The amount and areal extent of alluvial dewatering is relatively limited. Groundwater conditions in Bitter Creek alluvium adjacent to Pit Three are described fully in the Reclamation Plan under section *Projected Rate Of Recovery For Water Table In Alluvium Near Pit 3* where an estimate is made of the time required for full groundwater level recovery in Pit Three backfill and Bitter Creek alluvium. In that text the groundwater flow rate from the alluvium to Pit Three is estimated at 28 gpm, based on the water table configuration shown for October 1994 on Exhibit MP-51. The alluvial water table near Pit Three began to decline after late 1989 and drawdown up to about seven feet has been recorded in alluvial wells nearest the mine pit. By about mid-1991 the water table reached a state of equilibrium

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with the mine pit. Conditions governing postmining groundwater elevations in the Pit Three backfill and adjacent alluvium are described in the Reclamation Plan section referenced above.

In summary, the Bitter Creek alluvial aquifer exhibits the highest transmissivity of the undisturbed water-bearing strata. The Fort Union sandstones which subcrop beneath the Bitter Creek alluvial deposits exhibit the next highest transmissivities (Appendix D6). Fort Union, Lance and Almond coal seams all exhibit relatively low transmissivities (generally between 1 to 7 ft^2/day, Appendix D6). Tests on the backfilled spoils of Pit Two and Pit Three indicate that they are very productive, having transmissivity values that range from 6,521 ft^2/day to 45,770 ft^2/day. Therefore, the only significant producible groundwater in the Black Butte Mine area, excluding that from the underlying Ericson Formation, comes from the Bitter Creek alluvium. The Fort Union sandstones and the backfilled spoils are also highly productive, although both are recharged by Bitter Creek alluvial groundwater. When defining the importance of a water-bearing strata as an aquifer, consideration must also be given to the quality of the groundwater. The Bitter Creek alluvial groundwater is typically of very poor quality having high concentrations of dissolved solids exceeding the Class III (livestock use) suitability limit of 5,000 milligrams per liter. The water type is generally a sodium chloride or sodium sulfate. The dissolved boron concentrations and sodium adsorption ratio (SAR) values are also very high and commonly exceed the Class II (agricultural use) suitability limits.

The 1993 Annual Hydrology Report contains a detailed discussion on the Bitter Creek alluvial groundwater quality monitoring results through that reporting period. Specifics on water quality types and trends observed at select alluvial groundwater sampling sites are addressed in that report. Since then, Black Butte Coal Company implemented revisions to the alluvial groundwater monitoring network, including the addition of 15 new observation wells (site numbers 93 through 107). Water quality samples were collected from eight of these new alluvial groundwater monitoring wells in October 1994. These samples were taken to provide a more complete description of the Bitter Creek alluvial groundwater quality throughout the mine permit area. Full groundwater quality analyses (in accordance with WDEQ/LQD Guideline No. 8, Appendix 1) of these samples are included in the 1994 Annual Hydrology Report. The alluvial groundwater's total dissolved solids (TDS) concentrations observed at

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that time are shown in Figure MP-17a. TDS concentrations recorded at each respective well are plotted against the well's linear distance from the farthest upstream monitoring site (site number 93). As this graph illustrates, no downstream trend, moving from site number 93 to site number 105, in the alluvial groundwater's TDS concentration was observed. In general, the TDS concentration in groundwater sampled from the alluvium along Bitter Creek is highly variable, depending upon location throughout the mine/study area. Radial plots of all the groundwater samples collected from the Bitter Creek alluvium in

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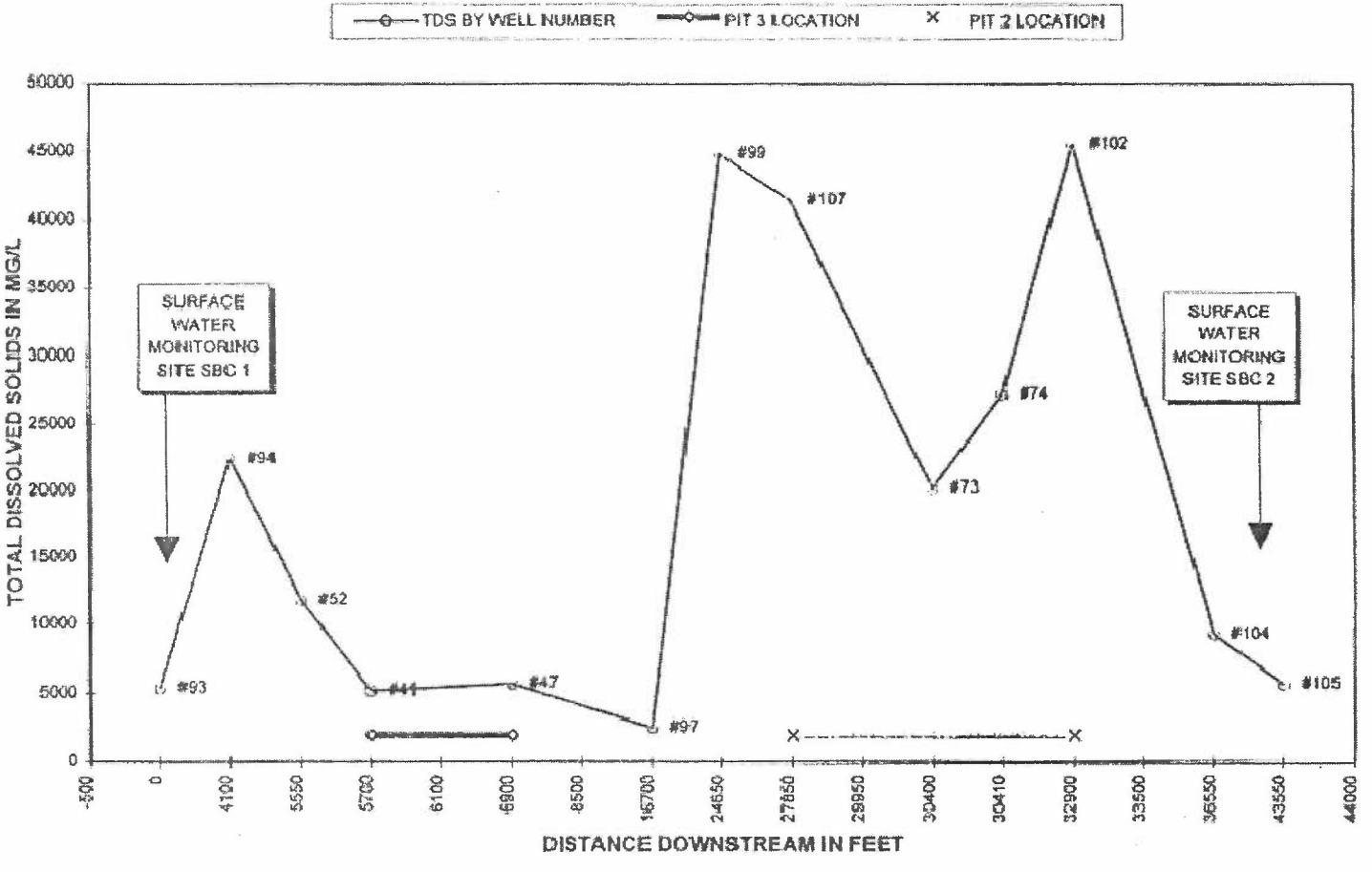
FIGURE MP-17a. TOTAL DISSOLVED SOLIDS CONCENTRATION OF BITTER CREEK ALLUVIAL GROUNDWATER VERSES DOWNSTREAM DISTANCE



SAMPLE DATES ARE OCT 1994

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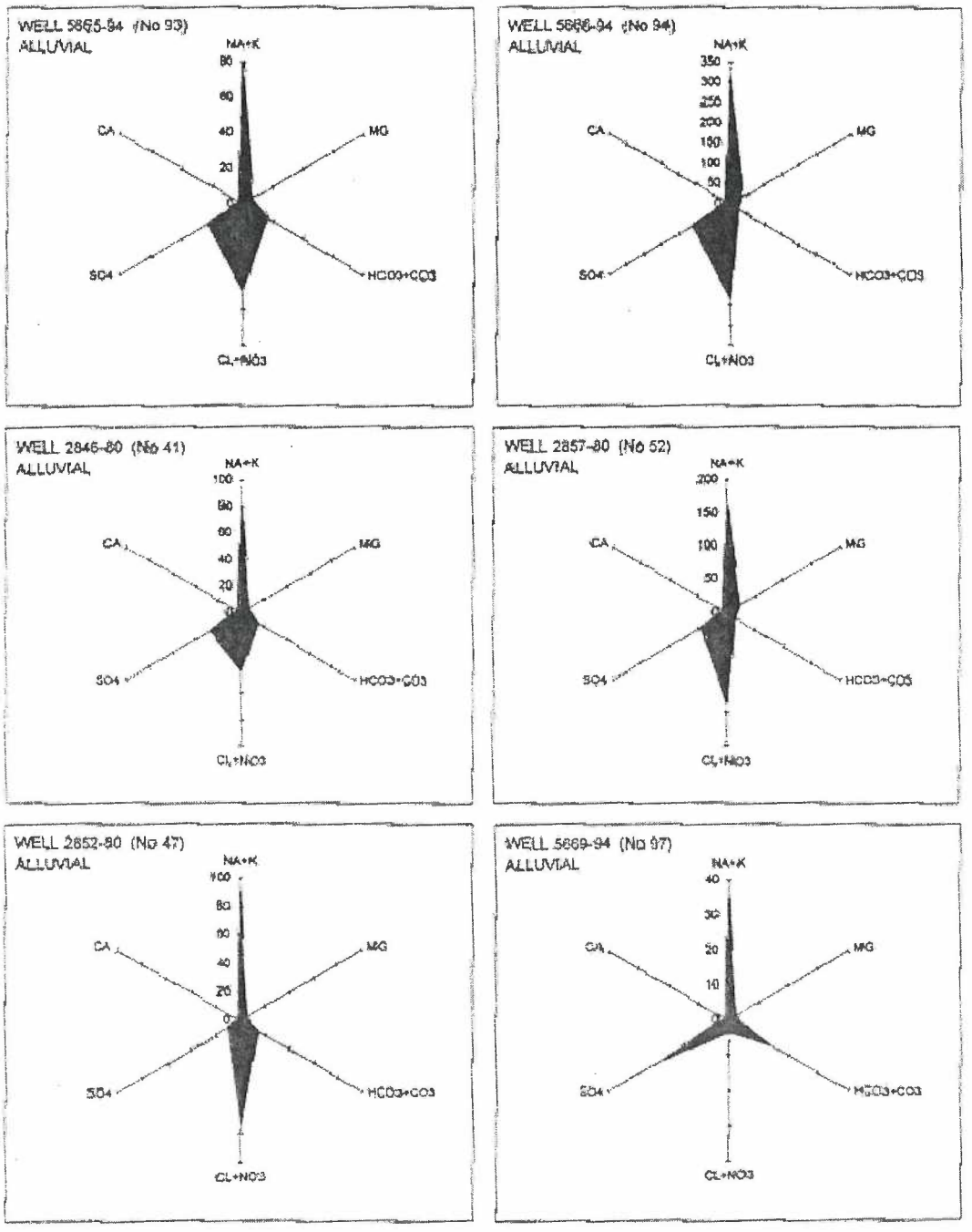

FIGURE MP-17b. WATER QUALITY AT SELECT ALLUVIAL WELLS AS ONE MOVES DOWNGRADIENT FROM SBC1 TO SBC2.

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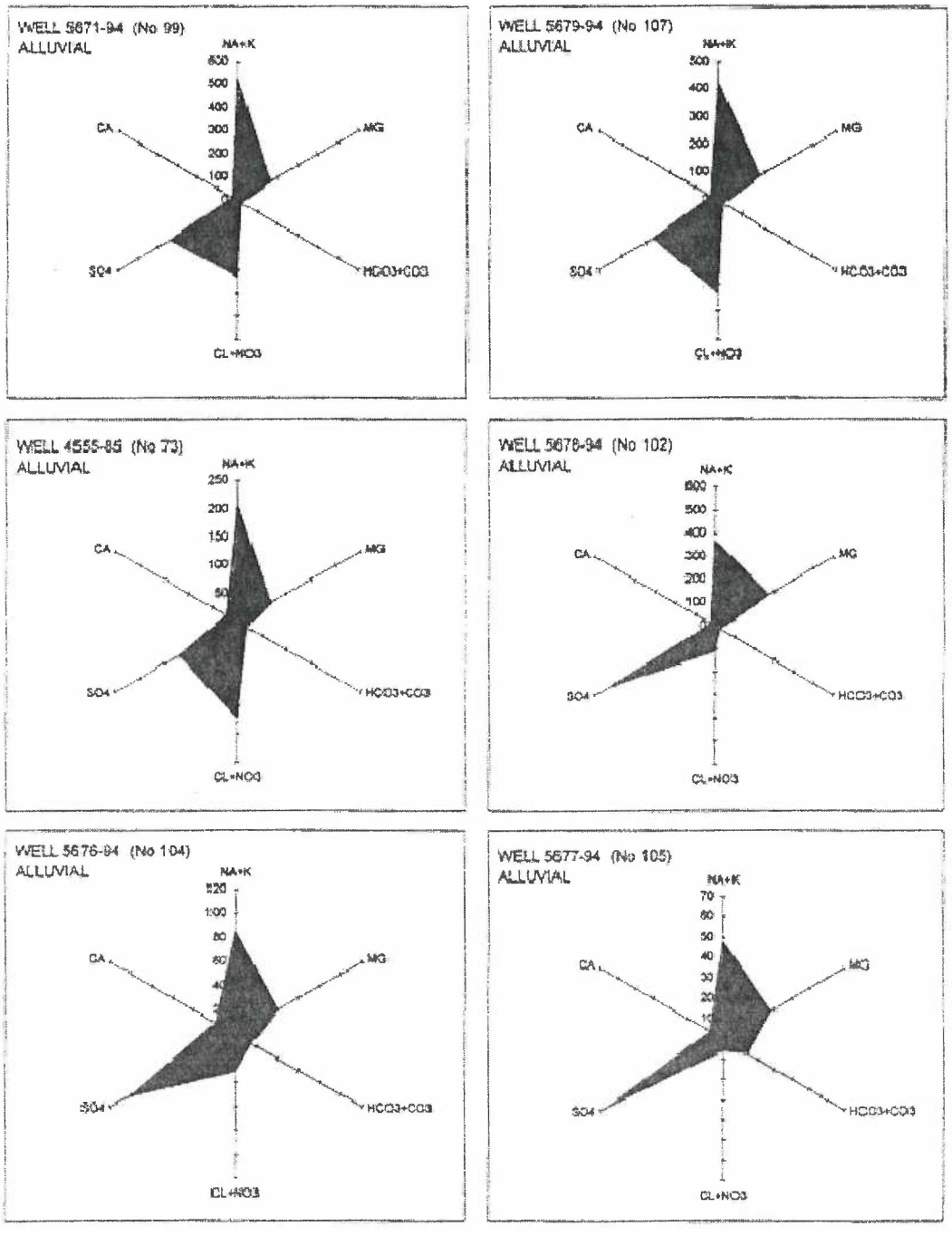

FIGURE MP-17c. WATER QUALITY AT SELECT ALLUVIAL WELLS AS ONE MOVES DOWNGRADIENT FROM SBC1 TO SBC2.

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October 1994 are presented in Figures MP-17b and MP-17c. Each individual plot represents the relative concentrations of anions and cations and the relative shape of each plot characterizes the water type at each well accordingly. Figures MP-17a through MP-17c illustrate the apparent random changes in chemical constituent compositions and concentrations along the length of Bitter Creek through the permit/study area.

In effort to observe any anomalous changes in the quality of Bitter Creek alluvial groundwater during mining, samples will continue to be collected from the alluvial monitoring wells as outlined in Table MP-23. Annual Hydrology Reports will include the data and technical analyses.

Backfilled Spoils

Those parts of aquifers or water-bearing strata that are removed by mining will be replaced by spoil materials. Appendix D6 includes the aquifer pumping test results and discussions on the hydraulic properties of the identified water-bearing strata that will be disturbed and/or removed by mining. Studies by Rahn (1975) indicate that spoil material obtained from the Fort Union Formation ranges widely in permeability, depending upon whether the spoils were moved by dragline or by scraper. Dragline-laid spoils, which undergo gravity sorting and minimal compaction by machinery, may be a hundred times more permeable than scraper-laid spoils which are not sorted and undergo considerable compaction by the scraper wheels. Data reported by Rahn show that dragline-laid spoils near Monarch, Wyoming have an average hydraulic conductivity (permeability) of 35.5 ft/day and scraper-laid spoils at the nearby Big Horn Coal Mine have an average hydraulic Conductivity of only 0.4 ft/day. Therefore, the spoil material at the Black Butte mine, which will be largely excavated and moved by dragline, should have a greater longterm capacity to store and transmit ground water than the combined total of the removed aquifers. Hence, the spoil aquifer can be expected to yield larger quantities

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of water to any wells which might be completed in it than would the original aquifers.

Special studies on spoil material were completed in 1981 and 1982 at the request of the Wyoming DEQ/LQD to address the aquifer reconstruction-restoration issue at the Black Butte Mine. A detailed discussion of the Black Butte Spoil Study is included in the Reclamation Plan (Addendum RP-A). Based on these laboratory tests, it was determined that the spoil material would exhibit porosity and permeability of the same order as the predisturbance state. Laboratory tests indicate that porosity will be on the order of 20% to 30%, accounting for reduction of the swell with time.

For backfilled spoils to resaturate and become a reestablished aquifer, there must be a source of recharge. Recharge will occur from two sources: precipitation and lateral groundwater movement from adjacent undisturbed aquifers. Precipitation will be insignificant compared to the lateral component of recharge. The lateral recharge component is dependent on the permeability of the backfilled spoils, the surface area of contact between the two, and the hydraulic gradient. This component was determined by applying Darcy's Law and is discussed in detail in Addendum RP-A. Based on laboratory test results, the calculations and assumptions made for the estimates of time for resaturation to take place are presented in Addendum RP-A. These recharge rate predictions assume that the backfilled spoil materials will readily accept subsurface inflow from a contiguous aquifer at a rate that is determined by the hydraulic properties of that adjacent aquifer and the spoils. The parameters used in the calculations were based on the assumption that only the coal seams would be the source aquifers contiguous to the backfilled pits. Therefore, the prevailing permeabilities, as determined from aquifer pumping test data of the coal seams mined within each pit area were used for the spoil recharge prediction calculations. Time estimates made in Addendum RP-A, depending on the

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pit, are from 60 to 240 years. In addition, when Addendum, RP-A was written in 1981 there were no saturated in-pit spoils at the Black Butte Mine on which to conduct aquifer pumping tests, so the permeability values for spoil material used in the resaturation estimates were derived from the laboratory tests.

The final backfilling and reclamation of Pit Two was completed in 1985. As shown on Exhibit MP-6 and in Tables MP-23 and MP-24, several groundwater monitoring wells have been completed in the backfilled spoils of Pit Two. The historical groundwater level data and respective hydrographs for these spoil wells (included in the 1993 Annual Hydrology Report) indicate that recharge to the Pit Two spoils has occurred much more rapidly than was predicted in Addendum RP-A. The saturation level across the Pit Two area has been relatively uniform areally and at a rate of approximately 8.5 feet per year. Aquifer pumping tests conducted on the Pit Two wells (site numbers 79, 82 and 83) indicate that it is a very productive aquifer. Pumping rates of 82 and 74 gallons per minute were maintained and transmissivity values range from 6,521 ft2/day to 45,770 ft2/day. The test data and interpretations are presented in the 1990 Annual Hydrology Report. A summary of the hydraulic parameters of the Pit Two backfilled spoils, as determined by these two pumping tests performed in 1990, is presented in Table MP-24b.

Pit Two directly intersected saturated Bitter Creek alluvial deposits for a distance of approximately 1,500 feet along the western edge of the excavation. The Pit Two operation mined the Fort Union FUC Coal seam, and pit backsloping caused the physical removal of alluvial deposits in the Bitter Creek valley. Upon backfilling, the spoils were placed in direct contact with the saturated in-situ Bitter Creek alluvium, thus providing a much more significant source of groundwater recharge to the reclaimed spoils than the adjacent undisturbed FUC Coal seam would have. Based on groundwater level information recorded by the Pit Two spoil wells, the direction of groundwater movement through the spoils is from the west to the

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Table MP-24b. Reclaimed Spoil Aquifer Pumping Tests

Site Number	Pit	Date	Type of Test	Discharge (gpm)	Transmissivity (ft^2/day)	Storage Coefficient	Comments
79	2	5/11/1990	Jacob Time Drawdown	81.7	45,770	-	Single-well test. Pumped 3.0 hours. Specific capacity = 194.6 gpm/ft.
			Jacob Time Recovery		45,055		
83	2	5/13/1990	Jacob Time Drawdown	73.9	6,521	-	Multiple-well test. Pumped well. Pumped 9.6 hours. Specific capacity = 3.23 gpm/ft. Poor well efficiency (less than 50%).
			Jacob Time Recovery		8,152		
82	2	5/13/1990	Jacob Time Drawdown	-	15,620	$7x10^{-2}$	Observation well to #83. Artesian type curve fit for the Theis method.
			Jacob Time Recovery		20,066		
			Theis Time Drawdown		15,727	$7x10^{-2}$	
91	3	5/28/1994	Jacob Time Drawdown	39.9	640		Multiple-well test. Pumped well. Pumped 7.5 hours. Specific capacity = 2.57 gpm/ft. Good well efficiency (greater than 70%).
			Jacob Time Recovery		640		
92	3	5/28/1994	Jacob Time Drawdown	-	838	$2x10^{-3}$	Observation well to #91. Excellent non-leaky artesian type curve fit for the Theis method.
			Jacob Time Recovery		838		
			Theis Time Drawdown		764	$3x10^{-3}$	

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east-northeast. As of 1994, the saturation level of the Pit Two spoils had risen to nearly equal that of the contiguous Bitter Creek alluvium, particularly at site number 73. Clearly, these significantly permeable backfilled overburden materials are in direct hydraulic communication with the Bitter Creek alluvial system and are therefore receiving subsurface recharge at a much higher rate than was predicted in the 1981 Spoil Study (Addendum RP-A).

The Fort Union Formation, FUA and FUC Coal seams are mined in Pit Three. Two post-mining monitoring wells were completed in the reclaimed spoils near the northern end of Pit Three in 1994 (site numbers 91 and 92). At that time, mining in Pit Three was not yet completed, although much of the pit had been backfilled and reclaimed. Hydraulic coefficients obtained from an aquifer pumping test subsequently conducted on these two spoil wells (well completion schedules, test data and interpretation are included in the 1994 Annual Hydrology Report) indicate that the reclaimed spoils in that particular area of the pit are considerably productive. A pumping rate of 40 gallons per minute was maintained during the test and the transmissivity was determined to be 747 ft2/day. A summary of the hydraulic parameters determined by that aquifer pumping test is included in Table MP-24b. The Pit Three spoils, particularly at the northern end of the excavation where they are in direct contact with the very transmissive sandstone strata of the Fort Union Formation that subcrop under the adjacent Bitter Creek alluvial deposits, are receiving subsurface recharge from the alluvial aquifer. Similar to the conditions observed at Pit Two, the permeable backfilled overburden materials of Pit Three are recharged via a much more productive source aquifer at a significantly higher rate than predicted in the 1981 Spoil Study (Addendum RP-A).

Included in the Reclamation Plan, specifically within Addendum RP-A, the "Black Butte Spoil Study" are postmining groundwater quality predictions. This study, conducted in 1981, employed the leachate extract (or column leach testing)

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method to predict the quality of groundwater within the backfilled spoils. At that time there were no saturated in-pit spoils at the Black Butte Mine from which postmining groundwater samples could be collected. Since 1987, actual groundwater quality information has been collected from the Pit Two and Pit Three spoil monitoring wells. The groundwater quality data for the resaturated Pit Two and Pit Three spoils is worse, with respect to dissolved chemical constituents, than the laboratory test predictions. The concentrations of chemical constituents were predicted by analyzing the leachate from representative overburden materials using carbonated distilled water. Obviously, because Bitter Creek alluvial groundwater, rather than distilled water, is recharging the spoils and the concentration of dissolved chemical constituents in the alluvial groundwater is considerably high, the results of the column leach testing underestimated the concentrations of dissolved chemical constituents in the postmining spoil groundwater.

The chemical quality of waters in the backfilled spoils of Pits Two and Three strongly reflect the quality of Bitter Creek alluvial groundwater observed in the near proximity of each respective pit. The predominant ions in all of the groundwater samples taken from the Pit Two spoils from 1988 through 1994 are consistently sodium and sulfate. This water type is very similar to that of the Bitter Creek alluvial groundwater sampled at monitoring site number 73. This similarity in water chemistry can be seen on a trilinear diagram, Figure MP-17d. The major dissolved inorganic constituents are represented on a trilinear diagram in percentage of total millequivalents per liter to facilitate comparisons in the composition of water from different sources. Each chemical analysis is represented by three points on the diagram. Based on ratios among cations and anions, a point is positioned in each of the equilateral triangles. The location of the third point is at the intersection of projection from the first two points into the rhombus. Analyses

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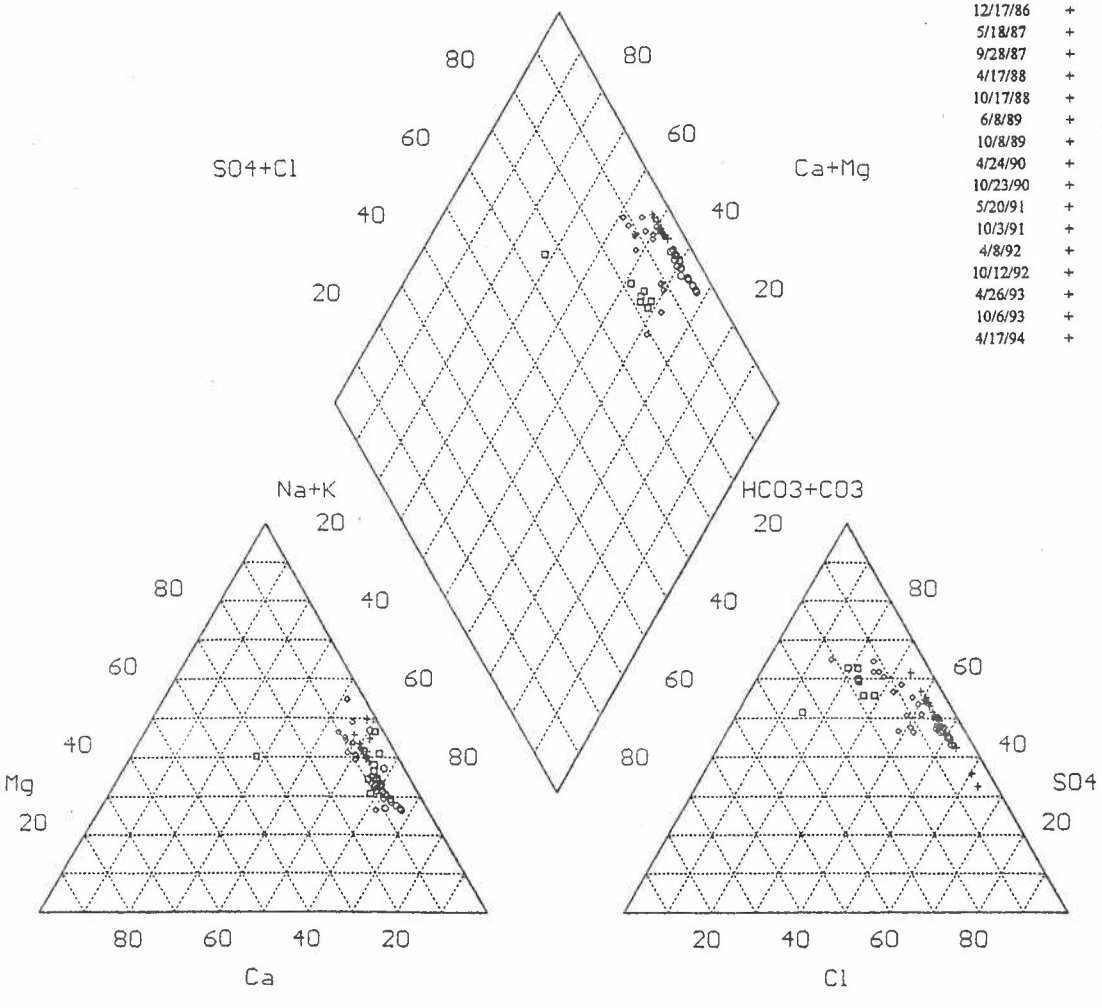
FIGURE MP-17d. 1988 THROUGH 1994 WATER QUALITY BITTER CREEK ALLUVIUM AND PIT 2 SPOILS

STATION	AQUIFER	SAMPLE DATE	PLOT CODE
5202-87 (#84)	SPOILS	4/17/88	o
		10/17/88	o
		5/30/89	o
		10/9/89	o
		4/24/90	o
		8/23/90	o
		10/2/90	o
		5/20/91	o
		10/3/91	o
		4/8/92	o
		10/12/92	o
		4/25/93	o
		10/15/93	o
		4/17/94	o
		10/9/94	o

STATION	AQUIFER	SAMPLE DATE	PLOT CODE
5203-87 (#82)	SPOILS	5/20/91	□
		10/3/91	□
		4/8/92	□
		10/12/92	□
		4/25/93	□
		10/5/93	□
		4/17/94	□
		10/9/94	□

STATION	AQUIFER	SAMPLE DATE	PLOT CODE
5204-87 (#83)	SPOILS	4/17/88	◊
		10/17/88	◊
		5/30/89	◊
		10/9/89	◊
		4/24/90	◊
		10/2/90	◊
		5/20/91	◊
		10/3/91	◊
		4/8/92	◊
		10/12/92	◊
		4/25/93	◊
		10/5/93	◊
		4/17/94	◊
		10/9/94	◊
4555-85 (#73)	QAL	4/14/86	+
		12/17/86	+
		5/18/87	+
		9/28/87	+
		4/17/88	+
		10/17/88	+
		6/8/89	+
		10/8/89	+
		4/24/90	+
		10/23/90	+
		5/20/91	+
		10/3/91	+
		4/8/92	+
		10/12/92	+
		4/26/93	+
		10/6/93	+
		4/17/94	+



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with identical individual ion ratios plot identically on the diagram. Conversely, different locations on the diagram represent different ion ratios. As Figure MP-17d illustrates, analyses of the samples collected from Pit Two spoil wells (site numbers 82, 83 and 84) plot very close to those from the nearby Bitter Creek alluvial well (site number 73). The total dissolved solids of these same samples are plotted in Figure MP-17e to show how the alluvial groundwater is consistently higher in concentration than the spoils, although all exceed the Class III limitation of 5,000 milligrams per liter. Not shown in graph-form are the concentrations of boron and the SAR, which typically exceed the Class II limitations from both sources. Figure MP-17f is a trilinear diagram comparing the composition of water samples collected in October 1994 from select Bitter Creek alluvial monitoring wells throughout the study/mine area and spoil monitoring wells in Pits Two and Three. The clustering of intersection points in the rhombus confirms that the chemical characteristics of groundwaters in the backfilled spoils of these two pits is very similar to that in the Bitter Creek alluvium nearby.

A sudden decrease in the total dissolved solids concentrations of the samples collected from two of the Pit Two spoil wells (site numbers 82 and 84) in 1993 is depicted in Figure MP-17e. These two particular spoil wells were located very close to the Pit Two Final Impoundment. In 1993, surface runoff into the impoundment was great enough to increase the impoundment's pond surface elevation to a level slightly greater than the ground surface at the two well site locations. Surface water, which was surrounding the wells, then migrated in some manner, probably down the bore hole/casing annulus, and diluted the concentrations of chemical constituents in those groundwater samples subsequently collected. This accounts for the sudden decrease in the total dissolved solids concentrations. Further evidence of surface water contamination of the groundwater samples collected from these two spoil wells is illustrated by the trilinear diagrams of Figures MP-17d and MP-17f.

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FIGURE MP-17e. 1986 THROUGH 1994 TOTAL DISSOLVED SOLIDS: BITTER CREEK ALLUVIUM AND PIT 2 SPOILS

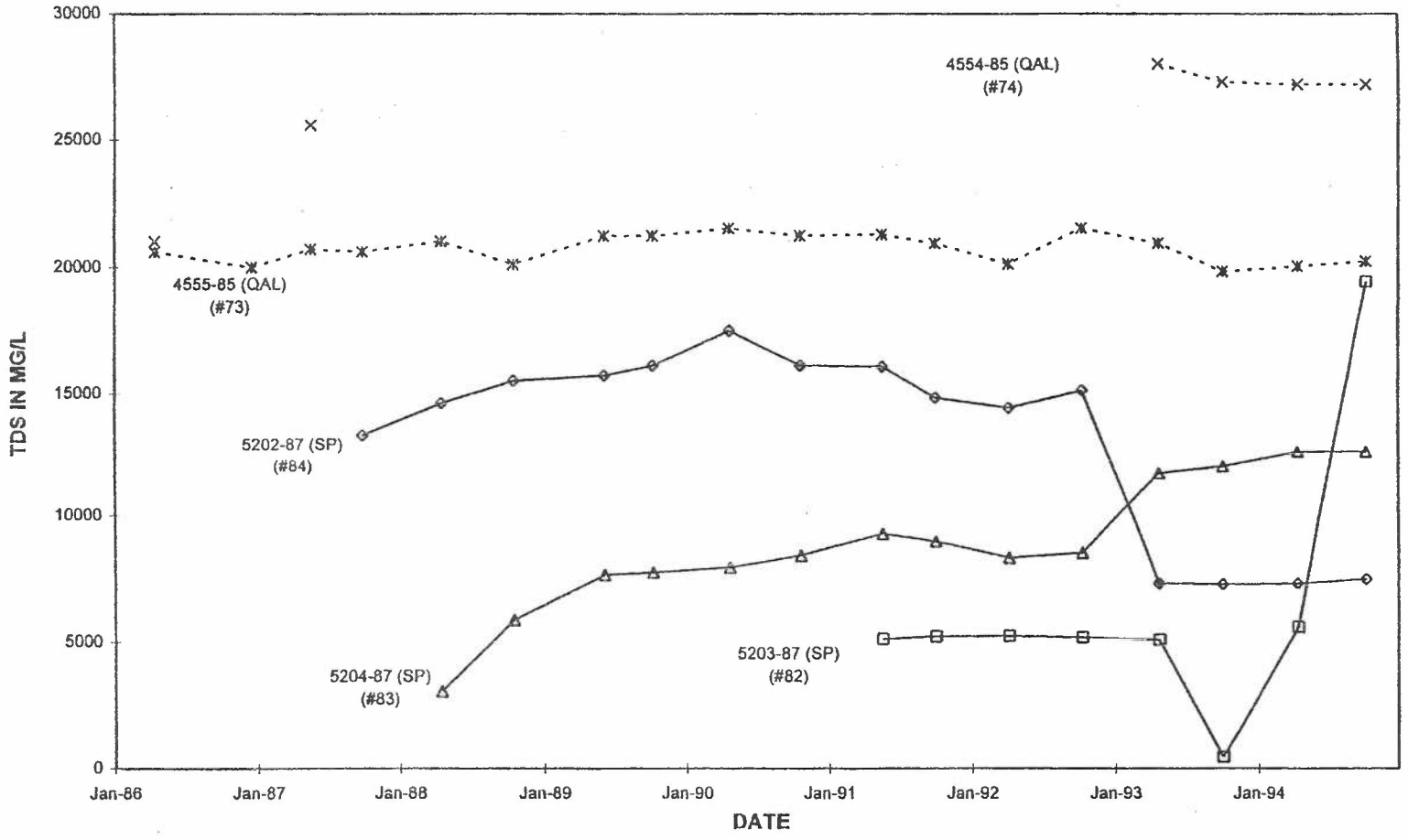

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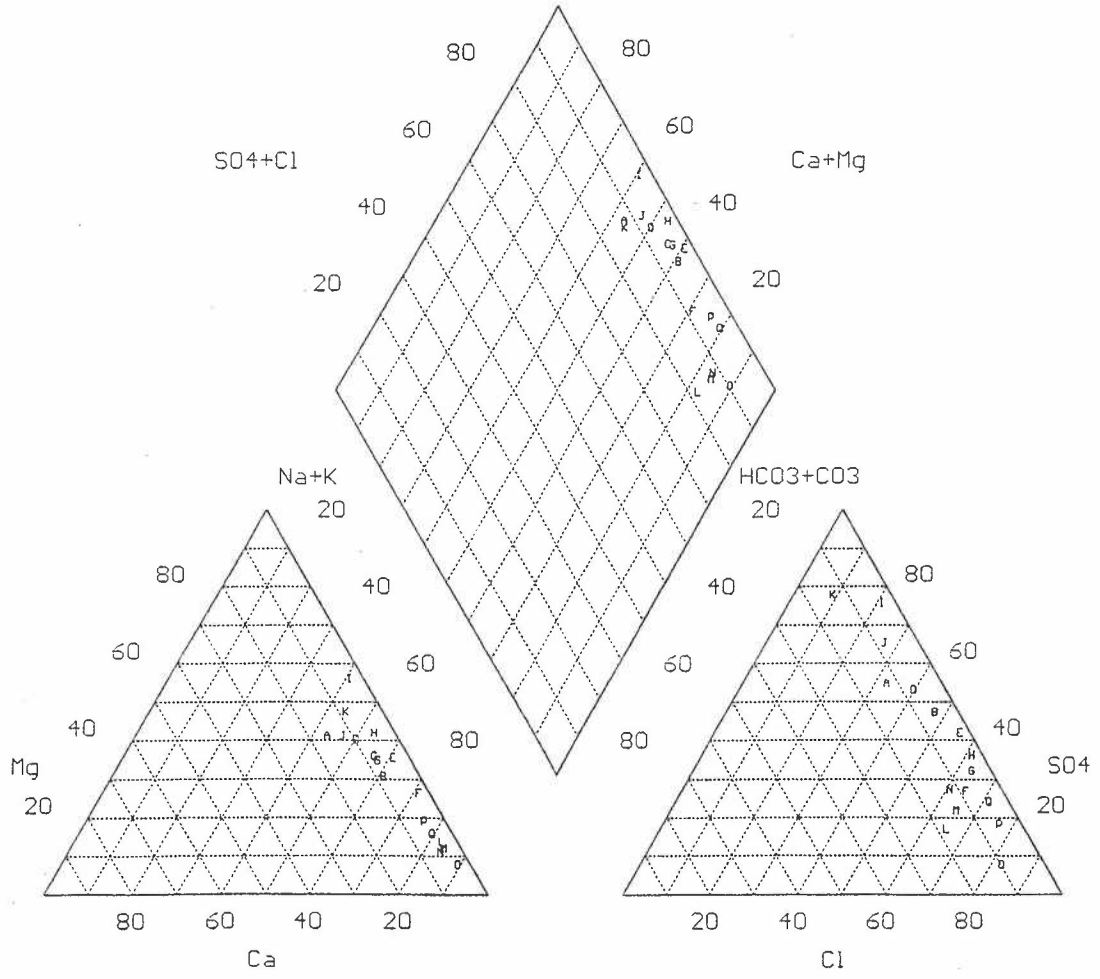
FIGURE MP-17f. 1994 WATER QUALITY: BITTER CREEK ALLUVIUM, PIT 2 AND PIT 3

STATION	AQUIFER	GENERAL LOCATION	SAMPLE DATE	PLOT CODE
5100-86 (#79)	SPOILS	PIT 2	10/9/94	A
5202-87 (#84)	SPOILS	PIT 2	10/9/94	B
5203-87 (#82)	SPOILS	PIT 2	10/9/94	C
5204-87 (#83)	SPOILS	PIT 2	10/9/94	D
5671-94 (#99)	QAL	UP GRAD PIT 2	10/12/94	E
4554-85 (#74)	QAL	PIT 2	10/9/94	F
4555-85 (#73)	QAL	PIT 2	10/9/94	G
5679-94 (#107)	QAL	PIT 2	10/12/94	H
5674-94 (#102)	QAL	PIT 2	10/12/94	I
5676-94 (#104)	QAL	DOWN GRAD PIT 2	10/12/94	J
5677-94 (#105)	QAL	DOWN GRAD PIT 2	10/11/94	K

STATION	AQUIFER	GENERAL LOCATION	SAMPLE DATE	PLOT CODE
5663-94 (#91)	SPOILS	PIT 3	10/13/94	L
5665-94(#93)	QAL	UP GRAD PIT 3	10/11/94	M
2846-80 (#41)	QAL	PIT 3	10/13/94	N
2852-80 (#47)	QAL	PIT 3	10/10/94	O
2857-80 (#52)	QAL	PIT 3	10/10/94	P
5666-94 (#94)	QAL	PIT 3	10/13/94	Q



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water types were unaffected by the surface water's dilution, yet the concentration of dissolved constituents decreased.

Of all the other pits at the Black Butte Mine, only Pits Eight and Twelve are situated close enough to the Bitter Creek valley to have the remote potential for intersecting, either directly (like Pit Two) or indirectly (like Pit Three), subsurface recharge from the alluvial system. Pit Eight will not excavate or remove saturated Bitter Creek alluvial deposits and the Almond Formation mined in Pit Eight does not subcrop under the Bitter Creek alluvium downdip of the pit to the east. Pit Twelve will not mine into the Bitter Creek alluvium to directly intercept alluvial groundwater. The Lance Formation mined in Pit Twelve does not subcrop into the alluvium east of and immediately adjacent to the pit, although the potential for alluvial groundwater migration to the pit is slight due to an absence of permeable Lance Formation strata at the subcrop. Therefore, the estimates of time for resaturation to take place at all of the pits other than Pits Two and Three, represented in Addendum RP-A, are the best that can be made.

One other spoils monitoring well existed at the Black Butte Mine as of 1994: Site Number 88, located in Pit Five. This well's litholog and completion description are included in the 1993 Annual Hydrology Report. No groundwater was encountered during the drilling of this well and it was dry through the 1994 reporting period.

Addendum RP-A in the Reclamation Plan was prepared in 1981 and therefore is only a prediction of what the post-mining groundwater quality at each of the reclaimed pits will be. As mining and reclamation continue, Black Butte Coal Company will monitor and record the actual post-mining groundwater quality at each of the pits as they are reclaimed and resaturation (if any) occurs. At the close of the post-mining water quality prediction study is a statement which concludes: "When recharge to spoils occurs laterally from adjacent aquifers, which in fact will

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be the primary and major component, degradation of water quality will be minimized. Shallow groundwater occurring in and around the Black Butte mine area is of poor quality and high concentrations of ions already existed prior to mining. It is therefore doubtful that addition to these concentrations from available salts in the spoil materials will significantly detract from the existing water quality or its potential use. In addressing the impacts from mining on groundwater quality, the premining use, or potential use, must be compared to the post-mining use. Based upon that consideration, the only potential use for shallow groundwater from shallow water-bearing strata at Black Butte is stock watering and in most instances the quality is too poor for even livestock use. However, shallow groundwater is of such limited supply in most areas that even this use is neither economical nor feasible. Where there is abundant supply, namely the Bitter Creek alluvial groundwater, quality is not suitable for any purpose." Groundwater quality data collected through 1994 from the saturated spoils indicates that the quality may not be quite as bad as that from the Bitter Creek alluvium, although still not suitable for any purpose.

All groundwater data collected from the backfilled spoils and Bitter Creek alluvial monitoring wells, along with a discussion on the hydrologic significance of the hydraulic communication between the two, will continue to be included in the mine's Annual Hydrology Reports.

Further evidence of hydraulic discontinuity between Bitter Creek surface water and alluvial groundwater are the differences in water quality. Bitter Creek surface water is typically a sodium bicarbonate type having a total dissolved solids concentration ranging from 300 to 2,600 milligrams per liter, while the alluvial groundwater is typically a sodium chloride/sulfate type having a total dissolved solids concentration ranging from 5,000 to over 20,000 milligrams per liter.

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Surface Water Regime

Changes in surface water quality and quantity could be expected to occur where any natural drainage was disturbed by mining activity. Because there are no plans to mine through the primary channel of Bitter Creek, the hydraulics of the major drainage system will remain unchanged. Temporary changes in both quality and quantity of runoff may occur as mining progresses through the minor tributaries to Bitter Creek as a result of interception and diversion of runoff around the mine area(s). Because of the relatively small surface areas which will be impacted in this manner compared to the total surface area of the Bitter Creek watershed, (at maximum development, the mining activities will have disturbed approximately 14,000 acres, slightly more than 4% of the total surface area of the watershed - approximately 400,000 acres) it is doubtful, based on studies to date (e.g. McWhorter and Rowe 1976, Black Butte 1982) that any detectable changes in either quality or quantity will result.

The Black Butte Mine is a total containment mine requiring a number of control or containment structures. These structures are built in order to control runoff from various disturbed areas within the mine. As a result of these structures, certain contributing areas to the Bitter Creek watershed are temporarily removed, reducing the availability of runoff and sediment that normally enter Bitter Creek. Since the appropriation of this water by the State Engineer's Office for all sediment control structures calls for the water to be returned to the original drainage basin as soon as it meets effluent standards, the withdrawal of water as a result of sediment control structures is considered only temporary. A total temporary reduction in contributing area to the Bitter Creek watershed, as measured at SBC2 (the downstream gauging site) is on the order of 4%.

To further quantify the area involved and estimate the potential loss of runoff due to the control structures, a year-by-year life of mine study was conducted. The specific runoff for the Bitter Creek watershed is from 0.1 to 0.2 inches per year (Busby 1966). Based on this specific runoff figure, flow in Bitter Creek, as measured at site SBC2 (downstream gauging station) is calculated at 4000 to 8000 acre-feet per year. A highest impact estimate can be made by using the lower end figure of 4000 acre-feet per year.

The temporary reduction in flow to Bitter Creek has been calculated for each year of mining activity and compared to an average annual discharge of 4000 acre-feet. This is shown graphically on Figure MP 18. For any given year of mining at Black Butte the maximum percent of temporary flow reduction is approximately 4%. The reader is referred to Addendum MP-A for a year-by-year compilation of ponds constructed and percent of flow affected. The 4% figure

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equates to 160 acre-feet of water per year temporarily removed from Bitter Creek. This temporary loss of 160 acre-feet per year will not affect any downstream surface water rights.

Pit 15 mining will cross through ephemeral stream channels of Subbasin 3 east of Pit 11 and north of Pit 10. Subbasin 3 is tributary to Bitter Creek and is the second largest ephemeral watershed at Black Butte Mine. Subbasin boundaries are outlined on Exhibits D6-12 and D6-13 of the historic Appendix D6 (Vol. 5D). Flows in the main channel of Subbasin 3 will be diverted around mining, consequently flow losses to Bitter Creek will be minimized. Losses in flow to Bitter Creek will be from contributing areas that are bypassed by the diversion channel. This includes some areas adjacent to the main channel for Subbasin 3 and a tributary to the south. Approximately 830 acres (1.3 square miles) are bypassed by the diversion channel. Section 2.2 of Addendum D6-H prepared for the Pit 15/Pit 10 South amendment reports an annual unit runoff volume of 0.8 acre feet (AF) per square mile. The annual estimate of lost runoff is 1.04 AF. The bypassed runoff will be captured by Pit 15 mining where it will be temporarily lost from watershed runoff to evaporation, infiltration, or mine related uses such as dust control on haul roads. Addendum D6-H reports an estimated annual runoff from Subbasin 3 entering the amendment area of approximately 5 AF, with about seven to eight AF exiting the area. Given these facts, the conclusion reached above that mining will not affect downstream water rights in Bitter Creek is still considered accurate.

The natural undisturbed channels below the control structures will experience temporary loss of flows until the structure is removed and the disturbed area reclaimed. Since the channels are ephemeral in nature, the temporary loss of flow should not have any impact. Once the control structure is removed the channels will be tied into the reclaimed area channels using sound hydrologic engineering practices. Reclaimed areas will not significantly alter the size of the drainage basins therefore allowing the natural channels to convey flows as they did in premining state. Slopes of reclaimed areas will be topsoiled and vegetated so that the disturbed area will not experience a significant increase in specific runoff.

Some changes in water quality may be experienced as a result of the control structures. This will come in the form of a reduced sediment load, both dissolved and suspended. The amount of reduction in sediment is assumed to be proportional to the reduction in flow. In 1982, Bitter Creek carried an average load of 1120 mg/1 of sediment. Using a flow volume of 4000 acre-feet results in an estimate of 6090 tons of sediment passing through the Black Butte Mine. A 4% reduction in sediment would be 245 tons per year.

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FIGURE MP-18

Bitter Creek is classified as a Class 2C stream by the Wyoming Department of Environmental Quality - Water Quality Division. Class 2C streams are known to support or have the potential to support nongame fish populations or spawning and nursery areas at least seasonally. Based on the status of Bitter Creek, the relatively low temporary reduction in flow and sediment yield, it is concluded that the construction of control structures at the Black Butte Mine will have negligible impact on Bitter Creek and its watershed.

The lithologic units through which the ground water moves and over which the surface water flows contain an abundance of soluble minerals.

Both ground water and surface water movement is slow and recharge to both systems is severely limited, due either to the low hydraulic conductivities (in the case of ground water) or the low annual precipitation.

The monitoring of Bitter Creek discharge and water quality has always been at sites SBC1 and SBC2. Site SBC1 is located upstream of all Black Butte mining activity within the Bitter Creek watershed while SBC2 is located downstream of all activity. Each site is equipped with a staff gage which is checked during water quality sampling to allow calculation of the flow rate. Water quality samples were typically collected on a quarterly basis at both sites through March 1986 and analyzed for the full suite of water quality parameters (as per WDEQ/LQD Guideline No. 8). Since 1987, discharge measurements and water quality samples were typically collected on a monthly basis as conditions allowed during the ice-free period of the year. The samples were analyzed for total dissolved solids (TDS) and total suspended solids (TSS). Black Butte Mine also voluntarily collected full-suite Guideline No. 8 samples at SBC1 and SBC2 in 2013, 2015, 2016 and 2017. Addendum D6-J contains analytical results for all samples collected from stations SBC1 and SBC2 from the inception of sampling in 1975 through 2015. In 2019, the mine began semi-annual analyses of samples collected at SBC1 and SBC2 for the constituents listed in Section A. of Appendix 7 of LQD Guideline No. 8 (May 2015). This list is identical to Table 1 of Appendix 8 of former Guideline No. 8 (March 2005). Refer to section Hydrologic Monitoring During Mining for complete details on the current hydrologic monitoring program at Black Butte Mine.

Sections in Appendix D6 (SURFACE WATER DISCHARGE and SURFACE WATER QUALITY) contain detailed discussions on the results of monitoring Bitter Creek at sites SBC1 and SBC2. In addition, the 1993 and subsequent Annual Hydrology Reports contain a comprehensive assessment of the Bitter Creek flow regime through the respective reporting periods. In effort to maintain continuity and document the ultimate effects that the Black Butte

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Mining operation will have upon the local and regional surface water system, the present surface water monitoring program will continue to be used both during and after mining.

The previous section (Groundwater Regime) discussed the hydraulic characteristics of the Bitter Creek alluvium. Based upon the results of aquifer pumping tests and lithologic drill hole descriptions, it is concluded that within the mine area Bitter Creek alluvial groundwater is confined within the coarse-grained basal zone beneath the overlying silts and clays. The basal sands and gravels are the primary transmitter of groundwater in the alluvial deposits. The upper fine-grained alluvial deposits are relatively impervious and sufficiently thick enough to isolate surface flow in Bitter Creek from the alluvial groundwater throughout the stream's length within the mine area.

In an effort to verify if any interaction between the Bitter Creek alluvial groundwater system and Bitter Creek surface water exists within the mine permit area, Black Butte Coal initiated a stream gauging analysis of Bitter Creek streamflow in 1993. Actual current meter measurements of streamflow at select locations along Bitter Creek, from site SBC1 to site SBC2, are made during various flow conditions to quantify any gaining or losing reaches. Water quality samples are also collected at each streamflow measurement site at the time of gauging and analyzed for total suspended solids and total dissolved solids. The details and results of this stream gauging, or "seepage run", analysis is presented in the 1993 and subsequent Annual Hydrology Reports. The study will be discontinued when the results have confirmed the absence or presence of any hydraulic communication between the Bitter Creek surface water and alluvial groundwater regimes within the mine/study area. Given the results of the initial baseflow seepage run, streamflow was constant throughout the mine area and no significant gaining or losing reaches were identified. As concluded in the 1993 Annual Hydrology Report: "based upon all usable historic data through the 1993 reporting period, there does not appear to be any increasing or decreasing water quality trends occurring between SBC1 and SBC2 in relation to total suspended solids of total dissolve solids concentrations".

Further evidence of hydraulic discontinuity between Bitter Creek surface water and alluvial groundwater are the differences in water quality. Bitter Creek surface water is typically a sodium bicarbonate type having a total dissolved solids concentration ranging from 300 to 2,600 milligrams per liter, while the alluvial groundwater is typically a sodium chloride/sulfate type having a total dissolved solids concentration ranging from 5,000 to over 20,000 milligrams per liter.

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Potential Surface Water Impacts from Dewatering Activities

As explained in the section *Hydrologic Implications of Mine Dewatering Wells*, it was necessary to dewater overburden at Pit 11 early in pit development in order to stabilize unconsolidated, highly permeable sands that are a risk for highwall failure. Although Pit 11 mining ended in early 2018, the descriptions presented in this section have been retained to preserve a template that may be followed should there again be a need to dewater strata in advance of mining.

Plans were formulated to pump four wells positioned along the southern and southwestern boundary of the pit in combination with a pit sump located in the southwestern corner of the pit. The initial groundwater production rate of the five pumping sites combined was estimated to be 635 gallons per minute (gpm). Water produced from the pit sump was conveyed to existing mine sedimentation ponds. Water produced from the four dewatering wells, estimated at 435 gpm, was conveyed via closed pipe to an outfall on a local ephemeral tributary under a NPDES discharge 052.

Outfall 052 was located in the SESE Sec. 10, T19N, R100W, southwest (downstream) of Pit 11 on a major ephemeral tributary to Bitter Creek. Outfall 052 was the point of compliance for discharges from the dewatering wells and discharges from sedimentation pond SP-A1, also located in the SESE Sec. 10. The ephemeral tributary has a drainage area of about 6,300 acres at the point of the outfall. Using the standard Triangular Hydrograph Method, the peak runoff rate of the 2-year, 24-hour storm event (the "agriculturally useful flood") is approximately 90 cubic feet per second (cfs) at the point of the outfall. With an estimated discharge rate of 435 gpm, equivalent to about 1 cfs, dewatering well discharges were insignificant relative to the flow of the 2-year, 24-hour event; consequently, the dewatering discharges were predicted to not cause additional stream channel or bank erosion.

Although the available hydrologic data are insufficient to support any firm conclusions, there is some probability that the ephemeral tributary was a recharge source for the groundwater to be dewatered, either via direct stream flow infiltration down the plane or gouge zone of the Pit 11 south boundary fault, or via groundwater infiltration from saturated unconsolidated deposits down the fault plane or gouge zone. A principal branch of the ephemeral tributary crosses the fault plane near the southeastern boundary of Pit 11. Saturated unconsolidated deposits may mantle the fault over areas broader than just where the stream channel crosses the fault plane. The effects of dewatering wells and pit drainage on suppressing water table elevations in the unconsolidated deposits and reducing ephemeral channel flows were predicted to be local to Pit 11 and replenished downstream from the pit by discharges conveyed at outfall 052.

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Groundwater Supplies

There are two sources of groundwater available for use at the Black Butte Mine: (1) groundwater from pit dewatering, and (2) groundwater from six industrial supply wells. Groundwater from pit dewatering is derived from the various formations directly affected by mining. This water is pumped via portable sump pumps to containment ponds, settled and allowed to evaporate, and used in dust suppression. Volume calculations of pit inflows are presented in Tables MP-20 through MP-22 and under the text section Estimated Groundwater Inflow Rates At Pit 14.

Six industrial-type wells developed in the Ericson Formation are available as water supply sources for the mine. These wells are designated Bluebell 13 (well No. WB01-75), Darter 1 (well No. WD01-75), Darter 2 (well No. WD02-79), and Chandler Simpson (well No. WCS1-75). The Chandler Simpson well, in existence before and not constructed by the mine, is not used by the mine. Two additional groundwater wells were drilled in 1985, Squawfish #1 and Squawfish #2. A discussion of the hydraulic system design for these wells is presented in Figure MP-4. Completion data for these wells are given in Table MP-25. As indicated in the section entitled "1998 Update on Impacts of Groundwater Withdrawal on the Ericson Formation" of this Mine Plan, Black Butte Mine utilized the Bluebell 13, Darter 1 and Squawfish #1 wells for its water needs from mid-1997 to mid-1998. Wells Darter #2, Squawfish #2 and Chandler Simpson were not used during that period. The mine utilizes the groundwater for washing trucks, dust abatement, at the coal plant and for potable water needs. In general, that is without reference to specific usage records, the daily water demand is estimated to be approximately 90,000 gpd for truck wash, 70,000 gpd for dust abatement, 45,000 gpd for the coal plant and 2,000 gpd for potable water supply, or approximately 144 gpm. The section entitled "1998 Update on Impacts of Groundwater Withdrawal on the Ericson Formation" provides approximate, average, monthly use rates for the three wells for the period mid-1997 and mid-1998.

Water Usage at Pits 14, 15 and Pit 10 South Expansion

No additional water supply wells will be required to supply consumptive needs (mostly dust suppression) at Pit 14, Pit 15 and the Pit 10 South expansion. Groundwater usage rates for Black Butte Mine as a whole are not anticipated to change significantly with the continuation of mining, primarily because as mining develops in new or expanded pit areas it terminates in other areas. As an example, Pit 11 was mined out by early 2018 and only Pits 10 and 14 were in production that entire year. Pit 15 will likely produce enough groundwater to supply most or all of the consumptive needs for both Pit 15 and Pit 10 South. Longwall tunnel mining processes planned at the mine do not normally require significant water usage.

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Table MP-25. Industrial Wells - Completion Data.

Well No.	Well Name	Permit No.	Sec.	T	R	Northing	Easting	Total Depth (ft)	Perf. Interval	Surface Elev. (ft)	Casing Type	Perf. Casing Dia (in)	Approx. Capacity (GPM)
WB01-75	Bluebell #13	P28456W	33	19N	100W	332,073	517,596	1,219	930/1219	6,610.0	STL	6 5/8	230
WCS1-75	Chandler Simpson #1	P30220W	8	18N	100W	320,445	509,125	4,932	685/2070	6,629.0	STL	5 5/8	250
WD01-75	Darter #1	P45085W	29	19N	100W	336,328	513,520	2,077	1775/2076	6,584.0	STL	6 5/8	500
WD02-75	Darter #2	P51015W	20	18N	100W	311,720	513,010	2,003	1740/1982	6,802.4	STL	6	350
	Squawfish #1	P69248	5	18N	101W	328,949	510,374	688	455/475 617/677	6,618.0	STL	12	400
	Squawfish #2	P69249	5	18N	101W	330,064	511,694	760	555/575 690/750	6,603.0	STL	12	400
WW5362-91	Red Hill #1	UW85363	11	19N	100W	353,875	528,700	190	130/170	6,755.0	PVC	8	50*
WW5363-91	Red Hill #2	UW85364	11	19N	100W	353,866	528,395	170	110/150	6,763.0	PVC	8	50*

* Pumps not set

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Impact of Groundwater Withdrawal on the Ericson Formation

In the early 1980's, Black Butte Mine prepared a worst-case estimate of groundwater drawdown in the Ericson Formation through year 2004 that was based on a potential irrigation demand of 425 gpm supplied by three wells, the Bluebell 13, Darter 1 and Darter 2 wells. This assessment, presented in Addendum MP-B, utilized the Theis Nonequilibrium Equation (after Lohman, 1972) to estimate drawdown and a line source/sink method also prescribed by Lohman (1972) to estimate average annual recharge to the aquifer occurring over formation outcrops found west of the operating wells. The aquifer transmissivity and storage used in the calculations were apparently taken from some unreferenced literature source or were otherwise estimated.

The recharge rate estimated in Addendum MP-B applies 5 percent of the annual precipitation over the outcrop area of the Canyon Creek member of the Ericson, the unit in which Black Butte completed all of its five Ericson wells. The outcrop area was measured only proximate to the mine permit boundary for conservative purposes. The Canyon Creek member, identified as "Kec" on Exhibit MP-49, is a light gray, fine to coarse-grained, cross-bedded sandstone. As shown on Table MP-25, the Chandler Simpson well is over twice as deep as the deepest Ericson wells constructed by Black Butte Mine. Since the Chandler Simpson well may draw from Ericson members lying below the Canyon Creek member and because water from the well had not (and has not) been used by the mine, the drawdown predictions of Addendum MP-B did not combine drawdown from the well with that calculated for wells Bluebell 13, Darter 1 and Darter 2.

Although the recharge estimates of Addendum MP-B are still valid, the drawdown predictions of the addendum are obsolete for the following principal reasons: 1) There are no current plans for future irrigation in the mine reclamation and, as shown in the following text section, actual groundwater usage rates have been much less than 425 gpm; 2) Two additional wells, the Squawfish 1 and Squawfish 2 wells (see Table MP-25), were constructed in the Ericson to supply a portion of the mine's industrial water needs after Addendum MP-B was prepared; 3) Data from step-drawdown tests conducted on the two Squawfish wells and reported in Addendum D6-D (Appendix D6) allow reasonably accurate estimation of the aquifer transmissivity values at the wells, with the values thus estimated being significantly different than the value used in Addendum MP-B. The addendum has been retained in its entirety, however, in the interest of preserving the aquifer recharge calculations presented therein.

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The step-drawdown tests of the two Squawfish wells in Addendum D6-D were completed in March 1985 soon after the wells were constructed. Squawfish 1 was tested for 26 hours at rates ranging from 410 gpm to 1,000 gpm while Squawfish 2 was tested for 8 hours at rates ranging from about 390 gpm to 1,000 gpm. The specific capacity at the end of the test on Squawfish 1 was approximately 5.4 gpm/ft drawdown and the specific capacity at the end of the test on Squawfish 2 was about 5.0 gpm/ft drawdown.

Walton (1962) equates the specific capacity of a well discharging at a constant rate in a homogeneous, isotropic, nonleaky artesian aquifer infinite in areal extent to the parameters of the Theis Nonequilibrium Equation according to the following expression:

$Q/s = T/(264 \log (Tt/2693\ r_w2\ S) — 65.6)$

Where:

Q/s = specific capacity, in gpm/ft

Q = discharge, in gpm

s = drawdown, in ft

T = aquifer transmissivity, gpd/ft

S = aquifer storage coefficient, fraction

rw = nominal radius of well, in ft

t = time since pumping began, in mins.

The aquifer storage coefficient was estimated following a technique recommended by Lohman (1979) wherein the saturated thickness of a confined aquifer is multiplied by 1E-6. The thickness of the Canyon Creek member averages about 255 feet (Appendix D5), which equates to an aquifer storativity of 0.0003.

Walton's (1962) equation was solved for the specific capacity values observed at the ends of the test periods referenced above for each Squawfish well utilizing an aquifer storage coefficient of 0.0003 to derive aquifer transmissivities of 10,035 gpd/ft and 8,846 gpd/ft for Squawfish 1 and Squawfish 2, respectively.

1998 Update on Impacts of Groundwater Withdrawal on the Ericson Formation

As of October 1998, the six industrial supply wells described above are still available for use at the Black Butte Mine, although the Chandler Simpson well has not and likely will not be used by the mine. The current demand for water continues to be for the truck/vehicle wash bay, dust abatement, coal plant and domestic/potable consumption.

The discharge from each of these production wells is continuously measured and recorded. Water usage from mid-1997 to mid-1998 was as follows:

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- Bluebell 13

  The monthly average is 376,1000 gallons, or 12,365 gallons per day.

  In use 12 months per year.

- Darter 1

  The monthly average is 1,974,240 gallons, or 65,808 gallons per day.

  In use 12 months per year.

- Darter 2

  Not presently in use.

- Squawfish #1

  The monthly average is 2,205,956 gallons, or 73,532 gallons per day.

  Not used 3 months (December, January and February) per year.

- Squawfish #2

  Not presently in use.

- Chandler Simpson

  Constant artesian discharge. Not in use by the mine.

The water system for each of these wells has not been altered and the pump capacity of each well, as tabulated in Table MP-25, is still correct. For example, the pump in Bluebell 13 produces 230 gpm, the pump in Darter 1 produces 500 gpm, the pump in Darter 2 produces 350 gpm, the pumps in Squawfish 1 and Squawfish 2 each produce 400 gpm and the Chandler Simpson well still flows. Collectively, wells Bluebell 13, Darter 1 and Squawfish I produced 151,705 gallons per day, or 105 gpm from mid-1997 to mid-1998, ignoring the three months during which Squawfish 1 was not used. As stated in the previous section of this text, total groundwater supply needs from the Ericson have been estimated to average about 144 gpm.

The drawdown predictions of Addendum MP-B simulated 23 years of groundwater production from the Ericson Formation, through year 2004. Clearly, Black Butte Mine will be in existence for longer than 23 years. Potentiometric head declines in the Ericson for the life of the mine, now arbitrarily assumed to be 40 years, have been computed for two groundwater use rate scenarios using a well field operations model written by Aqua Terra Consultants. The model utilizes the Theis Nonequilibrium Equation (after Lohman, 1979) to compute water table or potentiometric head declines at designated drawdown points assigned

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coordinates consistent with the coordinate system used to locate singular or multiple production wells. The model simulates both unconfined and confined aquifer conditions and for unconfined conditions the transmissivity is corrected to account for aquifer dewatering as drawdown increases. Under confined aquifer conditions the model simulates both leaky and nonleaky aquicludes. Drawdowns resultant from multiple operating wells are summed following the law of superimposition to derive cumulative drawdown at the designated drawdown calculation points.

The well field operations model was employed to compute potentiometric head declines associated with 40 years of well field operation under two scenarios: 1) for a total groundwater production rate of 105 gpm distributed among wells Bluebell 13, Darter 1 and Squawfish 1 according to the average daily use rates observed between mid-1997 and mid- 1998 listed above, and; 2) for a total groundwater production rate of 144 gpm wherein 105 gpm were distributed as set forth under Item #1 plus with the addition of 39 gpm assigned to well Darter 2. Well Squawfish 2 was not included under either modeling scenario under the logic that, since the two Squawfish wells are located relatively close together, only one of the wells would be used at any one time. The model was run in the nonleaky artesian mode; consequently, the results may overestimate drawdown since leakage from the overlying Almond Formation could potentially buffer potentiometric declines in the Ericson over time. The modeled drawdowns may also be biased high because no allowances were made for discontinuous operation of wells. Conversely, no hydraulic barrier boundaries, such as those potentially associated with local structural faulting, were input into the model. This could cause underprediction of drawdown particularly within the interior of the mine in areas south of the fault found about 2000 feet north of well Darter 1. The Chandler Simpson well, drilled in 1962, was not included in the groundwater modeling because of the reasons given in the previous text section for the well not having been included in the original (now obsolete) water supply well drawdown predictions of Addendum MP-B.

Exhibit MP-49 illustrates the locations of the Ericson production wells, principal fault traces, and geologic formation and formation member boundaries together with the model's axis grid and points of drawdown calculation. Input data for the two modeling scenarios are listed below:

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Well No.	Transmissivity (gpd/ft)	Storage Ratio	Flow Rate (gpm)	Aquifer Tickness (ft)	Head Above Aquifer Floor (ft)
Squawfish 1	10035	0.0003	51	274	746
Bluebell 13	9260	0.0003	9	289	799
Darter 1	9260	0.0003	46	301	799
Darter 2	9260	0.0003	39	242	799

The transmissivity assigned to well Squawfish 1 is that derived from analysis of the step drawdown test of the well described in the previous text section while the transmissivity values assigned to the remaining three wells are equivalent to the arithmetic average found for Squawfish 1 and Squawfish 2 wells. The thickness of the aquifer at Squawfish 1 is taken from information provided in Addendum D6-A while the aquifer thicknesses assigned to the other three wells are equivalent to the respective perforation intervals reported on Table MP- 25. The head above the aquifer floor assigned to Squawfish 1 was computed from information provided in Addendum D6-A; specifically, as the sum of the shut-in pressure head above the top of the aquifer (472 feet) plus the thickness of the aquifer (274 feet). Computed in identical fashion, the head above the aquifer floor at well Squawfish 2 was 852 feet when the well was first tested after construction. The arithmetic average of these two Squawfish values (799 feet) is the head above aquifer floor value assigned to the remaining three wells listed above. On Table MP-25 the total perforation interval for Bluebell 13 is listed as 289 feet (930-1219 feet), and from a statement in Addendum D6-A that the shut-in head on the well is 34 psi, the total head above the floor of the aquifer could be computed as 1298 feet (1219 + (34 x 2.31 ft/psi)). The well field operations model was rerun using a total head above aquifer floor value of 1298 feet for well Bluebell 13 with the finding that the computational results were identical to those computed using the values tabulated above. As described below, total drawdowns are small relative to the potentiometric heads above the top of the aquifer and it is for this reason that the model is insensitive to large differences in input values for total heads above the floor of the aquifer.

Exhibit MP-49 shows the areas projected to be encompassed by 10 feet or greater drawdown as determined by the two modeling scenarios. The fault lying about 2000 feet north of Darter 1 well is inferred to be a hydraulic barrier to the drawdown, although drawdown values computed by the model without regard to the existence of the fault are also shown north of the fault. The effect of faulting on groundwater movement in the Fort Union Formation near Pit 11 is described in the section *Fault Control On Groundwater Movement and Drawdown* in this Mine Plan. Exhibit MP-49 also shows drawdowns computed at the wells, with the greatest projected drawdown being 23.1 feet at well

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Squawfish 1. Although the 10-foot drawdown was selected for illustration, even this amount of drawdown is relatively insignificant when compared to the hydrostatic heads existing above the top of the aquifer. Heads above the top of the aquifer average about 500 feet, as can be seen by subtracting the aquifer thickness values from the heads above aquifer floor values listed above.

Black Butte's water supply wells will cause potentiometric declines in the Ericson Formation in areas east, west and south of the mine permit boundary and, if local faults do not act as effective barriers to groundwater flow, drawdown will also occur north of the mine. Throughout all areas, however, even at the production wells themselves, the declines will be small relative to the aquifer's thickness and even relative to the aquifer's hydrostatic head. West of the mine, the drawdown will intercept the outcrop zone of the Canyon Creek member of the Ericson where the aquifer is probably unconfined, but recharge occurring on the outcrops will prevent updip migration of drawdown, as is shown on Exhibit MP-49. The reader is cautioned that the drawdown values shown on Exhibit MP-49 are approximate, depending not only upon the hydraulic effects of local faults and variations in the aquifer hydraulic coefficients, but also upon variations in Black Butte's groundwater use rates. Variations in groundwater use rates and the practice of intermittently operating some of the wells will cause actual drawdowns to deviate from the model projected drawdowns, but the differences will likely be restricted to areas proximate to the wells within the interior of the permit area and in all cases the drawdowns will remain small relative to the hydrostatic heads existing above the top of the aquifer.

Ericson Formation Water

As mentioned in Appendix D6 - Hydrology, several seeps from the Ericson Formation occur along a sandstone outcrop in Section 2, T18N, R101W, where topography interrupts the beds. These seeps flow a few hundred feet where they disappear into the alluvium. The seeps occur along the extreme western boundary of the permit and will not be affected directly by mining. There also will not be any detectable change in these seeps as a result of removal of water from the Ericson from supply wells which tap the Ericson a few miles downdip.

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APPENDIX E –
2024 HYDROLOGIC SUPPORT DOCUMENT FOR THE BLACK BUTTE COAL MINE

BLACK BUTTE COAL COMPANY

Permit No. 520-T7

2024 HYDROLOGIC SUPPORT DOCUMENT

December 1, 2023 through November 30, 2024

Prepared by

Water & Environmental
TECHNOLOGIES

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NARRATIVE

BLACK BUTTE COAL COMPANY 2024 ANNUAL HYDROLOGY REPORT DECEMBER 1, 2023 THROUGH NOVEMBER 30, 2024

INTRODUCTION

This section of the Black Butte Coal Company's (BBCC) 2024 Annual Report contains a summary of hydrologic data collected in the vicinity of the Black Butte Mine. Historically, report periods extended through December, however, a change was necessitated to accommodate current Wyoming Department of Environmental Quality's (DEQ) required submittal date for the annual report from January to December. The hydrologic report is organized into a narrative on the mine's monitoring activities, interpretation of data regarding water quantity and quality, and a discussion of any effects mining has had on the hydrologic regime in the general area. All groundwater and surface water data are contained as tables and figures following the narration. Also included is the current hydrologic monitoring sites map.

HYDROLOGIC SETTING

Groundwater

The United States Geological Survey has analyzed the regional hydrogeologic system and these publications are listed in Appendix D6 of BBCC's Mine Permit. Details of the regional and local geology are presented in Appendix D5 while site-specific geologic information is included in the Mine Plan as geologic cross-sections.

The Black Butte Mine is located on a dissected arid upland situated on the eastern slope of a large anticlinal dome called the Rock Springs Uplift. Rocks along the southeastern flank of this uplift dip to the east-southeast at 3^{o} to 10^{o}. The geologic formations which outcrop within the BBCC permit area are, in ascending order: the Ericson, Almond, Lewis Shale, Fox Hills Sandstone and the Lance Formation of late Cretaceous age; the Fort Union and Wasatch Formations of early Tertiary age; and the alluvial and colluvial deposits of Quaternary age. The permit area is roughly bisected from the southeast to the northwest by the region's most significant drainage: Bitter

Creek. The Bitter Creek valley is broad and flat and underlain by alluvial deposits up to 80 feet thick.

Coal seams from portions of the Almond and Fort Union Formations are being uncovered and mined. The recoverable coal beds and respective reserves within these two formations are listed in Appendix D5 (Tables D5-3 and D5-4) of the Permit.

The Almond Formation has been mined in Pit Eight and Pit Fourteen. Pit Eight contained 3 mineable coal beds ranging in thickness from 2.5 to 15 feet, it has been mined out and is nearly backfilled. Pit Fourteen is currently open and contains 4 mineable coal beds ranging in thickness from 1.5 to 12.0 feet.

The Lance Formation is found in Pits Seven, Twelve and Thirteen. It contains up to 11 coal beds (depending on the pit/area) that range in thickness from 2.0 to 13.0 feet. Lance Formation coal was historically mined in Pits Five and Six, prior to backfilling. Currently there are no active Lance pits.

The Fort Union Formation contains up to 2 beds ranging from 10.0 to 26.0 feet in thickness. It was mined in Pit Ten and in the southern portion of Pit Fifteen in 2023. Fort Union Formation coal was historically mined in Pits One, Two, Three, Four, Nine and Eleven. Backfilling and rough grading continued at Pit Eleven in 2024.

The Almond coal continues to be mined in Pit Fourteen in 2023. Pit Eight has been mined out and is being backfilled. Some topsoil replacement occurred during this report period.

Pits One, Two, Four, Five, and Six, and the northern area above Ramp 6 in Pit Three are backfilled. Coal removal is complete in the southern leg of Pit Three.

Within the mine area, groundwater occurs in the alluvium of Bitter Creek, the localized alluvial/colluvial deposits of some of Bitter Creek's ephemeral tributaries, and the Fort Union, Lance, Almond and Ericson Formations. For the most part, the Fox Hills, Lewis Shale and the Wasatch Formations are dry. The Ericson Formation is a regionally significant aquifer capable of high yields and is an important industrial water supply.

All the principal water-bearing strata in the general area are confined or semi-confined. The direction of groundwater movement for the formational strata is typically downdip off the eastern flank of the Rocks Springs uplift toward the Washakie Basin to the east. Structural faulting plays a significant role in controlling the direction of

groundwater flow by disrupting the continuity of the formational strata and creating hydraulic barriers. Faulting is more prevalent in the northern portion of the mine area (Appendix D5, Exhibit D5-1). Groundwater movement within the Bitter Creek alluvium is down-valley, generally toward the north and northwest through the mine permit area.

In defining the relative importance of water-bearing strata as an aquifer (defined as "a zone, stratum or a group of strata that can store and transmit water in sufficient quantities for a specific use") in the general area, consideration must be given to the areal extent of the lithologic zone. Coal seams within the Fort Union, Lance and Almond Formations and Bitter Creek alluvium are the only lithologic units that are large in areal extent. The discontinuous water-bearing sandstone lenses that are present primarily in the Fort Union Formation cannot be defined as regional aquifers and have only localized hydrologic significance.

The hydraulic characteristics and physical descriptions of each shallow water-bearing stratum in the Black Butte Mine area are identified in Appendix D6 of the Mine Permit. The results of all the aquifer pumping tests that were conducted through 1986 as baseline investigation are presented in Table D6-2 and Addendum D6-C. Within the Aquifer Characteristics Summary section (page D6-32), it is stated that, "Bitter Creek alluvium exhibits consistently high transmissivity values since the deposits are fairly uniform" and "the average transmissivity is approximately 2,200 ft^2/day based on the results of two multiple well tests". The Fort Union sandstones exhibit the next highest transmissivities (average of 1,850 ft^2/day) when near the Bitter Creek valley. Fort Union coal seams showed much lower transmissivities (generally, between 1 to 3 ft^2/day). Aquifer tests in the Lance and Almond Formation's water-bearing coal seams also exhibited relatively low transmissivities (average between 2 to 7 ft^2/day). The only significant producible groundwater, excluding that from the Ericson Formation, comes from the Bitter Creek alluvium and discontinuous Fort Union sandstone beds which are recharged by Bitter Creek alluvial groundwater at their alluvial subcrops.

Aquifer tests may occasionally be conducted during mining to more thoroughly identify the hydraulic characteristics of the affected water-bearing strata and the resaturated spoils. For example, spoils monitoring wells completed in backfilled Pit Two were pump tested in 1990, and the data and interpretations are included in the 1990

Annual Hydrologic Report. Contained within the 1994 Annual Hydrologic Report are data, interpretations and tabular results of the aquifer pumping tests which were conducted on the monitoring wells installed in the Pit Three spoils and the Bitter Creek alluvium in 1994.

Recharge to the water-bearing strata occurs at the outcrop areas, and more importantly, at the low-lying subcrop areas beneath the Bitter Creek alluvium where water availability is great. Groundwater then moves downdip, generally toward the Washakie Basin to the east, or it is intercepted by the mine's pits which intersect these water-bearing strata. The natural, pre-mining gradients can be affected (i.e. warped toward the excavations), especially near the pit area. Premining potentiometric surface maps are included in Appendix D6 of the Mine Permit. The October 1994 potentiometric surface maps of the Fort Union, Lance and Almond Formations, and the Bitter Creek Alluvium, are included in the 1994 Annual Hydrologic Report.

Consideration must also be given to water quality when defining the importance of a water-bearing stratum as an aquifer. The premining water quality characteristics of each water-bearing stratum are identified in Appendix D6. In general, shallow groundwater present in the Black Butte Mine area is of poor quality. The Bitter Creek alluvial groundwater is typically a sodium-chloride or sodium-sulfate type having very high concentrations of chemical constituents. Groundwater in the formational, confined systems (Fort Union, Lance and Almond) also exhibit high degrees of mineralization, usually of a sodium sulfate or sodium bicarbonate type. Little seasonal variation is noted. Due to high concentrations of dissolved ionic constituents (typically sulfate and chloride), groundwater from all of the water-bearing strata fails to meet the drinking water/domestic use standards. High dissolved solids concentrations and high SAR values also make the waters unsuitable for irrigation. Groundwater from the Bitter Creek alluvial system has the highest ionic concentrations of all the shallow groundwater, making it unsuitable for livestock use. Groundwater sampled from some of the wells in the Fort Union and Lance Formations has also been found to be unsuitable for livestock use.

Surface Water

The drainage area within the Black Butte Coal permit boundary lies almost entirely within the confines of the Bitter Creek watershed. However, a small portion of the northern permit area, approximately 1.5 square miles, drains into the Deadman Wash watershed. Also, about 1.5 square miles within the southern permit boundary drains into Black Butte Creek. Exhibit D6-10 of Mine Permit 467 shows the general relationship of the Bitter Creek, Deadman Wash, and Black Butte Creek watersheds to the Black Butte mine permit boundary. The portion of Deadman Wash within the permit boundary is outside of the proposed area of mining activity. The drainage area of Bitter Creek upstream of the permit boundary is approximately 488 square miles (drainage area above site SBC1-75). Approximately 107 square miles of Bitter Creek's watershed lies within the confines of the BBCC permit boundary (between monitoring sites SBC1-75 and SBC2-75).

Bitter Creek flows through the Black Butte Mine in a north-to-northwest direction and nearly dissects the mine in two with active or historic reclaimed pits on either side of the Bitter Creek valley. Bitter Creek is the major surface hydrologic feature of the area. It is highly incised and its flows can be characterized as intermittent, flowing mainly in direct response to snowmelt and precipitation events. The area upstream of the Black Butte Mine consists of arid plains which offer an abundant supply of fine-grained sediments. The Bitter Creek alluvial valley throughout the mine area consists of mostly unconsolidated fine-grained sands, silts, and clays. As a result of the fine-grained sediments available for transport and the makeup of deposited sediments within the Bitter Creek valley, the Bitter Creek channel consists of loosely compacted, fine-grained material that lends itself to unstable conditions.

All tributary watersheds to Bitter Creek within the Black Butte Coal permit boundary are ephemeral in nature. Ranging in size from 0.11 to 23.14 square miles, the majority of these ephemeral drainages are characterized by deeply incised narrow channels in the steeper portions of the watersheds. Closer to Bitter Creek, they generally flatten out, with channels becoming much wider and shallower. At the point of confluence with Bitter Creek, they may lose definition, braid, or result in a series of small rills. A complete description of these tributary watersheds and their morphology is given

within the **SURFACE WATER HYDROLOGY** section of Appendix D6, Permit 467. Exhibit D6-12 in the Permit is the premining drainage basin map and gives the location of each tributary ephemeral drainage to Bitter Creek within the permit boundary.

MONITORING NETWORK

Groundwater Monitoring Program

Contained within the Permit document are thorough descriptions of the area's regional and site-specific geohydrology; including geologic structure, lithology and stratigraphy, groundwater occurrence and identification of aquifers, aquifer coefficients, recharge and discharge areas and the predicted effects on the groundwater system both during and after mining.

The groundwater monitoring schedule for the Black Butte Mine, as presented in Permit 467, can be found in Table MP-23 of the Mine Plan. Table 1 of this report contains a description of the Black Butte Mine's groundwater monitoring wells (including location, completion and specific monitoring information) that are currently active. Exhibit 1, Hydrology Monitoring Sites, shows the location and monitoring status of all observation wells which have been completed within the Black Butte Mine area.

The type and frequency of monitoring activities performed at each observation well are presented in the "Monitoring Information" column of Table 1. Every attempt is made by mine and contract personnel to perform these monitoring activities on a consistent schedule, although late or missing data can result if adverse weather conditions prohibit access to the well site. When each observation well is visited, the integrity of the surface seal between the casing and the well bore is visually inspected. Should an annulus ever open up between site visits, it will be resealed immediately. The total depths of all wells in the network are also measured on an annual basis to further verify completion integrity. Results of the measured total depths are included in Table 16. During this report period, no annulus needed to be resealed.

Table 2 lists all of the monitoring wells that have been destroyed by mining. The format is similar to Table 1, with the exception of a "Final Water Elevation" column and the date that the well was destroyed is listed in the "Monitoring Information" column.

Changes to the Groundwater Monitoring Program

Methodologies used in obtaining groundwater information have not been altered during this reporting period. As a matter of routine practice, those wells which are removed by the mining operation that are crucial to the network are replaced either prior to the well's loss or as quickly as possible afterwards to maintain continuity of record on a particular aquifer within a specific area. It may be necessary to reinstate a certain deleted well or it may be necessary to install a new well, depending on the circumstances. Table 1 also lists observation wells which are not being actively monitored (discontinued wells). These sites have not been abandoned or reclaimed (filled with bentonite) so that monitoring can be reinstated if/when necessary. In addition, monitoring in the vicinity of any proposed pit will be initiated one year in advance of the opening of a pit.

As indicated in Table 4, there were no changes to the groundwater monitoring program in 2024.

Surface Water Monitoring Program

Surface water quantity and quality of Bitter Creek streamflow passing into and out of the permit boundary are monitored at sites SBC1-75 and SBC2-75, respectively. SBC1-75 is located upstream of all Black Butte Coal mining activity within the Bitter Creek watershed while SBC2-75 is located downstream of all activity. Both monitoring sites are depicted on Exhibit 1 of this report. Table 3 lists the surface water monitoring sites within the presently active network and includes name, location, elevation, monitoring equipment present, and it describes the activities performed at each site. A complete description of BBCC's monitoring efforts on Bitter Creek, both historically and at the present time, is provided in the SURFACE WATER DISCHARGE and SURFACE WATER QUALITY sections of Appendix D6, Permit 467. The 1994 Annual Hydrologic Report also has a section entitled "History of Surface Water Monitoring of Bitter Creek."

Streamflow/stage measurements are obtained monthly during the ice-free period, which is typically March through October. These stage measurements are then converted to streamflow values utilizing the Manning's equation.

Additional required inputs into the Manning's equation methodology are the channel hydraulic radius and the slope of the surface water profile. These are obtained by

surveying the channel cross section and profile at SBC1-75 and SBC2-75. These channel surveys should be updated occasionally, due to the dynamic characteristics of the Bitter Creek channel. Channel geometry can readily change as a result of the hydraulic energy created by high flows, the shifting nature of the fine-grained channel sediments and the extremely high sediment loads that are characteristic of this stream. Should any flood event cause an appreciable change in the channel geometry at either of the two gaging stations, the respective channel cross section will be resurveyed as soon thereafter as possible.

Each site is also equipped with a crest stage gage that is set high in the channel bank, and a horizontal staff gage. These measurement devices are checked monthly and when high flow occurs, it leaves a mark on the calibrated rod of the crest gage that is then converted to a water surface elevation and applied to the Manning's equation methodology to obtain an estimated peak discharge rate.

In conjunction with flow measurements, monthly water quality samples are collected during the ice-free period at SBC1-75 and SBC2-75 and analyzed for total dissolved solids and total suspended solids concentrations.

Changes to the Surface Water Monitoring Program

Methodologies used in obtaining surface water information have not been altered during this report period. Surface water monitoring sites and frequencies, for the most part, remain unchanged over time so as to record relative changes/trends in water quality and quantity. No changes to the surface water monitoring network occurred during this reporting period. The latest channel and profile surveys were conducted in July 2014 and an updated rating table for each station was developed from this information. In recent years the mine has opted to collect supplemental samples from Bitter Creek for expanded analytical parameters.

GROUNDWATER

Mining operations at Black Butte impact the local hydrologic regime by removing portions of certain water-bearing strata, thus interrupting, or altering premining groundwater levels, flow patterns and availability. Changes to premining groundwater

quality are also caused by resaturation of the backfilled overburden spoil materials. Water-bearing strata now affected are within the Fort Union, Lance and Almond Formations. A small portion of the Bitter Creek alluvial aquifer was removed during mining of the western-most edge of Pit Two and there now is a hydraulic connection between the Bitter Creek alluvium and the backfilled Pit Two spoils. The northern edge of Pit Three is very close to the Bitter Creek valley, and even though the excavation does not directly intersect or disturb the Bitter Creek alluvium, Bitter Creek alluvial groundwater is intercepted through subcropping permeable strata of the Fort Union Formation that was mined and exposed in Pit Three.

The groundwater inflow estimation tables in the Mine Plan section of the Permit (Tables MP-20, 21 and 22) address which pits intercept groundwater, predicted inflow rates and the respective formations mined at each pit.

Groundwater Levels

The groundwater monitoring network at Black Butte was established in part to observe the effects created by mining activities on groundwater levels. Groundwater elevation data recorded during this report period are presented in Table 5. At present, the mine plan identifies fourteen pits in various stages of mining or reclamation and mining has yet to commence at several of the pit areas. Mining operations in Pit Two concluded in 1984 when the last coal was removed, and all regrade work was completed in 1985. BBCC was directed by the WDEQ/LQD to initiate work on the Alternate Regraded Surface for Pit Two in 1993 and this backfilling was completed in 1997, and topsoil placement was nearly completed at the end of the 1998 report period. Pits Two, Four, Five, and Six are now backfilled. Pits Three and Nine are nearly backfilled. Backfilling has commenced in Pit Eleven Pits Ten, and Fourteen and Fifteen were actively mined in 2023.

What follows are discussions by aquifer on the various responses to groundwater resulting from mining at the Black Butte Mine. The discussions do not include groundwater conditions within and near Pits 2 (Fort Union Formation) or Pit 6 (Lance Formation) because the WDEQ/LQD has acknowledged that groundwater performance criteria for these three pits have been met. The criteria have also been met for that

portion of Pit 3 (Fort Union Formation) located southwest of Twn. 18N, Rng. 100W, Section 31, and all of Pit 4 where the mined strata were not saturated prior to mining. Details regarding the WDEQ/LQD's acknowledgement are found in its Annual Report review memorandum dated April 17, 2015.

Fort Union Formation

The rate and extent of groundwater level declines in the Fort Union Formation is a function of the geology, size and location of the excavation, distance from the excavation, and distance from the principal recharge source area (i.e., the Bitter Creek alluvial subcrop). Comprehensive listings of the historic groundwater level elevations observed at all of the Fort Union monitoring wells that have been installed at the Black Butte Mine through 1995 are included in previous Annual Hydrologic Reports. The historic data from Fort Union wells that are currently monitored are depicted as hydrographs, Figures 1 through 8 in this report. As these graphs illustrate, Fort Union wells are recording either stable or recovering water levels, with the exceptions of some recent variability at wells 65 and 81 which remain depressed near Pit 10, and at wells 112, 113, 85R and 87R near Pit 11. The declines in these wells are consistent with projections of potential impacts to groundwater from mining

Well No. 65 lies northeast of Pit 10 on approximate strike with the formation. Water levels at this location declined over 21 feet between October 1988 and November 2007 and the well was dry in 2008.

The geohydrologic cross section of Pit Three (Permit 467, Appendix 6, Exhibit D6-15) illustrates how the strata become structurally elevated and is naturally dry toward the southern end of this southwest-trending pit. As shown in Figure 2, two of the Fort Union monitoring wells demonstrate historic, mine-related aquifer drawdown less than one half mile southeast of Pit Three. Well 76 is the southern-most Fort Union monitoring well for Pit Three. It recorded only about 7 feet of drawdown through 1992. Subsequently water levels have recovered about 1 to 2 feet. The maximum drawdown recorded by these four wells to date is about 50 feet at Well 75, where water levels have subsequently risen nearly 40 feet since 1994. Water levels at Wells 75 and 89 have increased since 1994 at similar steady rates, while the levels at Well 90 were stable from 1999 through 2009. Recovering levels at Well 90 have since risen about 12 feet through 2023.

Figure 3 shows hydrographs of other Fort Union wells located near the Bitter Creek alluvial subcrop, and proximate to Pit Three. These wells continue to show minimal drawdown, with water level declining on the order of a few feet since 1981.

Exhibit D6-4 in the approved permit shows that the Fort Union formation within all of Pit Four, and the area south of Ramp 6 in Section 31 in Pit Three, were not initially saturated with groundwater. Therefore, in April 17, 2015 correspondence to Black Butte Coal Company, the DEQ determined that there are no groundwater performance criteria for these two pit areas.

Measured groundwater level elevations at Well 86 (Figure 6), located downgradient of Pit Nine, have increased about 17 feet since 2003. This rise is consistent with projections of recovering water levels during backfilling.

As shown in Figure 7, water level elevations at the two remaining wells in the Pit Ten area (Wells 65 and 81) show drawdown in response to active mining. Well 65 became dry in 2008 and will be temporarily inactive until Pit 10 is backfilled. Two monitoring wells (Wells 112 and 113, Figure 8) were installed in 2005, prior to the opening of Pit Eleven in 2006. Also, two replacement wells (85R and 87R) are now used to monitor groundwater near Pit Eleven in place of the historic baseline wells (85 and 87) which were both destroyed by mining in 2011. Declines in water levels since 2006 are evident at Wells 85 and 85R, 112 and 113, while the water level at Well 87 remained relatively stable through its last monitored event in 2009. Subsequently, monitored water levels at Well 87R have declined as much as 32 feet from the highest recorded level since construction. The rate of decline observed at Well 87R is comparable to that observed at other Pit Eleven monitoring well locations and water level are expected to continue to decline at this well as long as mining progresses.

Lance Formation

Although Pits Five South, Seven, Twelve and Thirteen are slated to mine Lance coals, no mining disturbances within these four pits has occurred to date. Only Pits Five and Six have disturbed the Lance Formation. Both historically mined pits have been reclaimed. The WDEQ/LQD has acknowledged that groundwater performance criteria associated with reclaimed Pit 6 have been met.

The backfilled disturbances of the northern portion of Pit Five, near the Lance Formation outcrop, are structurally higher and at higher elevation than the Lance Formation's subcrop beneath the Bitter Creek alluvial valley. The pre-mining recharge to the water-bearing strata in this area was by precipitation infiltration at the outcrops. Groundwater quality data from the southern end of Pit 5 backfill show distinct similarities to the Bitter Creek alluvial aquifer, suggesting that the alluvial aquifer is an important recharge source to this area of Pit 5 (see text below under "Groundwater Quality Reclaimed Spoils".

A comprehensive listing of historic groundwater levels measured at all Lance monitoring wells at Black Butte Mine through 1995 is included in previous Annual Hydrologic Reports. Historical data from currently monitored Lance wells are depicted as hydrographs in this report (Figures 9 through 12).

Figure 9 presents the historical groundwater level hydrographs of the four observation wells in the Pit Five area that are situated downdip and outside of the pit disturbance boundary. Through about 2002, Well 21 recorded a total drawdown of approximately 80 feet since the well's installation in 1978. From 2003 to 2006 water levels abruptly rose 60 feet and stabilized briefly, before fluctuating downward to more typical range. The historic water level fluctuations at Well 21 are presently attributed to reduced groundwater density from dissolved coal bed gases. Well 21 does not, currently exhibit well head venting, and its apparent measured water level declined a total of about 110 feet by 2018. Subsequently, monitoring personnel report that the well has been obstructed since 2019 at about 86 feet below the top of the established measuring point. The groundwater levels recorded at Well 22 gradually declined at about one to one-half foot per year from 1981 to 2002 and have since been stable. Wells 24 and 35 are located between Pits Five and Five South, are close together and are similar in completion. Both

wells are currently not monitored but, the most recent water levels recorded at these two sites indicate that total drawdown at both locations has been minimal (respectively about 2 to 4 feet).

The historical hydrographs of Lance monitoring wells in the Pit Five South area (Figure 10) continue to demonstrate groundwater levels in this area have been relatively unaffected by Pit Five activities. About 4 to 5 feet of recovery has occurred at Well 66.

Historical hydrographs recorded by Lance Formation wells that are located at unopened/inactive pits (Pits Seven, Twelve and Thirteen) are included in Figure 12. Well 1, in the Pit Seven area, is completed within a structural fault block and is situated a short distance downdip (east) of the monitored strata's outcrop. This well is therefore monitoring groundwater levels within a hydraulically isolated fault block. As illustrated by its hydrograph, groundwater levels fluctuated considerably from 1980 through 1986, possibly related to variations in annual precipitation infiltration recharge at the outcrop. Monitoring was discontinued from 1987 through November 1990. When monitoring resumed in November 1990, the well was dry. Since that time the well has been visited annually and it continued to be dry through 2001. A total depth of 156 feet below land surface was measured in 1995, indicating that approximately 8 feet of the perforated interval (144 feet to 164 feet below land surface) has silted in. Records show that Well 1 was obstructed from 2002-2009. Subsequent levels through 2014 were dry, or nearly dry, at about 154 feet below ground surface. Well 5 is also located within the Pit Seven area, but within a different fault block. Although historically dry at this location, the well contained a minor but measurable amount of water in 2005. Well 2 near Pit Thirteen is 198 feet deep and the depth to water has remained virtually unchanged at 176 to 179 feet below land surface since the well was completed in 1974. An obstruction was noted in Well 2 at about 178 feet in September 2004 and any reported water level elevations since that time appear to correspond with this obstruction. The hydrograph for Well 4, located in Pit Twelve, reflects the variability of recharge by precipitation infiltration, along with potential influence from historic operations in Pit Two. Groundwater levels observed at this well have fluctuated over 40 feet several times since its installation in 1974. Active monitoring in the Lance Formation has been temporarily postponed in Pits Seven, Twelve, or Thirteen, but will be reinstated one year prior the commencement of mining.

Almond Formation

Almond Formation coal was historically mined at Pit Eight and is currently mined in Pit Fourteen. As stated in the **HYDROLOGIC SETTING** section, there were four minable coal seams in Pit Eight, and the occurrence of groundwater is primarily associated with those coal seams. Groundwater recharge occurs at the outcrops in the uplands west of and adjacent to the pit area, and groundwater flows eastward from the outcrop, controlled by the structural gradient. Free- flowing conditions occur at some locations within the Pit Eight area.

The position of Pit Eight within the groundwater flow system is such that mining cuts essentially began along the water-bearing strata's (coal seam's) outcrop. Thus, the water-bearing strata's upgradient boundary was predicted to change gradually in response to mining, as was the downgradient hydraulic response. Mining in Pit Eight began in 1988 and concluded in 2010. The rate of groundwater inflow to Pit Eight excavations was and should continue to be very low to negligible as backfilling concludes.

Figure 13 presents the historical hydrographs of three Almond Formation observation wells in the Pit Eight area. Well 71, located at the northern end of the pit, exhibited artesian flow from August 1983 through 2001. As a result of reduced hydrostatic or coal gas pressures within the coal aquifer, this well no longer flows. Gas bubbles were readily observed at the well head of nearby Well 70 in 2001, during a regulatory inspection. Well 8 was located midway along the pit's length and was affected by mining starting in 1995 as mining proceeded toward the well. Pit advancement destroyed Well 8 in September 2003. Well 111 was completed and developed as a replacement for Well 8 in 2005. The well exhibited pressurized venting of coal bed gases during initial well development, and its apparent water level subsequently declined over 100 feet by 2010. However, with the continuing backfilling of Pit 8, the measured water levels from Well 111 currently show about 34 feet of recovery and have remained stable since 2019. Groundwater at Well 72, situated at the southern end of Pit Eight, has fluctuated from 23 feet below, to 10 feet above, the static water level observed when the well was installed. While this fluctuation in hydrostatic pressure could be attributed to naturally occurring variation in recharge from the infiltration of precipitation at the strata's outcrop, it is more likely associated with the reduced density of groundwater from

dissolved coal bed gases. A temporary decline in hydrostatic head of approximately 17 feet was observed at Well 72 between May and October 1995 and another decline occurred at the close of the 1998 report period. Between April and October 1999, water levels in this well rose nearly seven feet to approximately its historic average elevation. Reasons for the temporary declines in water levels at this location may be mine related, although they tended to recover quickly. Since 2008 the measurements at Well 72 are less erratic.

Nine monitoring wells were completed at three locations adjacent to Pit 14 from 2001 to 2005. The wells monitor groundwater above (the OB series), within (the CZ series) and below (the UB series) the Almond coal zone in three groups adjacent to the northeast, central and southwest portions of the pit (Exhibit 1). After completing baseline hydrologic monitoring and permitting, the pit was opened in 2008. Water level measurements for the central and southern monitoring well groups are shown in Figures 19a and 19b. Monitoring of water levels in the SW4 series wells confirms flowing conditions persisted in all three aquifer zones northwest of the pit. Subtle declines in water levels above and within the coal zone are evident in the central monitoring well group through 2015 when the drawdown subsequently increased. In 2017 the flowing conditions in the central underburden well ceased and the measured water levels declined to several feet below ground surface. Coal groundwater in this location may historically have been influenced by gas, as shown by sporadic fluctuations in groundwater elevations, and possibly by groundwater elevations that are anomalously high compared to those above the coal, and in comparison, to the coal groundwater elevations southwest of the pit. Southwest of the pit, both the overburden and coal exhibit subtle declines in groundwater elevations, but the coal elevations are substantially lower than those above the coal, and do not appear to be influenced by gas. Groundwater beneath the coal southwest of the pit has not been affected by mining.

Confined groundwater conditions beneath the coal are well-confirmed from groundwater monitoring adjacent to Pit 14. Mining has now affected groundwater levels in the coal, overburden, and underburden in the central area of Pit Fourteen. Data to date are inconclusive as to whether the groundwater elevations monitored in the coal near the southwestern end are from mining, gas, or are natural trends.

Bitter Creek Alluvium

The **HYDROLOGIC SETTING** section of this report and Appendix D6 of Permit 467 address the occurrence of groundwater within the Bitter Creek alluvium, its hydraulic characteristics, and its importance as a source of recharge to permeable subcropping strata, particularly of the Fort Union Formation. Prior to, and during the early phase of mining at Black Butte, numerous monitoring wells were installed for the purpose of studying and identifying the hydraulic characteristics, groundwater levels and water quality of the Bitter Creek alluvium. The majority of these "baseline" alluvial wells were installed in the Bitter Creek valley near the north end of Pit Three (Exhibit D6-7 in the Permit). As the Geologic Map (Exhibit D5-1 in the Permit) and the Fort Union Formation Potentiometric Surface Maps (Exhibit D6-4 in the Permit and Exhibit 2 in the 1994 Annual Hydrologic Report) illustrate, the Fort Union Formation subcrops under the Bitter Creek valley north of and adjacent to Pit Three, in the same area where the majority of the "baseline" alluvial wells were installed. The Pit Three operation mined the Fort Union Formation, and even though the excavation did not intersect or disturb Bitter Creek alluvium, it did intercept alluvial groundwater via the subcropping permeable strata that were exposed in the pit.

The premining Hydrologic Monitoring Sites map (Exhibit D6-7 in the Permit) shows that outside of the Pit Three area only four other "baseline" alluvial monitoring wells existed: Wells 3, 14, 73, and 74. The Bitter Creek alluvial groundwater monitoring network was evaluated in 1993. This involved a thorough review of every monitoring well's litholog and completion data, historical records and trends, and the importance of its location relative to mined or reclaimed areas and the Bitter Creek alluvial valley. It was determined that an insufficient number and distribution of wells along the Bitter Creek valley length through the permit area existed to adequately monitor and describe the alluvial groundwater regime. In addition, because some of the existing wells were improperly designed, constructed, or located, there has been information recorded which may not necessarily be a true representation of the alluvial aquifer's properties and conditions. As a result, BBCC implemented numerous revisions to the alluvial groundwater monitoring network in 1994. These changes were discussed in the 1994 Annual Hydrologic Annual Report. All the presently active Bitter Creek alluvial

groundwater monitoring wells are listed in Table 1 and their locations are depicted on Exhibit 1. The following discussion is based upon data that has been determined to be reliable and representative of the alluvial groundwater system.

Hydraulic characteristics of shallow water-bearing strata in the BBCC mine area are identified in Appendix D6 of the Permit. The results of all aquifer pumping tests which were conducted through 1986 as baseline investigations are presented in Table D6-2 and Addendum D6-C. Within the Aquifer Characteristics Summary section (page D6-32), it is stated that "Bitter Creek alluvium exhibits consistently high transmissivity values since the deposits are fairly uniform" and "the average transmissivity is approximately 2,200 ft^2/day based on the results of two multiple well tests." The General Hydrogeology section in Appendix D6 includes a physical description of each of the potentially affected aquifers, including Bitter Creek alluvium, and it states, "the major system for unconfined water is the Bitter Creek alluvium" and "isolated areas within the valley may give a confined appearance due to fine silts and clays overlying coarser-grained material."

Four additional pumping tests were conducted at Bitter Creek alluvial wells. Two of the tests were single-well (Well 93 and 105), and two tests were multiple-well (Wells 100 and 107, and Wells 103 and 104). These tests were conducted to provide a more complete description of the Bitter Creek alluvial aquifer's hydraulic properties throughout the mine’s permit area. Data, graphs and interpretation of these alluvial pumping tests are included in Appendix 2 of the 1994 Annual Hydrologic Report. Table 5 of that report summarizes the Bitter Creek alluvial aquifer's hydraulic parameters determined by all pumping tests conducted through 1994.

Based upon the results of the 1994 pumping tests, Bitter Creek alluvium does not exhibit consistently high transmissivity values throughout its length within BBCC mine's permit area, as it is stated in Appendix D6. The alluvium appears to be most transmissive in the area immediately north of Pit Three, although there may in fact be localized variations in transmissivity due to the discontinuous nature of the unconsolidated deposit's grain size, sorting and stratification.

Typically, confined aquifers have storage coefficients that range between 0.001 to 0.00001. Storage coefficient values determined from the Bitter Creek alluvial aquifer

pumping tests ranged between 0.002 and 0.0005 (1994 Annual Hydrologic Report, Table 5). These values indicate that the Bitter Creek alluvium is a confined aquifer. Therefore, groundwater occurs within a permeable zone of coarser-grained materials, which are overlain by finer-grained, impermeable or relatively impermeable materials.

The lithologs of the alluvial monitoring wells installed in 1994 (Appendix 1 of the 1994 Annual Hydrologic Report) accurately describe the lithology of the alluvium at every location. The Quaternary alluvial deposit has a maximum thickness of approximately 80 to 85 feet and typically consists of beds of very fine-grained silts and clays overlying a coarse-grained basal zone that is roughly 5 to 10 feet thick. The coarser materials at or near the base of the valley fill are comprised of medium- to coarse-grained sand and small pebble-sized gravels of local origin (i.e., clasts of weathered sandstones and siltstones) within a matrix of silt and clay. These are overlain by nearly 70 feet of fine to very fine-grained silts and clays and discontinuous interbedded lenses of sands and small gravels, all of which are locally derived from nearby Tertiary and Cretaceous age rock units.

During the alluvial well drilling operations, at a few select locations only a thin or no basal zone of coarser-grained materials was encountered. Wells completed at these sites yield very little or no groundwater. On the other hand, those wells completed wherever a significant thickness of basal gravels was encountered are capable of yields in the 10 to 50 gallons per minute range. Based upon this physical evidence and the aquifer pumping test analyses, it can now be concluded that within the study area, Bitter Creek alluvial groundwater is confined in the coarse-grained basal zone beneath the overlying silts and clays. The basal sands and gravels are the primary transmitter of groundwater in the alluvial deposits. The upper fine-grained alluvial deposits are impervious and sufficiently thick within this general section of Bitter Creek's length to isolate surface flow in Bitter Creek from the alluvial groundwater system. Recharge to the alluvium from Bitter Creek or vertical leakage occurs primarily upstream of the study area where the relatively impervious unit of the alluvium is not continuous and as it thins and changes in lithologic character, the alluvial aquifer becomes unconfined.

Using the hydrostatic levels measured in October 1994 at all the Bitter Creek alluvial monitoring wells, an analysis of the alluvial groundwater flow pattern throughout

the Black Butte Mine area was completed. The Bitter Creek alluvial potentiometric surface map is included in the 1994 Annual Hydrologic Report as Exhibit 5. As this map illustrates, the flow pattern trends from upstream to downstream at a relatively uniform gradient, although it is being affected in the vicinities of Pit Two and Pit Three.

Historical hydrographs of monitoring wells completed in the Bitter Creek alluvium proximate to Pit Two are presented in Figures 17 - 19. Monitoring data indicate that the potentiometric levels in the alluvium adjacent to Pit Two have risen or stabilized. These responses are consistent with projections of recovering alluvial water levels after adjacent pits have been backfilled.

The Pit Three mining in the Fort Union Formation, did not directly intersect or disturb Bitter Creek alluvium, however it did indirectly intercept alluvial groundwater via the subcropping permeable strata that are exposed in the pit. The coal seams, and more importantly the sandstone strata which have much higher transmissivities, provide conduits for the movement of Bitter Creek alluvial groundwater toward and into the historic open excavation and the now backfilled spoils. As illustrated by Exhibit 5 in the 1994 Annual Hydrologic Report, the alluvial aquifer's potentiometric surface was slightly depressed along the edge of the Bitter Creek valley adjacent to the northern end of the Pit Three excavation in October 1994. The amount and areal extent of alluvial dewatering is relatively limited. The inflow rate from the alluvium to Pit 3 was estimated to be about 28 gpm in the Reclamation Plan and drawdown of up to about seven feet was observed in alluvial wells nearest the mine pit. After backfilling of Pit Three is completed and hydrostatic equilibrium is established between the resaturated spoils and the permeable Fort Union Formation strata downgradient/downdip of the backfilled pit, there should be only a slight drawdown of the Bitter Creek alluvial aquifer's potentiometric surface in this area.

The Bitter Creek alluvial aquifer exhibits the highest transmissivity of the undisturbed water-bearing strata. Fort Union sandstones that subcrop beneath the Bitter Creek alluvial deposits exhibit the next highest transmissivities (Appendix D6 of the Permit). Fort Union, Lance and Almond coal seams all exhibit low transmissivities (generally between 1 to 7 ft^2/day, Appendix D6). Aquifer tests of the backfilled spoils in Pit Two and Pit Three indicate that the spoils are very productive, having transmissivity

values that range from 6,521 ft^2/day to 45,770 ft^2/day. Therefore, the only significant producible groundwater in the Black Butte Mine area, excluding that from the underlying Ericson Formation and isolated spoils, comes from Bitter Creek alluvium. Although the Fort Union sandstones and the backfilled spoils are highly productive, they are both recharged by Bitter Creek alluvial groundwater.

Table 5 and Figures 14 through 19 present groundwater level data recorded at Bitter Creek alluvial monitoring wells within the active groundwater monitoring network.

Figure 14 depicts hydrographs for Wells 93 and 94, alluvial wells the most upgradient wells with respect to alluvial groundwater. These wells exhibited a small but steady decline (of about 3 feet) in potentiometric elevation starting in 1999. However, the measurements at these locations indicate more stable conditions since about 2015 (at Well 93) and since about 2016 (at Well 94). Relative to their respective trend lines shown in Figure 14, the most recent water levels at both wells indicate the historic drawdown has recovered. While the apparent temporary declines may be related to mining in Pit Three, they may also reflect some natural decline related to climate and water available to recharge the alluvium. Monitoring at Well 94 discontinued in 2016 based upon the observed response at this location to the substantial progress in reclaiming the northern portion of Pit Three, which adjoins the alluvium about one mile downstream.

Figure 15 presents historical hydrographs for three alluvial wells adjacent to Pit Three. The groundwater level at Well 52 declined 4 to 5 feet from mid-1990 to mid-1991 with an additional 2 to 3 feet through 2011. Monitoring was discontinued at Well 41 in 1986, but it was reinstated in May 1991. During the interim, the water level at this location declined 5 to 6 feet with an additional 2 feet of drawdown through 2009. However, since 2010 water levels at Well 41 have recovered about 6 feet. Well 47 was dropped from the monitoring network in 1986 and at that time indicated that no drawdown in the alluvial water level had yet occurred at that location. Well 47 was reinstated into the groundwater monitoring well network in 1994 due to its strategic location relative to Pit Three and proper completion. Although about 5 feet of drawdown occurred initially at Well 47, little additional decline was observed after its reinstatement back into the network. The water level fluctuations in these wells from 2000 through 2005 are likely due to natural trends in alluvial groundwater which are exhibited

elsewhere in the valley bottom. Since 2015, water levels in Well 41 are shown to be several feet above its respective historic trend line, as was observed in those alluvial wells upgradient of the pit. Measurements at Wells 47 and 52 were discontinued in 2016.

Figure 16 presents hydrographs for Wells 95 through 98. These alluvial wells were installed in 1994 and are down-valley of the Pit Three area. Wells 95, 96 and 97, which are closest to Pit Three show similar declines in water levels since 2000 of about 3 feet, while a similar trend at Well 98 is not evident until 2005. The water level trend lines developed for the entire life of each well are very similar when compared to each other. While these declines probably include a natural trend in alluvial groundwater elevations (similar to those at Wells 104 and 105), it is possible that they also include subtle, far-field impacts from Pit 3. The considerable distances from Pit 3 (and the subcropping Fort Union sands) would normally preclude any likelihood of impacts to the alluvium far from Pit 3. Although the lower alluvium is confined, there are indirect connections to Pit 3 with the subcropping Fort Union sands, therefore some drawdown response in the alluvium might be expected far from the pit. Since about 2014 and 2015, the water levels decline at all four of these wells appear to have stabilized and have shown recovery shortly thereafter. As a result, measurements at Wells 95 and 98 were discontinued in 2016.

The WDEQ/LQD has acknowledged that groundwater performance criteria associated with the area encompassed by Pit 2 have been met (see text of Section Groundwater Levels) and water level measurements from Wells 74, 101, and 106 (Figure 18) were discontinued in 2016.

The hydrographs of the Bitter Creek alluvial groundwater elevations recorded at monitoring wells down-valley of the Pit 2, extending to the downstream permit boundary (Wells 102, 104 and 105), are presented in Figure 19. Measured water levels show an increasing and stabilizing trend at Well 102, which is located closest to Pit 2. Wells 104 and 105, farther down-valley, have shown similar declines in water levels since 2000. Subsequently, the drawdown at both Wells 104 and 105 appears to have stabilized in recent years. The relative amount and timing of the declining water levels is similar to that exhibited up-valley at Wells 95, 96 and 97, indicating that the declines may reflect natural trends.

In concluding this discussion on Bitter Creek alluvial groundwater levels, there are certain aspects about what is presently known of the alluvial aquifer's relationship with Bitter Creek streamflow that should be emphasized:

- Drawdown of alluvial groundwater has occurred along the edge of the Bitter Creek valley adjacent to the northern end the Pit Three. The amount and areal extent of drawdown has been relatively limited and there is no additional drawdown confirmed during this report period. Many of the alluvial wells nearest the influencing mine pits have shown notable recovery in response to backfilling. Declines in the alluvial groundwater do not appear to be affecting streamflow in Bitter Creek. As discussed in the **Surface Water Flow** section of this report, the streamflow seepage runs conducted to date indicate that there is no change in discharge values along the entire stream length through the permit area, indicating little or no connection between the stream and the alluvium.
- Alluvial monitoring wells installed in 1994 provided additional information and more thorough understanding of the physical lithology, stratification, and hydraulic properties of the Bitter Creek alluvium. Within the permit area, Bitter Creek alluvial groundwater is confined in the coarse-grained basal zone beneath the overlying silt and clay. The upper fine-grained alluvial deposits are essentially impervious and sufficiently thick enough to isolate surface flow in Bitter Creek from the alluvial groundwater system. Furthermore, the tight clay substrate lining the stream channel inhibits the interaction between Bitter Creek surface water and alluvial groundwater.
- Streamflow appears to be constant throughout the mine area during baseflow (approximately 1 cfs), including the areas near Pit Two and Pit Three. Although the potentiometric surface in the alluvial aquifer at some of the locations near these pits is depressed, consistent stream flow through these areas indicates that these depressions are not affecting streamflow.

Alluvial wells installed in 1994 near the Bitter Creek streamflow monitoring Sites (Well 93 at SBC1-75 and Well 105 at SBC2-75) were fitted with continuous groundwater level recorders. A comparison of the Bitter Creek alluvial groundwater hydrograph with the streamflow hydrograph recorded at these two locations is useful in confirming the lack of hydraulic communication between the saturated basal alluvium and Bitter Creek

streamflow. The information available to date is presented in Figures 20a and 20b. This information is further evidence that there is little or no connection between Bitter Creek surface water and groundwater levels in the adjacent alluvium during base flow conditions and significantly delayed response following sustained high flow conditions.

Reclaimed Spoils

For backfilled spoils to resaturate and reestablish as an aquifer, there must be a recharge source. Recharge to the backfill spoils will occur from two sources: precipitation and lateral groundwater movement from adjacent undisturbed water-bearing strata. At the Black Butte Mine, precipitation will be insignificant compared to the lateral component of groundwater recharge. The rate of lateral recharge will be a function of the permeability of the backfilled spoils, the permeability of the adjacent recharge aquifer, the surface area of contact between the two and the hydraulic gradient.

Several of the mined and reclaimed pits at Black Butte Mine have demonstrated reestablished groundwater conditions sufficient to meet postmining performance objectives. As detailed through the WDEQ/LQD April 17, 2015 annual report review memorandum, it is acknowledged that groundwater performance criteria for Pits Two, Four and Six have been met. In this same correspondence, the Department also confirms that there are no groundwater performance criteria for that portion of Pit Three southwest of Ramp 6 in Township 18N, Range 100W, Section 31, as the mine disturbance within Fort Union formation at this location was not saturated with groundwater prior to mining.

Fort Union Formation FUA and FUC Coal seams have been mined in Pit Three. Two post-mining monitoring wells (Wells 91 and 92) were installed in the backfilled/reclaimed spoils near the northern end of the pit in 1994. The lithologs and well completion information were included in Appendix 1 of the 1994 Annual Hydrologic Report. These monitoring wells were installed approximately 100 feet apart for the purpose of conducting a multiple-well aquifer pumping test. The aquifer test was conducted in May 1994, data for which are contained in the 1994 annual report. The hydraulic coefficients, summarized in Table 7 of the 1994 Annual Hydrologic Report, indicate that the reclaimed spoils in that area of the pit are considerably productive. A pumping rate of 40 gallons per minute was maintained during the test and the transmissivity was determined to be 747 ft^2/day. Pit Three spoils, particularly at the

northern end of the excavation where they are in direct contact with the highly transmissive sandstone strata of the Fort Union Formation that subcrops under the adjacent Bitter Creek alluvial deposits, are receiving subsurface recharge from the alluvial aquifer. Spoils Well 91 is in the active groundwater monitoring network, and its respective hydrograph is presented as Figure 22. The monitored groundwater levels declined a total of about 4 feet after its installation, most likely due to mining in Pit 3. The data at Well 91, at this time, appears to show a recovery trend that is contemporaneous with the progress in backfilling of the northern portions of Pit 3.

Two other reclaimed spoils monitoring wells presently exist at the Black Butte Mine: Well 88 is in Pit Five and was installed in January 1993 near the northern extents. This well was dry upon completion and remained dry through the 2014 report period when it was removed from the monitoring program. However, the initial water level measurement from the recently completed Pit 5 spoils well (RP5B) which is situated slightly over a mile south of Well 88 indicates there is currently over 44 feet of saturation in the backfill at its location. An obstruction was observed at about 136 feet below the top of the well casing at Well RSP5B in September 2021 and the well was again noted to be compromised in 2022 and 2023. The well will continue to be monitored to further evaluate conditions. Pre-mine conditions identified in Plate D6-5 show some hydrologic connection between the Bitter Creek alluvium and the coal that was eventually mined in Pit5. Therefore, the alluvium is expected to continue to indirectly recharge the spoils near the southern mined and reclaimed portion of Pit 5.

Groundwater Quality

The groundwater monitoring network is maintained to observe and document the effects created by mining activities on groundwater quality. Table 6 presents groundwater analytical testing results for all observation wells sampled as part of the approved monitoring plan at the Black Butte Mine during this reporting period. Table 1 lists the wells that were scheduled for sampling from the Fort Union, Lance, Almond, Bitter Creek alluvium, and reclaimed spoils wells. Although baseline water quality has been established, none of the Ericson Formation production wells are currently sampled. All monitoring wells are sampled by first bailing the well bore water until the field

parameters of temperature, conductivity and pH stabilize before obtaining a representative sample.

Premining water quality characteristics of water-bearing formations in the BBCC mine area are discussed in Appendix D6 of the Permit. In general, the premining quality of groundwater sampled from the affected water-bearing strata was poor, having high concentrations of chemical constituents, and was typically unsuitable for domestic and agricultural uses. Some groundwater from the targeted list of sampled wells, including all of those completed in the Bitter Creek alluvium, is unsuitable for livestock use. Chemical analyses of groundwater samples collected during the 2024 report period are provided in Table 6.

Fort Union Formation

In general, Fort Union Formation groundwater in the Pit Three area is of poor quality, particularly near the formation's Bitter Creek alluvial subcrop. Groundwater samples collected from Wells 37, 39 and 58 are predominantly of a sodium chloride type, having high total dissolved solids (TDS) concentrations (between about 3,000 and 10,000 milligrams per liter, mg/L). These three wells are all located adjacent to and downgradient of the Fort Union Formation's subcrop beneath the Bitter Creek valley, and water chemistry is indicative of alluvial groundwater recharge. Of these three wells, Well 37 yields the highest TDS concentrations and is located closest to the subcrop, while Well 39 is furthest from the alluvial subcrop and its samples typically have the lowest TDS concentrations. Historically, Piper diagrams were utilized to evaluate major ion concentrations at Well 39 confirmed relatively stable ion concentration ratios through time. The water type at wells 75 and 76 are sodium sulfate and sodium bicarbonate type, and total dissolved solids concentrations that are currently between 1,100 and 2,100 mg/L. The sodium adsorption ratio (SAR) at Well 75 has declined since the commencement of monitoring (approximately 20). Well 90, installed in 1994 near Well 39, is completed in only the "C" Coal seam. Due to this well's proximity to the Bitter Creek alluvial subcrop, the groundwater chemistry in this well may be influenced by alluvial groundwater quality.

With respect to use suitability criteria, groundwater from all six of these Fort Union wells presently being sampled in the Pit Three area fail to meet Class I and II (domestic

and agricultural) uses due to exceedingly high concentrations of one or more of the following constituents: TDS, SAR, chloride, sulfate or boron. Samples from Wells 37 and 58 do not meet Class III (livestock) use standards due to exceedingly high TDS and chloride concentrations. Well 76 is farthest from the Bitter Creek alluvial subcrop, and water from this well accordingly contains the lowest TDS concentrations in comparison to all other groundwater sampling sites in the Pit Three area. Water quality at this location and at Wells 39 and 90 are considered suitable for livestock.

Because the Pit Four area was not saturated with groundwater prior to mining, there are no groundwater performance criteria. However, the water quality at Well 9, located downdip and downgradient of Pit Four is similar to that observed at Well 76 near Pit Three and is suitable for agricultural or livestock use.

Groundwater quality in the Fort Union Formation downdip of Pit Nine is monitored at Well 86. The TDS concentration is currently approximately 11,000 mg/L, exceeding the Class I domestic use limit. The predominant ions are sodium and bicarbonate. The resultant SAR of approximately 87 is greater than the agricultural use limit of 8. The field pH of 9.2 exceeds the targeted livestock use limit. The total iron concentration historically exceeds both domestic and agricultural use suitability limits, however, dissolved iron concentrations are typically below 1.0 mg.

Fort Union well 81, located in the Pit Ten area, was sampled during this report period and the results confirm that it remains suitable for livestock. Historically, this well has shown some variability in TDS and major constituent concentrations.

Although Pit Eleven opened in 2006, Wells 85 and 87 were completed in 1990 and were initially utilized to define baseline groundwater conditions for this area through 1995. Groundwater from both wells was characterized as sodium bicarbonate type. The TDS concentration at Well 85 was about 1,300 mg/L, while at Well 87 TDS was around 2,400 mg/L. Chloride concentrations recorded for both sites were high, exceeding Class I and II use suitability limits. The sulfate concentration at Well 87 was also consistently high (around 700 mg/L, unsuitable for Class I and II uses). Red Hill #1 Well (Station 5363-91) is also completed in the Fort Union Formation in the Pit Eleven area. Although this well was installed for water supply purposes, due to an inadequate yield, there are no plans for its use. Like Wells 85 and 87, this well was initially sampled to document

baseline groundwater quality of the Fort Union Formation and was also dropped from the groundwater-sampling network in 1995. In preparing for the 2006 opening of Pit 11, two new monitoring wells (Wells 112 and 113) were installed and developed proximate to Pit 11 in 2005. Subsequently, seven quarterly monitoring events for water levels and water quality were conducted at Wells 85, 112, and 113, prior to implementing the current approved monitoring program. Two new Pit 11 wells (85R and 87R) were completed in 2008 as replacements for Wells 85 and 87, which were mined through in 2011. The last monitoring events indicated only little changes in TDS concentrations at Well 85 from those obtained during early 1990s baseline monitoring, and that these values were found to be consistent with those from 85R. Although water quality at Well 112 was found to be very similar to that of Well 85, water quality at Well 113 more closely resembled that found earlier at Well 87, containing increased sulfate (about 580 mg/L) and TDS (about 1,950 mg/L) concentrations. The TDS at 87R was about 1,500 mg/L, with less than 300 mg/L sulfate.

Well 108 is used to monitor water levels and water quality in the Fort Union Formation downgradient and downdip of backfilled Pit Two. This well was completed in the FUBC coal seam, which was mined in Pit Two. At this location, previous chemical evaluations confirm that spoils aquifer groundwater migrates into the adjacent downdip FUBC coal seam under natural gradient flow. Since well completion, TDS concentrations have been between about 1,630 and 3,100 mg/L. Sodium and bicarbonate are the predominant ions. Chloride levels remain consistently high, about 300 to 400 mg/L. Sulfate concentrations have fallen from about 450 mg/L to about 10 mg/L or less. Calculated SAR values from this well continue to exceed agricultural use limits and were about 80 for this report period.

While there is variability, no anomalous changes in the quality of groundwater were observed during this report period at any of the Fort Union Formation wells relative to the historic data.

Lance Formation

Only Pits Five and Six have disturbed the Lance Formation. Pits Five South, Seven, Twelve and Thirteen are slated to mine Lance coals, but no disturbance within those pits has occurred. Five select Lance Formation monitoring sites in the vicinities of Pit Five, Pit Five South and Pit Six are in the active groundwater monitoring network. Lance Formation groundwater quality is generally poor, failing to meet Classes I, II and in some areas, Class III use standards due to high concentrations of TDS, chloride, sulfate, boron or SAR.

Well 21 has been used to monitor groundwater in the deep coal seam downdip of Pit Five. Changes in the water quality have been occurring at this site since monitoring began in 1978 but the well became partially obstructed in 2017 and it is no longer possible to sample or measure. Through the life of the well, the TDS concentration increased from 1,630 mg/L in April 1994 to about 2,400 mg/L. Increases in TDS concentrations at this location correspond with the documented changes in the major ions historically observed from this well. Combined concentrations of calcium, magnesium, potassium and sulfate have declined from 409 to less than 50 milligram per liter since April 1994. Simultaneously, sodium and bicarbonate concentrations have more than doubled. The SAR value reported in April 1994 of 15 was recently as high as 100. Analyzed constituent levels remained within suitable range for (Class III) livestock consumption through at least 2016. No measurements or samples were obtained from this well during this report period.

Well 35 is a shallow (63 feet total depth) well completed in a Lance coal seam and is located at the seam's eroded edge that subcrops beneath the alluvial/colluvial deposits of an ephemeral tributary to Bitter Creek, separating Pit Five from Pit Five South. This location likely contributes to the poor water quality at Well 35, which is unsuitable for Class III use. The TDS concentration is about 20,000 mg/L, the chloride concentration is approximately 3,300 mg/L, the sulfate concentration is about 3,500 mg/L, and the SAR exceeds 150. These high constituent concentrations are not representative of the Lance Formation. Due to the well's location and completion, this water quality is more typical of the shallow groundwater associated with the ephemeral tributary alluvial deposits.

Monitoring at Well 35 was temporarily suspended in 2016, until one year prior to the commencement of mining in Pit 5 S.

Little groundwater is present in the Lance Formation strata in the Pit Five South area. Mining in Pits Five and Six has not affected groundwater levels in the Pit Five South area. In general, the quality of groundwater in the Lance Formation in this area is poor. Constituent concentrations in samples historically collected from Well 56 were consistent. Historically, the water type is sodium bicarbonate, the TDS concentration is approximately 3,700 mg/L, the chloride concentration is about 800 mg/L, the dissolved boron concentration is about 1.0 mg/L and SAR is about 100. Water sampling at Well 56 has been temporarily suspended but will resume one year in advance of mining Pit Five South. Constituent concentrations in samples from Well 66 results continue to confirm poor water quality. The water type is sodium chloride, and the chloride concentrations are over 4,000 mg/L. The SAR is about 100 and the dissolved boron concentration is over 2 mg/L. TDS concentrations at Well 66 are about 10,000 mg/L. Therefore, the Lance aquifer groundwater at this location is unsuitable for all three designated water use classifications.

The natural occurrence of selenium is demonstrated in the groundwater from Lance Formation with the permit boundary, including those areas near Pit 5S (Wells 56 and 66) and up-gradient of Pit 5S (Wells 67 and 68). The selenium concentration was determined to be 0.008 mg/L in the sample collected from Well 66 in June 2021 but was below 0.005 mg/L during the subsequent fall sampling event and from all samples in 2022 and 2023.

The WDEQ/LQD has acknowledged that groundwater performance criteria associated with the area encompassed by Pit Six have been met (see text of Section Groundwater Levels). Historic Lance Formation monitor well No. 67, positioned approximately 1,800 feet south of the final pit cut, may be retained as a stock well pending landowner agreement.

Almond Formation

Historically, the Almond Formation was disturbed only at Pit Eight. However, in 2008 Black Butte Coal commenced mining in this formation at Pit Fourteen. Groundwater level declines caused by mining operations at Pit Eight have been observed at Well 71 and at Well 8 which was destroyed by pit progression in 2003. Groundwater

quality from the two remaining Almond wells that are presently sampled (Wells 71 and 72) is similar. The water type is a sodium bicarbonate, TDS concentrations are about 1,600 to 2,500 mg/L respectively, dissolved boron concentrations are about 1 milligram per liter, and SAR is generally about 70. Groundwater from the Almond Formation in the Pit Eight area is classified as unsuitable for domestic and agricultural uses, but generally meets Class III standards for livestock use. Wells 71 and 72 will continue to be sampled during and after mining in Pit Eight. Well 72 shows a general increase in TDS concentrations of about 1200 mg/L over the life of the well. Although selenium has occasionally been above 0.05 mg/L at Well 71, groundwater at these locations is considered suitable for livestock use.

Bitter Creek Alluvium

The quality of Bitter Creek alluvial groundwater is poor. Solute concentrations are very high and are also variable, both spatially and temporally. With few exceptions, TDS concentrations exceed the Class III (livestock use) suitability limit of 5,000 mg/L at every alluvial well that is sampled. The water type is generally a sodium chloride or sodium sulfate. Dissolved boron concentrations and sodium adsorption ratio (SAR) values are also high and commonly exceed Class II (agricultural use) suitability limits. Elevated selenium concentrations above 0.05 mg/L are observed in alluvial groundwater along the middle reach of the Bitter Creek Valley proximate to the Lance Formation near Pit 12.

In Figure 22 of the 1994 Annual Hydrologic Report, TDS concentrations of the groundwater samples collected October 1994 at select alluvial monitoring wells are plotted against the respective well's linear distance from Well 93. No trend moving down-valley (from Well 93 to Well 105) in alluvial groundwater quality was evident, but the TDS concentration was observed to be highly variable between sites. Radial plots of ionic concentrations of the same October 1994 groundwater samples are presented in Figure 23 of the 1994 Annual Hydrologic Report. These figures illustrate the apparent random changes in groundwater quality in the alluvial groundwater, as well as the high solute concentrations in general.

TDS concentrations exceed the 5,000 mg/L livestock-use suitability limit at all of the Bitter Creek alluvial wells sampled in 2024, except at Well 97 and from Well 41. SAR values ranged from 0.02 at Well 104, to about 46 at Well 93. All of the alluvial

well samples collected yielded SAR values exceeding the agricultural use suitability limit of 8. Concentrations of boron, iron and manganese are also typically high, and can exceed domestic and agricultural use suitability limits.

As shown in Figures 29 and 31, TDS concentrations at the four wells proximate to reclaimed Pit Two have changed in response to the final reclamation. Water level recovery within the alluvium corresponds generally with stabilizing TDS at Wells 73 and 74. As shown in Figure 31, both Wells 102 and 107 exhibited decreasing TDS concentrations until 2005. Currently, the TDS at both wells appears to have stabilized. However, concentrations at Well 102 remain less than one-half of those concentrations first observed from this well in 1994. These recent trends may be attributed to residual minerals that were concentrated during drawdown but are now re-dissolved and establishing an equilibrated chemical state. The TDS in the alluvium near Pit 2 is expected to remain above livestock use limits.

TDS concentrations have steadily decreased or have stabilized in alluvial wells near Pit 3 since 2000. With some variability, TDS at Wells 47 and 52 (Figure 28) indicate subtle declines in TDS concentrations, while Well 41 exhibits stabilized TDS concentrations near 5000 mg/L.

Reclaimed Spoils

Within the **Groundwater Levels** section is a discussion on the recharge to and resaturation of backfilled spoils in Pits Two and Three. Groundwater level monitoring information collected to date indicates that the source of recharge to the spoils in these two pits is primarily the Bitter Creek alluvial aquifer, which is either in direct or indirect hydraulic contact with the spoils. High concentrations of specific inorganic chemicals that occur naturally in the alluvial groundwater are also present in the postmining spoil groundwater of Pits Two and Three. These constituent concentrations further confirm significant recharge contribution from Bitter Creek alluvial groundwater.

The analytical results from samples collected in 2004 are provided in Table 6 and Figures 32, 37 and 42 respectively show water quality concentration plots for TDS, dissolved and total iron from the spoils wells. Predominant ions are sodium and sulfate, which are consistent with the chemical composition of groundwater samples from the historical Pit Two spoil wells. The WDEQ/LQD has acknowledged that groundwater

performance criteria associated with the area encompassed by Pit 2 have been met (see text of Section Groundwater Levels).

Well 91 is completed in reclaimed spoils near the northeastern end of Pit Three. Much of this pit is now backfilled and regraded. At the northern end of the excavation, the Pit Three backfilled spoils are in direct contact with the very transmissive sandstone strata of the Fort Union Formation that subcrops beneath the adjacent Bitter Creek alluvium, and therefore the spoils receive significant subsurface recharge from the alluvial aquifer. Pit Three spoils groundwater chemistry strongly reflects that of Bitter Creek alluvial groundwater observed proximate to the pit area. Analytical results of the two groundwater samples collected during this report period from Well 91 are included in Table 6. Figure 32 shows relative consistent decline in the TDS concentrations in recent years. However significant spikes in the total solute concentrations occurred in late 2020, early 2021, both samples in 2023,and the early sample in 2024. All TDS concentrations exceed the Class III use suitability limitation of 5,000 mg/L. The concentration of chloride also classifies the Pit Three spoil groundwater as unsuitable for livestock use. The SAR values in Well 91 are above or within the historic range of 60 to 70, and much higher than the Class II use limit of 8. Future monitoring in the Pit Three spoils will be used to determine if any additional trends in groundwater quality develop in the area northeast of Ramp 6 which is situated in Section 31.

The adjacent water-bearing strata do not recharge the northern extents Pit Five, as historically monitored at Well 88. Therefore, spoils in this area have not resaturated. The water quality samples from the recently completed well (RP-5B) in the southern extents of the Pit Five reclamation, shows distinctive similarities to the Bitter Creek alluvial aquifer which is expected to be a significant source of recharge to this portion of Pit 5, based upon historic groundwater movement. In recent years, TDS concentrations at RP-5B exceed 15,000 mg/L and sulfate concentrations are about 10,000 mg/L; unfortunately, monitoring personnel report it is obstructed in 2023 and the well cannot be sampled.

Ericson Formation

The Ericson Formation is a relatively productive aquifer of significant value as a source of industrial water supply throughout the general area and several wells were installed for the purpose of high-yield production wells that supply water used for the mine's support facilities, coal process wash down, water treatment plant, fire protection, and dust abatement.

The Ericson Formation water quality has been evaluated by Black Butte Coal and relative to the quality of groundwater that occurs in the other water-bearing strata monitored in the Black Butte Mine area, water from the Ericson Formation is generally good, with TDS concentrations ranging from about 800 to 1,400 mg/L. Predominant ions are typically calcium, sodium and sulfate. Historically, the monitored Ericson production well exceeds Class I and II use standards for iron and manganese.

SURFACE WATER

Drainages Affected by Mining

Although Bitter Creek flows through the Black Butte Coal mine, it has not been directly affected by the mine operation. However, historic construction activities unrelated to the Black Butte Coal Mine affected Bitter Creek within the Black Butte permit boundary. A number of Bitter Creek channel reaches were rechannelized or adjusted to accommodate the construction of the Union Pacific railroad through the Bitter Creek valley. This resulted in a few different effects to Bitter Creek. Some reaches were completely rechannelized, such as the one-mile channel section in T18N, R100W, Section 5 and T19N, R100W, Section 32 (Exhibit 1). Some channel reaches were straightened resulting in man-made oxbows such as those found in T18N, R100W, Section 32. Channelization, such as straightening and shortening the stream, results in increased overall slope and shortening of the streambed which may in turn cause higher stream velocities and increased channel erosion.

As well as the alterations to the Bitter Creek channel, three railroad crossings are located within the Black Butte Coal permit boundary. These bridge crossings may act to

some degree as structural controls because of the amount of rock material added to the channel to help stabilize alluvial materials in these locations.

There are several small tributary ephemeral drainages to Bitter Creek within the permit boundary that are currently affected by mining. Figure 90 in the 1993 Annual Hydrologic Report shows the area affected by mining operations and major drainage structures. Black Butte Coal captures all disturbed land runoff within control structures. Furthermore, upon final reclamation, Black Butte Coal is committed to establishing the disturbed ephemeral drainages to as near pre-mining conditions as possible. A complete description of the commitment to reestablish disturbed drainages is given within the Reclamation Plan section of the Permit.

Surface Water Flow

Streamflow of Bitter Creek, as stated under the **Monitoring Network** section, is monitored monthly during the ice-free period. Data collection at the time of observation consists of recording the stream stage, which is read from the horizontal staff gages installed at SBC1-75 and SBC2-75. This staff reading is converted to a streamflow using the Manning's equation. The Manning's Methodology is described in detail in the 1994 Annual Hydrologic Report section, **Manning's Equation Methodology**.

Analysis of Methodology Results

Historical streamflow data from the old SBC1-75 and SBC2-75 Parshall flume sites from April 1975 through September 1985 can be found in the Hydrology Data Support Document, 1987 Annual Hydrologic Report. Because of the questionable nature of the data prior to September 1985, it will not be discussed in this report. Following is a discussion of the data collected utilizing the SBC1-75 and SBC2-75 sites installed in September 1987.

All historical staff height readings obtained at SBC1-75 and SBC2-75 since the installation of the horizontal staff gages in September 1987 are presented in Table 7. Included are the estimated streamflow values as derived using the previously outlined Manning's methodology. The date of the cross-section survey used to estimate each streamflow value is also provided in Table 7. Information for the 9/22/87 through 6/17/93 surveys was provided in the 1993 Annual Report. Detailed information for the 1995 surveys is provided in Appendix 2 of the 1995 Annual Report. Detailed

information for the 1996 surveys is provided in Appendix 2 of the 1996 Annual Report. Detailed information for the 2014 surveys, which are the most recent surveys to date, is provided in Appendix A of this report. Figure 43 shows the stage-discharge relationships at the two Bitter Creek sites. Because of their similar channel characteristics, the stage-discharge relationships are very similar at SBC1-75 and SBC2-75.

Mine personnel indicate that the stations were found to be dry, ponded, or frozen during each of the monthly site visits in 2024, with exception to the May 15 visit. It is reported that the flows at both stations on that day were obviously significantly less than the flow rate derived from the obtained staff gage readings and corresponding rating formula. Therefore, the respective flow rates reported in Table 7 from this date are estimated to be less than <0.25 cfs. Monitoring personnel will evaluate the channel conditions in 2025 to ensure there are no significant accumulations of sediment in the channel bottoms, or debris blockage downstream from both gaging stations. Significant sedimentation may result in the need to resurvey the channel profile and cross-section at each station and update the corresponding rating formulae.

Streamflow values represented in Table 7 and Figure 42 are estimates of the true streamflow at SBC1-75 and SBC2-75 and represent a "snap-shot" in time. The low to moderate flow values (up to 10 cubic feet per second) were verified with actual stream gaging analyses conducted on June 18, 1993, November 9, 1993, March 17, 1994, July 19, 1994 and July 14, 1998. Confirmation gaging has not been conducted since the 2014 channel surveys at the monitoring locations. However, the calculated flow rates from 2014 agree reasonably with previously measured stage-discharge ranges. Subsequent high stage flow values obtained since 2014 have not yet been verified. The next section (**Streamflow Gaging Analysis**) of this report discusses, in greater detail, the stream gaging monitoring along Bitter Creek and the effort to verify roughness coefficients.

Figure 44 presents streamflow hydrographs for the period of September 1987 through November 2024 for sites SBC1-75 and SBC2-75. As discussed above the reported flow rates from the May 15, 2024 monitoring event were estimated at both stations to be <0.25 cfs. These values not plotted on Figure 44. Gaps in the streamflow data exist during the winter period (typically November-December through February) when Bitter Creek is frozen.

Table 8 gives the descriptive statistics for the recorded streamflow observations at SBC1-75 and SBC2-75, respectively, from September 1987 through November 2023. The average estimated streamflows based on the monitoring methodology used at BBCC for SBC1-75 and SBC2-75, respectively, are 10.74 and 7.13 cfs. Except for the mode, the descriptive statistics imply that there is little significant difference between the quantities of streamflow occurring at SBC1-75 verses SBC2-75. Since these average values are based on a single observation during a given month, they represent a very rough approximation of the true average flow at these two Bitter Creek sites. This methodology does however allow a viable comparison to be made between the magnitudes of flows at SBC1-75 to those at SBC2-75.

Upon reviewing the streamflow data referenced in Table 7, it is evident that there are some minor differences between streamflow at SBC1-75 and SBC2-75. There are a number of factors that may individually, or in combination, result in differences of observed streamflow at SBC1-75 verses SBC2-75: 1) transit time for streamflow to travel between the two sites; 2) errors in observation measurements; 3) localized runoff from ephemeral tributary drainages; 4) possible ice-blockage within the channel during spring runoff periods; and 5) variations inherent to Manning's method of estimation.

Streamflow values presented in Table 7 represent only an instant in time and approximate the streamflow at the moment that the observer recorded the horizontal staff gage reading. Typically, both the upstream and downstream sites are visited on the same day. In nature it takes time for a unit of water to travel from one upstream point within a stream to a downstream point. The streamflow transit time between SBC2-75 (upstream station) and SBC1-75 (downstream station) is estimated to be approximately 40 hours. This is based on a streamflow velocity of 0.35 feet per second (low flow conditions) and a channel thalweg distance between SBC2-75 and SBC1-75 of 9.8 miles. Therefore, streamflow measured at SBC2-75 verses SBC1-75 may not be equal due to influences that have not yet manifested themselves at one or the other sites.

Upstream verses downstream differences in streamflow estimates could be due to human error such as misreading the horizontal staff gage or selecting the wrong roughness coefficient when applying the Manning equation. However, every effort is taken to limit the influence of human error in streamflow data collection. Black Butte

Coal is attempting to fine-tune Manning's roughness coefficients used to estimate streamflow at SBC1-75 and SBC2-75 by actual verification of low and high streamflows using current-meter discharge measurements and back-calculating the roughness coefficient value.

Another factor that can result in differences between observed streamflows at SBC1-75 and SBC2-75 is the influence of ephemeral runoff between the two sites. There is currently approximately 67 square miles of drainage area draining into Bitter Creek between SBC1-75 and SBC2-75 (this does not include those drainages being withheld by sediment control structures). It is reasonable to assume that some of the differences in flows observed between the two sites are due to runoff from these ephemeral drainages. These runoff events are more apt to occur as a result of localized thunderstorm activity. Precipitation data will be presented later in the **Climatological Data** section of this report.

Possible ice-blockage within the channel during spring runoff periods may have an effect on specific flows observed at either of the Bitter Creek sites. Such effects have been observed historically and can be attributed to ice blockages. There may be years during the spring runoff period when ice flows block the channel at isolated locations along Bitter Creek. These blockages may occur at railroad bridges, culverts, or natural channel confinements such as sharp meanders or channel constrictions. The blockage of flow by an ice jamb can result in increased water depths behind it, resulting in staff gage readings that are incorrect for use in Manning’s equation. The blockage also affects other Manning’s parameters that results in incorrect estimates of flow.

As discussed above, there is little or no connection between alluvial groundwater and Bitter Creek. However, because of the considerable length (9.8 miles) of stream between SBC2-75 and SBC1-75, there is potential for specific reaches of Bitter Creek to be classified as gaining or losing. A gaining stream reach is one that receives water from the groundwater system while a losing stream reach is one that contributes water to the groundwater system. Black Butte Coal has attempted to quantify Bitter Creek according to gaining and losing reaches by conducting actual current meter discharge measurements at selected sites throughout Bitter Creek from above SBC2-75 to below SBC1-75 during base flow conditions.

Gains and losses to the surface water system can result from factors other than the alluvial groundwater system. Additional gains can exist from natural springs or seeps along the stream course. However, no springs or seeps have been noted between SBC2-75 and SBC1-75. Man-caused discharges to the stream system from uncapped flowing wells may add water to the surface system. Water flowing from the Chandler-Simpson well located in T18N, R100W, Section 8 has historically contributed up to 0.5 cfs of water to Bitter Creek, but due to natural processes of well failure, only about 2 gallons per minute reached Bitter Creek in recent years.

Evapotranspiration losses also occur along the Bitter Creek channel between SBC2-75 and SBC1-75. These losses would be difficult to quantify but are assumed to be minor since no significant riparian community exists throughout the reach and the surface water area exposed to evaporation is small.

Historically, there have been beaver ponds located along Bitter Creek upstream of SBC2-75. If larger in extent, these ponds would have a tendency to significantly increase evaporation. However, evaporation is probably minor because the ponds have a small areal extent, due mainly to the incised nature of Bitter Creek.

Streamflow Gaging Analysis

BBCC may conduct stream gaging analyses of Bitter Creek streamflow. Historically, this analysis consists of a minimum of six separate gaging runs performed during various stream stage/flow conditions. These stream gaging sessions have a two-fold purpose: 1) stream gaging during base (low) flow conditions will help to identify the Bitter Creek flow regime and 2) stream gaging during low, medium and high flow conditions will allow the adjustment of the Manning's roughness coefficients used in estimating streamflow at SBC1-75 and SBC2-75.

Stream gaging to determine the flow regime consists of conducting a seepage run test. This seepage run test consists of performing low flow stream gaging measurements at a number of locations throughout the channel reach from upstream (SBC1-75) to downstream (SBC2-75) in a single day. By calculating the streamflow at these key locations throughout the permit boundary under low flow conditions, one can determine any potential gaining or losing stream reaches. This portion of the stream gaging analysis was completed in 1993 and 1994. Stream gaging during various flow conditions at SBC2-

75 and SBC1-75 will also allow verification of the actual Manning's roughness coefficient (**n**) to be used in the calculations of the estimated streamflow at these two sites. Because velocities and discharges calculated using the Manning's equation are sensitive to the value of **n**, it is advantageous to calculate **n** for at least one low and one high flow current meter discharge measurement. This direct determination of **n** has been discussed in detail in the section titled **Manning's Equation Methodology** in the 1994 Annual Hydrologic Report. Figure 26 in the 1994 Annual Report and its associated tables represent the 1993 and 1994 seepage run stream gaging efforts along Bitter Creek. An analysis of this data is also included in the 1994 Annual Report. In general, results of these seepage run tests suggest that base flow in the Bitter Creek regime may be controlled by micro influences in the immediate channel bottom material or surrounding bank material. Under base flow conditions, flow at all of the seepage run sites is less than 1 cfs. No significant gaining or losing stream reaches are identifiable. This correlates well with the geohydrologic regime noted under the groundwater section that shows that there are no significant interactions occurring between the surface water system and the groundwater system within the BBCC mine area during typical base flow conditions.

Surface Water Quality

Surface water quality samples are normally taken monthly during the ice-free period (typically March - November) and in conjunction with staff gage measurements at the SBC2-75 and SBC1-75 sites on Bitter Creek. These monthly grab samples are collected at each site for subsequent analysis of total suspended solids and total dissolved solids concentrations per the approved Permit 467. Samples are collected by Black Butte Coal personnel or their representatives and shipped to Pace Analytical (formerly Intermountain Laboratories) in Sheridan, Wyoming for analysis.

Analytical laboratory results for all samples taken at SBC2-75 and SBC1-75 since January 1986 are presented in Table 9. Included in this table are dates sampled and the associated estimated discharges derived from the Manning's methodology as outlined in the previous section.

Table 10 gives the descriptive statistics for the data presented in Table 9 (1986 through 2023). Two sets of statistical values are presented for SBC2-75 and SBC1-75 for

the analyzed constituents of total suspended solids and total dissolved solids. One set includes statistics on all samples taken and the second set has had the highest and lowest values removed prior to the calculation of the statistical parameters. The second statistical set is an attempt to remove extreme anomalies that may skew the normal statistical values. Extremely large anomalous values such as those found for total suspended solids in the April 19, 1991 samples have a tendency to skew the statistical parameters away from the normal value.

There are a number of reasons why anomalous values may occur in the water quality analysis results: 1) sampler error at the time of sampling, 2) laboratory analytical error, 3) abnormal disturbance of channel bottom sediments immediately upstream of the sample site, 4) natural streamflow turbulence resulting from ice flow, 5) natural extreme variability in sediment production upstream of the sample site, and 6) man-caused sediment production upstream of the sample site. Any one or a combination of these factors could result in an extreme value for a given constituent, such as total suspended solids, for a given sample date.

The following discussion on mean and range values references the second set of statistical data presented in Table 10 for the period from March 1986 to November 2023. The mean total suspended solids values for the samples taken at SBC1-75 and SBC2-75 are 565 and 489 mg/L, respectively. Total suspended solids concentrations range from 5 to 9,785 mg/L at SBC1-75 and from <5 to 11,100 mg/L at SBC2-75. The mean total dissolved solids values are 1,064 mg/L at SBC1-75 and 1,031 mg/L at SBC2-75. Total dissolved solids concentrations range from 210 to 2,780 mg/L at SBC1-75 and from 92 to 3,240 mg/L at SBC2-75.

Plots of historical total suspended solids concentration values over time at sites SBC1-75 and SBC2-75 are shown in Figure 45. As expected, total suspended solids concentrations are higher during the spring runoff period than during the base flow period. The graphed concentrations and associated trend line indicate there has been a similar increase in total suspended solids through time at both of the upstream and downstream monitoring stations.

Plots of all historical total dissolved solids concentration values over time for sites SBC1-75 and SBC2-75 are shown in Figure 46. A slight downward trend is

demonstrated with respect to total dissolved solids concentrations at both SBC1-75 and SBC2-75, although some seasonal trends in TDS can be discerned. Total dissolved solids concentrations are lower during the peak flows due to the dilution effect of the larger volume of water. It appears that during periods of low flow, total dissolved solids concentrations at SBC1-75 are slightly higher upstream than those found downstream at SBC2-75.

The relationship between total suspended solids and total dissolved solids was addressed in the 1993 Annual Hydrologic Report and proves to be typical of most surface water systems such as Bitter Creek that indicate that TDS concentrations decrease with increases in TSS concentrations. A statistical comparison between TSS concentrations and TDS concentrations at Site SBC1-75 verses SBC2-75 is also included in the 1993 Annual Hydrologic Report. From that analysis, there does not appear to be any historical increasing or decreasing trends occurring between the two sites in relation to these water quality parameters.

Total dissolved solids load and sediment load data for SBC1-75 and SBC2-75 are presented in Tables 11 and 12 respectively. As can be expected, the total dissolved solids load and the total suspended solids load transported by Bitter Creek, when compared with the surface flow hydrographs at each site, reveal that total dissolved solids and total suspended solids loads are at a maximum during the higher flow periods (spring runoff) and lowest during the base flow period.

No significant variations are evident in total dissolved solids and total suspended solids loads between SBC1-75 and SBC2-75, except for the minor increase of total suspended solids load downstream during high flows and the minor overall higher total dissolved solids loads at SBC2-75 verses SBC1-75.

The annual average total dissolved solids load and total sediment load for the two Bitter Creek sites for 1986 through 2024 were estimated by finding the average loads for low flow and high flow conditions. The number of days each year that flow occurs for each condition was estimated as described in footnote No. 2 of Table 13. It is assumed that the estimated flows shown in Tables 11 and 12 represent daily averages. Table 13 shows this information and the resulting estimates. The estimated annual total dissolved solids load at SBC1-75 is 5,571 tons, while it is estimated to be 4,341 tons at SBC2-75.

The estimated annual total suspended sediment load at SBC1-75 is 14,458 tons and at SBC2-75 is 9,521 tons. Further analysis of the results shown in Table 13 yields the following general conclusions: 1) the dissolved solids load during high flows is lower downstream at SBC2-75, 2) the dissolved solids load during low flows is higher downstream at SBC2-75, and 3) the sediment load at SBC1-75 is higher than at SBC2-75 during both high and low flows. The reasons for these differences have been discussed in previous paragraphs of this section.

Bitter Creek Surface Water and Alluvial Groundwater Interaction

Bitter Creek water was sampled in the spring and fall of 1994 through 1996 at sites SBC1-75 and SBC2-75 and analyzed for the full suite of parameters listed in Appendix 1 of the WDEQ/LQD Guideline No. 8. Alluvial monitoring wells 93 and 105 were sampled concurrently and analyzed for the full suite of parameters. Table 14 of the 1997 Annual Hydrologic Report lists the dates that samples have historically been taken and the major anions, cations and total dissolved solids concentrations of those samples.

Bitter Creek alluvial groundwater is chemically much different than the Bitter Creek stream water throughout the permit area. As stated in the **GROUNDWATER** section, waters sampled from the alluvium along Bitter Creek are a sodium chloride or a sodium sulfate type, containing total dissolved solids concentrations in the 4,000 to nearly 50,000 mg/L range. As shown in Table 14 (1997 Annual Hydrologic Report), the average total dissolved solids concentration of the alluvial groundwater sampled at Well 93 was 6,462 mg/L, while the average total dissolved solids concentration of the surface water sampled at SBC1-75 was 1,196 mg/L. The average total dissolved solids concentration of the alluvial groundwater sampled at Well 105 was 4,650 mg/L, while the average total dissolved solids concentration of the surface water sampled concurrently at SBC2-75 was 1,120 mg/L.

Figure 31 of the 1997 Annual Hydrologic Report presents radial plots that graphically illustrate average water chemistry and constituent concentrations at the Bitter Creek surface water and alluvial groundwater sampling sites. Water quality at site SBC2-75 is very similar to that from site SBC1-75, as depicted by these plots. The predominant ions in the samples from both surface sites are sodium, bicarbonate and sulfate. The

predominant ions in the groundwater samples from Well 93 are sodium and chloride, while the predominant ions in the samples from Well 105 are sodium and sulfate.

Aquifer tests of the Bitter Creek alluvium provided very low storage coefficient values, indicating that the groundwater is confined within permeable coarse-grained materials overlain by relatively impermeable clay and silt deposits. The installation of alluvial observation wells within the permit area in 1994 confirmed this depositional stratigraphy and the occurrence of groundwater only within the basal zone of the alluvium (**GROUNDWATER** section). The Bitter Creek stream channel is separated from the saturated coarser basal zone by roughly 60 feet of silt and clay.

The **GROUNDWATER** section of this report includes a discussion on the dewatering and resultant drawdown of Bitter Creek alluvial groundwater levels in the vicinities of Pits Two and Three. As discussed in the **Streamflow Gaging Analysis** section, streamflow gaging runs conducted to date indicate that the discharge values are not being affected by the depressed alluvial aquifer's potentiometric surface within these areas.

Continuous alluvial groundwater level data recorded at Wells 93 and 105 are presented on Figure 20a and 20b along with the adjacent Bitter Creek streamflow. The streamflow peaks do not produce an immediate rise in the alluvial groundwater level immediately adjacent to the stream channel at either of these locations. These data comparisons continue to substantiate the hydraulic discontinuity between Bitter Creek streamflow and alluvial groundwater within the mine permit area under typical conditions.

Based upon currently available data, there does not appear to be any notable gaining or losing stream reaches during base flow conditions, and it is concluded that there is no notable connection between surface water and alluvial groundwater between sites SBC1-75 and SBC2-75.

Mine Discharge Impacts to the Bitter Creek Drainage

Black Butte Coal Mine has operated 11 pit areas (Pits 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, and 14) within their current permit boundary. These pits are under varying degrees of mining or reclamation. These pits currently affect about 41 square miles of drainages that are natural tributaries to Bitter Creek.

The Black Butte Coal mine does not normally discharge any water from disturbed lands into the Bitter Creek drainage. Total containment ponds, sediment ponds, evaporation ponds, and retention ponds contain all disturbed land runoff. If these ponds should become full, they may be pumped down to allow sufficient storage volume for the 10-year, 24-hour storm event once the water meets discharge standards. Exhibit MP-46 (Mine Plan section of the Permit) shows the locations of all drainage structures for the life of mine. The general location of the major drainage structures that are currently in place and how they relate to the affected areas are also depicted on Figure 90 of the 1993 Annual Hydrologic Report. Although the ponds are designed for total containment, occasionally spring snowmelt events or summer thunderstorm runoff events are such that some of these structures require pump evacuation in order to maintain the required storage volume for the 10-year, 24-hour storm event. If necessary, a drainage structure may be pump evacuated after the contained water meets the required water quality discharge standards. Any pumped discharges are released into the Bitter Creek drainage system from designated locations specified in NPDES Permit WY0030261. As shown in Table 14, there was permitted discharge totaling 41.5 acre feet during the 2024 annual report period.

Some natural surface water runoff is currently prohibited from reaching Bitter Creek because of the mining activities at Black Butte Coal. Flows from snowmelt and precipitation runoff within the disturbed areas are currently collected by drainage control structures installed at strategic down-slope locations of all disturbed land. As stated above, the affected area equals approximately 41 square miles. The average annual runoff from the Bitter Creek watershed ranges between 0.1 and 0.2 inches (Busby, 1966). This is the amount of runoff which, if spread uniformly over the entire watershed, would have a depth of between 0.1 and 0.2 inches. If one assumes that the unit runoff for the area disturbed by mining is 0.2 inches per year, then approximately 525 acre-feet of

runoff is currently being withheld from reaching Bitter Creek on an annual basis. Once reclamation is completed on disturbed areas, approval is obtained from WDEQ/LQD, and drainage control structures are removed, this runoff volume will be allowed to reestablish its natural flow back into Bitter Creek.

Reservoir Monitoring

Reservoirs at the Black Butte mine are inspected on a quarterly basis for dam stability and integrity, inlet and outlet stability, and monitoring device condition.

Reservoirs are also inspected on an annual basis for sediment accumulation. This monitoring is conducted to demonstrate that each structure has sufficient total volume to retain the volume of a 10-year, 24-hour rainstorm event and 1 year's sediment volume. Any structure that does not contain a sufficient volume will be cleaned out so that the necessary volume exists.

The **Pond Inspection Report** section of the Black Butte Coal Annual Report lists the current inventory and status of the constructed reservoirs at Black Butte Mine. The report also includes associated operations documentation, maintenance, and records of scheduled monitoring activities.

Climatological Data

A complete discussion of the regional climatology of the Black Butte Coal area, as well as a complete discussion of the meteorological instrumentation being used, is given in the Climatology section of Permit 467, Appendix D4. In general, the region's climate is characterized by a generally high percentage of possible sunshine, high wind speeds and evaporation, and low humidity and precipitation.

Air in the region is generally of Pacific origin which has been modified by passage over the western mountain ranges. Precipitation most often accompanies low pressure areas south of the state such that warm, moist, southerly air flows override cooler air, causing precipitation. Station-to-station and year-to-year variation in precipitation is high, emphasizing the very local character of weather in the region.

Average daily precipitation is recorded at one site (Office site) within the BBCC permit boundary. The location for this site is shown on Exhibit 1 of this report. On June 14, 2012, Black Butte Mine installed a new tipping bucket precipitation monitoring device with an electronic data logger. The new system replaced an outdated chart recording

weighing bucket device that was historically used. Qualified daily and monthly precipitation totals are presented in Table 15. Black Butte Coal Company reports a total of 7.42 inches of precipitation occurring from December 2023 through November 30, 2024.

NON-MINING RELATED AREA IMPACTS

Ongoing hydrologic monitoring and historical mine records will be utilized to differentiate mining versus non-mining related hydrologic impacts should they occur. There are no notable non-mining related impacts to report for 2023.

SUMMARY

This report has presented a discussion of the general area's hydrologic regime, all monitoring activities, a compilation of all hydrologic data collected in the BBCC mine area during this reporting period and an interpretation of historic data recorded over the entire period of record.

Hydrologic data recovery for this report period is overall satisfactory Well RSP5B remains obstructed during attempts to measure and sample in 2024.

Problematic surface water flow measurements were obtained at both monitoring stations in May 2024, resulting in significantly less observed flow than was indicated by the corresponding staff gage and rating formula. Monitoring personnel will need to inspect the channel for sediment accumulation, growth of new brush, or potentially to remove any debris blockage downstream, of both locations. A significant change in the channel near the monitoring stations will trigger the need to resurvey and update the most recent rating formulae. Mine discharges occurring in the first calendar quarter of 2024 likely contributed to the frozen conditions observed in Bitter Creek during that time period

Black Butte Coal Company continues to monitor and further define the hydrologic setting in relationship to the mining operations. The most recent changes to the monitoring plan were implemented in April 2016 with an approved revision to Mine Plan Table MP-23. There is sufficient hydrologic monitoring in place to verify the hydrologic consequences during mining of any of the active or planned adjacent mining pits.

Mining activities continue to have minimal impacts on the water resources in the BBCC mine area. The most identifiable effects to date are declines in the hydrostatic pressure of certain coal seams, localized lowering of the Bitter Creek alluvial water table, resaturation of reclaimed mine spoils and minor streamflow loss to Bitter Creek. However significant recovery of the monitored drawdown within the alluvium has occurred since backfilling all of Pit 2 and the northeastern portion of Pit 3.

Due to the limited availability and poor quality of groundwater present in the coal seams, the hydrostatic water level declines are of minor consequence. Given the localized nature of the Bitter Creek alluvial groundwater declines near Pits Two and Three, and the extremely poor quality of the alluvial groundwater, these declines are also of minor consequence. Bitter Creek alluvium is the most productive shallow water-bearing formation in the Black Butte Mine area, yet it characteristically yields groundwater of such poor quality that it is unsuitable for all three of the state's beneficial-use classifications.

In its Annual Report review memorandum of April 17, 2015, the WDEQ/LQD acknowledged that groundwater performance criteria associated with the area encompassed by Pit Two have been met (see text of Section Groundwater Levels). The groundwater conditions supporting this determination are summarized in the memorandum.

Permeable Fort Union Formation strata (coal seams and sandstone lenses) that have been excavated at the northern extent of Pit Three and that subcrop beneath the adjacent Bitter Creek alluvium conduct alluvial groundwater into the open excavation and the backfilled spoils. The quality of the Pit Three spoils groundwater is similar to the alluvial groundwater quality near the Pit Three area. The April 17, 2015 Annual Report regulatory review memorandum verifies that the area of Pit Three southwest of Ramp 6 which is situated in Section 31, and all of Pit Four have no groundwater performance criteria because these pit areas were not saturated with groundwater prior to mining.

In addition to Pit Two, the WDEQ has declared successful groundwater restoration for all of Pit Six.

Any streamflow losses to Bitter Creek would be attributable to disturbed-land runoff captured by the mine's drainage control structures. Relative to the runoff volume

over the entire Bitter Creek drainage basin area, this loss of runoff from the disturbed land area is insignificant. Given the available data, streamflow is constant throughout the mine area during baseflow conditions. No significant gaining or losing reaches have been identified along Bitter Creek's stream length through the permit area under typical flow conditions. There does not appear, based upon all usable historic data, to be any significant increasing or decreasing trends in the water quality (particularly total suspended solids and total dissolved solids concentrations) occurring between monitoring sites SBC1-75 and SBC2-75. Natural processes occurring within the channel can generally explain any notable differences in streamflow and water quality. Intermittent flows in Bitter Creek were measured in May 2024, unfortunately, targeted water samples were not recovered.

Then mine reported discharge from its WYPDES facilities during the report period, most of it occurring during the first calendar quarter.

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TABLES

TABLE 1. ACTIVE GROUNDWATER MONITORING NETWORK

SITE NO.	STATION & AQUIFER ID	LOCATION - MINE COORDINATES	GROUND ELEVATION	TOTAL DEPTH	CASING TYPE, DIAM.	COMPLETION, PERFORATION ZONE	PACKER DEPTH	PIT/AREA MONITORED	INITIAL WATER ELEV.	DATE COMPLETED	MONITORING INFORMATION
9	0593 74 FU	323634.88N 529778.63E	6796.53	250	PVC 4"	FT. UNION 236 - 248	233	PIT 4	6589.53	11/23/74	Annual water levels and water quality samples.
21	2004 78 KLB	328589.70N 521514.10E	6910.80	400	PVC 5"	LANCE 364 - 374	362	PIT 5	6749.71	5/24/78	Semi-annual water levels and water quality samples. *Obstruction in well - unable to measure or sample since 6/4/2019.*
22	2005 78 KLE	322644.10N 521273.50E	6679.80	223	PVC 5"	LANCE 213 - 223	203, 213	PIT 5	6493.16	5/24/78	Semi-annual water levels.
33	2721 80 KLD	319213.50N 518135.70E	6709.80	130	PVC 5"	LANCE 118 - 130	-	PIT 5S	6616.73	8/5/80	Semi-annual water levels.
37	2842 80 FUASH	314255.30N 521205.00E	6634.10	130	PVC 5"	FT. UNION 80 - 90	-	PIT 3	6623.92	12/3/80	Semi-annual water levels and water quality samples.
39	2844 80 FUCSS	311869.40N 523146.80E	6634.00	90	PVC 5"	FT. UNION 30 - 90	30	PIT 3	6611.82	12/4/80	Semi-annual water levels and water quality samples.
40	2845 80 FUCSS	312614.90N 522341.00E	6639.10	130	PVC 5"	FT. UNION 30 - 130	30	PIT 3	6623.77	12/5/80	Semi-annual water levels.
41	2846 80 QAL	312958.20N 522943.90E	6631.50	82	PVC 5"	ALLUVIUM 58 - 78	GRAVEL PACKED	PIT 3	6624.4	12/4/80	Semi-annual water levels and water quality samples.
58	2863 80 FUSS	313258.80N 522103.50E	6642.00	100	PVC 5"	FT. UNION 60 - 100	-	PIT 3	6624.42	12/6/80	Semi-annual water levels and annual water quality samples.
66	3053 81 KL	321154.00N 519451.70E	6758.00	288	PVC 5"	LANCE 274 - 285	252, 272	PIT 5S	6604.48	6/23/81	Semi-annual water levels and water quality samples.
68	3051 81 KL	313692.00N 514808.80E	6731.40	109	PVC 5"	LANCE 97 - 105	85, 105	PIT 6	6645.31	6/16/81	Annual water levels and water quality samples.
71	3306 82 AL	328165.80N 508793.90E	6665.30	201	PVC 5"	ALMOND 166 - 198	119	PIT 8	6661.47	4/28/82	Semi-annual water levels and water quality samples.
72	3307 82 AL	314885.10N 501631.40E	6784.20	224	PVC 5"	ALMOND 200 - 220	170	PIT 8	6756.14	4/28/82	Semi-annual water levels and water quality samples.
73	4555 85 QAL	331899.57N 513302.73E	6589.85	76	PVC 5"	ALLUVIUM 56 - 76	GRAVEL PACKED	PIT 2	6519.1	8/21/85	Semi-annual water levels and water quality samples.
75	5059 86 FU	307061.80N 518183.00E	6790.30	402	PVC 5"	FT. UNION 302 - 382	39	PIT 3	6632.05	11/6/86	Semi-annual water levels and water quality samples.
76	5060 86 FU	300308.80N 511319.50E	6903.60	362	PVC 5"	FT. UNION 292 - 352	45	PIT 3	6755.85	11/7/86	Semi-annual water levels and water quality samples.
81	5025 86 FU	353566.60N 532695.60E	6803.70	280	PVC 5"	FT. UNION 171 - 255	170 238	PIT 10	6736.7	10/27/86	Semi-annual water levels and water quality samples.

TABLE 1. ACTIVE GROUNDWATER MONITORING NETWORK

SITE NO.	STATION & AQUIFER ID	LOCATION - MINE COORDINATES	GROUND ELEVATION	TOTAL DEPTH	CASING TYPE, DIAM.	COMPLETION, PERFORATION ZONE	PACKER DEPTH	PIT/AREA MONITORED	INITIAL WATER ELEV.	DATE COMPLETED	MONITORING INFORMATION
85R	11-08085R FUC	355398.28N 530023.82E	6803.37	281	PVC 4"	FT. UNION 260-281	258	PIT 11	6716.87	7/9/08	Semi-annual water levels.
86	5349 90 FU	338783.81N 524027.65E	6774.20	401	STEEL 5"	FT. UNION 364-389	359	PIT 9	6532.49	9/18/90	Annual water levels and water quality samples.
87R	11-08087R FUC1	355296.30N 530051.97E	6803.40	228	PVC 4"	FT. UNION 212-228	207	PIT 11	6591.4	7/8/08	Semi-annual water levels.
89	5661 94 FUA	304621.52N 516909.65E	6819.47	372	PVC 5"	FT. UNION 362 - 372	SAND PACKED	PIT 3	6629.34	4/94	Semi-annual water levels.
90	5662 94 FUC	311732.34N 524303.60E	6639.68	230	PVC 5"	FT. UNION 210 - 230	SAND PACKED	PIT 3	6605.93	4/94	Semi-annual water levels and water quality samples.
91	5663 94 SP	313387.20N 520372.40E	6643.70	90	PVC 5"	RECL. SPOIL 20 - 90	SAND PACKED	PIT 3	6617.33	4/94	Quarterly water levels and semi-annual water quality.
93	5665 94 QAL	309308.90N 527769.40E	6641.00	80	PVC 5"	ALLUVIUM 20 - 80	SAND PACKED	UP-GRADIENT	6631.38	5/94	Monthly water levels and semi-annual water quality.
96	5668 94 QAL	316570.60N 517530.90E	6619.90	80	PVC 6"	ALLUVIUM 20 - 80	SAND PACKED	DOWN-GRADIENT	6606.28	5/94	Semi-annual water levels.
97	5669 94 QAL	318614.40N 514816.70E	6614.30	84	PVC 5"	ALLUVIUM 24 - 84	SAND PACKED	DOWN-GRADIENT	6592.53	5/94	Semi-annual water levels and water quality samples.
99	5671 94 QAL	326201.20N 512594.50E	6596.20	80	PVC 5"	ALLUVIUM 20 - 80	SAND PACKED	MID-GRADIENT	6569.25	5/94	Quarterly water levels and semi-annual water quality.
102	5674 94 QAL	334096.80N 512986.80E	6583.00	85	PVC 5"	ALLUVIUM 25 - 85	SAND PACKED	MID-GRADIENT	6541.81	5/94	Semi-annual water levels and water quality samples.
104	5676 94 QAL	338146.80N 511828.00E	6574.90	85	PVC 6"	ALLUVIUM 25 - 85	SAND PACKED	DOWN-GRADIENT	6551.12	5/94	Quarterly water levels and semi-annual water quality.
105	5677 94 QAL	341510.70N 506108.40E	6563.30	89	PVC 5"	ALLUVIUM 29 - 89	SAND PACKED	DOWN-GRADIENT	6542.47	5/94	Monthly water levels and semi-annual water quality.
107	5679 94 QAL	329777.40N 512923.60E	6589.90	84	PVC 6"	ALLUVIUM 24 - 84	SAND PACKED	MID-AGRADIENT	6555.55	5/94	Semi-annual water levels and water quality samples.
108	5680 94 FUBC	335550.70N 521314.10E	6697.10	320	PVC 5"	FT. UNION 287 - 313	SAND PACKED	PIT 2	6543.57	5/94	Annual water levels and water quality samples.
110	5682 98 SP	335457.00N 516926.93E	6626.38	142	PVC 5"	SPOIL 82 - 142	SAND PACKED	PIT 2	6539.42	4/98	Annual water levels and water quality samples.
111	AL	322520.75N 506509.3E	6696.80	255	PVC 4"	ALMOND 227 - 247	SAND PACKED	PIT 8	6689.00	7/05	Semi-annual water levels and water quality samples.
112	11205 FU U.B	355161.32N 530015.17E	6803.00	315	PVC 4"	FT. UNION 290 - 310	SAND PACKED	PIT 11	6727.10	7/05	Semi-annual water levels.

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113	11305 FU O.B	355215.61N 530050.73E	6802.90	175	PVC 4"	FT. UNION 150 - 170	SAND PACKED	PIT 11	6713.10	7/05	Semi-annual water levels.
RP-5B	RP-5B SP	324234.49N 519905.27E	6727.46	183	PVC 4"	SPOIL 143 - 183	GRAVEL PACKED	PIT 5	6588.71	10/9/15	Quarterly water levels and water quality for the 1st year to acquire baseline data. (Then semi-annual water levels and water quality samples.) *Obstruction in well - unable to measure or sample since 9/14/2021.*
SW1-OB	SW1-OB AL	294997.4N 491019.2E	6987.70	150	PVC 4"	ALMOND 125 - 145	SAND PACKED	PIT 14	6971.5	8/2/05	Semi-annual water levels and water quality samples.
SW1-CZ	SW1-CZ AL	294963.32N 490992.49E	6991.85	252	PVC 4.95" OD	ALMOND 197 - 252	GRAVEL PACKED	PIT 14	6958.1	9/7/01	Semi-annual water levels and water quality samples.
SW1-UB	SW1-UB AL	295022.4N 491039.5E	6988.03	290	PVC 4"	ALMOND 265 - 285	SAND PACKED	PIT 14	FLOWING	8/1/05	Semi-annual water levels and water quality samples.
SW3-OB	SW3-OB AL	288369.2N 483387.9E	7051.30	82	PVC 4"	ALMOND 57 - 77	SAND PACKED	PIT 14	6998.2	8/4/05	Semi-annual water levels and water quality samples.
SW3-CZ	SW3-CZ AL	288370.2N 4883398.82E	7051.80	112	PVC 4"	ALMOND 92 - 112	SAND PACKED	PIT 14	6969.8	8/4/05	Semi-annual water levels.
SW3-UB	SW3-UB AL	288370.23N 483409.7E	7052.00	150	PVC 4"	ALMOND 125 - 145	SAND PACKED	PIT 14	6999.6	8/3/05	Semi-annual water levels.
SW4-OB	SW4-OB AL	304033.58N 496569.97E	6844.50	165	PVC 4"	ALMOND 140 - 160	SAND PACKED	PIT 14	FLOWING	8/7/05	Semi-annual water levels.
SW4-CZ	SW4-CZ AL	304044.15N 496565.13E	6844.30	250	PVC 4"	ALMOND 185 - 245	SAND PACKED	PIT 14	FLOWING	8/6/05	Semi-annual water levels.
SW4-UB	SW4-UB AL	304055.7N 496557.85E	6844.40	300	PVC 4"	ALMOND 270 - 290	SAND PACKED	PIT 14	FLOWING	8/5/05	Semi-annual water levels.
WATER SUPPLY	WB01 75 ERIC	332073.00N 517596.00E	6600.00	1219	STEEL	ERICSON 930 - 1219	---	---		4/75	Semi-annual water levels (Head) Facilities Supply Bluebell #13 well. Pressure gauge on wellhead, convert to head (2.31' per lb psi)
P10MW1	P10MW1 UB FU Underbur	348271.41N 534950.23E	6946.56	500	PVC 4"	FT. UNION 475 - 495	470 - 495	PIT 10	6700.52	9/24/14	Semi-annual water levels and water quality samples.
P10MW1	P10MW1 CZ FU Coal Zon	348261.87N 534946.57E	6946.82	451	PVC 4"	FT. UNION 411 - 451	405 - 451	PIT 10	6558.82	10/2/14	Semi-annual water levels and water quality samples.
P10MW1	P10MW1 OB FU Overburd	348252.26N 534943.22E	6946.78	365	PVC 4"	FT. UNION 325 - 365	320 - 365	PIT 10	6734.75	10/3/14	Semi-annual water levels and water quality samples.

This table reflects updated monitoring information from the current approved Table MP-23. (Revised 4/16) During Mining Groundwater Monitoring Network.

TABLE 1A. INACTIVE GROUNDWATER MONITORING NETWORK

SITE NO.	STATION & AQUIFER ID	LOCATION - MINE COORDINATES	GROUND ELEVATION	TOTAL DEPTH	CASING TYPE, DIAM.	COMPLETION, PERFORATION ZONE	PACKER DEPTH	PIT/AREA MONITORED	INITIAL WATER ELEV.	DATE COMPLETED	MONITORING INFORMATION
1	0534 74 KLD	346812.91N 520267.95E	6898.13	164	PVC 4"	LANCE 144 - 164	24	PIT 7	6757.63	11/22/74	Not presently monitored. Annual water levels will resume 1 year prior to any mining activity in Pit 7, 12 or 13.
2	0535 74 KLDE	353087.60N 514502.87E	6927.41	198	PVC 4"	LANCE 178 - 198	18	PIT 13	6748.41	11/22/74	Not presently monitored. Annual water levels will resume 1 year prior to any mining activity in Pit 7, 12 or 13.
3	0536 74 KLQAL	337694.99N 511350.87E	6575.35	56	PVC 4"	ALLUVIUM 36 - 56	GRAVEL PACKED	DOWN-GRADIENT	6558.2	11/23/74	Semi-annual water levels and water quality samples. Discontinued monitoring 1994.
4	0537 74 KLI	334000.00N 509000.00E	6660.00	150	PVC 4"	LANCE 130 - 150	126	PIT 12	6645.88	11/24/74	Not presently monitored. Annual water levels will resume 1 year prior to any mining activity in Pit 7, 12 or 13.
5	0547 74 KLAB	343099.63N 518425.31E	6924.93	205	PVC 4"	LANCE 184 - 204	24	PIT 7	DRY	10/20/74	Not presently monitored. Annual water levels will resume 1 year prior to any mining activity in Pit 7, 12 or 13.
10	0595 74 QAL	312149.29N 524637.99E	6634.67	40	PVC 4"	ALLUVIUM 20 - 40	GRAVEL PACKED	UP-GRADIENT	6625.15	11/24/74	Semi-annual water levels and water quality samples. Discontinued monitoring 1994.
12	0603 74 FU	299500.00N 516523.22E	7014.12	150	PVC 4"	WASATCH 130 - 150	40	EAST PIT 3	6999.12	11/25/74	Improper completion. Will no longer be monitored.
14	1749 75 QAL	326811.71N 512283.87E	6595.91	80	PVC 4"	ALLUVIUM 6 - 80	GRAVEL PACKED	MID-GRADIENT	6585.2	12/30/75	Semi-annual water levels. Discontinued monitoring 1994.
24	0594 74 KL	321999.86N 519802.22E	6667.71	65	PVC 4"	LANCE 54 - 65	52	PIT 5	6619.71	11/24/74	Semi-annual water levels. Discontinued monitoring 2016.
29	2717 80 QAL	314474.00N 519996.30E	6627.40	37	PVC 5"	ALLUVIUM 17 - 37	GRAVEL PACKED	PIT 3	6620.32	7/29/80	Pump test obs. well. Not presently monitored.
30	2718 80 QAL	314511.90N 520039.90E	6627.00	28	PVC 5"	ALLUVIUM 8 - 28	GRAVEL PACKED	PIT 3	6619.58	7/30/80	Semi-annual water levels and water quality samples. Discontinued monitoring 1994.
31	2719 80 QAL	314559.60N 520068.40E	6627.00	28	PVC 5"	ALLUVIUM 8 - 28	GRAVEL PACKED	PIT 3	6620.12	7/30/80	Pump test obs. well. Not presently monitored.
32	2720 80 KLA	319716.60N 516107.20E	6768.50	129	PVC 4"	LANCE 109 - 129	109	PIT 5S	DRY	8/1/80	Baseline established (dry). Not presently monitored.
35	2723 80 KLF	322256.40N 520153.50E	6667.00	63	PVC 5"	LANCE 56 - 60	-	PIT 5	6621.64	8/5/80	Monitoring is temporarily suspended and will commence one year prior to opening Pit 5S. {Semi-annual water levels and water quality samples.}

TABLE 1A. INACTIVE GROUNDWATER MONITORING NETWORK

SITE NO.	STATION & AQUIFER ID	LOCATION - MINE COORDINATES	GROUND ELEVATION	TOTAL DEPTH	CASING TYPE, DIAM.	COMPLETION, PERFORATION ZONE	PACKER DEPTH	PIT/AREA MONITORED	INITIAL WATER ELEV.	DATE COMPLETED	MONITORING INFORMATION
38	2843 80 QAL	312914.30N 523003.20E	6631.80	80	PVC 5"	ALLUVIUM 50 - 80	GRAVEL PACKED	PIT 3	6621.36	12/3/80	Pump test well. Not presently monitored.
42	2847 80 QAL	312857.40N 522957.90E	6631.70	80	PVC 5"	ALLUVIUM 57 - 77	GRAVEL PACKED	PIT 3	6624.25	12/5/80	Pump test well. Not presently monitored.
46	2851 80 QAL	314114.50N 522651.70E	6629.80	74	PVC 5"	ALLUVIUM 34 - 74	GRAVEL PACKED	PIT 3	6621.42	12/6/80	Pump test well. Not presently monitored.
47	2852 80 QAL	314081.50N 522750.80E	6630.80	76	PVC 5"	ALLUVIUM 36 - 76	GRAVEL PACKED	PIT 3	6622.45	12/7/80	Semi-annual water levels and water quality samples. Discontinued monitoring 2016.
48	2853 80 QAL	313976.30N 522690.80E	6631.10	77	PVC 5"	ALLUVIUM 37 - 77	GRAVEL PACKED	PIT 3	6622.56	12/7/80	Pump test well. Not presently monitored.
49	2854 80 QAL	314015.70N 523605.70E	6630.90	80	PVC 5"	ALLUVIUM 40 - 80	GRAVEL PACKED	PIT 3	6623.65	12/8/80	Pump test well. Not presently monitored.
50	2855 80 QAL	313428.60N 523818.80E	6632.50	79	PVC 5"	ALLUVIUM 39 - 79	GRAVEL PACKED	PIT 3	6624.16	12/9/80	Pump test well. Not presently monitored.
51	2856 80 QAL	313316.40N 523850.10E	6631.90	80	PVC 5"	ALLUVIUM 40 - 80	GRAVEL PACKED	PIT 3	6624.46	12/9/80	Pump test well. Not presently monitored.
52	2857 80 QAL	313393.90N 523916.80E	6632.50	70	PVC 5"	ALLUVIUM 30 - 70	GRAVEL PACKED	PIT 3	6623.97	12/10/80	Semi-annual water levels and water quality samples. Discontinued monitoring 2016.
53	2858 80 FUSS	316274.90N 525136.00E	6670.20	161	PVC 5"	FT. UNION 101 - 151	80, 100	PIT 4S	6624.23	12/10/80	Baseline established. Not presently monitored.
54	2859 80 FUSS	317722.90N 524312.60E	6660.50	100	PVC 5"	FT. UNION 40 - 100	-	PIT 4S	6622.65	12/15/80	Baseline established. Not presently monitored.
55	2860 80 FUSS	317729.50N 525464.20E	6673.70	100	PVC 5"	FT. UNION 60 - 100	-	PIT 3	6623.14	12/12/80	Semi-annual water levels. Discontinued monitoring 2016.
56	2861 80 KLCST	318439.20N 517244.20E	6729.60	180	PVC 5"	LANCE 160 - 180	158	PIT 5S	6604.47	12/4/80	Monitoring is temporarily suspended and will commence one year prior to opening Pit 5S. {Semi-annual water levels.}
57	2862 80 KLA	318872.60N 516505.30E	6755.10	180	PVC 5"	LANCE 160 - 180	-	PIT 5S	6596.03	12/5/80	Monitoring is temporarily suspended and will commence one year prior to opening Pit 5S. {Semi-annual water levels.}
65	3050 81 FU	344462.20N 530553.30E	6919.10	165	PVC 5"	FT. UNION 130 - 160	109, 129	PIT 10	6793.72	6/16/81	Not presently monitored (Dry). Resume monitoring upon completion of backfill.

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SITE NO.	STATION & AQUIFER ID	LOCATION - MINE COORDINATES	GROUND ELEVATION	TOTAL DEPTH	CASING TYPE, DIAM.	COMPLETION, PERFORATION ZONE	PACKER DEPTH	PIT/AREA MONITORED	INITIAL WATER ELEV.	DATE COMPLETED	MONITORING INFORMATION
67	3052 81 KL	305478.50N 509762.70E	6870.30	167	PVC 5"	LANCE 153 - 162	128, 148	PIT 6	6809.99	6/17/81	Monitoring suspended 2016. Leave for stock well.
70	3305 82 AL	329112.90N 508726.70E	6668.20	200	PVC 5"	ALMOND 168 - 196	166	PIT 8	FLOWING	4/27/82	Pump test well. Not presently monitored.
74	4554 85 QAL	331461.75N 512853.39E	6589.17	62	PVC 5"	ALLUVIUM 37 - 57	GRAVEL PACKED	PIT 2	6525.58	8/21/85	Semi-annual water levels and water quality samples. Discontinued monitoring 2016.
88	5585 93 SP	330236.04N 520168.75E	6962.24	200	PVC 5"	RECL. SPOIL 160 - 200	GRAVEL PACKED	PIT 5	DRY	1/6/93	Semi-annual water levels (dry). Not presently monitored.
92	5664 94 SP	313449.20N 520306.00E	6643.10	80	PVC 5"	RECL. SPOIL 20 - 80	SAND PACKED	PIT 3	6616.99	4/94	Pump test well. Not presently monitored.
94	5666 94 QAL	311732.30N 524303.10E	6634.10	80	PVC 5"	ALLUVIUM 20 - 80	SAND PACKED	UP-GRADIENT	6623.15	5/94	Quarterly water levels and semi-annual water quality. Discontinued monitoring 2016.
95	5667 94 QAL	317165.20N 516054.70E	6617.80	80	PVC 5"	ALLUVIUM 20 - 80	SAND PACKED	DOWN-GRADIENT	6600.60	5/94	Semi-annual water levels. Discontinued monitoring 2016.
98	5670 94 QAL	320904.30N 512471.70E	6607.10	64	PVC 5"	ALLUVIUM 14 - 64	SAND PACKED	MID-GRADIENT	6587.89	5/94	Quarterly water levels. Discontinued monitoring 2016.
100	5672 94 QAL	329765.50N 512854.90E	6589.90	83	PVC 5"	ALLUVIUM 23 - 83	SAND PACKED	MID-GRADIENT	6555.87	5/94	Pump test well. Not presently monitored.
101	5673 94 QAL	333069.10N 513093.10E	6586.70	61	PVC 5"	ALLUVIUM 11 - 61	SAND PACKED	MID-GRADIENT	6531.54	5/94	Quarterly water levels. Discontinued monitoring 2016.
103	5675 94 QAL	338160.30N 511876.40E	6575.00	84	PVC 5"	ALLUVIUM 24 - 84	SAND PACKED	DOWN-GRADIENT	6551.07	5/94	Pump test well. Not presently monitored.
106	5678 94 QAL	333613.70N 512214.30E	6583.50	57	PVC 5"	ALLUVIUM 17 - 57	SAND PACKED	MID-GRADIENT	6540.18	5/94	Quarterly water levels. Discontinued monitoring 2016.
109	5681 98 SP	332862.96N 515114.88E	6601.31	202	PVC 5"	SPOIL 77 - 202	SAND PACKED	PIT 2	6538.89	4/98	Semi-annual water levels and water quality samples. Discontinued monitoring 2016.
SW-2	SW01-045C AL	290501.20N 488001.29E	7071.94	251	PVC	ALMOND 181 - 251	GRAVEL PACKED	PIT 14	6980.2	9/27/01	Monitoring discontinued after Sept. 2006.
WATER SUPPLY	WCS1 62 ERIC	320445.00N 509125.00E	6629.00	4932	STEEL	ERICSON OPEN HOLE	---	---		12/62	Not presently sampled. Chandler Simpson #1 well.
WATER SUPPLY	WD01 79 ERIC	336328.00N 513520.00E	6584.00	2077	STEEL	ERICSON 1775 - 2076	---	---		1/79	Annual water quality samples. *Darter #1 well. Not presently monitored.

TABLE 1A. INACTIVE GROUNDWATER MONITORING NETWORK

SITE NO.	STATION & AQUIFER ID	LOCATION - MINE COORDINATES	GROUND ELEVATION	TOTAL DEPTH	CASING TYPE, DIAM.	COMPLETION, PERFORATION ZONE	PACKER DEPTH	PIT/AREA MONITORED	INITIAL WATER ELEV.	DATE COMPLETED	MONITORING INFORMATION
WATER SUPPLY	WD0279 ERIC	311720.00N 513010.00E	6802.40	2003	STEEL	ERICSON 1740 - 1982	---	---		1/79	Not presently monitored. Darter #2 well.
WATER SUPPLY	WSF1 85 ERIC	328949.00N 510374.00E	6618.00	688	STEEL	ERICSON 455 - 677	---	PIT 8		3/85	Not presently sampled. Squawfish #1 well.
WATER SUPPLY	WSF2 85 ERIC	330064.00N 511694.00E	6603.00	760	STEEL	ERICSON 555 - 750	---	PIT 8		3/85	Not presently sampled. Squawfish #2 well.
WATER SUPPLY	5362 91 KFU	353686.60N 528239.50E	6754.3	260	PVC 8"	FT UNION 110-150	---	PIT 11		6/18/91	Not presently sampled. Red Hill #2 well.
WATER SUPPLY	5363 91 KFU	353875.40N 528700.10E	6763.20	260	PVC 8"	FT UNION 130-170	---	PIT 11		6/18/91	Not presently sampled. Red Hill #1 well.

TABLE 2. GROUNDWATER MONITORING NETWORK, WELLS DESTROYED BY MINING

SITE NO.	STATION & AQUIFER ID	LOCATION - MINE COORDINATES	GROUND ELEVATION	TOTAL DEPTH	CASING TYPE, DIAM.	COMPLETION, PERFORATION ZONE	PACKER DEPTH	PIT/AREA MONITORED	INITIAL WATER ELEV.	FINAL WATER ELEV.	DATE COMPLETED	MONITORING INFORMATION
6	0588 74 FUC	339477.3 N 523156.4 E	6735.08	271	PVC 4"	FT. UNION 240 - 270	230	PIT 9	6615.98	6568.81	11/10/74	Semi-annual water levels and water quality samples. Destroyed 10/87.
7	0589 74 FUC	350392.78N 531857.50E	6885.65	205	PVC 6"	FT. UNION 186 - 205	185	PIT 10	6753.44	6749.60	11/23/74	Semi-annual water levels and water quality samples. Destroyed approx. 8/94.
8	0590 74 ALA1	324723.78N 505642.57E	6744.88	137	PVC 6"	ALMOND 117 - 137	115	PIT 8	6734.8		11/24/74	Semi-annual water levels and water quality samples. Destroyed 2003.
11	0602 74 FUC	304460.2 N 512605.4 E	6874.25	176	PVC 4"	FT. UNION 156 - 176	150	PIT 3	6699.52	6737.27	11/25/74	Water levels and water quality samples. Destroyed 1/84.
13	0604 74 KLC	310599.8 N 511948.3 E	6806.81	150	PVC 4"	LANCE 130 - 150	40	PIT 6	6738.43	6724.68	11/24/74	Water levels and water quality samples. Destroyed 5/85.
15	1750 75 FUC	333003.7 N 514432.2 E	6598.42	180	PVC 4"	FT. UNION 153 - 180		PIT 2	6565.85	6567.42	12/30/75	Water levels and water quality samples. Destroyed 9/80.
16	1772 75 KL	330318.2 N 519241.1 E	6955.09	100	PVC 4"	LANCE 83 - 92		PIT 5	6861.79	6860.63	12/2/75	Water levels and water quality samples. Destroyed 1983.
17	1773 75 ALX	319920.77N 501248.97E	6900.91	100	PVC 4"	ALMOND 70 - 100		PIT 8	6832.15	6825.37	12/30/75	Water levels and water quality samples. Destroyed 8/91.
18	2001 78 FUC	335863.1 N 519037.5 E	6780.30	320	PVC 5"	FT. UNION 298 - 318	274, 294	PIT 1,2,9	6584.65	6564.78	5/22/78	Water levels and water quality samples. Destroyed 1/84.
19	2002 78 FUC	334162.3 N 516944.7 E	6684.52	306	PVC 5"	FT. UNION 275 - 305	245, 275	PIT 2	6599.81	6562.36	5/16/78	Water levels and water quality samples. Destroyed 1/84.
20	2003 78 FUC	332938.5 N 515663.7 E	6609.50	250	PVC 5"	FT. UNION 227 - 250	210, 227	PIT 2	6560.64	6550.64	5/26/78	Water levels and water quality samples. Destroyed 1/84.
23	0545 74 FU	333865.92N 515761.37E	6636.26	225	PVC 4"	FT. UNION 205 - 225	190	PIT 2	6566.3	6514.32	8/20/74	Water levels and water quality samples. Destroyed 1984.

TABLE 2. GROUNDWATER MONITORING NETWORK, WELLS DESTROYED BY MINING

SITE NO.	STATION & AQUIFER ID	LOCATION - MINE COORDINATES	GROUND ELEVATION	TOTAL DEPTH	CASING TYPE, DIAM.	COMPLETION, PERFORATION ZONE	PACKER DEPTH	PIT/AREA MONITORED	INITIAL WATER ELEV.	FINAL WATER ELEV.	DATE COMPLETED	MONITORING INFORMATION
25	1748 75 FU	355864.7 N 525447.3 E	6850.50	195	PVC 4"	FT. UNION 168 - 195		PIT 11	DRY	DRY	12/20/75	Water levels and water quality samples. Destroyed 5/79.
26	2645 80 FUC	303764.5 N 511153.2 E	6891.20	139	PVC 4"	FT. UNION 123 - 139		PIT 3	DRY	DRY	7/23/80	Water levels and water quality samples. Destroyed 1984.
27	2715 80 FUASH	309881.4 N 518006.3 E	6718.30	135	PVC 4"	FT. UNION 112 - 130		PIT 3	6639.45	6636.05	7/23/80	Water levels and water quality samples. Destroyed 7/83.
28	2716 80 FUASH	309927.0 N 518051.3 E	6718.30	125	PVC 4"	FT. UNION 110 - 125		PIT 3	6636.42	6633.92	7/80	Water levels and water quality samples. Destroyed 7/83.
34	2722 80 NK										8/80	Casing broke upon completion. Not monitored. Reclaimed 10/80.
36	2724 80 KLC	328586.5 N 591362.8 E	6929.30	125	PVC 5"	LANCE 119 - 125		PIT 5	DRY	DRY	8/7/80	Water levels and water quality samples. Destroyed 4/82.
43	2848 80 FU	311898.80N 520945.20E	6698.10	95	PVC 5"	FT. UNION 68 - 88	67	PIT 3	6609.31	6621.66	12/5/80	Water levels and water quality samples. Destroyed 1990.
44	2849 80 FUSS	309023.0 N 517898.0 E	6755.80	167	PVC 5"	FT. UNION	125	PIT 3	6638.04	6633.33	12/5/80	Water levels and water quality samples. Destroyed 8/85.
45	2850 80 FUSS	309816.1 N 520153.9 E	6706.6	205	PVC 5"	FT. UNION	173	PIT 3	6637.12	DRY	12/6/80	Water levels. Destroyed 4/84.
59	2864 80 FUCSH	310728.9 N 518837.4 E	6747.00	160	PVC 5"	FT. UNION 120 - 160		PIT 3	6634.95	DRY	11/21/80	Water levels and water quality samples. Destroyed 4/84.
60	2865 80 FUCSH	304937.6 N 511699.5 E	6832.70	115	PVC 5"	FT. UNION	75	PIT 3	6768.6	DRY	11/24/80	Water levels and water quality samples. Destroyed 5/83.
61	2866 80 FUASH	301996.8 N 508766.3 E	6954.00	143	PVC 5"	FT. UNION 123 - 143	120	PIT 3	DRY	DRY	11/23/80	Water levels. Destroyed 4/84.

TABLE 2. GROUNDWATER MONITORING NETWORK, WELLS DESTROYED BY MINING

SITE NO.	STATION & AQUIFER ID	LOCATION - MINE COORDINATES	GROUND ELEVATION	TOTAL DEPTH	CASING TYPE, DIAM.	COMPLETION, PERFORATION ZONE	PACKER DEPTH	PIT/AREA MONITORED	INITIAL WATER ELEV.	FINAL WATER ELEV.	DATE COMPLETED	MONITORING INFORMATION
62	2867 80 FUCSH	301015.2 N 509995.1 E	6919.10	230	PVC 5"	FT. UNION 210 - 230		PIT 3	6736.14	DRY	11/23/80	Water levels and water quality samples. Destroyed 4/84.
63	2826 80 FUCSH	307654.0 N 516802.4 E	6786.92	221	PVC 5"	FT. UNION 191 - 211	180, 190	PIT 3	6599.11	DRY	11/11/80	Water levels. Destroyed 4/84.
64	2839 80 ALAA1	321133.20N 502881.30E	6839.30	124	PVC 5"	ALMOND 107 - 119		PIT 8	6775.12	6777.41	11/22/80	Semi-annual water levels and water quality samples. Destroyed 11/92.
69	3022 81 FU	348927.70N 532474.30E	6913.60	260	PVC 5"	FT. UNION 229 - 255	208, 228	PIT 10	6762.79		5/31/81	Semi-annual water levels and water quality samples. Destroyed Summer 2002
77	5098 86 SP	332890.50N 514247.50E	6591.60	150	PVC 5"	RECL. SPOIL 130 - 150	GRAVEL PACKED	PIT 2	6489.1	6517.20	11/19/86	Monthly water levels and semi-annual water quality. Destroyed 12/92.
78	5099 86 SP	332882.50N 514179.20E	6597.00	153	PVC 5"	RECL. SPOIL 133 - 153	GRAVEL PACKED	PIT 2	6507.79	6520.55	11/20/86	Monthly water levels. Destroyed 12/92.
79	5100 86 SP	335395.20N 516967.10E	6575.60	128	PVC 5"	RECL. SPOIL 108 - 128	GRAVEL PACKED	PIT 2	6468.94	6529.78	11/20/86	Monthly water levels and semi-annual water quality. Destroyed 12/95.
80	3695 83 FU	332042.30N 532672.50E	6908.40	297	PVC 5"	FT. UNION 273 - 293	251 271	PIT 4	6703.98	6703.98	3/16/83	Dry upon completion. Not presently monitored. Destroyed approx. 1988.
82	5203 87 SP	333378.72N 515562.87E	6524.68	128	PVC 5"	RECL. SPOIL 62.5 - 122.5	GRAVEL PACKED	PIT 2	6480.86	FLOWING 6523.14	10/27/87	Monthly water levels and semi-annual water quality. Destroyed 10/94.
83	5204 87 SP	333413.08N 515601.06E	6526.55	129	PVC 5"	RECL. SPOIL 64 - 124	GRAVEL PACKED	PIT 2	6480.8	6527.75	10/28/87	Monthly water levels and semi-annual water quality. Destroyed 5/95.
84	5202 87 SP	332851.31N 515121.57E	6529.62	141	PVC 5"	RECL. SPOIL 73 - 133	GRAVEL PACKED	PIT 2	6480.44	6529.17	10/20/87	Monthly water levels and semi-annual water quality. Destroyed 5/95.
85	5348 90 FU	354253.56N 529226.36E	6776.42	277	PVC 5"	FT. UNION 228-265	---	PIT 11	6708.22	6667.58	9/17/90	Semi-annual water levels and water quality samples. Destroyed in 2011.
87	5456 91 KFU	353630.01N 528775.02E	6767.00	180	PVC 5"	FT. UNION 120-160	---	PIT 11	6727.43	6726.51	6/18/91	Semi-annual water levels and water quality samples. Destroyed in 2011.

TABLE 3. SURFACE WATER MONITORING NETWORK

SITE NAME (NUMBER)	LOCATION MINE COORDINATES	LOCATION U.S.G.S. COORDINATES	GROUND ELEVATION	MONITORING STATION TYPE	COMMENTS
UPPER BITTER CREEK (SBC1-75)	309500.0N 528100.0E	dcd S.23 T18N,R100W	6640.9	HORIZONTAL "CHAIN" STAFF GAGE. ONE CREST GAGE. WATER QUALITY SAMPLING SITE.	MONTHLY SITE VISITATION TO TAKE STAFF GAGE READING FOR INSTANTANEOUS FLOW (CFS) MEASUREMENT AND CHECK CREST GAGE FOR PEAK FLOW RECORDING. GRAB SAMPLED MONTHLY FOR TSS AND TDS ANALYSES IN CONJUCTION WITH STAFF GAGE READING. ESTABLISHED IN 1987.
LOWER BITTER CREEK (SBC2-75)	341500.0N 506200.0E	cdc S.19 T19N,R100W	6563.5	HORIZONTAL "CHAIN" STAFF GAGE. ONE CREST GAGE. WATER QUALITY SAMPLING SITE.	MONTHLY SITE VISITATION TO TAKE STAFF GAGE READING FOR INSTANTANEOUS FLOW (CFS) MEASUREMENT AND CHECK CREST GAGE FOR PEAK FLOW RECORDING. GRAB SAMPLED MONTHLY FOR TSS AND TDS ANALYSES IN CONJUCTION WITH STAFF GAGE READING. ESTABLISHED IN 1987.

TABLE 4. CHANGES TO BLACK BUTTE'S GROUNDWATER MONITORING PROGRAM (2024)

SITE NO.	STATION NO.	CHANGED	ADDED	DELETED	MOVED	COMMENTS

No changes to the monitoring program

TABLE 5. GROUNDWATER ELEVATION REPORT

Station Name	Site No.	Aquifer	Meas. Date	Input DTW ft	Elev SWL ft MSL	Comments
59374	9	FU	09/25/24	133.41	6663.12	
200578	22	KLE	06/04/24	63.03	6618.52	
200578	22	KLE	08/28/24	62.94	6618.61	
272180	33	KLD	06/04/24	99.86	6611.27	
272180	33	KLD	08/28/24	100.09	6611.04	
284280	37	FUASH	06/05/24	15.18	6622.84	
284280	37	FUASH	09/05/24	15.85	6622.17	
284480	39	FUCSS	06/05/24	25.43	6611.22	
284480	39	FUCSS	09/05/24	26.49	6610.16	
284580	40	FUCSS	06/05/24	19.91	6621.86	
284580	40	FUCSS	08/29/24	20.46	6621.31	
284680	41	QAL	06/05/24	10.74	6622.66	
284680	41	QAL	09/05/24	11.45	6621.95	
286380	58	FUSS	06/05/24	24.36	6620.62	
286380	58	FUSS	09/05/24	24.91	6620.07	
305381	66	KL	06/04/24	149.31	6610.65	
305381	66	KL	09/25/24	150.56	6609.40	
305181	68	KL	06/05/24	86.41	6647.07	
330682	71	AL	06/04/24	68.17	6597.13	
330682	71	AL	09/16/24	69.85	6595.45	
330782	72	AL	06/04/24	52.24	6732.63	
330782	72	AL	09/10/24	52.55	6732.32	
455585	73	QAL	06/04/24	29.45	6562.20	
455585	73	QAL	09/05/24	29.64	6562.01	
505986	75	FU	06/05/24	173.84	6617.71	
505986	75	FU	09/16/24	173.83	6617.72	
506086	76	FU	06/05/24	153.98	6751.20	
506086	76	FU	09/16/24	154.21	6750.97	
502586	81	FU	06/05/24	140.54	6664.86	
502586	81	FU	09/17/24	140.85	6664.55	
1108085R	85R	FU	06/05/24	139.58	6665.79	
1108085R	85R	FU	08/29/24	139.60	6665.77	
534990	86	FU	09/25/24	229.01	6547.19	
1108087R	87R	KFU	06/05/24	153.82	6651.58	
1108087R	87R	KFU	08/29/24	154.56	6650.84	
566194	89	FUA	06/05/24	165.57	6655.78	
566194	89	FUA	08/29/24	165.80	6655.55	
566294	90	FUC	06/05/24	20.18	6621.32	
566294	90	FUC	09/05/24	20.20	6621.30	
566394	91	SP	03/29/24	26.53	6618.47	
566394	91	SP	06/05/24	24.98	6620.02	
566394	91	SP	09/16/24	26.23	6618.77	
566394	91	SP	10/10/24	26.20	6618.80	
566594	93	QAL	12/05/23	10.87	6631.88	
566594	93	QAL	01/08/24	10.80	6631.95	
566594	93	QAL	02/08/24	10.50	6632.25	
566594	93	QAL	03/06/24	10.30	6632.45	
566594	93	QAL	04/10/24	10.31	6632.44	
566594	93	QAL	05/15/24	10.20	6632.55	
566594	93	QAL	06/06/24	10.23	6632.52	
566594	93	QAL	07/08/24	10.86	6631.89	
566594	93	QAL	08/13/24	10.75	6632.00	
566594	93	QAL	09/03/24	11.61	6631.14	
566594	93	QAL	10/10/24	11.63	6631.12	
566594	93	QAL	11/06/24	11.63	6631.12	
566894	96	QAL	06/05/24	16.33	6605.52	
566894	96	QAL	08/29/24	16.94	6604.91	
566994	97	QAL	06/05/24	23.97	6592.28	
566994	97	QAL	09/23/24	25.72	6590.53	
567194	99	QAL	03/29/24	18.20	6579.50	
567194	99	QAL	06/04/24	18.02	6579.68	

TABLE 5. GROUNDWATER ELEVATION REPORT

Station Name	Site No.	Aquifer	Meas. Date	Input DTW ft	Elev SWL ft MSL	Comments
567194	99	QAL	09/05/24	18.43	6579.27	
567194	99	QAL	10/10/24	18.46	6579.24	
567494	102	QAL	06/04/24	23.22	6561.53	
567494	102	QAL	09/23/24	24.27	6560.48	
567694	104	QAL	03/29/24	30.68	6545.82	
567694	104	QAL	06/05/24	30.51	6545.99	
567694	104	QAL	09/10/24	31.95	6544.55	
567694	104	QAL	10/10/24	31.90	6544.60	
567794	105	QAL	12/05/23	25.80	6538.95	
567794	105	QAL	01/08/24	25.75	6539.00	
567794	105	QAL	02/08/24	25.30	6539.45	
567794	105	QAL	03/06/24	25.20	6539.55	
567794	105	QAL	04/10/24	25.36	6539.39	
567794	105	QAL	05/15/24	25.40	6539.35	
567794	105	QAL	06/06/24	25.00	6539.75	
567794	105	QAL	07/08/24	24.93	6539.82	
567794	105	QAL	08/13/24	24.70	6540.05	
567794	105	QAL	09/03/24	27.64	6537.11	
567794	105	QAL	10/10/24	27.69	6537.06	
567794	105	QAL	11/06/24	27.60	6537.15	
567994	107	QAL	06/04/24	18.89	6572.71	
567994	107	QAL	09/05/24	19.31	6572.29	
568094	108	FUBC	09/16/24	141.23	6557.57	
568298	110	SPOIL	09/17/24	64.93	6563.45	
11105	111	AL	06/04/24	90.58	6608.42	
11105	111	AL	09/10/24	91.55	6607.45	
11205	112	FU	06/05/24	155.95	6649.05	
11205	112	FU	08/29/24	156.10	6648.90	
11305	113	FU	06/05/24	159.71	6645.99	
11305	113	FU	08/29/24	159.85	6645.85	
WB01 75	Bluebell #13	ERIC	10/10/24	127.05	6727.05	Shut in pressure at well head. 55 psi
WB01 75	Bluebell #13	ERIC	11/04/24	129.36	6729.36	Shut in pressure at well head. 56 psi
P10MW1 CZ	P10MW1 CZ	FUCZ	06/04/24	322.62	6626.70	
P10MW1 CZ	P10MW1 CZ	FUCZ	09/24/24	319.21	6630.11	
P10MW1 OB	P10MW1 OB	FUOB	06/04/24	254.55	6694.73	
P10MW1 OB	P10MW1 OB	FUOB	09/24/24	253.04	6696.24	
P10MW1 UB	P10MW1 UB	FUUB	06/04/24	331.01	6618.05	
P10MW1 UB	P10MW1 UB	FUUB	09/24/24	338.02	6611.04	
SW1-CZ	SW1-CZ	AL	06/04/24	149.71	6844.34	
SW1-CZ	SW1-CZ	AL	09/10/24	152.42	6841.63	
SW1-OB	SW1-OB	AL	06/04/24	101.54	6889.46	
SW1-OB	SW1-OB	AL	09/10/24	103.62	6887.38	
SW1-UB	SW1-UB	AL	06/04/24	101.29	6889.14	
SW1-UB	SW1-UB	AL	09/10/24	103.15	6887.28	
SW3-CZ	SW3-CZ	AL	06/04/24	91.46	6962.64	
SW3-CZ	SW3-CZ	AL	08/29/24	95.54	6958.56	
SW3-OB	SW3-OB	AL	06/04/24	61.31	6992.49	
SW3-OB	SW3-OB	AL	09/10/24	61.88	6991.92	
SW3-UB	SW3-UB	AL	06/04/24	60.72	6993.78	
SW3-UB	SW3-UB	AL	08/29/24	61.34	6993.16	
SW4-CZ	SW4-CZ	AL	06/04/24	19.17	6828.33	
SW4-CZ	SW4-CZ	AL	08/29/24	20.05	6827.45	
SW4-OB	SW4-OB	AL	06/04/24	31.04	6816.16	
SW4-OB	SW4-OB	AL	08/29/24	32.24	6814.96	
SW4-UB	SW4-UB	AL	06/04/24	15.90	6831.30	
SW4-UB	SW4-UB	AL	08/29/24	16.30	6830.90	

Notes:

*Site Nos. 21 and RP5B semi-annual water levels were unable to be obtained due to obstructions in the wells.

TABLE 6. GROUNDWATER QUALITY REPORT

Station Name:		59374	284280	284280	284480
Station Number:		9	37	37	39
Aquifer:		FU	FUASH	FUASH	FUCSS
Sample Date:		9/25/2024	6/5/2024	9/5/2024	6/5/2024
Sample Time:		1402	1305	0734	1555
Sampler:		RM	TS/WWC	RM	TS/WWC
Laboratory Code:		Pace	Pace	Pace	Pace
Laboratory Number:		S2409473-003	S2406138-025	S2409116-001	S2406138-029
Lab Received Date:		9/27/2024	6/7/2024	9/9/2024	6/7/2024
Lab Received Time:		1015	1107	0925	1107
FIELD MEASUREMENTS					
Field pH	(S.U.)	8.0	7.7	8.0	7.5
Field Conductivity	(umhos/cm)	2386	13785	12190	5965
Field Temperature	(°C)	9.0	22.5	9.1	17.0
LABORATORY MEASUREMENTS					
Lab pH	(S.U.)	8.2	8.3	8.3	8.2
Lab Conductivity	(umhos/cm)	2350	13800	14500	6140
TDS (180°C)	(mg/L)	1620	8400	8280	3770
TDS (Calc)	(mg/L)	1590	9530	8430	3610
Total Acidity as CaCO3	(mg/L)	<5	<5	<5	<5
Total Alk. as CaCO3	(mg/L)	377	1100	1040	671
Total Hardness as CaCO3	(mg/L)	266	413	414	338
Sodium Adsorption Ratio		13.4	70.6	71.8	29.4
Ammonia Nitrogen as N	(mg/L)	1.4	<0.1	<0.1	1.5
Boron	(mg/L)	0.22	0.82	0.85	0.89
Nitrate as NO3	(mg/L)	0.31	8.93	9.90	<0.05
Total Phosphorus	(mg/L)	0.3	0.1	0.2	<0.1
ANIONS					
Bicarb as HCO3	(mg/L)	460	1340	1250	818
Bicarbonate	(meq/L)	7.53	21.96	20.49	13.41
Carb as CO3	(mg/L)	<5	<5	10	<5
Carbonate	(meq/L)	<0.01	<0.01	0.33	<0.01
Hydroxide as OH	(mg/L)	<5	<5	<5	<5
Hydroxide	(meq/L)	<0.01	<0.01	<0.01	<0.01
Chloride	(mg/L)	[D]21.3	[D]4610	[D]3520	[D]1020
Chloride	(meq/L)	0.60	130.04	99.28	28.66
Fluoride	(mg/L)	0.4	1.9	1.9	2.7
Fluoride	(meq/L)	0.02	0.09	0.10	0.14
Nitrate + Nitrite as N	(mg/L)	0.1	2.0	2.2	<0.05
Nitrate + Nitrite as N	(meq/L)	<0.01	0.14	0.15	<0.01
Sulfate	(mg/L)	[D]749	[D]812	[D]772	[D]841
Sulfate	(meq/L)	15.58	16.90	16.07	17.50
CATIONS					
Calcium	(mg/L)	55	58	62	59
Calcium	(meq/L)	2.73	2.90	3.08	2.93
Magnesium	(mg/L)	32	65	63	46
Magnesium	(meq/L)	2.58	5.35	5.19	3.82
Potassium	(mg/L)	8	19	23	6
Potassium	(meq/L)	0.21	0.49	0.58	0.16
Sodium	(mg/L)	501	3300	3360	1240
Sodium	(meq/L)	21.77	143.45	146.08	54.05
BALANCE					
Lab Determined Cations	(meq/L)	27.40	152.20	154.95	61.08
Lab Determined Anions	(meq/L)	23.75	169.15	136.44	59.72
Lab Determined Ion Difference	(meq/L)	3.65	16.94	18.50	1.36
TRACE METALS (Dissolved)					
Aluminum	(mg/L)	<0.1	<0.1	<0.1	<0.1
Arsenic	(mg/L)	<0.005	<0.005	<0.005	<0.005
Barium	(mg/L)	<0.5	<0.5	<0.5	<0.5
Cadmium	(mg/L)	<0.002	<0.002	<0.002	<0.002
Chromium	(mg/L)	<0.01	<0.01	<0.01	<0.01
Copper	(mg/L)	<0.01	<0.01	<0.01	<0.01
Iron	(mg/L)	<0.05	<0.05	<0.05	<0.05
Lead	(mg/L)	<0.02	<0.02	<0.02	<0.02
Manganese	(mg/L)	0.17	<0.02	<0.02	0.23
Mercury	(mg/L)	<0.001	<0.001	<0.001	<0.001
Molybdenum	(mg/L)	<0.02	<0.02	<0.02	<0.02
Nickel	(mg/L)	<0.01	<0.01	<0.01	<0.01
Selenium	(mg/L)	<0.005	<0.005	<0.005	<0.005
Zinc	(mg/L)	<0.01	<0.01	0.01	<0.01
TRACE METALS (Total)					
Total Iron	(mg/L)	0.60	0.46	1.56	1.08

**Wells 21 and RP-5B are obstructed and samples were unobtainable.*

[D]Report limit raised due to dilution.

TABLE 6. GROUNDWATER QUALITY REPORT

Station Name:		284480	284680	284680	286380
Station Number:		39	41	41	58
Aquifer:		FUCSS	QAL	QAL	FUSS
Sample Date:		9/5/2024	6/5/2024	9/5/2024	6/5/2024
Sample Time:		0804	1430	0825	1345
Sampler:		RM	TS/WWC	RM	TS/WWC
Laboratory Code:		Pace	Pace	Pace	Pace
Laboratory Number:		S2409116-002	S2406138-027	S2409116-003	S2406138-026
Lab Received Date:		9/9/2024	6/7/2024	9/9/2024	6/7/2024
Lab Received Time:		0925	1107	0925	1107
FIELD MEASUREMENTS					
Field pH	(S.U.)	7.8	7.4	7.6	7.5
Field Conductivity	(umhos/cm)	5230	7672	7620	9794
Field Temperature	(°C)	7.5	16.4	8.4	16.3
LABORATORY MEASUREMENTS					
Lab pH	(S.U.)	8.2	8.1	8.3	8.2
Lab Conductivity	(umhos/cm)	5450	7920	8190	10000
TDS (180°C)	(mg/L)	3260	4880	4900	6360
TDS (Calc)	(mg/L)	3080	4770	4710	6680
Total Acidity as CaCO3	(mg/L)	<5	<5	<5	<5
Total Alk. as CaCO3	(mg/L)	647	721	699	1200
Total Hardness as CaCO3	(mg/L)	388	461	478	471
Sodium Adsorption Ratio		22.6	33.0	35.2	44.8
Ammonia Nitrogen as N	(mg/L)	0.5	2.2	1.7	2.6
Boron	(mg/L)	0.88	0.77	0.80	1.07
Nitrate as NO3	(mg/L)	<0.05	<0.05	<0.05	<0.05
Total Phosphorus	(mg/L)	<0.1	<0.1	<0.1	0.1
ANIONS					
Bicarb as HCO3	(mg/L)	790	880	853	1460
Bicarbonate	(meq/L)	12.94	14.42	13.98	23.97
Carb as CO3	(mg/L)	<5	<5	<5	<5
Carbonate	(meq/L)	<0.01	<0.01	<0.01	<0.01
Hydroxide as OH	(mg/L)	<5	<5	<5	<5
Hydroxide	(meq/L)	<0.01	<0.01	<0.01	<0.01
Chloride	(mg/L)	[D]764	[D]1540	[D]1390	[D]2370
Chloride	(meq/L)	21.53	43.37	39.32	66.89
Fluoride	(mg/L)	1.7	2.8	2.9	4.7
Fluoride	(meq/L)	0.09	0.14	0.15	0.24
Nitrate + Nitrite as N	(mg/L)	<0.05	<0.05	<0.05	<0.05
Nitrate + Nitrite as N	(meq/L)	<0.01	<0.01	<0.01	<0.01
Sulfate	(mg/L)	[D]778	[D]1020	[D]969	[D]1210
Sulfate	(meq/L)	16.19	21.29	20.17	25.08
CATIONS					
Calcium	(mg/L)	65	76	81	54
Calcium	(meq/L)	3.25	3.77	4.05	2.69
Magnesium	(mg/L)	55	66	67	82
Magnesium	(meq/L)	4.51	5.44	5.51	6.72
Potassium	(mg/L)	7	8	11	13
Potassium	(meq/L)	0.17	0.21	0.27	0.32
Sodium	(mg/L)	1020	1630	1770	2230
Sodium	(meq/L)	44.45	70.82	76.92	97.18
BALANCE					
Lab Determined Cations	(meq/L)	52.43	80.41	86.89	107.10
Lab Determined Anions	(meq/L)	50.76	79.24	73.63	116.21
Lab Determined Ion Difference	(meq/L)	1.66	1.16	13.25	9.10
TRACE METALS (Dissolved)					
Aluminum	(mg/L)	<0.1	<0.1	<0.1	<0.1
Arsenic	(mg/L)	<0.005	<0.005	<0.005	<0.005
Barium	(mg/L)	<0.5	<0.5	<0.5	<0.5
Cadmium	(mg/L)	<0.002	<0.002	<0.002	<0.002
Chromium	(mg/L)	<0.01	<0.01	<0.01	<0.01
Copper	(mg/L)	<0.01	<0.01	<0.01	<0.01
Iron	(mg/L)	<0.05	<0.05	<0.05	<0.05
Lead	(mg/L)	<0.02	<0.02	<0.02	<0.02
Manganese	(mg/L)	0.26	0.52	0.64	0.20
Mercury	(mg/L)	<0.001	<0.001	<0.001	<0.001
Molybdenum	(mg/L)	<0.02	<0.02	<0.02	<0.02
Nickel	(mg/L)	<0.01	<0.01	<0.01	<0.01
Selenium	(mg/L)	<0.005	<0.005	<0.005	<0.005
Zinc	(mg/L)	<0.01	<0.01	<0.01	<0.01
TRACE METALS (Total)					
Total Iron	(mg/L)	0.76	1.91	2.55	0.69

**Wells 21 and RP-5B are obstructed and samples were unobtainable.*

[D]Report limit raised due to dilution.

TABLE 6. GROUNDWATER QUALITY REPORT

Station Name:		286380	305381	305381	305181
Station Number:		58	66	66	68
Aquifer:		FUSS	KL	KL	KL
Sample Date:		9/5/2024	6/4/2024	9/25/2024	6/5/2024
Sample Time:		0846	1910	1334	1130
Sampler:		RM	TS/WWC	RM	TS/WWC
Laboratory Code:		Pace	Pace	Pace	Pace
Laboratory Number:		S2409116-004	S2406138-016	S2409473-002	S2406138-023
Lab Received Date:		9/9/2024	6/7/2024	9/27/2024	6/7/2024
Lab Received Time:		0925	1107	1015	1107
FIELD MEASUREMENTS					
Field pH	(S.U.)	8.4	7.6	7.7	7.8
Field Conductivity	(umhos/cm)	8810	17541	17020	6320
Field Temperature	(°C)	8.5	12.8	9.6	17.6
LABORATORY MEASUREMENTS					
Lab pH	(S.U.)	8.6	8.2	8.2	8.4
Lab Conductivity	(umhos/cm)	9250	17200	18300	6530
TDS (180°C)	(mg/L)	5440	10800	11000	4680
TDS (Calc)	(mg/L)	5430	11700	11300	4520
Total Acidity as CaCO3	(mg/L)	<5	<5	<5	<5
Total Alk. as CaCO3	(mg/L)	1090	2570	2630	2110
Total Hardness as CaCO3	(mg/L)	269	103	92	326
Sodium Adsorption Ratio		52.6	204	212	38.2
Ammonia Nitrogen as N	(mg/L)	<0.1	8.6	7.9	1.6
Boron	(mg/L)	0.89	2.29	1.79	1.30
Nitrate as NO3	(mg/L)	8.44	<0.05	<0.05	3.09
Total Phosphorus	(mg/L)	<0.1	0.2	0.2	0.4
ANIONS					
Bicarb as HCO3	(mg/L)	1220	3140	3210	2510
Bicarbonate	(meq/L)	19.92	51.42	52.56	41.14
Carb as CO3	(mg/L)	57	<5	<5	30
Carbonate	(meq/L)	1.88	<0.01	<0.01	1.00
Hydroxide as OH	(mg/L)	<5	<5	<5	<5
Hydroxide	(meq/L)	<0.01	<0.01	<0.01	<0.01
Chloride	(mg/L)	[D]2010	[D]5290	[D]5000	[D]68
Chloride	(meq/L)	56.78	149.32	141.05	1.92
Fluoride	(mg/L)	5.3	1.3	1.2	3.3
Fluoride	(meq/L)	0.27	0.07	0.06	0.17
Nitrate + Nitrite as N	(mg/L)	1.9	<0.05	<0.05	0.7
Nitrate + Nitrite as N	(meq/L)	0.13	<0.01	<0.01	0.05
Sulfate	(mg/L)	[D]690	[D]<241	[D]<241	[D]1500
Sulfate	(meq/L)	14.35	<0.01	<0.01	31.14
CATIONS					
Calcium	(mg/L)	27	18	16	30
Calcium	(meq/L)	1.33	0.88	0.78	1.48
Magnesium	(mg/L)	49	14	13	61
Magnesium	(meq/L)	4.03	1.18	1.05	5.02
Potassium	(mg/L)	12	18	17	9
Potassium	(meq/L)	0.31	0.44	0.44	0.23
Sodium	(mg/L)	1980	4780	4670	1590
Sodium	(meq/L)	86.14	207.76	203.10	69.00
BALANCE					
Lab Determined Cations	(meq/L)	91.82	210.89	205.94	75.86
Lab Determined Anions	(meq/L)	93.37	200.82	193.68	75.44
Lab Determined Ion Difference	(meq/L)	1.54	10.07	12.26	0.42
TRACE METALS (Dissolved)					
Aluminum	(mg/L)	<0.1	<0.1	<0.1	<0.1
Arsenic	(mg/L)	<0.005	<0.005	<0.005	<0.005
Barium	(mg/L)	<0.5	4.0	3.9	<0.5
Cadmium	(mg/L)	<0.002	<0.002	<0.002	<0.002
Chromium	(mg/L)	<0.01	<0.01	<0.01	<0.01
Copper	(mg/L)	<0.01	<0.01	<0.01	<0.01
Iron	(mg/L)	<0.05	<0.05	<0.05	<0.05
Lead	(mg/L)	<0.02	<0.02	<0.02	<0.02
Manganese	(mg/L)	<0.02	<0.02	<0.02	0.11
Mercury	(mg/L)	<0.001	<0.001	<0.001	<0.001
Molybdenum	(mg/L)	<0.02	<0.02	<0.02	<0.02
Nickel	(mg/L)	<0.01	<0.01	<0.01	<0.01
Selenium	(mg/L)	<0.005	<0.005	<0.005	<0.005
Zinc	(mg/L)	<0.01	<0.01	<0.01	<0.01
TRACE METALS (Total)					
Total Iron	(mg/L)	0.28	0.17	2.16	0.08

**Wells 21 and RP-5B are obstructed and samples were unobtainable.*

[D]Report limit raised due to dilution.

TABLE 6. GROUNDWATER QUALITY REPORT

Station Name:		330682	330682	330782	330782
Station Number:		71	71	72	72
Aquifer:		AL	AL	AL	AL
Sample Date:		6/4/2024	9/16/2024	6/4/2024	9/10/2024
Sample Time:		1230	1108	1430	0919
Sampler:		TS/WWC	RM	TS/WWC	RM
Laboratory Code:		Pace	Pace	Pace	Pace
Laboratory Number:		S2406138-009	S2409324-004	S2406138-011	S2409230-004
Lab Received Date:		6/7/2024	9/18/2024	6/7/2024	9/13/2024
Lab Received Time:		1107	1027	1107	1012
FIELD MEASUREMENTS					
Field pH	(S.U.)	No Data	8.2	7.9	8.0
Field Conductivity	(umhos/cm)	No Data	2970	3916	4100
Field Temperature	(°C)	No Data	11.0	14.5	9.3
LABORATORY MEASUREMENTS					
Lab pH	(S.U.)	8.3	8.6	8.3	8.5
Lab Conductivity	(umhos/cm)	3330	3100	4080	4110
TDS (180°C)	(mg/L)	2040	1820	2450	2460
TDS (Calc)	(mg/L)	2110	1880	2560	2500
Total Acidity as CaCO3	(mg/L)	<5	<5	<5	<5
Total Alk. as CaCO3	(mg/L)	1680	1480	1800	1730
Total Hardness as CaCO3	(mg/L)	62	26	36	31
Sodium Adsorption Ratio		49.8	70.6	80.2	84.8
Ammonia Nitrogen as N	(mg/L)	2.4	1.5	2.6	1.9
Boron	(mg/L)	0.96	0.87	1.00	0.89
Nitrate as NO3	(mg/L)	<0.05	<0.05	<0.05	<0.05
Total Phosphorus	(mg/L)	0.7	1.3	0.1	0.1
ANIONS					
Bicarb as HCO3	(mg/L)	2030	1700	2170	2010
Bicarbonate	(meq/L)	33.34	27.82	35.52	32.90
Carb as CO3	(mg/L)	10	56	12	52
Carbonate	(meq/L)	0.32	1.86	0.39	1.72
Hydroxide as OH	(mg/L)	<5	<5	<5	<5
Hydroxide	(meq/L)	<0.01	<0.01	<0.01	<0.01
Chloride	(mg/L)	[D]162	[D]145	[D]364	[D]353
Chloride	(meq/L)	4.58	4.09	10.26	9.95
Fluoride	(mg/L)	3.9	4.4	3.3	3.5
Fluoride	(meq/L)	0.20	0.23	0.17	0.18
Nitrate + Nitrite as N	(mg/L)	<0.05	<0.05	<0.05	<0.05
Nitrate + Nitrite as N	(meq/L)	<0.01	<0.01	<0.01	<0.01
Sulfate	(mg/L)	[D]<12.3	[D]<12.3	[D]<12.3	[D]<12.3
Sulfate	(meq/L)	<0.01	<0.01	<0.01	<0.01
CATIONS					
Calcium	(mg/L)	16	6	7	6
Calcium	(meq/L)	0.80	0.30	0.36	0.31
Magnesium	(mg/L)	5	3	4	4
Magnesium	(meq/L)	0.42	0.21	0.34	0.30
Potassium	(mg/L)	13	12	13	13
Potassium	(meq/L)	0.32	0.30	0.33	0.33
Sodium	(mg/L)	900	828	1100	1080
Sodium	(meq/L)	39.13	36.02	47.75	47.17
BALANCE					
Lab Determined Cations	(meq/L)	40.86	36.95	48.98	48.25
Lab Determined Anions	(meq/L)	38.45	34.01	46.36	44.76
Lab Determined Ion Difference	(meq/L)	2.40	2.93	2.61	3.48
TRACE METALS (Dissolved)					
Aluminum	(mg/L)	0.40	<0.1	<0.1	<0.1
Arsenic	(mg/L)	<0.005	<0.005	<0.005	<0.005
Barium	(mg/L)	0.8	0.5	<0.5	<0.5
Cadmium	(mg/L)	<0.002	<0.002	<0.002	<0.002
Chromium	(mg/L)	<0.01	<0.01	<0.01	<0.01
Copper	(mg/L)	<0.01	<0.01	<0.01	<0.01
Iron	(mg/L)	6.42	<0.05	<0.05	<0.05
Lead	(mg/L)	<0.02	<0.02	<0.02	<0.02
Manganese	(mg/L)	0.35	<0.02	<0.02	<0.02
Mercury	(mg/L)	<0.001	<0.001	<0.001	<0.001
Molybdenum	(mg/L)	<0.02	<0.02	<0.02	<0.02
Nickel	(mg/L)	<0.01	<0.01	<0.01	<0.01
Selenium	(mg/L)	<0.005	<0.005	<0.005	<0.005
Zinc	(mg/L)	0.02	<0.01	<0.01	<0.01
TRACE METALS (Total)					
Total Iron	(mg/L)	7.20	16.30	0.75	0.86

**Wells 21 and RP-5B are obstructed and samples were unobtainable.*

[D]Report limit raised due to dilution.

TABLE 6. GROUNDWATER QUALITY REPORT

Station Name:		455585	455585	505986	505986
Station Number:		73	73	75	75
Aquifer:		QAL	QAL	FU	FU
Sample Date:		6/4/2024	9/5/2024	6/5/2024	9/16/2024
Sample Time:		0920	1011	1650	0937
Sampler:		TS/WWC	RM	TS/WWC	RM
Laboratory Code:		Pace	Pace	Pace	Pace
Laboratory Number:		S2406138-004	S2409116-005	S2406138-030	S2409324-002
Lab Received Date:		6/7/2024	9/9/2024	6/7/2024	9/18/2024
Lab Received Time:		1107	0925	1107	1027
FIELD MEASUREMENTS					
Field pH	(S.U.)	7.0	7.5	7.9	8.2
Field Conductivity	(umhos/cm)	21459	11420	2973	3130
Field Temperature	(°C)	11.1	8.8	15.6	9.9
LABORATORY MEASUREMENTS					
Lab pH	(S.U.)	7.7	8.1	8.4	8.5
Lab Conductivity	(umhos/cm)	23900	23000	3090	3070
TDS (180°C)	(mg/L)	16800	14400	2010	2030
TDS (Calc)	(mg/L)	20000	15400	1980	2000
Total Acidity as CaCO3	(mg/L)	<5	<5	<5	<5
Total Alk. as CaCO3	(mg/L)	938	775	1070	1020
Total Hardness as CaCO3	(mg/L)	4150	3300	238	239
Sodium Adsorption Ratio		42.6	35.2	20.0	21.0
Ammonia Nitrogen as N	(mg/L)	4.9	<0.1	1.9	1.6
Boron	(mg/L)	2.15	1.72	1.48	1.35
Nitrate as NO3	(mg/L)	0.27	35.70	<0.05	<0.05
Total Phosphorus	(mg/L)	0.6	0.3	<0.1	<0.1
ANIONS					
Bicarb as HCO3	(mg/L)	1140	946	1270	1200
Bicarbonate	(meq/L)	18.75	15.50	20.85	19.65
Carb as CO3	(mg/L)	<5	<5	17	24
Carbonate	(meq/L)	<0.01	<0.01	0.56	0.80
Hydroxide as OH	(mg/L)	<5	<5	<5	<5
Hydroxide	(meq/L)	<0.01	<0.01	<0.01	<0.01
Chloride	(mg/L)	[D]7480	[D]5350	[D]18	[D]16
Chloride	(meq/L)	211.05	150.98	0.50	0.44
Fluoride	(mg/L)	0.8	0.8	0.8	0.7
Fluoride	(meq/L)	0.04	0.03	0.04	0.03
Nitrate + Nitrite as N	(mg/L)	0.1	8.1	<0.05	<0.05
Nitrate + Nitrite as N	(meq/L)	<0.01	0.57	<0.01	<0.01
Sulfate	(mg/L)	[D]4370	[D]3890	[D]532	[D]543
Sulfate	(meq/L)	90.94	80.89	11.08	11.29
CATIONS					
Calcium	(mg/L)	531	433	32	31
Calcium	(meq/L)	26.47	21.60	1.60	1.52
Magnesium	(mg/L)	686	540	38	40
Magnesium	(meq/L)	56.50	44.47	3.15	3.25
Potassium	(mg/L)	25	21	7	8
Potassium	(meq/L)	0.63	0.53	0.18	0.20
Sodium	(mg/L)	6310	4660	711	746
Sodium	(meq/L)	274.61	202.52	30.92	32.44
BALANCE					
Lab Determined Cations	(meq/L)	358.57	269.14	36.00	37.54
Lab Determined Anions	(meq/L)	320.79	248.00	33.05	32.24
Lab Determined Ion Difference	(meq/L)	37.78	21.14	2.95	5.30
TRACE METALS (Dissolved)					
Aluminum	(mg/L)	0.1	<0.1	<0.1	<0.1
Arsenic	(mg/L)	<0.005	<0.005	<0.005	<0.005
Barium	(mg/L)	<0.5	<0.5	<0.5	<0.5
Cadmium	(mg/L)	<0.002	<0.002	<0.002	<0.002
Chromium	(mg/L)	0.01	<0.01	<0.01	<0.01
Copper	(mg/L)	<0.01	<0.01	<0.01	<0.01
Iron	(mg/L)	<0.05	<0.05	<0.05	<0.05
Lead	(mg/L)	<0.02	<0.02	<0.02	<0.02
Manganese	(mg/L)	3.71	<0.02	0.03	0.03
Mercury	(mg/L)	<0.001	<0.001	<0.001	<0.001
Molybdenum	(mg/L)	<0.02	<0.02	<0.02	<0.02
Nickel	(mg/L)	0.06	<0.01	<0.01	<0.01
Selenium	(mg/L)	<0.005	<0.005	<0.005	<0.005
Zinc	(mg/L)	<0.01	<0.01	<0.01	<0.01
TRACE METALS (Total)					
Total Iron	(mg/L)	1.40	0.79	0.32	0.18

**Wells 21 and RP-5B are obstructed and samples were unobtainable.*

[D]Report limit raised due to dilution.

TABLE 6. GROUNDWATER QUALITY REPORT

Station Name:		506086	506086	502586	502586
Station Number:		76	76	81	81
Aquifer:		FU	FU	FU	FU
Sample Date:		6/5/2024	9/16/2024	6/5/2024	9/17/2024
Sample Time:		1740	1009	0850	0824
Sampler:		TS/WWC	RM	TS/WWC	RM
Laboratory Code:		Pace	Pace	Pace	Pace
Laboratory Number:		S2406138-031	S2409324-003	S2406138-020	S2409324-007
Lab Received Date:		6/7/2024	9/18/2024	6/7/2024	9/18/2024
Lab Received Time:		1107	1027	1107	1027
FIELD MEASUREMENTS					
Field pH	(S.U.)	7.2	7.2	7.4	7.6
Field Conductivity	(umhos/cm)	1569	1530	3336	3460
Field Temperature	(°C)	15.1	9.6	12.2	8.8
LABORATORY MEASUREMENTS					
Lab pH	(S.U.)	7.9	7.9	8.1	8.3
Lab Conductivity	(umhos/cm)	1640	1620	3500	3520
TDS (180°C)	(mg/L)	1100	1100	2440	2420
TDS (Calc)	(mg/L)	1070	1060	2420	2340
Total Acidity as CaCO3	(mg/L)	<5	<5	<5	<5
Total Alk. as CaCO3	(mg/L)	373	350	634	593
Total Hardness as CaCO3	(mg/L)	568	542	405	368
Sodium Adsorption Ratio		3.3	3.5	16.3	17.1
Ammonia Nitrogen as N	(mg/L)	2.0	1.6	1.4	0.9
Boron	(mg/L)	0.55	0.49	0.35	0.30
Nitrate as NO3	(mg/L)	<0.05	<0.05	<0.05	<0.05
Total Phosphorus	(mg/L)	<0.1	<0.1	<0.1	<0.1
ANIONS					
Bicarb as HCO3	(mg/L)	455	428	773	723
Bicarbonate	(meq/L)	7.45	7.00	12.67	11.85
Carb as CO3	(mg/L)	<5	<5	<5	<5
Carbonate	(meq/L)	<0.01	<0.01	<0.01	<0.01
Hydroxide as OH	(mg/L)	<5	<5	<5	<5
Hydroxide	(meq/L)	<0.01	<0.01	<0.01	<0.01
Chloride	(mg/L)	[D]13	13	[D]29.4	[D]29
Chloride	(meq/L)	0.35	0.35	0.82	0.81
Fluoride	(mg/L)	0.3	0.3	0.8	0.8
Fluoride	(meq/L)	0.01	0.01	0.04	0.04
Nitrate + Nitrite as N	(mg/L)	<0.05	<0.05	<0.05	<0.05
Nitrate + Nitrite as N	(meq/L)	<0.01	<0.01	<0.01	<0.01
Sulfate	(mg/L)	[D]453	[D]469	[D]1110	[D]1070
Sulfate	(meq/L)	9.42	9.75	23.21	22.32
CATIONS					
Calcium	(mg/L)	115	106	81	71
Calcium	(meq/L)	5.72	5.27	4.03	3.51
Magnesium	(mg/L)	69	68	49	47
Magnesium	(meq/L)	5.63	5.57	4.05	3.84
Potassium	(mg/L)	11	11	8	7
Potassium	(meq/L)	0.28	0.26	0.19	0.19
Sodium	(mg/L)	183	185	755	757
Sodium	(meq/L)	7.96	8.06	32.83	32.91
BALANCE					
Lab Determined Cations	(meq/L)	19.75	19.29	41.22	40.54
Lab Determined Anions	(meq/L)	17.25	17.13	36.75	35.04
Lab Determined Ion Difference	(meq/L)	2.49	2.15	4.46	5.49
TRACE METALS (Dissolved)					
Aluminum	(mg/L)	<0.1	<0.1	<0.1	<0.1
Arsenic	(mg/L)	<0.005	<0.005	<0.005	<0.005
Barium	(mg/L)	<0.5	<0.5	<0.5	<0.5
Cadmium	(mg/L)	<0.002	<0.002	<0.002	<0.002
Chromium	(mg/L)	<0.01	<0.01	<0.01	<0.01
Copper	(mg/L)	<0.01	<0.01	<0.01	<0.01
Iron	(mg/L)	<0.05	0.06	<0.05	<0.05
Lead	(mg/L)	<0.02	<0.02	<0.02	<0.02
Manganese	(mg/L)	0.40	0.39	0.06	0.05
Mercury	(mg/L)	<0.001	<0.001	<0.001	<0.001
Molybdenum	(mg/L)	<0.02	<0.02	<0.02	<0.02
Nickel	(mg/L)	<0.01	<0.01	<0.01	<0.01
Selenium	(mg/L)	<0.005	<0.005	<0.005	<0.005
Zinc	(mg/L)	<0.01	<0.01	<0.01	<0.01
TRACE METALS (Total)					
Total Iron	(mg/L)	0.23	0.15	0.73	2.24

**Wells 21 and RP-5B are obstructed and samples were unobtainable.*

[D]Report limit raised due to dilution.

TABLE 6. GROUNDWATER QUALITY REPORT

Station Name:		534990	566294	566294	566394
Station Number:		86	90	90	91
Aquifer:		FU	FUC	FUC	SP
Sample Date:		9/25/2024	6/5/2024	9/5/2024	6/5/2024
Sample Time:		1254	1515	0751	1225
Sampler:		RM	TS/WWC	RM	TS/WWC
Laboratory Code:		Pace	Pace	Pace	Pace
Laboratory Number:		S2409473-001	S2406138-028	S2409116-006	S2406138-024
Lab Received Date:		9/27/2024	6/7/2024	9/9/2024	6/7/2024
Lab Received Time:		1015	1107	0925	1107
FIELD MEASUREMENTS					
Field pH	(S.U.)	9.2	8.5	8.1	7.1
Field Conductivity	(umhos/cm)	20900	3090	3220	33559
Field Temperature	(°C)	11.8	16.0	8.8	16.1
LABORATORY MEASUREMENTS					
Lab pH	(S.U.)	8.2	8.7	8.8	7.9
Lab Conductivity	(umhos/cm)	18200	3190	3280	32500
TDS (180°C)	(mg/L)	10800	1910	1900	24900
TDS (Calc)	(mg/L)	11400	1930	1940	27500
Total Acidity as CaCO3	(mg/L)	<5	<5	<5	<5
Total Alk. as CaCO3	(mg/L)	2440	1470	1440	1830
Total Hardness as CaCO3	(mg/L)	96	14	14	2830
Sodium Adsorption Ratio		215.0	98.6	100.0	83.5
Ammonia Nitrogen as N	(mg/L)	7.3	1.0	0.8	3.5
Boron	(mg/L)	1.86	0.54	0.55	3.92
Nitrate as NO3	(mg/L)	<0.05	<0.05	<0.05	<0.05
Total Phosphorus	(mg/L)	<0.1	0.3	0.3	0.1
ANIONS					
Bicarb as HCO3	(mg/L)	2980	1670	1590	2230
Bicarbonate	(meq/L)	48.80	27.36	26.09	36.57
Carb as CO3	(mg/L)	<5	61	81	<5
Carbonate	(meq/L)	<0.01	2.01	2.71	<0.01
Hydroxide as OH	(mg/L)	<5	<5	<5	<5
Hydroxide	(meq/L)	<0.01	<0.01	<0.01	<0.01
Chloride	(mg/L)	[D]5000	[D]187	[D]198	[D]9780
Chloride	(meq/L)	141.18	5.28	5.57	275.96
Fluoride	(mg/L)	1.3	12.1	11.7	3.3
Fluoride	(meq/L)	0.07	0.63	0.61	0.17
Nitrate + Nitrite as N	(mg/L)	<0.05	<0.05	<0.05	<0.05
Nitrate + Nitrite as N	(meq/L)	<0.01	<0.01	<0.01	<0.01
Sulfate	(mg/L)	[D]<241	[D]15	[D]10	[D]5620
Sulfate	(meq/L)	<0.01	0.30	0.21	117.04
CATIONS					
Calcium	(mg/L)	17	2	2	254
Calcium	(meq/L)	0.82	0.12	0.12	12.68
Magnesium	(mg/L)	13	2	2	534
Magnesium	(meq/L)	1.09	0.15	0.15	43.98
Potassium	(mg/L)	18	4	5	25
Potassium	(meq/L)	0.45	0.11	0.11	0.63
Sodium	(mg/L)	4840	838	859	10200
Sodium	(meq/L)	210.51	36.45	37.36	444.62
BALANCE					
Lab Determined Cations	(meq/L)	213.41	36.91	37.82	502.18
Lab Determined Anions	(meq/L)	190.06	35.61	35.21	429.76
Lab Determined Ion Difference	(meq/L)	23.35	1.29	2.60	72.42
TRACE METALS (Dissolved)					
Aluminum	(mg/L)	<0.1	<0.1	<0.1	<0.1
Arsenic	(mg/L)	<0.005	<0.005	<0.005	<0.005
Barium	(mg/L)	3.9	<0.5	<0.5	<0.5
Cadmium	(mg/L)	<0.002	<0.002	<0.002	<0.002
Chromium	(mg/L)	<0.01	<0.01	<0.01	<0.01
Copper	(mg/L)	<0.01	<0.01	<0.01	<0.01
Iron	(mg/L)	0.07	<0.05	<0.05	<0.05
Lead	(mg/L)	<0.02	<0.02	<0.02	<0.02
Manganese	(mg/L)	<0.02	<0.02	<0.02	1.70
Mercury	(mg/L)	<0.001	<0.001	<0.001	<0.001
Molybdenum	(mg/L)	<0.02	<0.02	<0.02	<0.02
Nickel	(mg/L)	<0.01	<0.01	<0.01	<0.01
Selenium	(mg/L)	<0.005	<0.005	<0.005	<0.005
Zinc	(mg/L)	<0.01	<0.01	<0.01	<0.01
TRACE METALS (Total)					
Total Iron	(mg/L)	0.22	0.08	0.56	4.09

**Wells 21 and RP-5B are obstructed and samples were unobtainable.*

[D]Report limit raised due to dilution.

TABLE 6. GROUNDWATER QUALITY REPORT

Station Name:		566394	566594	566594	566994
Station Number:		91	93	93	97
Aquifer:		SP	QAL	QAL	QAL
Sample Date:		9/16/2024	6/5/2024	9/10/2024	6/5/2024
Sample Time:		0848	1840	0954	1045
Sampler:		RM	TS/WWC	RM	TS/WWC
Laboratory Code:		Pace	Pace	Pace	Pace
Laboratory Number:		S2409324-001	S2406138-032	S2409230-005	S2406138-022
Lab Received Date:		9/18/2024	6/7/2024	9/13/2024	6/7/2024
Lab Received Time:		1027	1107	1012	1107
FIELD MEASUREMENTS					
Field pH	(S.U.)	7.6	7.2	7.7	7.6
Field Conductivity	(umhos/cm)	16790	17351	17000	3499
Field Temperature	(°C)	8.9	15.8	8.8	14.5
LABORATORY MEASUREMENTS					
Lab pH	(S.U.)	8.1	8.0	8.2	8.2
Lab Conductivity	(umhos/cm)	18200	17100	17800	3650
TDS (180°C)	(mg/L)	9900	11600	11400	2430
TDS (Calc)	(mg/L)	11300	12100	12400	2350
Total Acidity as CaCO3	(mg/L)	<5	<5	<5	<5
Total Alk. as CaCO3	(mg/L)	1300	840	792	677
Total Hardness as CaCO3	(mg/L)	796	1490	1430	275
Sodium Adsorption Ratio		69.2	47.7	50.0	21.7
Ammonia Nitrogen as N	(mg/L)	2.7	3.4	0.8	0.2
Boron	(mg/L)	1.31	0.91	0.92	0.93
Nitrate as NO3	(mg/L)	<0.05	<0.05	7.96	<0.05
Total Phosphorus	(mg/L)	0.3	0.2	<0.1	<0.1
ANIONS					
Bicarb as HCO3	(mg/L)	1590	1020	967	826
Bicarbonate	(meq/L)	26.04	16.79	15.84	13.54
Carb as CO3	(mg/L)	<5	<5	<5	<5
Carbonate	(meq/L)	<0.01	<0.01	<0.01	<0.01
Hydroxide as OH	(mg/L)	<5	<5	<5	<5
Hydroxide	(meq/L)	<0.01	<0.01	<0.01	<0.01
Chloride	(mg/L)	[D]4820	[D]4200	[D]4310	[D]169
Chloride	(meq/L)	136.07	118.60	121.66	4.75
Fluoride	(mg/L)	4.7	2.4	2.4	1.5
Fluoride	(meq/L)	0.24	0.12	0.12	0.07
Nitrate + Nitrite as N	(mg/L)	<0.05	<0.05	1.8	<0.05
Nitrate + Nitrite as N	(meq/L)	<0.01	<0.01	0.12	<0.01
Sulfate	(mg/L)	[D]950	[D]2720	[D]2850	[D]866
Sulfate	(meq/L)	19.77	56.71	59.27	18.03
CATIONS					
Calcium	(mg/L)	95	193	166	42
Calcium	(meq/L)	4.72	9.63	8.26	2.11
Magnesium	(mg/L)	136	244	247	41
Magnesium	(meq/L)	11.18	20.11	20.36	3.39
Potassium	(mg/L)	17	15	15	2
Potassium	(meq/L)	0.43	0.38	0.38	0.04
Sodium	(mg/L)	4490	4230	4350	828
Sodium	(meq/L)	195.22	184.04	189.29	35.99
BALANCE					
Lab Determined Cations	(meq/L)	211.76	214.41	218.35	41.55
Lab Determined Anions	(meq/L)	182.13	192.24	197.04	36.41
Lab Determined Ion Difference	(meq/L)	29.62	22.17	21.31	5.14
TRACE METALS (Dissolved)					
Aluminum	(mg/L)	<0.1	<0.1	<0.1	<0.1
Arsenic	(mg/L)	0.005	<0.005	<0.005	<0.005
Barium	(mg/L)	<0.5	<0.5	<0.5	<0.5
Cadmium	(mg/L)	<0.002	<0.002	<0.002	<0.002
Chromium	(mg/L)	<0.01	<0.01	<0.01	<0.01
Copper	(mg/L)	<0.01	<0.01	<0.01	<0.01
Iron	(mg/L)	0.19	<0.05	0.07	<0.05
Lead	(mg/L)	<0.02	<0.02	<0.02	<0.02
Manganese	(mg/L)	1.14	0.96	0.33	0.29
Mercury	(mg/L)	<0.001	<0.001	<0.001	<0.001
Molybdenum	(mg/L)	0.04	<0.02	<0.02	0.03
Nickel	(mg/L)	<0.01	<0.01	<0.01	<0.01
Selenium	(mg/L)	<0.005	<0.005	<0.005	<0.005
Zinc	(mg/L)	<0.01	<0.01	<0.01	<0.01
TRACE METALS (Total)					
Total Iron	(mg/L)	9.96	1.96	3.42	0.80

**Wells 21 and RP-5B are obstructed and samples were unobtainable.*

[D]Report limit raised due to dilution.

TABLE 6. GROUNDWATER QUALITY REPORT

Station Name:		566994	567194	567194	567494
Station Number:		97	99	99	102
Aquifer:		QAL	QAL	QAL	QAL
Sample Date:		9/23/2024	6/4/2024	9/5/2024	6/4/2024
Sample Time:		1238	1120	0917	1000
Sampler:		RM	TS/WWC	RM	TS/WWC
Laboratory Code:		Pace	Pace	Pace	Pace
Laboratory Number:		S2409421-006	S2406138-007	S2409116-007	S2406138-005
Lab Received Date:		9/25/2024	6/7/2024	9/9/2024	6/7/2024
Lab Received Time:		0958	1107	0925	1107
FIELD MEASUREMENTS					
Field pH	(S.U.)	7.3	7.2	7.5	6.9
Field Conductivity	(umhos/cm)	1800	16973	17970	18897
Field Temperature	(°C)	9.2	12.4	8.5	10.4
LABORATORY MEASUREMENTS					
Lab pH	(S.U.)	8.3	7.8	8.1	7.5
Lab Conductivity	(umhos/cm)	2020	17400	19500	21400
TDS (180°C)	(mg/L)	1280	13200	12500	20000
TDS (Calc)	(mg/L)	1300	14500	13700	19700
Total Acidity as CaCO3	(mg/L)	<5	<5	<5	<5
Total Alk. as CaCO3	(mg/L)	548	997	953	893
Total Hardness as CaCO3	(mg/L)	314	2400	2330	7160
Sodium Adsorption Ratio		10.2	42.3	41.9	25.8
Ammonia Nitrogen as N	(mg/L)	<0.1	4.5	3.7	5.8
Boron	(mg/L)	0.37	1.95	1.81	2.34
Nitrate as NO3	(mg/L)	<0.05	<0.05	<0.05	<0.05
Total Phosphorus	(mg/L)	0.1	0.1	0.4	0.9
ANIONS					
Bicarb as HCO3	(mg/L)	655	1220	1160	1090
Bicarbonate	(meq/L)	10.74	19.94	19.05	17.85
Carb as CO3	(mg/L)	7	<5	<5	<5
Carbonate	(meq/L)	0.22	<0.01	<0.01	<0.01
Hydroxide as OH	(mg/L)	<5	<5	<5	<5
Hydroxide	(meq/L)	<0.01	<0.01	<0.01	<0.01
Chloride	(mg/L)	[D]34	[D]4120	[D]3910	[D]3530
Chloride	(meq/L)	0.97	116.15	110.18	99.48
Fluoride	(mg/L)	0.8	1.2	1.2	1.2
Fluoride	(meq/L)	0.04	0.06	0.06	0.06
Nitrate + Nitrite as N	(mg/L)	<0.05	<0.05	<0.05	<0.05
Nitrate + Nitrite as N	(meq/L)	<0.01	<0.01	<0.01	<0.01
Sulfate	(mg/L)	[D]417	[D]4330	[D]3920	[D]8630
Sulfate	(meq/L)	8.67	90.07	81.57	179.65
CATIONS					
Calcium	(mg/L)	59	320	298	609
Calcium	(meq/L)	2.96	15.97	14.86	30.40
Magnesium	(mg/L)	40	388	386	1370
Magnesium	(meq/L)	3.31	31.94	31.74	112.78
Potassium	(mg/L)	2	17	16	33
Potassium	(meq/L)	0.04	0.42	0.40	0.83
Sodium	(mg/L)	415	4760	4650	5020
Sodium	(meq/L)	18.03	206.86	202.19	218.15
BALANCE					
Lab Determined Cations	(meq/L)	24.35	255.53	249.46	362.60
Lab Determined Anions	(meq/L)	20.65	226.23	210.88	297.05
Lab Determined Ion Difference	(meq/L)	3.70	29.29	38.58	65.55
TRACE METALS (Dissolved)					
Aluminum	(mg/L)	<0.1	<0.1	<0.1	0.1
Arsenic	(mg/L)	<0.005	<0.005	<0.005	<0.005
Barium	(mg/L)	<0.5	<0.5	<0.5	<0.5
Cadmium	(mg/L)	<0.002	<0.002	<0.002	<0.002
Chromium	(mg/L)	<0.01	<0.01	<0.01	0.02
Copper	(mg/L)	<0.01	<0.01	0.01	0.06
Iron	(mg/L)	<0.05	<0.05	<0.05	<0.05
Lead	(mg/L)	<0.02	<0.02	<0.02	<0.02
Manganese	(mg/L)	0.02	1.14	0.97	0.80
Mercury	(mg/L)	<0.001	<0.001	<0.001	<0.001
Molybdenum	(mg/L)	<0.02	<0.02	<0.02	<0.02
Nickel	(mg/L)	<0.01	0.01	<0.01	0.04
Selenium	(mg/L)	<0.005	<0.005	0.007	<0.005
Zinc	(mg/L)	<0.01	<0.01	<0.01	<0.01
TRACE METALS (Total)					
Total Iron	(mg/L)	2.30	16.1	55.8	53.1

**Wells 21 and RP-5B are obstructed and samples were unobtainable.*

[D]Report limit raised due to dilution.

TABLE 6. GROUNDWATER QUALITY REPORT

Station Name:		567494	567694	567694	567794
Station Number:		102	104	104	105
Aquifer:		QAL	QAL	QAL	QAL
Sample Date:		9/23/2024	6/5/2024	9/10/2024	6/4/2024
Sample Time:		1056	0950	0735	1205
Sampler:		RM	TS/WWC	RM	TS/WWC
Laboratory Code:		Pace	Pace	Pace	Pace
Laboratory Number:		S2409421-004	S2406138-021	S2409230-001	S2406138-008
Lab Received Date:		9/25/2024	6/7/2024	9/13/2024	6/7/2024
Lab Received Time:		0958	1107	1012	1107
FIELD MEASUREMENTS					
Field pH	(S.U.)	7.1	7.2	7.5	7.3
Field Conductivity	(umhos/cm)	19820	11062	10390	7323
Field Temperature	(°C)	9.0	15.1	8.3	12.6
LABORATORY MEASUREMENTS					
Lab pH	(S.U.)	7.9	8.0	8.0	7.9
Lab Conductivity	(umhos/cm)	22600	11600	12100	7580
TDS (180°C)	(mg/L)	19200	10300	10400	7010
TDS (Calc)	(mg/L)	18500	9770	10200	6100
Total Acidity as CaCO3	(mg/L)	<5	<5	<5	<5
Total Alk. as CaCO3	(mg/L)	839	685	646	750
Total Hardness as CaCO3	(mg/L)	6210	3410	3280	2510
Sodium Adsorption Ratio		25.0	17.2	18.0	11.1
Ammonia Nitrogen as N	(mg/L)	5.2	0.4	0.2	2.1
Boron	(mg/L)	1.73	1.22	1.08	1.42
Nitrate as NO3	(mg/L)	<0.05	<0.05	<0.05	<0.05
Total Phosphorus	(mg/L)	0.4	0.1	<0.1	0.1
ANIONS					
Bicarb as HCO3	(mg/L)	1020	835	788	915
Bicarbonate	(meq/L)	16.77	13.69	12.91	15.00
Carb as CO3	(mg/L)	<5	<5	<5	<5
Carbonate	(meq/L)	<0.01	<0.01	<0.01	<0.01
Hydroxide as OH	(mg/L)	<5	<5	<5	<5
Hydroxide	(meq/L)	<0.01	<0.01	<0.01	<0.01
Chloride	(mg/L)	[D]3420	[D]1090	[D]1230	[D]498
Chloride	(meq/L)	96.53	30.86	34.63	14.04
Fluoride	(mg/L)	1.3	1.2	1.2	0.9
Fluoride	(meq/L)	0.06	0.06	0.06	0.04
Nitrate + Nitrite as N	(mg/L)	<0.05	<0.05	<0.05	<0.05
Nitrate + Nitrite as N	(meq/L)	<0.01	<0.01	<0.01	<0.01
Sulfate	(mg/L)	[D]8260	[D]4920	[D]5230	[D]3140
Sulfate	(meq/L)	171.91	102.47	108.97	65.31
CATIONS					
Calcium	(mg/L)	505	480	421	304
Calcium	(meq/L)	25.17	23.92	21.02	15.16
Magnesium	(mg/L)	1200	538	542	425
Magnesium	(meq/L)	99.03	44.30	44.64	34.98
Potassium	(mg/L)	30	5	6	8
Potassium	(meq/L)	0.76	0.13	0.15	0.21
Sodium	(mg/L)	4530	2320	2370	1280
Sodium	(meq/L)	197.09	100.75	103.09	55.56
BALANCE					
Lab Determined Cations	(meq/L)	322.44	169.14	168.93	106.07
Lab Determined Anions	(meq/L)	285.29	147.09	156.58	94.41
Lab Determined Ion Difference	(meq/L)	37.15	22.04	12.34	11.66
TRACE METALS (Dissolved)					
Aluminum	(mg/L)	<0.1	<0.1	<0.1	<0.1
Arsenic	(mg/L)	<0.005	<0.005	<0.005	<0.005
Barium	(mg/L)	<0.5	<0.5	<0.5	<0.5
Cadmium	(mg/L)	<0.002	<0.002	<0.002	<0.002
Chromium	(mg/L)	<0.01	<0.01	<0.01	<0.01
Copper	(mg/L)	<0.01	0.02	<0.01	<0.01
Iron	(mg/L)	5.7	<0.05	<0.05	<0.05
Lead	(mg/L)	<0.02	<0.02	<0.02	<0.02
Manganese	(mg/L)	0.65	3.96	3.80	0.80
Mercury	(mg/L)	<0.001	<0.001	<0.001	<0.001
Molybdenum	(mg/L)	<0.02	<0.02	<0.02	<0.02
Nickel	(mg/L)	<0.01	0.01	<0.01	0.01
Selenium	(mg/L)	<0.005	<0.005	<0.005	<0.005
Zinc	(mg/L)	<0.01	<0.01	<0.01	<0.01
TRACE METALS (Total)					
Total Iron	(mg/L)	44.2	0.81	0.94	8.5

**Wells 21 and RP-5B are obstructed and samples were unobtainable.*

[D]Report limit raised due to dilution.

TABLE 6. GROUNDWATER QUALITY REPORT

Station Name:		567794	567994	567994	568094
Station Number:		105	107	107	108
Aquifer:		QAL	QAL	QAL	FUBC
Sample Date:		9/10/2024	6/4/2024	9/5/2024	9/16/2024
Sample Time:		0810	1040	0949	1210
Sampler:		RM	TS/WWC	RM	RM
Laboratory Code:		Pace	Pace	Pace	Pace
Laboratory Number:		S2409230-002	S2406138-006	S2409116-008	S2409324-005
Lab Received Date:		9/13/2024	6/7/2024	9/9/2024	9/18/2024
Lab Received Time:		1012	1107	0925	1027
FIELD MEASUREMENTS					
Field pH	(S.U.)	7.7	7.1	7.4	8.2
Field Conductivity	(umhos/cm)	5460	21938	22800	3060
Field Temperature	(°C)	7.3	11.6	8.5	9.7
LABORATORY MEASUREMENTS					
Lab pH	(S.U.)	8.0	7.6	7.9	8.6
Lab Conductivity	(umhos/cm)	5560	23300	24800	3070
TDS (180°C)	(mg/L)	4550	16300	15800	1740
TDS (Calc)	(mg/L)	4030	17300	17600	1810
Total Acidity as CaCO3	(mg/L)	<5	<5	<5	<5
Total Alk. as CaCO3	(mg/L)	791	960	920	1070
Total Hardness as CaCO3	(mg/L)	1570	3260	2940	17
Sodium Adsorption Ratio		9.2	43.2	50.9	83.5
Ammonia Nitrogen as N	(mg/L)	0.4	5.9	4.9	0.4
Boron	(mg/L)	1.31	1.95	1.87	0.66
Nitrate as NO3	(mg/L)	<0.05	<0.05	0.22	<0.05
Total Phosphorus	(mg/L)	0.3	0.2	0.4	0.1
ANIONS					
Bicarb as HCO3	(mg/L)	965	1170	1120	1230
Bicarbonate	(meq/L)	15.82	19.19	18.39	20.22
Carb as CO3	(mg/L)	<5	<5	<5	35
Carbonate	(meq/L)	<0.01	<0.01	<0.01	1.17
Hydroxide as OH	(mg/L)	<5	<5	<5	<5
Hydroxide	(meq/L)	<0.01	<0.01	<0.01	<0.01
Chloride	(mg/L)	[D]147	[D]6850	[D]6690	[D]358
Chloride	(meq/L)	4.13	193.12	188.65	10.08
Fluoride	(mg/L)	0.6	1.0	1.0	3.8
Fluoride	(meq/L)	0.03	0.05	0.05	0.20
Nitrate + Nitrite as N	(mg/L)	<0.05	<0.05	0.1	<0.05
Nitrate + Nitrite as N	(meq/L)	<0.01	<0.01	<0.01	<0.01
Sulfate	(mg/L)	[D]2090	[D]3200	[D]3090	[D]<12.3
Sulfate	(meq/L)	43.56	66.55	64.27	<0.01
CATIONS					
Calcium	(mg/L)	226	428	401	4
Calcium	(meq/L)	11.28	21.36	20.00	0.17
Magnesium	(mg/L)	243	532	471	2
Magnesium	(meq/L)	20.03	43.81	38.77	0.16
Potassium	(mg/L)	5	19	22	4
Potassium	(meq/L)	0.13	0.49	0.57	0.09
Sodium	(mg/L)	839	5680	6350	800
Sodium	(meq/L)	36.51	246.85	276.00	34.79
BALANCE					
Lab Determined Cations	(meq/L)	67.99	312.94	335.69	35.26
Lab Determined Anions	(meq/L)	63.56	278.92	271.37	31.69
Lab Determined Ion Difference	(meq/L)	4.43	34.02	64.32	3.56
TRACE METALS (Dissolved)					
Aluminum	(mg/L)	<0.1	<0.1	<0.1	<0.1
Arsenic	(mg/L)	<0.005	<0.005	<0.005	<0.005
Barium	(mg/L)	<0.5	<0.5	<0.5	<0.5
Cadmium	(mg/L)	<0.002	<0.002	<0.002	<0.002
Chromium	(mg/L)	<0.01	0.01	<0.01	<0.01
Copper	(mg/L)	<0.01	<0.01	<0.01	<0.01
Iron	(mg/L)	<0.05	<0.05	<0.05	<0.05
Lead	(mg/L)	<0.02	<0.02	<0.02	<0.02
Manganese	(mg/L)	0.57	0.60	0.51	<0.02
Mercury	(mg/L)	<0.001	<0.001	<0.001	<0.001
Molybdenum	(mg/L)	<0.02	<0.02	<0.02	<0.02
Nickel	(mg/L)	<0.01	0.01	<0.01	<0.01
Selenium	(mg/L)	<0.005	<0.005	0.007	<0.005
Zinc	(mg/L)	<0.01	<0.01	<0.01	<0.01
TRACE METALS (Total)					
Total Iron	(mg/L)	12.90	19.1	35.9	0.47

**Wells 21 and RP-5B are obstructed and samples were unobtainable.*

[D]Report limit raised due to dilution.

TABLE 6. GROUNDWATER QUALITY REPORT

Station Name:		568298	11105	11105	P10MW1 CZ
Station Number:		110	111	111	P10MW1 CZ
Aquifer:		SP	AL	AL	FU
Sample Date:		9/17/2024	6/4/2024	9/10/2024	6/4/2024
Sample Time:		0740	1335	0855	0745
Sampler:		RM	TS/WWC	RM	TS/WWC
Laboratory Code:		Pace	Pace	Pace	Pace
Laboratory Number:		S2409324-006	S2406138-010	S2409230-003	S2406138-002
Lab Received Date:		9/18/2024	6/7/2024	9/13/2024	6/7/2024
Lab Received Time:		1027	1107	1012	1107
FIELD MEASUREMENTS					
Field pH	(S.U.)	7.1	8.8	9.0	8.2
Field Conductivity	(umhos/cm)	7280	2119	1946	2201
Field Temperature	(°C)	10.6	14.1	9.3	10.6
LABORATORY MEASUREMENTS					
Lab pH	(S.U.)	7.9	8.6	8.8	8.4
Lab Conductivity	(umhos/cm)	8090	2180	2150	2370
TDS (180°C)	(mg/L)	6600	1340	1310	1360
TDS (Calc)	(mg/L)	5970	1360	1320	1390
Total Acidity as CaCO3	(mg/L)	<5	<5	<5	<5
Total Alk. as CaCO3	(mg/L)	1070	1100	1070	742
Total Hardness as CaCO3	(mg/L)	2170	57	47	21
Sodium Adsorption Ratio		11.5	33.7	35.1	57.7
Ammonia Nitrogen as N	(mg/L)	1.3	2.3	1.6	0.7
Boron	(mg/L)	0.85	0.66	0.57	0.44
Nitrate as NO3	(mg/L)	14.80	<0.05	<0.05	<0.05
Total Phosphorus	(mg/L)	<0.1	0.1	0.1	0.3
ANIONS					
Bicarb as HCO3	(mg/L)	1310	1260	1180	884
Bicarbonate	(meq/L)	21.42	20.63	19.26	14.48
Carb as CO3	(mg/L)	<5	43	62	11
Carbonate	(meq/L)	<0.01	1.43	2.06	0.35
Hydroxide as OH	(mg/L)	<5	<5	<5	<5
Hydroxide	(meq/L)	<0.01	<0.01	<0.01	<0.01
Chloride	(mg/L)	[D]528	[D]51	[D]44	[D]306
Chloride	(meq/L)	14.90	1.42	1.23	8.62
Fluoride	(mg/L)	0.2	2.6	2.8	2.4
Fluoride	(meq/L)	0.01	0.13	0.14	0.12
Nitrate + Nitrite as N	(mg/L)	3.3	<0.05	<0.05	<0.05
Nitrate + Nitrite as N	(meq/L)	0.23	<0.01	<0.01	<0.01
Sulfate	(mg/L)	[D]2870	[D]30	[D]51	[D]21
Sulfate	(meq/L)	59.73	0.63	1.05	0.42
CATIONS					
Calcium	(mg/L)	298	7	6	5
Calcium	(meq/L)	14.88	0.36	0.29	0.24
Magnesium	(mg/L)	346	9	8	2
Magnesium	(meq/L)	28.49	0.76	0.65	0.17
Potassium	(mg/L)	34	18	17	4
Potassium	(meq/L)	0.86	0.45	0.43	0.09
Sodium	(mg/L)	1230	582	554	612
Sodium	(meq/L)	53.70	25.33	24.11	26.62
BALANCE					
Lab Determined Cations	(meq/L)	98.04	27.08	25.61	27.19
Lab Determined Anions	(meq/L)	96.31	24.25	23.76	24.02
Lab Determined Ion Difference	(meq/L)	1.72	2.82	1.84	3.17
TRACE METALS (Dissolved)					
Aluminum	(mg/L)	<0.1	0.10	<0.1	0.20
Arsenic	(mg/L)	<0.005	<0.005	<0.005	<0.005
Barium	(mg/L)	<0.5	<0.5	<0.5	<0.5
Cadmium	(mg/L)	<0.002	<0.002	<0.002	<0.002
Chromium	(mg/L)	<0.01	<0.01	<0.01	<0.01
Copper	(mg/L)	<0.01	<0.01	<0.01	<0.01
Iron	(mg/L)	<0.05	0.07	<0.05	0.06
Lead	(mg/L)	<0.02	<0.02	<0.02	<0.02
Manganese	(mg/L)	0.16	<0.02	<0.02	0.03
Mercury	(mg/L)	<0.001	<0.001	<0.001	<0.001
Molybdenum	(mg/L)	<0.02	<0.02	<0.02	<0.02
Nickel	(mg/L)	0.03	<0.01	<0.01	<0.01
Selenium	(mg/L)	<0.005	<0.005	<0.005	<0.005
Zinc	(mg/L)	0.01	<0.01	<0.01	<0.01
TRACE METALS (Total)					
Total Iron	(mg/L)	0.33	0.63	0.26	1.33

**Wells 21 and RP-5B are obstructed and samples were unobtainable.*

[D]Report limit raised due to dilution.

TABLE 6. GROUNDWATER QUALITY REPORT

Station Name:		P10MW1 CZ	P10MW1 OB	P10MW1 OB	P10MW1 UB
Station Number:		P10MW1 CZ	P10MW1 OB	P10MW1 OB	P10MW1 UB
Aquifer:		FU	FU	FU	FU
Sample Date:		9/24/2024	6/4/2024	9/24/2024	6/4/2024
Sample Time:		0824	0730	0810	0810
Sampler:		RM	TS/WWC	RM	TS/WWC
Laboratory Code:		Pace	Pace	Pace	Pace
Laboratory Number:		S2409421-008	S2406138-001	S2409421-007	S2406138-003
Lab Received Date:		9/25/2024	6/7/2024	9/25/2024	6/7/2024
Lab Received Time:		0958	1107	0958	1107
FIELD MEASUREMENTS					
Field pH	(S.U.)	8.3	8.3	9.4	7.9
Field Conductivity	(umhos/cm)	2430	2280	2350	1469
Field Temperature	(°C)	9.5	9.2	8.4	10.3
LABORATORY MEASUREMENTS					
Lab pH	(S.U.)	8.7	8.4	8.6	8.3
Lab Conductivity	(umhos/cm)	2290	2530	2640	1510
TDS (180°C)	(mg/L)	1300	1700	1890	910
TDS (Calc)	(mg/L)	1350	1840	1780	940
Total Acidity as CaCO3	(mg/L)	<5	<5	<5	<5
Total Alk. as CaCO3	(mg/L)	734	537	531	652
Total Hardness as CaCO3	(mg/L)	17	47	42	7
Sodium Adsorption Ratio		62.1	43.3	46.0	69.0
Ammonia Nitrogen as N	(mg/L)	0.4	0.9	0.3	0.2
Boron	(mg/L)	0.39	0.49	0.44	0.28
Nitrate as NO3	(mg/L)	<0.05	<0.05	0.53	<0.05
Total Phosphorus	(mg/L)	0.4	<0.1	<0.1	0.2
ANIONS					
Bicarb as HCO3	(mg/L)	831	642	607	796
Bicarbonate	(meq/L)	13.62	10.51	9.94	13.04
Carb as CO3	(mg/L)	32	6	21	<5
Carbonate	(meq/L)	1.04	0.21	0.68	<0.01
Hydroxide as OH	(mg/L)	<5	<5	<5	<5
Hydroxide	(meq/L)	<0.01	<0.01	<0.01	<0.01
Chloride	(mg/L)	[D]276	[D]9	[D]9	[D]22
Chloride	(meq/L)	7.64	0.25	0.26	0.62
Fluoride	(mg/L)	2.7	1.2	1.2	3.3
Fluoride	(meq/L)	0.14	0.06	0.06	0.17
Nitrate + Nitrite as N	(mg/L)	<0.05	<0.05	0.1	<0.05
Nitrate + Nitrite as N	(meq/L)	<0.01	<0.01	<0.01	<0.01
Sulfate	(mg/L)	35	[D]801	[D]750	[D]102
Sulfate	(meq/L)	0.72	16.67	15.60	2.11
CATIONS					
Calcium	(mg/L)	4	11	9	3
Calcium	(meq/L)	0.18	0.52	0.42	0.13
Magnesium	(mg/L)	2	5	5	<1
Magnesium	(meq/L)	0.16	0.42	0.41	<0.01
Potassium	(mg/L)	4	5	6	2
Potassium	(meq/L)	0.10	0.12	0.14	0.06
Sodium	(mg/L)	595	685	683	418
Sodium	(meq/L)	25.88	29.81	29.72	18.16
BALANCE					
Lab Determined Cations	(meq/L)	26.36	30.95	30.72	18.37
Lab Determined Anions	(meq/L)	23.17	27.72	26.57	15.95
Lab Determined Ion Difference	(meq/L)	3.19	3.23	4.14	2.41
TRACE METALS (Dissolved)					
Aluminum	(mg/L)	0.10	<0.1	<0.1	<0.1
Arsenic	(mg/L)	<0.005	<0.005	<0.005	0.006
Barium	(mg/L)	<0.5	<0.5	<0.5	<0.5
Cadmium	(mg/L)	<0.002	<0.002	<0.002	<0.002
Chromium	(mg/L)	<0.01	<0.01	<0.01	<0.01
Copper	(mg/L)	<0.01	<0.01	<0.01	<0.01
Iron	(mg/L)	0.06	<0.05	<0.05	<0.05
Lead	(mg/L)	<0.02	<0.02	<0.02	<0.02
Manganese	(mg/L)	0.03	<0.02	<0.02	<0.02
Mercury	(mg/L)	<0.001	<0.001	<0.001	<0.001
Molybdenum	(mg/L)	<0.02	<0.02	<0.02	<0.02
Nickel	(mg/L)	<0.01	<0.01	<0.01	<0.01
Selenium	(mg/L)	<0.005	<0.005	<0.005	<0.005
Zinc	(mg/L)	<0.01	<0.01	<0.01	<0.01
TRACE METALS (Total)					
Total Iron	(mg/L)	5.34	<0.05	0.20	0.10

**Wells 21 and RP-5B are obstructed and samples were unobtainable.*

[D]Report limit raised due to dilution.

TABLE 6. GROUNDWATER QUALITY REPORT

Station Name:		P10MW1 UB	SW01-037C	SW01-037C	SW1-OB
Station Number:		P10MW1 UB	SW1-CZ	SW1-CZ	SW1-OB
Aquifer:		FU	AL	AL	AL
Sample Date:		9/24/2024	6/4/2024	9/10/2024	6/4/2024
Sample Time:		0836	1540	1101	1615
Sampler:		RM	TS/WWC	RM	TS/WWC
Laboratory Code:		Pace	Pace	Pace	Pace
Laboratory Number:		S2409421-009	S2406138-012	S2409230-006	S2406138-013
Lab Received Date:		9/25/2024	6/7/2024	9/13/2024	6/7/2024
Lab Received Time:		0958	1107	1012	1107
FIELD MEASUREMENTS					
Field pH	(S.U.)	8.1	7.3	7.4	7.1
Field Conductivity	(umhos/cm)	1418	1378	1331	1459
Field Temperature	(°C)	8.8	14.4	9.2	14.6
LABORATORY MEASUREMENTS					
Lab pH	(S.U.)	8.6	7.9	8.2	7.9
Lab Conductivity	(umhos/cm)	1490	1420	1410	1520
TDS (180°C)	(mg/L)	900	800	770	900
TDS (Calc)	(mg/L)	930	830	810	920
Total Acidity as CaCO3	(mg/L)	<5	<5	<5	<5
Total Alk. as CaCO3	(mg/L)	645	812	803	713
Total Hardness as CaCO3	(mg/L)	6	605	550	702
Sodium Adsorption Ratio		73.6	1.9	2.0	1.7
Ammonia Nitrogen as N	(mg/L)	<0.1	2.5	2.0	2.3
Boron	(mg/L)	0.24	1.03	0.89	0.88
Nitrate as NO3	(mg/L)	<0.05	<0.05	<0.05	<0.05
Total Phosphorus	(mg/L)	0.2	<0.1	<0.1	<0.1
ANIONS					
Bicarb as HCO3	(mg/L)	732	990	979	870
Bicarbonate	(meq/L)	11.99	16.23	16.05	14.26
Carb as CO3	(mg/L)	27	<5	<5	<5
Carbonate	(meq/L)	0.90	<0.01	<0.01	<0.01
Hydroxide as OH	(mg/L)	<5	<5	<5	<5
Hydroxide	(meq/L)	<0.01	<0.01	<0.01	<0.01
Chloride	(mg/L)	22	14	13	16
Chloride	(meq/L)	0.61	0.38	0.35	0.44
Fluoride	(mg/L)	3.6	0.2	0.2	0.6
Fluoride	(meq/L)	0.18	<0.01	0.01	0.03
Nitrate + Nitrite as N	(mg/L)	<0.05	<0.05	<0.05	<0.05
Nitrate + Nitrite as N	(meq/L)	<0.01	<0.01	<0.01	<0.01
Sulfate	(mg/L)	[D]94	[D]13	[D]15.5	[D]142
Sulfate	(meq/L)	1.94	0.27	0.32	2.95
CATIONS					
Calcium	(mg/L)	2	65	57	91
Calcium	(meq/L)	0.12	3.26	2.82	4.53
Magnesium	(mg/L)	<1	107	99	116
Magnesium	(meq/L)	<0.01	8.83	8.16	9.50
Potassium	(mg/L)	3	35	34	26
Potassium	(meq/L)	0.06	0.90	0.87	0.65
Sodium	(mg/L)	419	110	106	105
Sodium	(meq/L)	18.23	4.77	4.59	4.58
BALANCE					
Lab Determined Cations	(meq/L)	18.42	17.95	16.61	19.44
Lab Determined Anions	(meq/L)	15.64	16.90	16.74	17.70
Lab Determined Ion Difference	(meq/L)	2.77	1.05	0.13	1.74
TRACE METALS (Dissolved)					
Aluminum	(mg/L)	<0.1	<0.1	<0.1	<0.1
Arsenic	(mg/L)	0.007	<0.005	<0.005	<0.005
Barium	(mg/L)	<0.5	1.5	1.4	<0.5
Cadmium	(mg/L)	<0.002	<0.002	<0.002	<0.002
Chromium	(mg/L)	<0.01	<0.01	<0.01	<0.01
Copper	(mg/L)	<0.01	<0.01	<0.01	<0.01
Iron	(mg/L)	<0.05	<0.05	<0.05	<0.05
Lead	(mg/L)	<0.02	<0.02	<0.02	<0.02
Manganese	(mg/L)	0.04	<0.02	<0.02	0.04
Mercury	(mg/L)	<0.001	<0.001	<0.001	<0.001
Molybdenum	(mg/L)	<0.02	<0.02	<0.02	<0.02
Nickel	(mg/L)	<0.01	<0.01	<0.01	<0.01
Selenium	(mg/L)	<0.005	<0.005	<0.005	<0.005
Zinc	(mg/L)	<0.01	<0.01	<0.01	<0.01
TRACE METALS (Total)					
Total Iron	(mg/L)	0.40	1.0	0.10	1.51

**Wells 21 and RP-5B are obstructed and samples were unobtainable.*

[D]Report limit raised due to dilution.

TABLE 6. GROUNDWATER QUALITY REPORT

Station Name:		SW1-OB	SW1-UB	SW1-UB	SW3-OB
Station Number:		SW1-OB	SW1-UB	SW1-UB	SW3-OB
Aquifer:		AL	AL	AL	AL
Sample Date:		9/10/2024	6/4/2024	9/10/2024	6/4/2024
Sample Time:		1118	1650	1136	1720
Sampler:		RM	TS/WWC	RM	TS/WWC
Laboratory Code:		Pace	Pace	Pace	Pace
Laboratory Number:		S2409230-007	S2406138-014	S2409230-008	S2406138-015
Lab Received Date:		9/13/2024	6/7/2024	9/13/2024	6/7/2024
Lab Received Time:		1012	1107	1012	1107
FIELD MEASUREMENTS					
Field pH	(S.U.)	7.5	8.2	8.0	7.6
Field Conductivity	(umhos/cm)	1358	2439	2370	2376
Field Temperature	(°C)	9.2	14.2	9.7	11.8
LABORATORY MEASUREMENTS					
Lab pH	(S.U.)	8.1	8.4	8.6	8.2
Lab Conductivity	(umhos/cm)	1440	2540	2590	2450
TDS (180°C)	(mg/L)	830	1590	1540	1560
TDS (Calc)	(mg/L)	830	1650	1620	1610
Total Acidity as CaCO3	(mg/L)	<5	<5	<5	<5
Total Alk. as CaCO3	(mg/L)	689	1410	1370	925
Total Hardness as CaCO3	(mg/L)	601	16	16	147
Sodium Adsorption Ratio		1.7	79.4	77.9	21.6
Ammonia Nitrogen as N	(mg/L)	<0.1	0.9	0.6	1.0
Boron	(mg/L)	0.77	0.81	0.73	0.84
Nitrate as NO3	(mg/L)	5.79	<0.05	<0.05	<0.05
Total Phosphorus	(mg/L)	<0.1	0.1	0.3	<0.1
ANIONS					
Bicarb as HCO3	(mg/L)	840	1660	1580	1130
Bicarbonate	(meq/L)	13.77	27.24	25.91	18.49
Carb as CO3	(mg/L)	<5	30	44	<5
Carbonate	(meq/L)	<0.01	0.98	1.45	<0.01
Hydroxide as OH	(mg/L)	<5	<5	<5	<5
Hydroxide	(meq/L)	<0.01	<0.01	<0.01	<0.01
Chloride	(mg/L)	17	[D]51.4	[D]47.8	[D]10.6
Chloride	(meq/L)	0.48	1.45	1.34	0.29
Fluoride	(mg/L)	0.7	3.9	4.4	0.2
Fluoride	(meq/L)	0.03	0.20	0.23	<0.01
Nitrate + Nitrite as N	(mg/L)	1.3	<0.05	<0.05	<0.05
Nitrate + Nitrite as N	(meq/L)	0.09	<0.01	<0.01	<0.01
Sulfate	(mg/L)	[D]92.3	[D]<6.27	[D]<12.3	[D]367
Sulfate	(meq/L)	1.92	<0.01	<0.01	7.63
CATIONS					
Calcium	(mg/L)	80	4	4	24
Calcium	(meq/L)	3.97	0.17	0.17	1.21
Magnesium	(mg/L)	98	2	2	21
Magnesium	(meq/L)	8.04	0.14	0.14	1.71
Potassium	(mg/L)	23	16	16	32
Potassium	(meq/L)	0.57	0.41	0.42	0.82
Sodium	(mg/L)	97	731	725	602
Sodium	(meq/L)	4.21	31.78	31.51	26.18
BALANCE					
Lab Determined Cations	(meq/L)	16.81	32.58	32.30	30.02
Lab Determined Anions	(meq/L)	16.30	29.88	28.94	26.43
Lab Determined Ion Difference	(meq/L)	0.50	2.70	3.36	3.58
TRACE METALS (Dissolved)					
Aluminum	(mg/L)	<0.1	<0.1	<0.1	<0.1
Arsenic	(mg/L)	<0.005	<0.005	<0.005	<0.005
Barium	(mg/L)	<0.5	<0.5	<0.5	<0.5
Cadmium	(mg/L)	<0.002	<0.002	<0.002	<0.002
Chromium	(mg/L)	<0.01	<0.01	<0.01	<0.01
Copper	(mg/L)	<0.01	<0.01	<0.01	<0.01
Iron	(mg/L)	<0.05	<0.05	<0.05	0.17
Lead	(mg/L)	<0.02	<0.02	<0.02	<0.02
Manganese	(mg/L)	<0.02	<0.02	<0.02	0.05
Mercury	(mg/L)	<0.001	<0.001	<0.001	<0.001
Molybdenum	(mg/L)	<0.02	<0.02	<0.02	<0.02
Nickel	(mg/L)	<0.01	<0.01	<0.01	<0.01
Selenium	(mg/L)	<0.005	<0.005	<0.005	<0.005
Zinc	(mg/L)	<0.01	<0.01	<0.01	<0.01
TRACE METALS (Total)					
Total Iron	(mg/L)	0.45	0.18	1.32	0.17

**Wells 21 and RP-5B are obstructed and samples were unobtainable.*

[D]Report limit raised due to dilution.

TABLE 6. GROUNDWATER QUALITY REPORT

Station Name:		SW3-OB
Station Number:		SW3-OB
Aquifer:		AL
Sample Date:		9/23/2024
Sample Time:		1146
Sampler:		RM
Laboratory Code:		Pace
Laboratory Number:		S2409421-005
Lab Received Date:		9/25/2024
Lab Received Time:		0958
FIELD MEASUREMENTS		
Field pH	(S.U.)	7.7
Field Conductivity	(umhos/cm)	2250
Field Temperature	(°C)	9.2
LABORATORY MEASUREMENTS		
Lab pH	(S.U.)	8.4
Lab Conductivity	(umhos/cm)	2530
TDS (180°C)	(mg/L)	1560
TDS (Calc)	(mg/L)	1650
Total Acidity as CaCO3	(mg/L)	<5
Total Alk. as CaCO3	(mg/L)	917
Total Hardness as CaCO3	(mg/L)	158
Sodium Adsorption Ratio		21.6
Ammonia Nitrogen as N	(mg/L)	1.8
Boron	(mg/L)	0.74
Nitrate as NO3	(mg/L)	<0.05
Total Phosphorus	(mg/L)	0.1
ANIONS		
Bicarb as HCO3	(mg/L)	1070
Bicarbonate	(meq/L)	17.56
Carb as CO3	(mg/L)	24
Carbonate	(meq/L)	0.78
Hydroxide as OH	(mg/L)	<5
Hydroxide	(meq/L)	<0.01
Chloride	(mg/L)	[D]18.5
Chloride	(meq/L)	0.52
Fluoride	(mg/L)	0.2
Fluoride	(meq/L)	<0.01
Nitrate + Nitrite as N	(mg/L)	<0.05
Nitrate + Nitrite as N	(meq/L)	<0.01
Sulfate	(mg/L)	[D]370
Sulfate	(meq/L)	7.70
CATIONS		
Calcium	(mg/L)	24
Calcium	(meq/L)	1.19
Magnesium	(mg/L)	24
Magnesium	(meq/L)	1.97
Potassium	(mg/L)	35
Potassium	(meq/L)	0.88
Sodium	(mg/L)	624
Sodium	(meq/L)	27.13
BALANCE		
Lab Determined Cations	(meq/L)	31.31
Lab Determined Anions	(meq/L)	26.58
Lab Determined Ion Difference	(meq/L)	4.73
TRACE METALS (Dissolved)		
Aluminum	(mg/L)	<0.1
Arsenic	(mg/L)	<0.005
Barium	(mg/L)	<0.5
Cadmium	(mg/L)	<0.002
Chromium	(mg/L)	<0.01
Copper	(mg/L)	<0.01
Iron	(mg/L)	<0.05
Lead	(mg/L)	<0.02
Manganese	(mg/L)	0.05
Mercury	(mg/L)	<0.001
Molybdenum	(mg/L)	<0.02
Nickel	(mg/L)	<0.01
Selenium	(mg/L)	<0.005
Zinc	(mg/L)	<0.01
TRACE METALS (Total)		
Total Iron	(mg/L)	0.48

**Wells 21 and RP-5B are obstructed and samples were unobtainable.*

[D]Report limit raised due to dilution.

TABLE 6A. SURFACE WATER QUALITY REPORT

Station Name:		SBC1-75	SBC2-75
Station Number:			
Sample Date:			
Sample Time:			
Sampler:			
Laboratory Code:			
Laboratory Number:		*No samples obtained in 2024 report period.*	
Lab Received Date:			
Lab Received Time:			
LABORATORY MEASUREMENTS			
TDS (180°C)	(mg/L)		
Total Suspended Solids	(mg/L)		

TABLE 7. BITTER CREEK DISCHARGE AT SITES SBC1-75 AND SBC2-75

CHANNEL CROSS SECTION SURVEY DATE *	DATE	**SBC1-75** STAFF GAGE HEIGHT (ft.)	WATER SURFACE ELEVATION (ft.)	SBC1-75 DISCHARGE (cfs)	DATE	**SBC2-75** STAFF GAGE HEIGHT (ft.)	WATER SURFACE ELEVATION (ft.)	SBC2-75 DISCHARGE (cfs)
9/27/1987	9/28/1987	0.32	88.29	0.10	9/28/1987	1.27	88.47	2.66
	11/11/1987	0.40	88.37	0.27	11/11/1987	1.44	88.64	4.19
	3/1/1988	4.12	92.09	94.31	3/1/1988	5.25	92.45	96.57
	3/3/1988	4.76	92.73	122.49	3/3/1988	5.68	92.88	118.24
	3/22/1988	5.60	93.57	179.35	3/22/1988	6.55	93.75	170.49
	5/9/1988	0.70	88.67	1.46	5/9/1988	1.70	88.90	6.02
	6/23/1988	0.90	88.87	2.72	6/23/1988	1.86	89.06	7.03
	7/28/1988	0.90	88.87	2.72	7/28/1988	1.80	89.00	6.81
	8/26/1988	1.00	88.97	3.48	8/26/1988	1.50	88.70	4.59
4/20/1989	3/13/1989	2.23	89.73	22.96	3/13/1989	3.19	90.39	23.45
	4/19/1989	0.32	87.82	0.01	4/19/1989	1.15	88.35	1.82
	6/27/1989	0.30	87.80	0.01	6/27/1989	1.10	88.30	1.63
	7/13/1989	0.25	87.75	0.01	7/13/1989	1.25	88.45	2.24
	7/24/1989	0.20	87.70	0.01	7/24/1989	0.88	88.08	0.94
	8/5/1989	0.25	87.75	0.01	8/5/1989	1.05	88.25	1.46
	10/10/1989	0.20	87.70	0.01	10/10/1989	1.05	88.25	1.46
	11/13/1989	0.20	87.70	0.01	11/13/1989	0.90	88.10	0.99
	3/5/1990	3.10	90.60	47.54	3/5/1990	3.74	90.94	39.23
	4/24/1990	0.30	87.80	0.01	4/24/1990	1.05	88.25	1.46
	5/15/1990	0.22	87.72	0.01	5/15/1990	1.14	88.34	1.78
	6/8/1990	0.46	87.96	0.06	6/8/1990	1.16	88.36	1.86
	7/6/1990	0.60	88.10	0.30	7/6/1990	1.11	88.31	1.67
	8/27/1990	0.63	88.13	0.38	8/27/1990	1.04	88.24	1.42
	9/17/1990	0.60	88.10	0.30	9/17/1990	1.18	88.38	1.94
	10/2/1990	0.60	88.10	0.30	10/2/1990	1.26	88.46	2.29
6/17/1993	4/19/1991	0.95	88.45	0.49	4/19/1991	2.03	89.09	5.40
	5/8/1991	0.70	88.20	0.11	5/8/1991	1.12	88.18	1.06
	6/11/1991	0.81	88.31	0.22	6/11/1991	1.33	88.39	1.76
	7/10/1991	0.71	88.21	0.12	7/10/1991	1.49	88.55	2.70
	8/12/1991	0.70	88.20	0.11	8/12/1991	0.60	87.66	0.27
	9/3/1991	0.69	88.19	0.10	9/3/1991	0.50	87.56	0.18
	10/4/1991	0.62	88.12	0.05	10/4/1991	0.88	87.94	0.66
	3/3/1992	3.61	91.11	63.78	3/3/1992	4.49	91.55	44.31
	4/2/1992	1.31	88.81	2.15	4/2/1992	2.32	89.38	7.61
	5/5/1992	0.90	88.40	0.38	5/5/1992	0.80	87.86	0.53
	6/1/1992	0.96	88.46	0.51	6/1/1992	1.18	88.24	1.33
	7/13/1992	1.08	88.58	0.81	7/13/1992	0.90	87.96	0.70
	8/4/1992	1.08	88.58	0.81	8/4/1992	0.54	87.60	0.21
	9/3/1992	1.10	88.60	0.89	9/3/1992	0.90	87.96	0.70
	10/2/1992	1.24	88.74	1.68	10/2/1992	1.04	88.10	0.99
	11/3/1992	1.10	88.60	0.89	11/3/1992	1.06	88.12	1.03
	4/1/1993	1.95	89.45	10.47	4/1/1993	3.00	90.06	14.27
6/17/1993	4/26/1993	1.50	89.00	4.18	4/26/1993	1.10	88.16	1.13
	6/4/1993	1.15	88.65	1.15	6/4/1993	1.21	88.27	1.41
	7/6/1993	1.16	88.66	1.20	7/6/1993	0.98	88.04	0.85
	8/2/1993	1.13	88.63	1.04	8/2/1993	0.99	88.05	0.87
	9/3/1993	1.15	88.65	1.20	9/3/1993	1.10	88.16	1.13
	10/1/1993	1.18	88.68	1.32	10/1/1993	1.16	88.22	1.28
	11/2/1993	1.46	88.96	3.39	11/2/1993	1.06	88.12	1.03
	3/15/1994	1.86	89.36	8.13	3/15/1994	2.58	89.64	8.37

TABLE 7. BITTER CREEK DISCHARGE AT SITES SBC1-75 AND SBC2-75

CHANNEL CROSS SECTION SURVEY DATE *	DATE	**SBC1-75** STAFF GAGE HEIGHT (ft.)	WATER SURFACE ELEVATION (ft.)	SBC1-75 DISCHARGE (cfs)	DATE	**SBC2-75** STAFF GAGE HEIGHT (ft.)	WATER SURFACE ELEVATION (ft.)	SBC2-75 DISCHARGE (cfs)
	3/31/1994	1.02	88.52	0.67	3/31/1994	1.00	88.06	0.90
	4/20/1994	1.1	88.60	0.89	4/20/1994	1.07	88.13	1.06
	5/16/1994	1.62	89.12	5.04	5/16/1994	1.69	88.75	3.01
	6/8/1994	0.88	88.38	0.34	6/8/1994	0.99	88.05	0.87
	7/5/1994	1.08	88.58	0.81	7/5/1994	DRY		
	8/2/1994	0.6	88.10	0.04	8/2/1994	DRY		
	8/31/1994	0.39	87.89	0.01	8/31/1994	DRY		
	10/11/1994	0.75	88.25	0.16	10/11/1994	0.91	87.97	0.72
	11/1/1994	0.66	88.16	0.08	11/1/1994	0.51	87.57	0.19
5/17/95 (SBC1-75)	1/3/1995	Frozen			1/3/1995	Frozen		
6/19/95 (SBC2-75)	1/31/1995	2.28	90.43	28.14	1/31/1995	1.93	89.42	7.98
	3/1/1995	2.42	90.57	31.97	3/1/1995	2.35	89.84	11.94
	3/31/1995	0.62	88.77	0.85	3/31/1995	0.72	88.21	1.45
	5/2/1995	0.56	88.71	0.58	4/26/1995	0.62	88.11	1.24
	5/17/1995	0.55	88.70	0.54	5/2/1995	0.63	88.12	1.27
	6/2/1995	1.04	89.19	4.28	6/2/1995	1.15	88.64	2.97
	7/6/1995	0.53	88.68	0.49	7/6/1995	0.16	87.65	0.33
	7/26/1995	0.65	88.80	1.00	7/26/1995	0.66	88.15	1.35
	8/1/1995	DRY			8/1/1995	0.05	87.54	0.19
	9/6/1995	0.52	88.67	0.47	9/6/1995	0.46	87.95	0.87
	10/2/1995	0.58	88.73	0.67	10/2/1995	0.64	88.13	1.30
	10/19/1995	0.51	88.66	0.45	10/20/1995	0.68	88.17	1.41
	11/7/1995	0.62	88.77	0.85	11/9/1995	0.98	88.47	2.33
	12/18/1995	Frozen			12/18/1995	Frozen		
8/6/1996	1/16/1996	Frozen			1/16/1996	Frozen		
	2/9/1996	2.85	91.00	44.08	2/9/1996	2.58	90.07	10.84
	3/29/1996	0.62	88.77	1.35	3/29/1996	0.91	88.40	1.46
	4/30/1996	0.56	88.71	1.07	4/30/1996	0.54	88.03	0.66
	5/14/1996	0.5	88.65	0.84	5/14/1996	**		
	5/31/1996	1.14	89.29	6.27	5/31/1996	**		
	6/27/1996	0.45	88.60	0.68	6/27/1996	0.58	88.07	0.74
	7/29/1996	DRY			7/29/1996	DRY		
	8/30/1996	DRY			8/30/1996	DRY		
	10/7/1996	0.18	88.33	0.18	10/7/1996	DRY		
8/6/1996	10/14/1996	0.16	88.31	0.16	10/14/1996	DRY		
	11/4/1996	0.42	88.57	0.59	11/4/1996	0.55	88.04	0.68
	12/2/1996	Frozen			12/2/1996	Frozen		
	1/6/1997	Frozen			1/6/1997	Frozen		
	2/10/1997	Frozen			2/11/1997	Frozen		
	3/5/1997	Frozen			3/5/1997	Frozen		
	4/10/1997	1.09	88.94	2.54	4/9/1997	1.05	88.02	0.64
	5/12/1997	0.79	88.64	0.80	5/19/1997	0.93	87.90	0.44
	6/17/1997	1.01	88.86	1.89	6/18/1997	1.14	88.11	0.82
	7/10/1997	0.96	88.81	1.56	7/10/1997	1.29	88.26	1.13
	8/12/1997	1.09	88.94	2.54	8/14/1997	1.52	88.49	1.71
	9/15/1997	0.94	88.79	1.45	9/22/1997	1.43	88.40	1.46
	10/2/1997	0.94	88.79	1.45	10/1/1997	1.28	88.25	1.11
	10/21/1997	0.94	88.79	1.45	10/22/1997	1.00	87.97	0.55
	11/20/1997	Frozen			11/24/1997	Frozen		
	12/22/1997	Frozen			12/22/1997	Frozen		

TABLE 7. BITTER CREEK DISCHARGE AT SITES SBC1-75 AND SBC2-75

CHANNEL CROSS SECTION SURVEY DATE *	DATE	**SBC1-75** STAFF GAGE HEIGHT (ft.)	WATER SURFACE ELEVATION (ft.)	SBC1-75 DISCHARGE (cfs)	DATE	**SBC2-75** STAFF GAGE HEIGHT (ft.)	WATER SURFACE ELEVATION (ft.)	SBC2-75 DISCHARGE (cfs)
7/14/1998	1/30/1998	Frozen			1/30/1998	Frozen		
	2/24/1998	Frozen			2/24/1998	Frozen		
	3/31/1998	ND			3/31/1998	ND		
	4/27/1998	0.64	88.89	1.33	4/27/1998	1.13	88.00	0.89
	5/1/1998	ND			5/1/1998	ND		
	6/15/1998	1.14	89.39	5.95	6/15/1998	2.00	88.87	2.91
	7/14/1998	0.91	89.16	3.5	7/14/1998	1.82	88.69	2.35
	8/12/1998	0.95	89.20	3.88	8/12/1998	1.60	88.47	1.83
	9/16/1998	0.93	89.18	3.69	9/16/1998	1.57	88.44	1.76
	10/7/1998	0.94	89.19	3.79	10/8/1998	1.56	88.43	1.73
	11/17/1998	1.07	89.32	5.14	11/17/1998	1.68	88.55	2.04
	12/18/1998	Frozen			12/18/1998	Frozen		
7/14/1998	1/19/1999	Frozen			1/19/1999	Frozen		
	2/19/1999	Frozen			2/19/1999	Frozen		
	3/19/1999	Frozen			3/19/1999	Frozen		
	4/14/1999	0.44	88.69	0.51	4/14/1999	1.34	88.21	1.25
	5/13/1999	0.4	88.65	0.41	5/13/1999	**		
	6/11/1999	0.4	88.65	0.41	6/11/1999	**		
	7/16/1999	1.0	89.25	4.39	7/16/1999	**		
	8/26/1999	0.4	88.65	0.41	8/26/1999	**		
	9/8/1999	0.46	88.71	0.57	9/8/1999	**		
	10/21/1999	0.5	88.75	0.7	10/21/1999	**		
	11/8/1999	0.46	88.71	0.57	11/8/1999	**		
	12/14/1999	Frozen			12/14/1999	Frozen		
	1/20/2000	Frozen			1/20/2000	Frozen		
	2/22/2000	Frozen			2/22/2000	Frozen		
	3/29/2000	0.80	89.05	2.51	3/29/2000	2.65	89.52	5.67
	4/28/2000	0.30	88.55	0.25	4/28/2000	1.36	88.23	1.11
	5/29/2000	0.08	88.33	0.02	5/29/2000	1.06	87.67	0.80
	6/26/2000	DRY			6/26/2000	DRY		
	7/14/2000	0.16	88.41	0.07	7/14/2000	DRY		
	8/24/2000	0.10	88.35	0.03	8/24/2000	DRY		
	9/25/2000	0.06	88.31	0.02	9/25/2000	DRY		
	10/24/2000	DRY			10/24/2000	DRY		
	11/16/2000	Frozen			11/16/2000	Frozen		
	12/18/2000	Frozen			12/18/2000	Frozen		
	1/26/2001	Frozen			1/26/2001	DRY		
	2/13/2001	Frozen			2/13/2001	DRY		
	3/29/2001	Dry/Frozen			3/29/2001	DRY		
	4/26/2001	0.11	88.36	0.03	4/26/2001	0.14	86.88	0.01
	5/31/2001	0.1	88.35	0.03	5/31/2001	0.12	86.88	0.01
	6/13/2001	0.68	88.93	1.60	6/13/2001	0.76	87.30	0.43
	7/3/2001	0.12	88.37	0.04	7/3/2001	DRY		
	8/9/2001	ND			8/9/2001	DRY		
	9/11/2001	0.1	88.35	0.03	9/11/2001	DRY		
	10/12/2001	DRY			10/12/2001	DRY		
	11/20/2001	Dry/Frozen			11/20/2001	DRY		
	12/31/2001	Dry/Frozen			12/31/2001	DRY		
	1/11/2002	Frozen			1/11/2002	Frozen		
	2/11/2002	Frozen			2/11/2002	Frozen		
	3/16/2002	Frozen			3/16/2002	Frozen		
	4/18/2002	0.08	88.33	0.02	4/18/2002	1.20	88.07	0.99

TABLE 7. BITTER CREEK DISCHARGE AT SITES SBC1-75 AND SBC2-75

CHANNEL CROSS SECTION SURVEY DATE *	DATE	**SBC1-75** STAFF GAGE HEIGHT (ft.)	WATER SURFACE ELEVATION (ft.)	SBC1-75 DISCHARGE (cfs)	DATE	**SBC2-75** STAFF GAGE HEIGHT (ft.)	WATER SURFACE ELEVATION (ft.)	SBC2-75 DISCHARGE (cfs)
	5/20/2002	0.02	88.27	0.0005	5/20/2002	0.84	87.71	0.52
	6/17/2002	Dry			6/17/2002	Dry		
	7/18/2002	Dry			7/18/2002	Dry		
	8/23/2002	Dry			8/23/2002	Dry		
	9/12/2002	Dry			9/12/2002	Dry		
	10/15/2002	Dry			10/15/2002	Dry		
	11/27/2002	Frozen			11/27/2002	Frozen		
	12/30/2002	Frozen			12/30/2002	Frozen		
	1/20/2003	Frozen			1/20/2003	Frozen		
	2/28/2003	Frozen			2/28/2003	Frozen		
	3/20/2003	Frozen			3/20/2003	Frozen		
	4/3/2003	2.00	90.25	20.93	4/3/2003	2.90	89.77	6.94
	5/22/2003	Dry			5/22/2003	Dry		
	6/19/2003	Dry			6/19/2003	Dry		
	7/22/2003	Dry			7/22/2003	Dry		
	8/26/2003	Dry			8/26/2003	Dry		
	9/29/2003	Dry			9/29/2003	Dry		
	10/27/2003	Dry			10/27/2003	Dry		
	11/24/2003	Dry			11/24/2003	Dry		
	12/26/2003	Frozen			12/26/2003	Dry		
	1/21/2004	Frozen			1/21/2004	Frozen		
	2/3/2004	Frozen			2/3/2004	Frozen		
	3/4/2004	Frozen			3/4/2004	Frozen		
	4/9/2004	Invalid			4/9/2004	Invalid		
	5/19/2004	Invalid			5/19/2004	Invalid		
	6/24/2004	0.9	89.15	3.40	6/24/2004	Invalid		
	7/23/2004	Dry			7/23/2004	Dry		
	9/21/2004	0.2	88.45	0.11	9/21/2004	0.50	87.37	0.17
	11/1/2004	0.4	88.65	0.41	11/1/2004	1.70	88.57	2.09
	11/15/2004	Frozen			11/15/2004	Frozen		
	12/22/2004	Frozen			12/22/2004	Frozen		
	1/14/2005	Frozen			1/14/2005	Frozen		
	2/23/2005	Frozen			2/23/2005	Frozen		
	3/4/2005	Frozen			3/4/2005	Frozen		
	4/26/2005	0.8	89.05	2.51	4/26/2005	1.1	87.97	0.85
	5/26/2005	0.6	88.85	1.09	5/26/2005	1.6	88.47	1.83
	6/11/2005	0.3	88.55	0.25	6/11/2005	1.4	88.27	1.39
	7/27/2005	Dry			7/27/2005	Dry		
	8/28/2005	Dry			8/28/2005	Dry		
	9/11/2005	Dry			9/11/2005	Dry		
	10/2/2005	0.45	88.7	0.54	10/2/2005	Dry		
	11/20/2005	Frozen			11/20/2005	Frozen		
	12/21/2005	Frozen			12/21/2005	Frozen		
	1/31/2006	Frozen			1/31/2006	Frozen		
	2/22/2006	Frozen			2/22/2006	Frozen		
	3/23/2006	Dry			3/23/2006	1.20	88.07	0.99
	4/28/2006	0.55	88.80	0.91	4/28/2006	0.55	87.42	0.21
	5/31/2006	0.10	88.35	0.03	5/31/2006	Dry		
	6/28/2006	Dry			6/28/2006	Dry		
	7/30/2006	Dry			7/30/2006	Dry		
	8/30/2006	Dry			8/30/2006	0.40	87.27	0.10
	9/28/2006	0.38	88.63	0.38	9/28/2006	0.15	87.02	0.01
	10/25/2006	0.50	88.75	0.70	10/25/2006	1.40	88.27	1.37

TABLE 7. BITTER CREEK DISCHARGE AT SITES SBC1-75 AND SBC2-75

CHANNEL CROSS SECTION SURVEY DATE *	DATE	**SBC1-75** STAFF GAGE HEIGHT (ft.)	WATER SURFACE ELEVATION (ft.)	SBC1-75 DISCHARGE (cfs)	DATE	**SBC2-75** STAFF GAGE HEIGHT (ft.)	WATER SURFACE ELEVATION (ft.)	SBC2-75 DISCHARGE (cfs)
	11/18/2006	Frozen			11/18/2006	Frozen		
	12/6/2006	Frozen			12/6/2006	Frozen		
	1/29/2007	Frozen			1/29/2007	Frozen		
	2/21/2007	Frozen			2/21/2007	Frozen		
	3/24/2007	0.55	88.80	0.91	3/24/2007	0.35	87.22	0.07
	4/15/2007	0.50	88.75	0.70	4/15/2007	0.85	87.72	0.53
	5/15/2007	Dry			5/15/2007	Dry		
	6/26/2007	Dry			6/26/2007	Dry		
	7/13/2007	Dry			7/13/2007	Dry		
	8/14/2007	Dry			8/14/2007	0.7	87.57	0.36
	9/26/2007	0.90	89.15	3.40	9/26/2007	2.2	89.07	3.61
	10/13/2007	Dry			10/13/2007	Dry		
	11/27/2007	Frozen			11/27/2007	Frozen		
	12/15/2007	Frozen			12/15/2007	Frozen		
	1/31/2008	Frozen			1/31/2008	Frozen		
	2/27/2008	Frozen			2/27/2008	Frozen		
	3/14/2008	2.60	90.85	35.78	3/14/2008	Frozen		
	4/12/2008	0.80	89.05	2.51	4/12/2008	1.25	88.12	1.07
	5/25/2008	0.55	88.80	0.91	5/25/2008	0.85	87.72	0.53
	6/21/2008	Dry			6/21/2008	0.20	87.07	0.02
	7/19/2008	Dry			7/19/2008	Dry		
	8/30/2008	Dry			8/30/2008	Dry		
	9/27/2008	Dry			9/27/2008	0.70	87.57	0.36
	10/25/2008	0.60	88.85	1.09	10/25/2008	0.90	87.77	0.60
	11/15/2008	0.60	88.85	1.09	11/15/2008	0.80	87.67	0.47
	12/6/2008	Frozen			12/6/2008	Frozen		
	1/2/2009	Frozen			1/2/2009	Frozen		
	2/22/2009	Frozen			2/22/2009	Frozen		
	3/7/2009	0.30	88.55	0.25	3/7/2009	1.65	88.52	1.96
	3/21/2009	0.40	88.65	0.41	3/21/2009	1.60	88.47	1.83
	4/29/2009	0.70	88.95	1.74	4/29/2009	2.80	89.67	6.36
	5/28/2009	1.20	89.45	6.68	5/28/2009	2.05	88.92	3.03
	6/22/2009	0.30	88.55	0.25	6/22/2009	1.85	88.72	2.45
	7/11/2009	Damp			7/11/2009	0.90	87.77	0.60
	8/19/2009	Damp			8/19/2009	0.85	87.72	0.53
	9/26/2009	Damp			9/26/2009	Dry		
	10/26/2009	Frozen			10/26/2009	Frozen		
	11/18/2009	Frozen			11/18/2009	Frozen		
	12/14/2009	Frozen			12/14/2009	Frozen		
	1/6/2010	Frozen			1/6/2010	Frozen		
	2/3/2010	Frozen			2/3/2010	Frozen		
	3/29/2010	0.46	88.71	0.58	3/29/2010	1.53	88.40	1.66
	4/30/2010	0.62	88.87	1.22	4/30/2010	1.19	88.06	0.97
	5/26/2010	0.66	88.91	1.48	5/28/2010	1.23	88.10	1.03
	6/15/2010	Dry			6/18/2010	Dry		
	7/1/2010	0.33	88.58	0.29	7/1/2010	0.88	87.75	0.57
	8/25/2010	Dry			8/26/2010	Dry		
	9/29/2010	Dry			9/29/2010	Dry		
	10/28/2010	0.41	88.66	0.44	10/26/2010	0.57	87.44	0.23
	11/24/2010	Frozen			11/24/2010	Frozen		
	12/22/2010	Frozen			12/22/2010	Frozen		
	1/24/2011	Frozen			1/24/2011	Frozen		
	2/3/2011	Frozen			2/3/2011	Frozen		

TABLE 7. BITTER CREEK DISCHARGE AT SITES SBC1-75 AND SBC2-75

CHANNEL CROSS SECTION SURVEY DATE *	DATE	**SBC1-75** STAFF GAGE HEIGHT (ft.)	WATER SURFACE ELEVATION (ft.)	SBC1-75 DISCHARGE (cfs)	DATE	**SBC2-75** STAFF GAGE HEIGHT (ft.)	WATER SURFACE ELEVATION (ft.)	SBC2-75 DISCHARGE (cfs)
	3/3/2011	Invalid			3/3/2011	Invalid		
	4/1/2011	1.21	89.46	6.68	4/1/2011	1.82	88.69	2.40
	5/23/2011	1.40	89.65	9.54	5/23/2011	2.06	88.93	3.06
	6/6/2011	Dry			6/6/2011	Dry		
	7/7/2011	1.03	89.28	4.67	7/7/2011	1.26	88.13	1.08
	8/23/2011	Invalid			8/23/2011	1.34	88.21	1.22
	8/30/2011	0.86	89.11	2.96	8/30/2011	1.10	87.97	0.85
	9/2/2011	1.42	89.67	9.95	9/2/2011	1.01	87.88	0.73
	9/29/2011	0.74	88.99	1.94	9/29/2011	1.24	88.11	1.08
	10/4/2011	Dry			10/4/2011	Dry		
	11/3/2011	1.43	89.68	9.95	11/3/2011	0.73	87.60	0.39
	12/2/2011	Frozen			12/2/2011	Frozen		
	1/4/2012	Frozen			1/4/2012	Frozen		
	2/6/2012	Frozen			2/6/2012	Frozen		
	3/8/2012	Frozen			3/8/2012	Frozen		
	4/17/2012	0.74	88.99	1.94	4/17/2012	1.40	88.27	1.37
	5/10/2012	0.48	88.73	0.63	5/11/2012	1.24	88.11	1.08
	6/8/2012	0.42	88.67	0.48	6/8/2012	0.91	87.78	0.60
	7/5/2012	Dry			7/5/2012	Dry		
	8/17/2012	Dry			8/20/2012	Dry		
	9/21/2012	0.48	88.73	0.63	9/21/2012	Dry		
	9/28/2012	0.68	88.93	1.58	9/28/2012	1.00	87.87	0.73
	10/15/2012	0.78	89.03	2.32	10/15/2012	1.11	87.98	0.85
	11/20/2012	Frozen			11/22/2012	Frozen		
	12/31/2012	No Documented Visit			12/31/2012	No Documented Visit		
	1/10/2013	Frozen			1/10/2013	Frozen		
	2/28/2013	No Documented Visit			2/28/2013	No Documented Visit		
	3/5/2013	Frozen			3/4/2013	Frozen		
	4/5/2013	Frozen			4/5/2013	Frozen		
	5/4/2013	0.50	88.75	0.70	5/4/2013	1.20	88.07	0.99
	6/3/2013	0.40	88.65	0.41	6/3/2013	0.55	87.42	0.21
	7/26/2013	Dry			7/26/2013	Dry		
	8/26/2013	Dry			8/26/2013	Dry		
	9/30/2013	1.10	89.35	5.48	9/30/2013	1.60	88.47	1.83
	10/30/2013	0.80	89.05	2.51	10/30/2013	1.40	88.27	1.37
	11/5/2013				11/6/2013			
	11/26/2013	Frozen			11/26/2013	Frozen		
	12/27/2013	Frozen			12/27/2013	Frozen		
	1/29/2014	Frozen			1/29/2014	Frozen		
	2/18/2014	Frozen			2/18/2014	Frozen		
	3/20/2014	0.40	6630.70	0.49	3/20/2014	1.15	6551.95	3.53
	4/10/2014	0.55	6630.85	1.05	4/10/2014	1.05	6551.85	2.92
	5/28/2014	1.27	6631.57	8.55	5/28/2014	1.00	6551.80	2.63
	6/30/2014	Dry			6/30/2014	Dry		
	7/30/2014	Dry			7/30/2014	Dry		
	8/8/2014	Dry			8/8/2014	Dry		
	9/9/2014	1.20	6631.50	6.73	9/9/2014	1.11	6551.91	3.27
	9/30/2014	1.90	6632.20	34.9	9/30/2014	1.80	6552.60	8.54
	10/30/2014	Frozen			10/30/2014	Frozen		
	11/17/2014	Frozen			11/17/2014	Frozen		
	12/1/2014	Frozen			12/1/2014	Frozen		
	1/4/2015	Frozen			1/4/2015	Frozen		

TABLE 7. BITTER CREEK DISCHARGE AT SITES SBC1-75 AND SBC2-75

CHANNEL CROSS SECTION SURVEY DATE *	DATE	**SBC1-75** STAFF GAGE HEIGHT (ft.)	WATER SURFACE ELEVATION (ft.)	SBC1-75 DISCHARGE (cfs)	DATE	**SBC2-75** STAFF GAGE HEIGHT (ft.)	WATER SURFACE ELEVATION (ft.)	SBC2-75 DISCHARGE (cfs)
	2/1/2015	Frozen			2/1/2015	Frozen		
	3/16/2015	0.87	6631.17	3.20	3/16/2015	1.65	6552.45	7.15
	4/13/2015	0.45	6630.75	0.66	4/13/2015	1.30	6552.10	4.57
	5/5/2015	0.40	6630.70	0.49	5/5/2015	1.10	6551.90	3.21
	6/15/2015	0.35	6630.65	0.37	6/5/2015	1.40	6552.20	5.35
	7/6/2015	2.20	6632.50	53.35	7/6/2015	3.90	6554.70	59.18
	8/4/2015	Dry			8/4/2015	1.40	6552.20	5.35
	9/8/2015	Dry			9/8/2015	Dry		
	10/9/2015	Dry			10/9/2015	Dry		
	11/9/2015	0.40	6630.70	0.49	11/9/2015	Dry		
	12/4/2015	Frozen			12/4/2015	Frozen		
	1/5/2016	Frozen			1/5/2016	Frozen		
	2/10/2016	Frozen			2/10/2016	Frozen		
	3/10/2016	1.10	6631.40	4.77	3/10/2016	2.80	6553.60	25.38
	4/12/2016	1.90	6632.20	34.88	4/12/2016	1.60	6552.40	6.72
	5/4/2016	1.20	6631.50	6.73	5/4/2016	2.20	6553.00	13.69
	6/6/2016	0.15	6630.45		6/6/2016	0.90	6551.70	2.12
	7/5/2016	Dry			7/5/2016	Dry		
	8/15/2016	Dry			8/15/2016	Dry		
	9/6/2016	Dry			9/6/2016	Dry		
	10/10/2016	0.80	6631.10	2.54	10/10/2016	1.20	6552.00	3.85
	11/7/2016	0.50	6630.80	0.82	11/7/2016	0.95	6551.75	2.38
	12/7/2016	Frozen			12/7/2016	Frozen		
	1/14/2017	Frozen			1/14/2017	Frozen		
	2/21/2017	5.40	6635.70	315.32	2/21/2017	6.10	6556.90	233.81
	3/17/2017	1.80	6632.10	29.46	3/17/2017	2.60	6553.40	20.98
	4/5/2017	0.80	6631.10	2.54	4/5/2017	1.20	6552.00	3.85
	5/8/2017	0.70	6631.00	1.86	5/8/2017	0.80	6551.60	1.66
	6/6/2017	0.60	6630.90	1.27	6/6/2017	0.80	6551.60	1.66
	7/1/2017	Dry			7/1/2017	Dry		
	8/1/2017	Dry			8/1/2017	Dry		
	9/26/2017	1.20	6631.50	6.73	9/26/2017	1.10	6551.90	3.21
	10/9/2017	0.70	6631.00	1.86	10/9/2017	0.90	6551.70	2.12
	11/20/2017	0.80	6631.10	2.54	11/20/2017	0.60	6551.40	0.93
	12/12/2017	Frozen			12/12/2017	Frozen		
	1/11/2018	Frozen			1/11/2018	Frozen		
	2/7/2018	Frozen			2/7/2018	Frozen		
	3/27/2018	2.00	6632.30	40.68	3/27/2018	1.80	6552.60	8.54
	4/16/2018	1.90	6632.20	34.88	4/16/2018	1.60	6552.40	6.72
	5/29/2018	1.30	6631.60	9.33	5/29/2018	1.09	6551.89	3.21
	6/27/2018	Dry			6/27/2018	Dry		
	7/18/2018	Dry			7/18/2018	Dry		
	8/13/2018	Dry			8/13/2018	Dry		
	9/24/2018	Dry			9/24/2018	Dry		
	10/25/2018	Muddy - no flow			10/25/2018	Muddy - no flow		
	11/21/2018	Frozen			11/21/2018	Frozen		
	12/14/2018	Frozen			12/14/2018	Frozen		
	1/21/2019	Frozen			1/21/2019	Frozen		
	2/28/2019	Frozen			2/28/2019	Frozen		
	3/28/2019	Frozen			3/28/2019	Frozen		
	4/19/2019	Frozen			4/19/2019	Frozen		
	5/14/2019	1.20	6631.50	6.73	5/14/2019	1.40	6552.20	5.35
	6/10/2019	0.80	6631.10	2.54	6/10/2019	1.10	6551.90	3.21

TABLE 7. BITTER CREEK DISCHARGE AT SITES SBC1-75 AND SBC2-75

CHANNEL CROSS SECTION SURVEY DATE *	DATE	**SBC1-75** STAFF GAGE HEIGHT (ft.)	WATER SURFACE ELEVATION (ft.)	SBC1-75 DISCHARGE (cfs)	DATE	**SBC2-75** STAFF GAGE HEIGHT (ft.)	WATER SURFACE ELEVATION (ft.)	SBC2-75 DISCHARGE (cfs)
	7/23/2019	Dry			7/23/2019	Dry		
	8/1/2019	Dry			8/1/2019	Dry		
	9/3/2019	Dry			9/3/2019	Dry		
	10/7/2019	1.50	6631.80	16.20	10/7/2019	1.00	6551.80	2.63
	11/6/2019	Frozen			11/6/2019	Frozen		
	12/1/2019	Frozen			12/1/2019	Frozen		
	1/14/2020	Frozen			1/14/2020	Frozen		
	2/6/2020	Frozen			2/6/2020	Frozen		
	3/4/2020	Frozen			3/4/2020	Frozen		
	4/21/2020	Dry			4/21/2020	Dry		
	5/12/2020	Dry			5/12/2020	Dry		
	6/2/2020	1.70	6632.00	24.62	6/2/2020	1.00	6551.80	2.63
	7/13/2020	Dry			7/13/2020	Dry		
	8/11/2020	Dry			8/11/2020	Dry		
	9/4/2020	Dry			9/4/2020	Dry		
	10/7/2020	1.50	6631.80	16.20	10/7/2020	0.70	6551.50	1.27
	11/3/2020	Frozen			11/3/2020	Frozen		
	12/8/2020	Frozen			12/8/2020	Frozen		
	1/26/2021	Frozen			1/26/2021	Frozen		
	2/15/2021	Frozen			2/15/2021	Frozen		
	3/9/2021	Frozen			3/9/2021	Frozen		
	4/20/2021	No Flow			4/20/2021	No Flow		
	5/10/2021	No Flow			5/10/2021	No Flow		
	6/2/2021	No Flow			6/2/2021	No Flow		
	7/9/2021	No Flow			7/9/2021	No Flow		
	8/2/2021	Dry			8/2/2021	Dry		
	9/2/2021	Dry			9/2/2021	Dry		
	10/5/2021	No Flow			10/5/2021	No Flow		
	11/15/2021	No Flow			11/15/2021	No Flow		
	12/7/2021	Frozen			12/7/2021	Frozen		
	1/11/2022	Frozen			1/11/2022	Frozen		
	2/2/2022	Frozen			2/2/2022	Frozen		
	3/7/2022	Frozen			3/7/2022	Frozen		
	4/11/2022	Frozen			4/11/2022	Frozen		
	5/10/2022	1.0	6631.30	4.54	5/10/2022	0.8	6551.60	1.66
	6/16/2022	No Flow			6/16/2022	No Flow		
	7/11/2022	No Flow			7/11/2022	No Flow		
	8/4/2022	No Flow			8/4/2022	No Flow		
	9/12/2022	No Flow			9/12/2022	No Flow		
	10/19/2022	No Flow			10/19/2022	No Flow		
	11/8/2022	No Flow			11/8/2022	No Flow		
	12/8/2022	Frozen			12/8/2022	Frozen		
	1/9/2023	Frozen			1/9/2023	Frozen		
	2/7/2023	Frozen			2/7/2023	Frozen		
	3/6/2023	Frozen			3/6/2023	Frozen		
	4/6/2023	Frozen			4/6/2023	Frozen		
	5/1/2023	5.0	6635.30	284.22	5/1/2023	4.0	6554.80	63.17
	6/5/2023	4.0	6634.30	240.03	6/5/2023	3.0	6553.80	30.40
	7/12/2023	No Flow			7/12/2023	No Flow		
	8/14/2023	No Flow			8/14/2023	No Flow		
	9/12/2023	No Flow			9/12/2023	No Flow		
	10/6/2023	No Flow			10/6/2023	No Flow		
	11/2/2023	No Flow			11/2/2023	No Flow		
	12/5/2023	Frozen			12/5/2023	Frozen		
	1/8/2024	Frozen			1/8/2024	Frozen		
	2/8/2024	Frozen			2/8/2024	Frozen		
	3/6/2024	Frozen			3/6/2024	Frozen		

TABLE 7. BITTER CREEK DISCHARGE AT SITES SBC1-75 AND SBC2-75

CHANNEL CROSS SECTION SURVEY DATE *	DATE	**SBC1-75** STAFF GAGE HEIGHT (ft.)	WATER SURFACE ELEVATION (ft.)	SBC1-75 DISCHARGE (cfs)	DATE	**SBC2-75** STAFF GAGE HEIGHT (ft.)	WATER SURFACE ELEVATION (ft.)	SBC2-75 DISCHARGE (cfs)
	4/10/2024	No Flow			4/10/2024	No Flow		
	5/15/2024	**1.5		<0.25	5/15/2024	**1.6		<0.25
	6/6/2024	No Flow			6/6/2024	No Flow		
	7/8/2024	No Flow			7/8/2024	No Flow		
	8/13/2024	No Flow			8/13/2024	No Flow		
	9/3/2024	No Flow			9/3/2024	No Flow		
	10/10/2024	No Flow			10/10/2024	No Flow		
	11/6/2024	No Flow			11/6/2024	No Flow		

Notes:

* Staff gage heights are input with the respective channel cross section survey data to the Manning Equation.

** Ponding around gage. Flow rate estimated.

ND means no data available.

1997 values are based on adjustment resulting from plumb bob and cable replacement at both sites.

1998 - 2013 values are based on calibration of Mannings Roughness Coefficient from stream gaging conducted 7/14/98.

2014 values are from developed rating curves using July 2014 channel surveys and Mannings Equation.

2014 survey indicates 0.2 ft of water ponds in cross section before flow commences at both stations.

SBC2-75 discharge values were previously reported incorrectly for 10/25/08 and 11/15/08 in the 2008 Annual Report.

These values have been corrected from 3.94 to 0.60 and 3.52 to 0.47 in Tables 7 - 13.

Assume invalid due to ice January through early April 2013.

October 30, 2013 sample holding time exceeded, resampled November 5 and 6, 2013 without stage measurements.

SBC1-75 discharge value for June 6, 2016 was <0.10 CFS. This value was not plotted on Figure 43.

Reported values for SBC1-75 and SBC2-75 on February 21, 2017 may have been affected by ice in channels.
Discharge <0.25 CFS values for May 15, 2024 were not plotted on Figure 43.

TABLE 8. DESCRIPTIVE (SUMMARY) STATISTICS FOR ESTIMATED STREAMFLOW AT SBC1-75 AND SBC2-75 (1987 - 2024)

	SBC1-75	SBC2-75
Mean	10.74	7.13
Standard Error	2.701	1.834
Median	1.05	1.46
Mode	0.01	1.46
Standard Deviation	36.63	24.87
Variance	1497.49	618.57
Kurtosis	38.950	49.929
Skewness	6.001	6.641
Range	315.31	233.80
Minimum	0.01	0.01
Maximum	315.32	233.81
Sum	2126.06	1311.42
Count	198	184
Confidence Level (95%)	5.1025	3.5936

This table remains the same as the 2023 annual report due to no streamflow in 2024.

TABLE 9. DISCHARGE AND WATER QUALITY FOR SITES SBC1-75 AND SBC2-75 (1986 - 2024)

STATION SBC1-75			
	DISCHARGE		
DATE	(CFS)	TSS (MG/L)	TDS (MG/L)
3/12/1986		772	770
9/28/1987	0.10	87	1190
11/11/1987	0.27	147	1180
3/1/1988	94.31	371	488
3/3/1988	122.49	488	552
3/22/1988	179.35		
5/9/1988	1.46	184	1480
6/23/1988	2.72	74	1180
7/28/1988	2.72	94	1100
8/26/1988	3.48	93	1180
9/30/1988		99	1050
10/31/1988		55	1220
3/13/1989	22.96	1930	506
4/19/1989	0.01	203	1760
6/27/1989	0.01	61	1650
7/13/1989	0.01	46	1920
7/24/1989	0.01	39	2220
9/5/1989	0.01	79	1440
10/10/1989	0.01	80	1350
11/13/1989	0.01	141	1750
3/5/1990	47.54	371	654
4/24/1990	0.01	180	1638
5/15/1990	0.01	232	1730
6/8/1990	0.06	76	1638
7/6/1990	0.30	32	1536
8/26/1990	0.38	31	1460
9/7/1990	0.30	186	1440
10/2/1990	0.30	180	1340
4/19/1991	0.49	9790	792
5/8/1991	0.11	270	1360
6/11/1991	0.22	220	880
7/10/1991	0.12	3100	508
8/12/1991	0.11	24	1820
9/3/1991	0.10	52	1356
10/4/1991	0.05	168	1312
3/3/1992	63.78	920	290
4/2/1992	2.15	2740	340
5/5/1992	0.38	106	1720
6/1/1992	0.51	110	1400
7/13/1992	0.81	74	1200
8/4/1992	0.81	110	1200
9/3/1992	0.89	81	1200
10/2/1992	1.68	120	1200
11/3/1992	0.89	340	1210
4/1/1993	10.47	772	7820
4/27/1993	4.18	403	830
6/4/1993	1.15	110	1380
7/6/1993	1.20	79	1240
8/2/1993	1.04	225	940
9/3/1993	1.20	144	1200
10/1/1993	1.32	151	1170

STATION SBC2-75			
	DISCHARGE		
DATE	(CFS)	TSS (MG/L)	TDS (MG/L)
3/12/1986		694	768
9/28/1987	2.66	66	1190
11/11/1987	4.19	161	1210
3/1/1988	96.57	1090	546
3/3/1988	118.24	542	626
3/22/1988	170.49		
5/9/1988	6.02	201	1760
6/23/1988	7.03	59	1240
7/28/1988	6.81	115	1150
8/26/1988	4.59	73	1160
9/30/1988		105	1090
10/31/1988		66	1300
3/13/1989	23.45	2950	446
4/19/1989	1.82	149	1830
6/27/1989	1.63	18	1660
7/13/1989	2.24	3340	476
7/24/1989	0.94	38	2180
9/5/1989	1.46	95	1340
10/10/1989	1.46	103	1350
11/13/1989	0.99	108	1410
3/5/1990	39.23	245	944
4/24/1990	1.46	189	1536
5/15/1990	1.78	381	1934
6/8/1990	1.86	78	1780
7/6/1990	1.67	30	1606
8/27/1990	1.42	121	1470
9/7/1990	1.94	83	1964
10/2/1990	2.29	269	1416
4/19/1991	5.40	17980	542
5/8/1991	1.06	215	1746
6/11/1991	1.76	668	884
7/10/1991	2.70	211	2604
8/12/1991	0.27	22	1290
9/3/1991	0.18	19	922
10/4/1991	0.66	80	1302
3/3/1992	44.31	1210	920
4/2/1992	7.61	2460	280
5/5/1992	0.53	60	1820
6/1/1992	1.33	62	1500
7/13/1992	0.70	390	690
8/4/1992	0.21	29	1600
9/3/1992	0.70	75	1600
10/2/1992	0.99	70	1400
11/3/1992	1.03	100	1260
4/1/1993	14.27	360	3240
4/26/1993	1.13	729	960
6/4/1993	1.41	420	860
7/6/1993	0.85	19	1140
8/2/1993	0.87	52	782
9/3/1993	1.13	48	1270
10/1/1993	1.28	70	1220

TABLE 9. DISCHARGE AND WATER QUALITY FOR SITES SBC1-75 AND SBC2-75 (1986 - 2024)

STATION SBC1-75			
	DISCHARGE		
DATE	(CFS)	TSS (MG/L)	TDS (MG/L)
11/2/1993	3.39	283	1480
3/15/1994	8.13	3580	562
3/30/1994	0.67		
4/20/1994	0.89	260	1330
5/16/1994	5.04	3050	2020
6/8/1994	0.34	146	1220
7/5/1994	0.81	36	1420
8/4/1994	0.04	314	936
8/31/1994	0.01	145	1460
9/30/1994		352	1250
10/11/1994	0.16	476	776
11/1/1994	0.08	118	1310
1/31/1995	28.14		
2/6/1995		187	352
3/1/1995	31.97	390	504
3/31/1995	0.85		
5/2/1995	0.58	178	1540
5/17/1995	0.54	114	1180
6/2/1995	4.28	378	1150
7/6/1995	0.49	35	1580
7/26/1995	1.00	54	1050
8/1/1995	DRY		
9/6/1995	0.47	111	800
10/2/1995	0.67	142	1180
10/19/1995	0.45	108	1100
11/9/1995	0.85	184	702
2/9/1996	44.08	75	1220
3/29/1996	1.35	500	2780
4/30/1996	1.07	244	1480
5/14/1996	0.84	118	1370
5/31/1996	6.27	9150	650
6/27/1996	0.68	108	1330
7/29/1996	DRY		
8/30/1996	DRY		
10/7/1996	0.18	13	1440
10/14/1996	0.16	16	1450
11/4/1996	0.59	50	1250
4/10/1997	2.54	650	1070
5/12/1997	0.80	88	1120
6/17/1997	1.89	164	1000
7/10/1997	1.56	40	930
8/12/1997	2.54	34	850
9/15/1997	1.45	56	910
10/2/1997	1.45	130	
10/21/1997	1.45	55	1000
4/28/1998	1.33	142	1260
6/15/1998	5.95	57	900
7/14/1998	3.50	20	840
8/12/1998	3.88	80	890
9/16/1998	3.69	11	870
10/7/1998	3.79	92	990

STATION SBC2-75			
	DISCHARGE		
DATE	(CFS)	TSS (MG/L)	TDS (MG/L)
11/2/1993	1.03	90	1340
3/15/1994	8.37	1780	488
3/30/1994	0.90		
4/20/1994	1.06	64	1380
5/16/1994	3.01	204	1480
6/8/1994	0.87	14	1300
7/5/1994	DRY		
8/4/1994	DRY		
8/31/1994	DRY		
9/30/1994		10	782
10/11/1994	0.72	284	476
11/1/1994	0.19	4	1340
1/31/1995	7.98		
2/6/1995		30	320
3/1/1995	11.94	520	438
3/31/1995	1.45		
4/26/1995	1.24	65	1620
5/2/1995	1.27	92	1540
6/2/1995	2.97	271	1070
7/6/1995	0.33	17	1510
7/26/1995	1.35	20	1800
8/1/1995	0.19	80	1840
9/6/1995	0.87	72	722
10/2/1995	1.30	96	904
10/20/1995	1.41	116	686
11/9/1995	2.33	53	792
2/15/1996	10.84	114	366
3/29/1996	1.46	192	856
4/30/1996	0.66	56	1580
5/14/1996		676	1520
5/31/1996		254	720
6/27/1996	0.74	38	1410
7/29/1996	DRY		
8/30/1996	DRY		
10/7/1996	DRY		
10/14/1996	DRY		
11/4/1996	0.68	8	1610
4/9/1997	0.64	420	1510
5/19/1997	0.44	62	1260
6/18/1997	0.82	112	980
7/10/1997	1.13	43	970
8/14/1997	1.71	172	840
9/22/1997	1.46	1700	430
10/1/1997	1.11	174	
10/22/1997	0.55	180	1880
4/29/1998	0.89	102	1130
6/15/1998	2.91	50	900
7/14/1998	2.35	15	870
8/12/1998	1.83	70	910
9/16/1998	1.76	18	890
10/7/1998	1.73	23	1000

TABLE 9. DISCHARGE AND WATER QUALITY FOR SITES SBC1-75 AND SBC2-75 (1986 - 2024)

STATION SBC1-75			
	DISCHARGE		
DATE	(CFS)	TSS (MG/L)	TDS (MG/L)
11/17/1998	5.14	48	980
4/14/1999	0.51	176	890
5/13/1999	0.41	192	
6/11/1999	0.41	80	
7/16/1999	4.39	142	
8/26/1999	0.41	40	
9/8/1999	0.57	200	530
10/21/1999	0.70	190	1150
11/8/1999	0.57	60	1300
3/29/2000	2.51	620	1240
4/28/2000	0.25	160	1220
5/29/2000	0.02	36	1400
7/14/2000	0.07	14	1950
8/24/2000	0.03	22	2460
9/25/2000	0.02	30	1240
4/26/2001	0.03	2500	1150
5/31/2001	0.03	76	1280
6/13/2001	1.60	118	1345
7/3/2001	0.04	82	1638
9/11/2001	0.03	26	1160
4/19/2002	0.02	136	1270
5/20/2002	<0.01	50	1340
4/3/2003	20.93	4260	310
4/9/2004	Invalid	310	1290
5/19/2004	Invalid	64	1300
6/24/2004	3.40	1160	32
9/21/2004	0.11		
11/1/2004	0.41	1430	490
4/26/2005	2.51	196	1300
5/26/2005	1.09	208	1310
6/11/2005	0.25	176	1700
10/2/2005	0.54	<5	1560
3/23/2006			
4/28/2006	0.91	43	740
5/31/2006	0.03		
8/30/2006			
9/29/2006	0.38		
10/25/2006	0.70	1240	1320
3/24/2007	0.91	140	1100
4/15/2007	0.70	37	1000
8/14/2007			
9/26/2007	3.40	7800	720
10/13/2007	DRY		
11/27/2007	Frozen		
12/15/2007	Frozen		
1/31/2008			
2/27/2008			
3/14/2008	35.78	80	540
4/12/2008	2.51	360	520
5/25/2008	0.91	148	1190
6/21/2008			

STATION SBC2-75			
	DISCHARGE		
DATE	(CFS)	TSS (MG/L)	TDS (MG/L)
11/17/1998	2.04	42	1110
4/14/1999	1.25	188	660
5/13/1999		176	
6/11/1999		88	
7/16/1999		12	
8/26/1999		44	
9/8/1999		2150	630
10/21/1999		80	1200
11/8/1999		68	1280
3/29/2000	5.67	460	3360
4/28/2000	1.11	70	1190
5/29/2000	0.80	20	1010
7/14/2000			
8/24/2000			
9/25/2000			
4/26/2001	0.01	1900	970
5/31/2001	0.01	56	1450
6/13/2001	0.43	40	1470
7/3/2001			
9/11/2001			
4/19/2002	0.99	44	1190
5/20/2002	0.52	10	1560
4/3/2003	6.94	4100	360
4/9/2004	Invalid	92	1130
5/19/2004	Invalid	34	1500
6/24/2004	Invalid	1880	24
9/21/2004	0.17		
11/1/2004	2.09	1620	450
4/26/2005	0.85	212	1340
5/26/2005	1.83	76	1240
6/11/2005	1.39	60	1490
10/2/2005			
3/23/2006	0.99	<5	680
4/28/2006	0.21	54	500
5/31/2006			
8/30/2006	0.10		
9/29/2006	0.01	84	760
10/29/2006	1.37	34	1340
3/24/2007	0.07	60	820
4/15/2007	0.53	27	760
8/14/2007	0.36	12	730
9/26/2007	3.61	11100	360
10/13/2007	DRY		
11/27/2007	Frozen		
12/15/2007	Frozen		
1/31/2008			
2/27/2008			
3/14/2008			
4/12/2008	1.07	260	490
5/25/2008	0.53	18	1200
6/21/2008	0.02		

TABLE 9. DISCHARGE AND WATER QUALITY FOR SITES SBC1-75 AND SBC2-75 (1986 - 2024)

STATION SBC1-75			
DATE	DISCHARGE (CFS)	TSS (MG/L)	TDS (MG/L)
7/19/2008			
8/30/2008			
9/27/2008			
10/25/2008	1.09	60	1120
11/15/2008	1.09	20	980
12/6/2008			
1/2/2009	Frozen		
2/22/2009	Frozen		
3/7/2009	0.25	1090	410
3/21/2009	0.41	284	570
4/29/2009	1.74	1500	770
5/28/2009	6.68	4700	1170
6/30/2009	0.25	96	830
7/11/2009	Damp		
8/19/2009	Damp		
9/26/2009	Damp		
10/26/2009	Frozen		
11/18/2009	Frozen		
12/14/2009	Frozen		
1/6/2010	Frozen		
2/3/2010	Frozen		
3/29/2010	0.58	122	670
4/30/2010	1.22	102	920
5/26/2010	1.48	6540	1060
6/15/2010			
7/1/2010	0.29	23	1240
8/25/2010			
9/29/2010			
10/28/2010	0.44	27	1060
11/24/2010			
12/22/2010			
1/24/2011			
2/3/2011			
3/3/2011	Invalid	166	510
4/1/2011	6.68	348	540
5/23/2011	9.54	3940	510
6/6/2011			
7/7/2011	4.67	14	950
8/23/2011			
8/30/2011	2.96	14	810
9/2/2011	9.95	708	510
9/29/2011	1.94	34	900
10/4/2011			
11/3/2011	9.95	64	920
12/2/2011			
4/17/2012	1.94	50	1050
5/10/2012	0.63	55	1200
6/8/2012	0.48	27	1340
9/21/2012	0.63	34	970
9/28/2012	1.58	32	1090
10/15/2012	2.32	13	1200
5/4/2013	0.70		
6/3/2013	0.41		

STATION SBC2-75			
DATE	DISCHARGE (CFS)	TSS (MG/L)	TDS (MG/L)
7/19/2008			
8/30/2008			
9/27/2008	0.36		
10/25/2008	0.60		
11/15/2008	0.47	15	1130
12/6/2008			
1/2/2009	Frozen		
2/22/2009	Frozen		
3/7/2009	1.96	750	380
3/21/2009	1.83	512	500
4/29/2009	6.36	2220	460
5/28/2009	3.03	6200	790
6/22/2009	2.45	40	590
7/11/2009	0.60	34	480
8/19/2009	0.53		
9/26/2009	Dry		
10/26/2009	Frozen		
11/18/2009	Frozen		
12/14/2009	Frozen		
1/6/2010	Frozen		
2/3/2010	Frozen		
3/29/2010	1.66	124	530
4/30/2010	0.97	90	620
5/28/2010	1.03	32	1400
6/18/2010			
7/1/2010	0.57	<5	800
8/26/2010			
9/29/2010			
10/26/2010	0.23	25	760
11/24/2010			
12/22/2010			
1/24/2011			
2/3/2011			
3/3/2011	Invalid	82	400
4/1/2011	2.40	248	470
5/23/2011	3.06	1080	1030
6/6/2011			
7/7/2011	1.08	17	1020
8/23/2011	1.22		
8/30/2011	0.85	36	640
9/2/2011	0.73	32	770
9/29/2011	1.08	32	930
10/4/2011			
11/3/2011	0.39	18	1040
12/2/2011			
4/17/2012	1.37	300	1090
5/11/2012	1.08	127	1470
6/8/2012	0.60	52	1660
9/21/2012			
9/28/2012	0.73	14	1060
10/15/2012	0.85	28	1210
5/4/2013	0.99		
6/3/2013	0.21		

TABLE 9. DISCHARGE AND WATER QUALITY FOR SITES SBC1-75 AND SBC2-75 (1986 - 2024)

STATION SBC1-75			
	DISCHARGE		
DATE	(CFS)	TSS (MG/L)	TDS (MG/L)
9/30/2013	5.48	3160	390
2/18/2014	Frozen	115	280
3/20/2014	0.49	22	820
4/10/2014	1.05	310	1100
5/28/2014	8.55	40	830
9/9/2014	6.73	617	770
9/30/2014	34.88	518	1030
3/16/2015	3.20	1130	420
4/13/2015	0.66	66	1170
5/5/2015	0.49		1280
6/15/2015	0.37	38	1200
7/6/2015	53.35	2900	480
11/9/2015	0.49	40	1330
3/10/2016	4.77	614	310
4/12/2016	34.88	15640	474
5/4/2016	6.73	8	410
6/6/2016	<0.10	32	1003
10/10/2016	2.54	54	400
11/7/2016	0.82	9	936
2/21/2017	315.32	1358	229
3/17/2017	29.46	2944	300
4/5/2017	2.54	1754	460
5/8/2017	1.86	76	1100
6/6/2017	1.27	48	714
9/26/2017	6.73	11	633
10/9/2017	1.86	6	598
11/20/2017	2.54	35	873
3/27/2018	40.68	124	558
4/16/2018	34.88	64	811
5/29/2018	9.33	30	1172
5/14/2019	6.73	41	443
6/10/2019	2.54		920
10/7/2019	16.20		840
6/2/2020	24.62	8	870
10/7/2020	16.20	68	930
5/10/2022	4.54	110	1070
5/1/2023	284.22	2040	210
6/5/2023	240.03		

STATION SBC2-75			
	DISCHARGE		
DATE	(CFS)	TSS (MG/L)	TDS (MG/L)
9/30/2013	1.83	57	370
2/18/2014	Frozen	180	310
3/20/2014	3.53	33	600
4/10/2014	2.92	11	1030
5/28/2014	2.63	6300	760
9/9/2014	3.27	4020	540
9/30/2014	8.54	906	600
3/16/2015	7.15	1120	850
4/13/2015	4.57	23	1310
5/5/2015	3.21		1290
6/5/2015	5.35	46	610
7/6/2015	59.18	6050	520
8/4/2015	5.35	16	690
3/10/2016	25.38	530	340
4/12/2016	6.72	58	441
5/4/2016	13.69	127	340
6/6/2016	2.12	14	617
10/10/2016	3.85	98	380
11/7/2016	2.38	36	876
2/21/2017	233.81	1416	229
3/17/2017	20.98	2560	300
4/5/2017	3.85	6132	355
5/8/2017	1.66	590	1130
6/6/2017	1.66	36	720
9/26/2017	3.21	39	426
10/9/2017	2.12	14	712
11/20/2017	0.93	14	878
3/27/2018	8.54	64	508
4/16/2018	6.72	39	2470
5/29/2018	3.21	30	1186
5/14/2019	5.35	41	405
6/10/2019	3.21		660
10/7/2019	2.63		920
6/2/2020	2.63	17	950
10/7/2020	1.27	21	920
5/10/2022	1.66	17	720
5/1/2023	63.17	1190	240
6/5/2023	30.40		

Current report period sampling conducted by Black Butte Mine personnel.
Samples are typically analyzed as soon as possible after collection.
2010 reported flow measurements are REVISED from initial submittal.
Invalid flow measurement due to ice at SBC1-75 & SBC2-75 on 3/3/2011.
No samples were taken on 5/4/2013 or 6/3/2013.
TSS was not analyzed 5/5/2015, 6/10/2019 & 10/7/2019.
Reported values for SBC1-75 and SBC2-75 on February 21, 2017 may have been affected by ice in channels.
No samples obtained during the 2021 report period.
No samples obtained on 6/5/2023.
No samples obtained during the 2024 report period.

TABLE 10. DESCRIPTIVE STATISTICS FOR HISTORICAL TSS AND TDS CONCENTRATIONS AT SBC1-75 AND SBC2-75 (MAR 1986 - NOV 30, 2024).

SITE SBC1-75

	TSS	TDS		TSS*	TDS*
Mean	639	1095	Mean	565	1064
Standard Error	126.6	46.4	Standard Error	101.2	30.4
Median	111	1100	Median	111	1100
Mode	80	1200	Mode	80	1200
Standard Deviation	1767.5	644.7	Standard Deviation	1406.0	420.7
Sample Variance	3124192	415584	Sample Variance	1976968	177030
Kurtosis	33.77	61.36	Kurtosis	21.19	1.21
Skewness	5.26	6.03	Skewness	4.32	0.47
Range	15645	7610	Range	9785	2570
Minimum	-5	210	Minimum	5	210
Maximum	15640	7820	Maximum	9790	2780
Sum	124587	211319	Sum	108952	203270
Count	195	193	Count	193	191
Confidence Level(95.0%)	248.1	90.9	Confidence Level(95.0%)	198.4	59.7

SITE SBC2-75

	TSS	TDS		TSS*	TDS*
Mean	602	1041	Mean	489	1031
Standard Error	135.7	38.7	Standard Error	97.0	36.9
Median	76	970	Median	76	970
Mode	14	1340	Mode	14	1340
Standard Deviation	1850	525	Standard Deviation	1315	497
Sample Variance	3423497	275457	Sample Variance	1730476	247463
Kurtosis	48.22	2.71	Kurtosis	29.33	1.55
Skewness	6.23	1.13	Skewness	4.94	0.83
Range	17985.0	3131.0	Range	11105.0	3148.0
Minimum	-5	229	Minimum	-5	92
Maximum	17980	3360	Maximum	11100	3240
Sum	112042	191537	Sum	90059	187680
Count	186	184	Count	184	182
Confidence Level(95.0%)	265.9	75.8	Confidence Level(95.0%)	190.1	72.3

* THE HIGHEST AND LOWEST VALUES HAVE BEEN REMOVED.
**This table remains the same as the 2023 annual report due to no samples in 2024.

TABLE 11. BITTER CREEK TOTAL DISSOLVED SOLIDS LOAD DATA

	SBC1-75				SBC2-75		
DATE	DISCHARGE (CFS)	TOTAL DISSOLVED SOLIDS (MG/L)	DISSOLVED SOLIDS LOAD (TONS/DAY) *	DATE	DISCHARGE (CFS)	TOTAL DISSOLVED SOLIDS (MG/L)	DISSOLVED SOLIDS LOAD (TONS/DAY) *
3/28/1986		770		3/28/1986		768	
9/28/1987	0.10	1190	0.32	9/28/1987	2.66	1190	8.54
11/11/1987	0.27	1180	0.86	11/11/1987	4.19	1210	13.67
3/1/1988	94.31	488	124.12	3/1/1988	96.57	546	142.21
3/3/1988	122.49	552	182.36	3/3/1988	118.24	626	199.63
5/9/1988	1.46	1480	5.83	5/9/1988	6.02	1760	28.58
6/23/1988	2.72	1180	8.66	6/23/1988	7.03	1240	23.51
7/28/1988	2.72	1100	8.07	7/28/1988	6.81	1150	21.12
8/26/1988	3.48	1180	11.07	8/26/1988	4.59	1160	14.36
3/13/1989	22.96	506	31.33	3/13/1989	23.45	446	28.21
4/19/1989	0.01	1760	0.05	4/19/1989	1.82	1830	8.98
6/27/1989	0.01	1650	0.04	6/27/1989	1.63	1660	7.30
7/13/1989	0.01	1920	0.05	7/13/1989	2.24	476	2.88
7/24/1989	0.01	2220	0.06	7/24/1989	0.94	2180	5.53
8/5/1989	0.01	1440	0.04	8/5/1989	1.46	1340	5.28
10/10/1989	0.01	1350	0.04	10/10/1989	1.46	1350	5.32
11/13/1989	0.01	1750	0.05	11/13/1989	0.99	1410	3.76
3/5/1990	47.54	654	83.85	3/5/1990	39.23	944	99.88
4/24/1990	0.01	1638	0.04	4/24/1990	1.46	1536	6.05
5/15/1990	0.01	1730	0.05	5/15/1990	1.78	1934	9.28
6/8/1990	0.06	1638	0.27	6/8/1990	1.86	1780	8.93
7/6/1990	0.30	1536	1.24	7/6/1990	1.67	1606	7.23
8/27/1990	0.38	1460	1.50	8/27/1990	1.42	1470	5.63
9/17/1990	0.30	1440	1.17	9/17/1990	1.94	1964	10.28
10/2/1990	0.30	1340	1.08	10/2/1990	2.29	1416	8.75
4/19/1991	0.49	792	1.05	4/19/1991	5.40	542	7.89
5/8/1991	0.11	1360	0.40	5/8/1991	1.06	1746	4.99
6/11/1991	0.22	880	0.52	6/11/1991	1.76	884	4.20
7/10/1991	0.12	508	0.16	7/10/1991	2.70	2604	18.96
8/12/1991	0.11	1820	0.54	8/12/1991	0.27	1290	0.94
9/3/1991	0.10	1356	0.37	9/3/1991	0.18	922	0.45
10/4/1991	0.05	1312	0.18	10/4/1991	0.66	1302	2.32
3/3/1992	63.78	290	49.88	3/3/1992	44.31	920	109.94
4/2/1992	2.15	340	1.97	4/2/1992	7.61	280	5.75
5/5/1992	0.38	1720	1.76	5/5/1992	0.53	1820	2.60
6/1/1992	0.51	1400	1.93	6/1/1992	1.33	1500	5.38
7/13/1992	0.81	1200	2.62	7/13/1992	0.70	690	1.30
8/4/1992	0.81	1200	2.62	8/4/1992	0.21	1600	0.91
9/3/1992	0.89	1200	2.88	9/3/1992	0.70	1600	3.02
10/2/1992	1.68	1200	5.44	10/2/1992	0.99	1400	3.74
11/3/1992	0.89	1210	2.90	11/3/1992	1.03	1260	3.50
4/1/1993	10.47	7820	220.82	4/1/1993	14.27	3240	124.70
4/26/1993	4.18	830	9.36	4/26/1993	1.13	960	2.93
6/4/1993	1.15	1380	24.25	6/4/1993	1.41	860	12.32
7/6/1993	1.20	1240	4.01	7/6/1993	0.85	1140	2.61
8/2/1993	1.04	940	2.64	8/2/1993	0.87	782	1.83
9/3/1993	1.20	1200	4.01	9/3/1993	1.13	1270	3.47
10/1/1993	1.32	1170	4.17	10/1/1993	1.28	1220	4.21
11/2/1993	3.39	1480	13.53	11/2/1993	1.03	1340	3.72
3/15/1994	8.13	562	12.32	3/15/1994	8.37	488	11.02
4/20/1994	0.89	1330	3.19	4/20/1994	1.06	1380	3.95
5/16/1994	5.04	2020	27.46	5/16/1994	3.01	1480	12.01

TABLE 11. BITTER CREEK TOTAL DISSOLVED SOLIDS LOAD DATA

	SBC1-75				SBC2-75		
DATE	DISCHARGE (CFS)	TOTAL DISSOLVED SOLIDS (MG/L)	DISSOLVED SOLIDS LOAD (TONS/DAY) *	DATE	DISCHARGE (CFS)	TOTAL DISSOLVED SOLIDS (MG/L)	DISSOLVED SOLIDS LOAD (TONS/DAY) *
6/8/1994	0.34	1220	1.12	6/8/1994	0.87	1300	3.05
7/5/1994	0.81	1420	3.10	7/5/1994	DRY		
8/4/1994	0.04	936	0.10	8/4/1994	DRY		
8/31/1994	0.01	1460	0.04	8/31/1994	DRY		
10/11/1994	0.16	776	0.33	10/11/1994	0.72	476	0.92
11/1/1994	0.08	1310	0.28	11/1/1994	0.19	1340	0.69
3/1/1995	31.97	504	43.46	3/1/1995	11.94	438	14.10
5/2/1995	0.58	1540	2.41	4/26/1995	1.24	1620	5.42
5/17/1995	0.54	1180	1.72	5/2/1995	1.27	1540	5.27
6/2/1995	4.28	1150	13.27	6/2/1995	2.97	1070	8.57
7/6/1995	0.49	1580	2.09	7/6/1995	0.33	1510	1.34
7/26/1995	1.00	1050	2.83	7/26/1995	1.35	1800	6.55
8/1/1995	DRY			8/1/1995	0.19	1840	0.94
9/6/1995	0.47	800	1.01	9/6/1995	0.87	722	1.69
10/2/1995	0.67	1180	2.13	10/2/1995	1.30	904	3.17
10/19/1995	0.45	1100	1.34	10/20/1995	1.41	686	2.61
11/9/1995	0.85	702	1.61	11/9/1995	2.33	792	4.98
2/9/1996	44.08	1220	145.04	2/15/1996	10.84	366	10.70
3/29/1996	1.35	2780	10.12	3/29/1996	1.46	856	3.37
4/30/1996	1.07	1480	4.27	4/30/1996	0.66	1580	2.81
5/14/1996	0.84	1370	3.10	5/14/1996		1520	
5/31/1996	6.27	650	10.99	5/31/1996		720	
6/27/1996	0.68	1330	2.44	6/27/1996	0.74	1410	2.81
7/29/1996	DRY			7/29/1996	DRY		
8/30/1996	DRY			8/30/1996	DRY		
10/7/1996	0.18	1440	0.70	10/7/1996	DRY		
10/14/1996	0.16	1450	0.63	10/14/1996	DRY		
11/4/1996	0.59	1250	1.99	11/4/1996	0.68	1610	2.95
4/10/1997	2.54	1070	7.33	4/9/1997	0.64	1510	2.61
5/12/1997	0.80	1120	2.42	5/19/1997	0.44	1260	1.50
6/17/1997	1.89	1000	5.10	6/18/1997	0.82	980	2.17
7/10/1997	1.56	930	3.91	7/10/1997	1.13	970	2.96
8/12/1997	2.54	850	5.82	8/14/1997	1.71	840	3.87
9/15/1997	1.45	910	3.56	9/22/1997	1.46	430	1.69
10/2/1997	1.45			10/1/1997	1.11		
10/21/1997	1.45	1000	3.91	10/22/1997	0.55	1880	2.79
4/28/1998	1.33	1260	4.52	4/29/1998	0.89	1130	2.71
6/15/1998	5.95	900	14.44	6/15/1998	2.91	900	7.06
7/14/1998	3.50	840	7.93	7/14/1998	2.35	870	5.51
8/12/1998	3.88	890	9.31	8/12/1998	1.83	910	4.49
9/16/1998	3.69	870	8.66	9/16/1998	1.76	890	4.22
10/7/1998	3.79	990	10.12	10/7/1998	1.73	1000	4.67
11/17/1998	5.14	980	13.59	11/17/1998	2.04	1110	6.11
4/14/1999	0.51	890	1.22	4/14/1999	1.25	660	2.23
5/13/1999	0.41			5/13/1999	DRY		
6/11/1999	0.41			6/11/1999	DRY		
7/16/1999	4.39			7/16/1999	DRY		
8/26/1999	0.41			8/26/1999	DRY		
9/8/1999	0.57	530	0.81	9/8/1999		630	
10/21/1999	0.70	1150	2.17	10/21/1999		1200	
11/8/1999	0.57	1300	2.00	11/8/1999		1280	
3/29/2000	2.51	1240	8.39	3/29/2000	5.67	3360	51.38

TABLE 11. BITTER CREEK TOTAL DISSOLVED SOLIDS LOAD DATA

	SBC1-75				SBC2-75		
DATE	DISCHARGE (CFS)	TOTAL DISSOLVED SOLIDS (MG/L)	DISSOLVED SOLIDS LOAD (TONS/DAY) *	DATE	DISCHARGE (CFS)	TOTAL DISSOLVED SOLIDS (MG/L)	DISSOLVED SOLIDS LOAD (TONS/DAY) *
4/28/2000	0.25	1220	0.82	4/28/2000	1.11	1190	3.56
5/29/2000	0.02	1400	0.08	5/29/2000	0.80	1010	2.18
7/14/2000	0.07	1950	0.37	4/26/2001	0.01	970	0.03
8/24/2000	0.03	2460	0.20	5/31/2001	0.01	1450	0.04
9/25/2000	0.02	1240	0.07	6/13/2001	0.43	1470	1.70
4/26/2001	0.03	1150	0.09	4/18/2002	0.99	1190	3.18
5/31/2001	0.03	1280	0.10	5/20/2002	0.52	1560	2.19
6/13/2001	1.60	1345	5.80	4/3/2003	6.94	360	6.74
7/3/2001	0.04	1638	0.18	11/1/2004	2.09	450	2.54
9/11/2001	0.03	1160	0.09	4/26/2005	0.85	1340	3.07
4/18/2002	0.02	1270	0.07	5/26/2005	1.83	1240	6.12
5/20/2002	<0.01	1340	0.04	6/11/2005	1.39	1490	5.59
4/3/2003	20.93	310	17.50	3/23/2006	0.99	680	1.82
6/24/2004	3.40	1160	32.00	4/28/2006	0.21	500	0.28
11/1/2004	0.41	490	0.54	9/29/2006	0.01	760	0.02
4/26/2005	2.51	1300	8.80	10/29/2006	1.37	1340	4.95
5/26/2005	1.09	1310	3.85	3/24/2007	0.07	820	0.15
6/11/2005	0.25	1700	1.15	4/15/2007	0.53	760	1.09
10/2/2005	0.54	1560	2.27	8/14/2007	0.36	730	0.71
4/28/2006	0.91	740	1.82	9/26/2007	3.61	360	3.51
10/25/2006	0.70	1320	2.49	4/12/2008	1.07	490	1.41
3/24/2007	0.91	1100	2.70	5/25/2008	0.53	1200	1.72
4/15/2007	0.70	1000	1.89	11/15/2008	0.47	1130	1.43
9/26/2007	3.40	720	6.60	3/7/2009	1.96	380	2.01
3/14/2008	35.78	540	52.11	3/21/2009	1.83	500	2.47
4/12/2008	2.51	520	3.52	4/29/2009	6.36	460	7.89
5/25/2008	0.91	1190	2.92	5/28/2009	3.03	790	6.46
10/25/2008	1.09	1120	3.29	6/22/2009	2.45	590	3.90
11/15/2008	1.09	980	2.88	7/11/2009	0.60	480	0.78
3/7/2009	0.25	410	0.28	3/29/2010	1.66	530	2.37
3/21/2009	0.41	570	0.63	4/30/2010	0.97	620	1.62
4/29/2009	1.74	770	3.61	5/28/2010	1.03	1400	3.89
5/28/2009	6.68	1170	21.08	7/1/2010	0.57	800	1.23
6/30/2009	0.25	830	0.56	10/26/2010	0.23	760	0.47
3/29/2010	0.58	670	1.05	4/1/2011	2.40	470	3.04
4/30/2010	1.22	920	3.03	5/23/2011	3.06	1030	8.50
5/26/2010	1.48	1060	4.23	7/7/2011	1.08	1020	2.97
7/1/2010	0.29	1240	0.97	8/30/2011	0.85	640	1.47
10/28/2010	0.44	1060	1.26	9/2/2011	0.73	770	1.52
4/1/2011	6.68	540	9.73	9/29/2011	1.08	930	2.71
5/23/2011	9.54	510	13.12	11/3/2011	0.39	1040	1.09
7/7/2011	4.67	950	11.97	4/17/2012	1.37	1090	4.03
8/30/2011	2.96	810	6.47	5/11/2012	1.08	1470	4.28
9/2/2011	9.95	510	13.69	6/8/2012	0.60	1660	2.69
9/29/2011	1.94	900	4.71	9/28/2012	0.73	1060	2.09
11/3/2011	9.95	920	24.69	10/15/2012	0.85	1210	2.77
4/17/2012	1.94	1050	5.49	9/30/2013	1.83	370	1.83
5/10/2012	0.63	1200	2.04	2/18/2014		310	
6/8/2012	0.48	1340	1.73	3/20/2014	3.53	600	5.71
9/21/2012	0.63	970	1.65	4/10/2014	2.92	1030	8.11
9/28/2012	1.58	1090	4.64	5/28/2014	2.63	760	5.39
10/15/2012	2.32	1200	7.51	9/9/2014	3.27	540	4.76
9/30/2013	5.48	390	5.76	9/30/2014	8.54	600	13.82

TABLE 11. BITTER CREEK TOTAL DISSOLVED SOLIDS LOAD DATA

	SBC1-75				SBC2-75		
DATE	DISCHARGE (CFS)	TOTAL DISSOLVED SOLIDS (MG/L)	DISSOLVED SOLIDS LOAD (TONS/DAY) *	DATE	DISCHARGE (CFS)	TOTAL DISSOLVED SOLIDS (MG/L)	DISSOLVED SOLIDS LOAD (TONS/DAY) *
2/18/2014		280		3/16/2015	7.15	850	16.39
3/20/2014	0.49	820	1.08	4/13/2015	4.57	1310	16.15
4/10/2014	1.05	1100	3.12	5/5/2015	3.21	1290	11.17
5/28/2014	8.55	830	19.14	6/5/2015	5.35	610	8.80
9/9/2014	6.73	770	13.98	7/6/2015	59.18	520	83.00
9/30/2014	34.88	1030	96.89	8/4/2015	5.35	690	9.96
3/16/2015	3.20	420	3.62	3/10/2016	25.38	340	23.27
4/13/2015	0.66	1170	2.08	4/12/2016	6.72	441	7.99
5/5/2015	0.49	1280	1.69	5/4/2016	13.69	340	12.55
6/15/2015	0.37	1200	1.20	6/6/2016	2.12	617	3.53
7/6/2015	53.35	480	69.06	10/10/2016	3.85	380	3.95
11/9/2015	0.49	1330	1.76	11/7/2016	2.38	876	5.62
3/10/2016	4.77	310	3.99	2/21/2017	233.81	229	144.40
4/12/2016	34.88	474	44.59	3/17/2017	20.98	300	16.97
5/4/2016	6.73	410	7.44	4/5/2017	3.85	355	3.69
6/6/2016	<0.10	1003		5/8/2017	1.66	1130	5.06
10/10/2016	2.54	400	2.74	6/6/2017	1.66	720	3.22
11/7/2016	0.82	936	2.07	9/26/2017	3.21	426	3.69
2/21/2017	315.32	229	194.75	10/9/2017	2.12	712	4.07
3/17/2017	29.46	300	23.84	11/20/2017	0.93	878	2.20
4/5/2017	2.54	460	3.15	3/27/2018	8.54	508	11.70
5/8/2017	1.86	1100	5.52	4/16/2018	6.72	2470	44.77
6/6/2017	1.27	714	2.45	5/29/2018	3.21	1186	10.27
9/26/2017	6.73	633	11.49	5/14/2019	5.35	405	5.84
10/9/2017	1.86	598	3.00	6/10/2019	3.21	660	5.71
11/20/2017	2.54	873	5.98	10/7/2019	2.63	920	6.53
3/27/2018	40.68	558	61.22	6/2/2020	2.63	950	6.74
4/16/2018	34.88	811	76.29	10/7/2020	1.27	920	3.15
5/29/2018	9.33	1172	29.49	5/10/2022	1.66	720	3.22
5/14/2019	6.73	443	8.04	5/1/2023	63.17	240	40.89
6/10/2019	2.54	920	6.30	*6/5/2023*	30.40		
10/7/2019	16.20	840	36.70				
6/2/2020	24.62	870	57.77				
10/7/2020	16.20	930	40.63				
5/10/2022	4.54	1070	13.10				
5/1/2023	284.22	210	160.97				
6/5/2023	240.03						

* TDS LOAD = TOTAL DISSOLVED SOLIDS (MG/L) x DISCHARGE (CFS) x 0.002697

SBC1-75 Total dissolved solids load for 5/20/02 based upon substitued flow rate of 0.01 CFS.
Invalid flow measurment due to ice at SBC1-75 & SBC2-75 on 3/3/2011 and 2/18/2014; samples were collected but no load calculation possible for this table.
Reported values for SBC1-75 and SBC2-75 on February 21, 2017 may have been affected by ice in channels.
No samples obtained during the 2021 report period.
No samples obtained on 6/5/2023.
No samples obtained during the 2024 report period.

TABLE 12. BITTER CREEK TOTAL SUSPENDED SEDIMENT LOAD DATA

SBC1-75				SBC2-75			
DATE	DISCHARGE (CFS)	TOTAL SUSPENDED SOLIDS (MG/L)	SEDIMENT LOAD (TONS/DAY) *	DATE	DISCHARGE (CFS)	TOTAL SUSPENDED SOLIDS (MG/L)	SEDIMENT LOAD (TONS/DAY) *
3/28/1986		772		3/28/1986		694	
9/28/1987	0.10	87	0.02	9/28/1987	2.66	66	0.47
11/11/1987	0.27	147	0.11	11/11/1987	4.19	161	1.82
3/1/1988	94.31	371	94.37	3/1/1988	96.57	1090	283.89
3/3/1988	122.49	488	161.21	3/3/1988	118.24	542	172.84
5/9/1988	1.46	184	0.72	5/9/1988	6.02	201	3.26
6/23/1988	2.72	74	0.54	6/23/1988	7.03	59	1.12
7/28/1988	2.72	94	0.69	7/28/1988	6.81	115	2.10
8/26/1988	3.48	93	0.87	8/26/1988	4.59	73	0.91
3/13/1989	22.96	1930	119.51	3/13/1989	23.45	2950	186.57
4/19/1989	0.01	203	0.01	4/19/1989	1.82	149	0.73
6/27/1989	0.01	61	0.00	6/27/1989	1.63	18	0.08
7/13/1989	0.01	46	0.00	7/13/1989	2.24	3340	20.18
7/24/1989	0.01	39	0.00	7/24/1989	0.94	38	0.10
8/5/1989	0.01	79	0.00	8/5/1989	1.46	95	0.37
10/10/1989	0.01	80	0.00	10/10/1989	1.46	103	0.41
11/13/1989	0.01	141	0.00	11/13/1989	0.99	108	0.29
3/5/1990	47.54	371	47.57	3/5/1990	39.23	245	25.92
4/24/1990	0.01	180	0.00	4/24/1990	1.46	189	0.74
5/15/1990	0.01	232	0.01	5/15/1990	1.78	381	1.83
6/8/1990	0.06	76	0.01	6/8/1990	1.86	78	0.39
7/6/1990	0.30	32	0.03	7/6/1990	1.67	30	0.14
8/27/1990	0.38	31	0.03	8/27/1990	1.42	121	0.46
9/17/1990	0.30	186	0.15	9/17/1990	1.94	83	0.44
10/2/1990	0.30	180	0.15	10/2/1990	2.29	269	1.66
4/19/1991	0.49	9790	12.94	4/19/1991	5.40	17980	261.86
5/8/1991	0.11	270	0.08	5/8/1991	1.06	215	0.61
6/11/1991	0.22	220	0.13	6/11/1991	1.76	668	3.17
7/10/1991	0.12	3100	1.00	7/10/1991	2.70	211	1.54
8/12/1991	0.11	24	0.01	8/12/1991	0.27	22	0.02
9/3/1991	0.10	52	0.01	9/3/1991	0.18	19	0.01
10/4/1991	0.05	168	0.02	10/4/1991	0.66	80	0.14
3/3/1992	63.78	920	158.25	3/3/1992	44.31	1210	144.60
4/2/1992	2.15	2740	15.89	4/2/1992	7.61	2460	50.49
5/5/1992	0.38	106	0.11	5/5/1992	0.53	60	0.09
6/1/1992	0.51	110	0.15	6/1/1992	1.33	62	0.22
7/13/1992	0.81	74	0.16	7/13/1992	0.70	390	0.74
8/4/1992	0.81	110	0.24	8/4/1992	0.21	29	0.02
9/3/1992	0.89	81	0.19	9/3/1992	0.70	75	0.14
10/2/1992	1.68	120	0.54	10/2/1992	0.99	70	0.19
11/3/1992	0.89	340	0.82	11/3/1992	1.03	100	0.28
4/1/1993	10.47	772	21.80	4/1/1993	14.27	360	13.86
4/26/1993	4.18	403	4.54	4/26/1993	1.13	729	2.22
6/4/1993	1.15	110	2.39	6/4/1993	1.41	420	1.37
7/6/1993	1.20	79	0.26	7/6/1993	0.85	19	0.04
8/2/1993	1.04	225	0.63	8/2/1993	0.87	52	0.12
9/3/1993	1.20	144	0.47	9/3/1993	1.13	48	0.15
10/1/1993	1.32	151	0.54	10/1/1993	1.28	70	0.24
11/2/1993	3.39	283	2.59	11/2/1993	1.03	90	0.25

TABLE 12. BITTER CREEK TOTAL SUSPENDED SEDIMENT LOAD DATA

	SBC1-75				SBC2-75		
DATE	DISCHARGE (CFS)	TOTAL SUSPENDED SOLIDS (MG/L)	SEDIMENT LOAD (TONS/DAY) *	DATE	DISCHARGE (CFS)	TOTAL SUSPENDED SOLIDS (MG/L)	SEDIMENT LOAD (TONS/DAY) *
3/15/1994	8.13	3580	78.50	3/15/1994	8.37	1780	40.18
4/20/1994	0.89	260	0.62	4/20/1994	1.06	64	0.18
5/16/1994	5.04	3050	41.46	5/16/1994	3.01	204	1.66
6/8/1994	0.34	146	0.13	6/8/1994	0.87	14	0.03
7/5/1994	0.81	36	0.08	7/5/1994	DRY		
8/4/1994	0.04	314	0.03	8/4/1994	DRY		
8/31/1994	0.01	145	0.00	8/31/1994	DRY		
10/11/1994	0.16	476	0.21	10/11/1994	0.72	284	0.55
11/1/1994	0.08	118	0.03	11/1/1994	0.19	4	0.00
3/1/1995	31.97	390	33.63	3/1/1995	11.94	520	16.75
5/2/1995	0.58	178	0.28	4/26/1995	1.24	65	0.22
5/17/1995	0.54	114	0.17	5/2/1995	1.27	92	0.32
6/2/1995	4.28	378	4.36	6/2/1995	2.97	271	2.17
7/6/1995	0.49	35	0.05	7/6/1995	0.33	17	0.02
7/26/1995	1.00	54	0.15	7/26/1995	1.35	20	0.07
8/1/1995	DRY			8/1/1995	0.19	80	0.04
9/6/1995	0.47	111	0.14	9/6/1995	0.87	72	0.17
10/2/1995	0.67	142	0.26	10/2/1995	1.30	96	0.34
10/19/1995	0.45	108	0.13	10/20/1995	1.41	116	0.44
11/9/1995	0.85	184	0.42	11/9/1995	2.33	53	0.33
2/9/1996	44.08	75	8.92	2/15/1996	10.84	114	3.33
3/29/1996	1.35	500	1.82	3/29/1996	1.46	192	0.76
4/30/1996	1.07	244	0.70	4/30/1996	0.66	56	0.10
5/14/1996	0.84	118	0.27	5/14/1996		676	
5/31/1996	6.27	9150	154.73	5/31/1996		254	
6/27/1996	0.68	108	0.20	6/27/1996	0.74	38	0.08
7/29/1996	DRY			7/29/1996	DRY		
8/30/1996	DRY			8/30/1996	DRY		
10/7/1996	0.18	13	0.01	10/7/1996	DRY		
10/14/1996	0.16	16	0.01	10/14/1996	DRY		
11/4/1996	0.59	50	0.08	11/4/1996	0.68	8	0.01
4/10/1997	2.54	650	4.45	4/9/1997	0.64	420	0.72
5/12/1997	0.80	88	0.19	5/19/1997	0.44	62	0.07
6/17/1997	1.89	164	0.84	6/18/1997	0.82	112	0.25
7/10/1997	1.56	40	0.17	7/10/1997	1.13	43	0.13
8/12/1997	2.54	34	0.23	8/14/1997	1.71	172	0.79
9/15/1997	1.45	56	0.22	9/22/1997	1.46	1700	6.69
10/2/1997	1.45	130	0.51	10/1/1997	1.11	174	0.52
10/21/1997	1.45	55	0.22	10/22/1997	0.55	180	0.27
4/28/1998	1.33	142	0.51	4/29/1998	0.89	102	0.24
6/15/1998	5.95	57	0.91	6/15/1998	2.91	50	0.39
7/14/1998	3.50	20	0.19	7/14/1998	2.35	15	0.10
8/12/1998	3.88	80	0.84	8/12/1998	1.83	70	0.35
9/16/1998	3.69	11	0.11	9/16/1998	1.76	18	0.09
10/7/1998	3.79	92	0.94	10/7/1998	1.73	23	0.11
11/17/1998	5.14	48	0.67	11/17/1998	2.04	42	0.23
4/14/1999	0.51	176	0.24	4/14/1999	1.25	188	0.63
5/13/1999	0.41	192	0.21	5/13/1999		176	
6/11/1999	0.41	80	0.09	6/11/1999		88	

TABLE 12. BITTER CREEK TOTAL SUSPENDED SEDIMENT LOAD DATA

SBC1-75				SBC2-75			
DATE	DISCHARGE (CFS)	TOTAL SUSPENDED SOLIDS (MG/L)	SEDIMENT LOAD (TONS/DAY) *	DATE	DISCHARGE (CFS)	TOTAL SUSPENDED SOLIDS (MG/L)	SEDIMENT LOAD (TONS/DAY) *
7/16/1999	4.39	142	1.68	7/16/1999		12	
8/26/1999	0.41	40	0.04	8/26/1999		44	
9/8/1999	0.57	200	0.31	9/8/1999		2150	
10/21/1999	0.70	190	0.36	10/21/1999		80	
11/8/1999	0.57	60	0.09	11/8/1999		68	
3/29/2000	2.51	620	4.20	3/29/2000	5.67	460	7.03
4/28/2000	0.25	160	0.11	4/28/2000	1.11	70	0.21
5/29/2000	0.02	36	0.00	5/29/2000	0.80	20	0.04
7/14/2000	0.07	14	0.00	4/26/2001	0.01	1900	0.05
8/24/2000	0.03	22	0.00	5/31/2001	0.01	56	0.00
9/25/2000	0.02	30	0.00	6/13/2001	0.43	40	0.05
4/26/2001	0.03	2500	0.20	4/18/2002	0.99	44	0.12
5/31/2001	0.03	76	0.01	5/20/2002	0.52	10	0.01
6/13/2001	1.60	118	0.51	4/3/2003	6.94	4100	76.74
7/3/2001	0.04	82	0.01	11/1/2004	2.09	1620	9.13
9/11/2001	0.03	26	0.00	4/26/2005	0.85	212	0.49
4/18/2002	0.02	136	0.01	5/26/2005	1.83	76	0.38
5/20/2002	<0.01	50	0.00	6/11/2005	1.39	60	0.22
4/3/2003	20.93	4260	240.47	3/23/2006	0.99	<5	0.01 **
6/24/2004	3.40	1160	10.64	4/28/2006	0.21	54	0.03
11/1/2004	0.41	1430	1.58	9/29/2006	0.01	84	0.00
4/26/2005	2.51	196	1.33	10/29/2006	1.37	34	0.13
5/26/2005	1.09	208	0.61	3/24/2007	0.07	60	0.01
6/11/2005	0.25	176	0.12	4/15/2007	0.53	27	0.04
10/2/2005	0.54	<5	0.01 **	8/14/2007	0.36	12	0.01
4/28/2006	0.91	43	0.11	9/26/2007	3.61	11100	108.07
10/25/2006	0.70	1240	2.34	4/12/2008	1.07	260	0.75
3/24/2007	0.91	140	0.34	5/25/2008	0.53	18	0.03
4/15/2007	0.70	37	0.07	11/15/2008	0.47	15	0.02
9/26/2007	3.40	7800	71.52	3/7/2009	1.96	750	3.96
3/14/2008	35.78	80	7.72	3/21/2009	1.83	512	2.53
4/12/2008	2.51	360	2.44	4/29/2009	6.36	2220	38.08
5/25/2008	0.91	148	0.36	5/28/2009	3.03	6200	50.67
10/25/2008	1.09	60	0.18	6/22/2009	2.45	40	0.26
11/15/2008	1.09	20	0.06	7/11/2009	0.60	34	0.06
3/7/2009	0.25	1090	0.73	3/29/2010	1.66	124	0.56
3/21/2009	0.41	284	0.31	4/30/2010	0.97	90	0.24
4/29/2009	1.74	1500	7.04	5/28/2010	1.03	32	0.09
5/28/2009	6.68	4700	84.68	7/1/2010	0.57	<5	<0.01
6/30/2009	0.25	96	0.06	10/26/2010	0.23	25	0.02
3/29/2010	0.58	122	0.19	4/1/2011	2.40	248	1.61
4/30/2010	1.22	102	0.34	5/23/2011	3.06	1080	8.91
5/26/2010	1.48	6540	26.10	7/7/2011	1.08	17	0.05
7/1/2010	0.29	23	0.02	8/30/2011	0.85	36	0.08
10/28/2010	0.44	27	0.03	9/2/2011	0.73	32	0.06
4/1/2011	6.68	348	6.27	9/29/2011	1.08	32	0.09
5/23/2011	9.54	3940	101.37	11/3/2011	0.39	18	0.02
7/7/2011	4.67	14	0.18	4/17/2012	1.37	300	1.11
8/30/2011	2.96	14	0.11	5/11/2012	1.08	127	0.37

TABLE 12. BITTER CREEK TOTAL SUSPENDED SEDIMENT LOAD DATA

	SBC1-75				SBC2-75		
DATE	DISCHARGE (CFS)	TOTAL SUSPENDED SOLIDS (MG/L)	SEDIMENT LOAD (TONS/DAY) *	DATE	DISCHARGE (CFS)	TOTAL SUSPENDED SOLIDS (MG/L)	SEDIMENT LOAD (TONS/DAY) *
9/2/2011	9.95	708	19.00	6/8/2012	0.60	52	0.08
9/29/2011	1.94	34	0.18	9/28/2012	0.73	14	0.03
11/3/2011	9.95	64	1.72	10/15/2012	0.85	28	0.06
4/17/2012	1.94	50	0.26	9/30/2013	1.83	57	0.28
5/10/2012	0.63	55	0.09	2/18/2014		180	
6/8/2012	0.48	27	0.03	3/20/2014	3.53	33	0.31
9/21/2012	0.63	34	0.06	4/10/2014	2.92	11	0.09
9/28/2012	1.58	32	0.14	5/28/2014	2.63	6300	44.69
10/15/2012	2.32	13	0.08	9/9/2014	3.27	4020	35.45
9/30/2013	5.48	3160	46.70 ***/	9/30/2014	8.54	906	20.87
2/18/2014		115		3/16/2015	7.15	1120	21.60
3/20/2014	0.49	22	0.03	4/13/2015	4.57	23	0.28
4/10/2014	1.05	310	0.88	5/5/2015	3.21	NA	
5/28/2014	8.55	40	0.92	6/5/2015	5.35	46	0.66
9/9/2014	6.73	617	11.20	7/6/2015	59.18	6050	965.63
9/30/2014	34.88	518	48.73	8/4/2015	5.35	16	0.23
3/16/2015	3.20	1130	9.75	3/10/2016	25.38	530	36.28
4/13/2015	0.66	66	0.12	4/12/2016	6.72	58	1.05
5/5/2015	0.49	NA		5/4/2016	13.69	127	4.69
6/15/2015	0.37	38	0.04	6/6/2016	2.12	14	0.08
7/6/2015	53.35	2900	417.27	10/10/2016	3.85	98	1.02
11/9/2015	0.49	40	0.05	11/7/2016	2.38	36	0.23
3/10/2016	4.77	614	7.90	2/21/2017	233.81	1416	892.91
4/12/2016	34.88	15640	1471.28	3/17/2017	20.98	2560	144.85
5/4/2016	6.73	8	0.15	4/5/2017	3.85	6132	63.67
6/6/2016	<0.10	32		5/8/2017	1.66	590	2.64
10/10/2016	2.54	54	0.37	6/6/2017	1.66	36	0.16
11/7/2016	0.82	9	0.02	9/26/2017	3.21	39	0.34
2/21/2017	315.32	1358	1154.87	10/9/2017	2.12	14	0.08
3/17/2017	29.46	2944	233.91	11/20/2017	0.93	14	0.04
4/5/2017	2.54	1754	12.02	3/27/2018	8.54	64	1.47
5/8/2017	1.86	76	0.38	4/16/2018	6.72	39	0.71
6/6/2017	1.27	48	0.16	5/29/2018	3.21	30	0.26
9/26/2017	6.73	11	0.20	5/14/2019	5.35	41	0.59
10/9/2017	1.86	6	0.03	6/10/2019	3.21	***	
11/20/2017	2.54	35	0.24	10/7/2019	2.63	***	
3/27/2018	40.68	124	13.60	6/2/2020	2.63	17	0.12
4/16/2018	34.88	64	6.02	10/7/2020	1.27	21	0.07
5/29/2018	9.33	30	0.75	5/10/2022	1.66	17	0.08
5/14/2019	6.73	41	0.74	5/1/2023	63.17	1190	202.74
6/10/2019	2.54	***		*6/5/2023*	30.40		
10/7/2019	16.20	***					
6/2/2020	24.62	8	0.53				
10/7/2020	16.20	68	2.97				
5/10/2022	4.54	110	1.35				
5/1/2023	284.22	2040	1563.74				
6/5/2023	240.03						

* SEDIMENT LOAD = TOTAL SUSPENDED SOLIDS (MG/L) x DISCHARGE (CFS) x 0.002697
** TSS VALUE WAS LOWER THEN DETECTABLE LIMIT, SO THE DETECTABLE LIMIT WAS USED IN CALCULATIONS
SBC1-75 Sediment load for 5/20/02 based upon substitued flow rate of 0.01 CFS.
Invalid flow measurment due to ice at SBC1-75 & SBC2-75 on 3/3/2011 and 2/18/2014;
samples were collected but no load calculation possible for this table.
***NA = Not analyzed
Reported values for SBC1-75 and SBC2-75 on February 21, 2017 may have been affected by ice in channels.
No samples obtained during the 2021 report period.
No samples obtained on 6/5/2023.
No samples obtained during the 2024 report period.

TABLE 13. ANNUAL LOAD CALCULATIONS FOR SBC1-75 AND SBC2-75.

	SBC1-75				SBC2-75		
DATE	DISCHARGE (CFS)	DISSOLVED SOLIDS LOAD (TONS/DAY) *	SEDIMENT LOAD (TONS/DAY) *	DATE	DISCHARGE (CFS)	DISSOLVED SOLIDS LOAD (TONS/DAY) *	SEDIMENT LOAD (TONS/DAY) *
5/20/2002	<0.01	0.04	0.00	4/26/2001	0.01	0.03	0.05
4/19/1989	0.01	0.05	0.01	5/31/2001	0.01	0.04	0.00
6/27/1989	0.01	0.04	0.00	9/29/2006	0.01	0.02	0.00
7/13/1989	0.01	0.05	0.00	3/24/2007	0.07	0.15	0.01
7/24/1989	0.01	0.06	0.00	9/3/1991	0.18	0.45	0.01
8/5/1989	0.01	0.04	0.00	11/1/1994	0.19	0.69	0.00
10/10/1989	0.01	0.04	0.00	8/1/1995	0.19	0.94	0.04
11/13/1989	0.01	0.05	0.00	8/4/1992	0.21	0.91	0.02
4/24/1990	0.01	0.04	0.00	4/28/2006	0.21	0.28	0.03
5/15/1990	0.01	0.05	0.01	10/26/2010	0.23	0.47	0.02
8/31/1994	0.01	0.04	0.00	8/12/1991	0.27	0.94	0.02
5/29/2000	0.02	0.08	0.00	7/6/1995	0.33	1.34	0.02
9/25/2000	0.02	0.07	0.00	8/14/2007	0.36	0.71	0.01
4/18/2002	0.02	0.07	0.01	11/3/2011	0.39	1.09	0.02
8/24/2000	0.03	0.20	0.00	6/13/2001	0.43	1.70	0.05
4/26/2001	0.03	0.09	0.20	5/19/1997	0.44	1.50	0.07
5/31/2001	0.03	0.10	0.01	11/15/2008	0.47	1.43	0.02
9/11/2001	0.03	0.09	0.00	5/20/2002	0.52	2.19	0.01
8/4/1994	0.04	0.10	0.03	5/5/1992	0.53	2.60	0.09
7/3/2001	0.04	0.18	0.01	4/15/2007	0.53	1.09	0.04
10/4/1991	0.05	0.18	0.02	5/25/2008	0.53	1.72	0.03
6/8/1990	0.06	0.27	0.01	10/22/1997	0.55	2.79	0.27
7/14/2000	0.07	0.37	0.00	7/1/2010	0.57	1.23	<0.01
11/1/1994	0.08	0.28	0.03	7/11/2009	0.6	0.78	0.06
9/28/1987	0.10	0.32	0.02	6/8/2012	0.60	2.69	0.08
9/3/1991	0.10	0.37	0.01	4/9/1997	0.64	2.61	0.72
5/8/1991	0.11	0.40	0.08	10/4/1991	0.66	2.32	0.14
8/12/1991	0.11	0.54	0.01	4/30/1996	0.66	2.81	0.10
7/10/1991	0.12	0.16	1.00	11/4/1996	0.68	2.95	0.01
10/11/1994	0.16	0.33	0.21	7/13/1992	0.70	1.30	0.74
10/14/1996	0.16	0.63	0.01	9/3/1992	0.70	3.02	0.14
10/7/1996	0.18	0.70	0.01	10/11/1994	0.72	0.92	0.55
6/11/1991	0.22	0.52	0.13	9/2/2011	0.73	1.52	0.06
4/28/2000	0.25	0.82	0.11	9/28/2012	0.73	2.09	0.03
6/11/2005	0.25	1.15	0.12	6/27/1996	0.74	2.81	0.08
3/7/2009	0.25	0.28	0.73	5/29/2000	0.80	2.18	0.04
6/30/2009	0.25	0.56	0.06	6/18/1997	0.82	2.17	0.25
11/11/1987	0.27	0.86	0.11	7/6/1993	0.85	2.61	0.04
7/1/2010	0.29	0.97	0.02	4/26/2005	0.85	3.07	0.49
7/6/1990	0.30	1.24	0.03	8/30/2011	0.85	1.47	0.08
9/17/1990	0.30	1.17	0.15	10/15/2012	0.85	2.77	0.06
10/2/1990	0.30	1.08	0.15	8/2/1993	0.87	1.83	0.12
6/8/1994	0.34	1.12	0.13	6/8/1994	0.87	3.05	0.03
6/15/2015	0.37	1.20	0.04	9/6/1995	0.87	1.69	0.17
8/27/1990	0.38	1.50	0.03	4/29/1998	0.89	2.71	0.24
5/5/1992	0.38	1.76	0.11	11/20/2017	0.93	2.20	0.04
5/13/1999	0.41		0.21	7/24/1989	0.94	5.53	0.10
6/11/1999	0.41		0.09	4/30/2010	0.97	1.62	0.24
8/26/1999	0.41		0.04	11/13/1989	0.99	3.76	0.29
11/1/2004	0.41	0.54	1.58	10/2/1992	0.99	3.74	0.19
3/21/2009	0.41	0.63	0.31	4/18/2002	0.99	3.18	0.12
10/28/2010	0.44	1.26	0.03	3/23/2006	0.99	1.82	0.01
10/19/1995	0.45	1.34	0.13	11/3/1992	1.03	3.50	0.28
9/6/1995	0.47	1.01	0.14	11/2/1993	1.03	3.72	0.25
6/8/2012	0.48	1.73	0.03	5/28/2010	1.03	3.89	0.09
4/19/1991	0.49	1.05	12.94	5/8/1991	1.06	4.99	0.61

TABLE 13. ANNUAL LOAD CALCULATIONS FOR SBC1-75 AND SBC2-75.

	SBC1-75				SBC2-75		
DATE	DISCHARGE (CFS)	DISSOLVED SOLIDS LOAD (TONS/DAY) *	SEDIMENT LOAD (TONS/DAY) *	DATE	DISCHARGE (CFS)	DISSOLVED SOLIDS LOAD (TONS/DAY) *	SEDIMENT LOAD (TONS/DAY) *
7/6/1995	0.49	2.09	0.05	4/20/1994	1.06	3.95	0.18
3/20/2014	0.49	1.08	0.03	4/12/2008	1.07	1.41	0.75
5/5/2015	0.49	1.69		7/7/2011	1.08	2.97	0.05
11/9/2015	0.49	1.76	0.05	9/29/2011	1.08	2.71	0.09
6/1/1992	0.51	1.93	0.15	5/11/2012	1.08	4.28	0.37
4/14/1999	0.51	1.22	0.24	10/1/1997	1.11		0.52
5/17/1995	0.54	1.72	0.17	4/28/2000	1.11	3.56	0.21
10/2/2005	0.54	2.27	0.01	4/26/1993	1.13	2.93	2.22
9/8/1999	0.57	0.81	0.31	9/3/1993	1.13	3.47	0.15
11/8/1999	0.57	2.00	0.09	7/10/1997	1.13	2.96	0.13
5/2/1995	0.58	2.41	0.28	4/26/1995	1.24	5.42	0.22
3/29/2010	0.58	1.05	0.19	4/14/1999	1.25	2.23	0.63
11/4/1996	0.59	1.99	0.08	5/2/1995	1.27	5.27	0.32
5/10/2012	0.63	2.04	0.09	10/7/2020	1.27	3.15	0.07
9/21/2012	0.63	1.65	0.06	10/1/1993	1.28	4.21	0.24
4/13/2015	0.66	2.08	0.12	10/2/1995	1.30	3.17	0.34
10/2/1995	0.67	2.13	0.26	6/1/1992	1.33	5.38	0.22
6/27/1996	0.68	2.44	0.20	7/26/1995	1.35	6.55	0.07
10/21/1999	0.70	2.17	0.36	10/29/2006	1.37	4.95	0.13
10/25/2006	0.70	2.49	2.34	4/17/2012	1.37	4.03	1.11
4/15/2007	0.70	1.89	0.07	6/11/2005	1.39	5.59	0.22
5/12/1997	0.80	2.42	0.19	6/4/1993	1.41	12.32	1.37
7/13/1992	0.81	2.62	0.16	10/20/1995	1.41	2.61	0.44
8/4/1992	0.81	2.62	0.24	8/27/1990	1.42	5.63	0.46
7/5/1994	0.81	3.10	0.08	8/5/1989	1.46	5.28	0.37
11/7/2016	0.82	2.07	0.02	10/10/1989	1.46	5.32	0.41
5/14/1996	0.84	3.10	0.27	4/24/1990	1.46	6.05	0.74
11/9/1995	0.85	1.61	0.42	3/29/1996	1.46	3.37	0.76
9/3/1992	0.89	2.88	0.19	9/22/1997	1.46	1.69	6.69
11/3/1992	0.89	2.90	0.82	6/27/1989	1.63	7.30	0.08
4/20/1994	0.89	3.19	0.62	3/29/2010	1.66	2.37	0.56
4/28/2006	0.91	1.82	0.11	5/8/2017	1.66	5.06	2.64
3/24/2007	0.91	2.70	0.34	6/6/2017	1.66	3.22	0.16
5/25/2008	0.91	2.92	0.36	5/10/2022	1.66	3.22	0.08
7/26/1995	1.00	2.83	0.15	7/6/1990	1.67	7.23	0.14
8/2/1993	1.04	2.64	0.63	8/14/1997	1.71	3.87	0.79
4/10/2014	1.05	3.12	0.88	10/7/1998	1.73	4.67	0.11
4/30/1996	1.07	4.27	0.70	6/11/1991	1.76	4.20	3.17
5/26/2005	1.09	3.85	0.61	9/16/1998	1.76	4.22	0.09
10/25/2008	1.09	3.29	0.18	5/15/1990	1.78	9.28	1.83
11/15/2008	1.09	2.88	0.06	4/19/1989	1.82	8.98	0.73
6/4/1993	1.15	24.25	2.39	8/12/1998	1.83	4.49	0.35
7/6/1993	1.20	4.01	0.26	5/26/2005	1.83	6.12	0.38
9/3/1993	1.20	4.01	0.47	3/21/2009	1.83	2.47	2.53
4/30/2010	1.22	3.03	0.34	9/30/2013	1.83	1.83	0.28
6/6/2017	1.27	2.45	0.16	6/8/1990	1.86	8.93	0.39
10/1/1993	1.32	4.17	0.54	9/17/1990	1.94	10.28	0.44
4/28/1998	1.33	4.52	0.51	3/7/2009	1.96	2.01	3.96
3/29/1996	1.35	10.12	1.82	11/17/1998	2.04	6.11	0.23
9/15/1997	1.45	3.56	0.22	11/1/2004	2.09	2.54	9.13
10/2/1997	1.45		0.51	6/6/2016	2.12	3.53	0.08
10/21/1997	1.45	3.91	0.22	10/9/2017	2.12	4.07	0.08
5/9/1988	1.46	5.83	0.72	7/13/1989	2.24	2.88	20.18
5/26/2010	1.48	4.23	26.10	10/2/1990	2.29	8.75	1.66
7/10/1997	1.56	3.91	0.17	11/9/1995	2.33	4.98	0.33
9/28/2012	1.58	4.64	0.14	7/14/1998	2.35	5.51	0.10

TABLE 13. ANNUAL LOAD CALCULATIONS FOR SBC1-75 AND SBC2-75.

	SBC1-75				SBC2-75		
DATE	DISCHARGE (CFS)	DISSOLVED SOLIDS LOAD (TONS/DAY) *	SEDIMENT LOAD (TONS/DAY) *	DATE	DISCHARGE (CFS)	DISSOLVED SOLIDS LOAD (TONS/DAY) *	SEDIMENT LOAD (TONS/DAY) *
6/13/2001	1.60	5.80	0.51	11/7/2016	2.38	5.62	0.23
10/2/1992	1.68	5.44	0.54	4/1/2011	2.40	3.04	1.61
4/29/2009	1.74	3.61	7.04	6/22/2009	2.45	3.90	0.26
5/8/2017	1.86	5.52	0.38	5/28/2014	2.63	5.39	44.69
10/9/2017	1.86	3.00	0.03	10/7/2019	2.63	6.53	
6/17/1997	1.89	5.10	0.84	6/2/2020	2.63	6.74	0.12
9/29/2011	1.94	4.71	0.18	9/28/1987	2.66	8.54	0.47
4/17/2012	1.94	5.49	0.26	7/10/1991	2.70	18.96	1.54
4/2/1992	2.15	1.97	15.89	6/15/1998	2.91	7.06	0.39
10/15/2012	2.32	7.51	0.08	4/10/2014	2.92	8.11	0.09
3/29/2000	2.51	8.39	4.20	6/2/1995	2.97	8.57	2.17
4/26/2005	2.51	8.80	1.33	5/16/1994	3.01	12.01	1.66
4/12/2008	2.51	3.52	2.44	5/28/2009	3.03	6.46	50.67
4/10/1997	2.54	7.33	4.45	5/23/2011	3.06	8.50	8.91
8/12/1997	2.54	5.82	0.23	5/5/2015	3.21	11.17	
10/10/2016	2.54	2.74	0.37	9/26/2017	3.21	3.69	0.34
4/5/2017	2.54	3.15	12.02	5/29/2018	3.21	10.27	0.26
11/20/2017	2.54	5.98	0.24	6/10/2019	3.21	5.71	
6/10/2019	2.54	6.30		9/9/2014	3.27	4.76	35.45
6/23/1988	2.72	8.66	0.54	3/20/2014	3.53	5.71	0.31
7/28/1988	2.72	8.07	0.69	9/26/2007	3.61	3.51	108.07
8/30/2011	2.96	6.47	0.11	10/10/2016	3.85	3.95	1.02
3/16/2015	3.20	3.62	9.75	4/5/2017	3.85	3.69	63.67
11/2/1993	3.39	13.53	2.59	11/11/1987	4.19	13.67	1.82
6/24/2004	3.40	32.00	10.64	4/13/2015	4.57	16.15	0.28
9/26/2007	3.40	6.60	71.52	8/26/1988	4.59	14.36	0.91
8/26/1988	3.48	11.07	0.87	6/5/2015	5.35	8.80	0.66
7/14/1998	3.50	7.93	0.19	8/4/2015	5.35	9.96	0.23
9/16/1998	3.69	8.66	0.11	5/14/2019	5.35	5.84	0.59
10/7/1998	3.79	10.12	0.94	4/19/1991	5.40	7.89	261.86
8/12/1998	3.88	9.31	0.84	3/29/2000	5.67	51.38	7.03
4/26/1993	4.18	9.36	4.54	5/9/1988	6.02	28.58	3.26
6/2/1995	4.28	13.27	4.36	4/29/2009	6.36	7.89	38.08
7/16/1999	4.39		1.68	4/12/2016	6.72	7.99	1.05
5/10/2022	4.54	13.10	1.35	4/16/2018	6.72	44.77	0.71
7/7/2011	4.67	11.97	0.18	7/28/1988	6.81	21.12	2.10
3/10/2016	4.77	3.99	7.90	4/3/2003	6.94	6.74	76.74
5/16/1994	5.04	27.46	41.46	6/23/1988	7.03	23.51	1.12
11/17/1998	5.14	13.59	0.67	3/16/2015	7.15	16.39	21.60
9/30/2013	5.48	5.76	46.70	4/2/1992	7.61	5.75	50.49
6/15/1998	5.95	14.44	0.91	3/15/1994	8.37	11.02	40.18
5/31/1996	6.27	10.99	154.73	9/30/2014	8.54	13.82	20.87
5/28/2009	6.68	21.08	84.68	3/27/2018	8.54	11.70	1.47
4/1/2011	6.68	9.73	6.27	2/15/1996	10.84	10.70	3.33
9/9/2014	6.73	13.98	11.20	3/1/1995	11.94	14.10	16.75
5/4/2016	6.73	7.44	0.15	5/4/2016	13.69	12.55	4.69
9/26/2017	6.73	11.49	0.20	4/1/1993	14.27	124.70	13.86
5/14/2019	6.73	8.04	0.74	3/17/2017	20.98	16.97	144.85
3/15/1994	8.13	12.32	78.50	3/13/1989	23.45	28.21	186.57
5/28/2014	8.55	19.14	0.92	3/10/2016	25.38	23.27	36.28
5/29/2018	9.33	29.49	0.75	3/5/1990	39.23	99.88	25.92
5/23/2011	9.54	13.12	101.37	3/3/1992	44.31	109.94	144.60
9/2/2011	9.95	13.69	19.00	7/6/2015	59.18	83.00	965.63
11/3/2011	9.95	24.69	1.72	5/2/2023	63.17	40.89	202.74
4/1/1993	10.47	220.82	21.80	3/1/1988	96.57	142.21	283.89
10/7/2019	16.20	36.70		3/3/1988	118.24	199.63	172.84

TABLE 13. ANNUAL LOAD CALCULATIONS FOR SBC1-75 AND SBC2-75.

	SBC1-75				SBC2-75		
DATE	DISCHARGE (CFS)	DISSOLVED SOLIDS LOAD (TONS/DAY) *	SEDIMENT LOAD (TONS/DAY) *	DATE	DISCHARGE (CFS)	DISSOLVED SOLIDS LOAD (TONS/DAY) *	SEDIMENT LOAD (TONS/DAY) *
10/7/2020	16.20	40.63	2.97	2/21/2017	233.81	144.40	892.91
4/3/2003	20.93	17.50	240.47				
3/13/1989	22.96	31.33	119.51				
6/2/2020	24.62	57.77	0.53				
3/17/2017	29.46	23.84	233.91				
3/1/1995	31.97	43.46	33.63				
9/30/2014	34.88	96.89	48.73				
4/12/2016	34.88	44.59	1471.28				
4/16/2018	34.88	76.29	6.02				
3/14/2008	35.78	52.11	7.72				
3/27/2018	40.68	61.22	13.60				
2/9/1996	44.08	145.04	8.92				
3/5/1990	47.54	83.85	47.57				
7/6/2015	53.35	69.06	417.27				
3/3/1992	63.78	49.88	158.25				
3/1/1988	94.31	124.12	94.37				
3/3/1988	122.49	182.36	161.21				
5/2/2023	284.22	160.97	1563.74				
2/21/2017	315.32	194.75	1154.87				
HIGH AVERAGE (1)		86.34	290.32			75.03	221.06
DAYS PER YEAR (2)		47.61	44.51			33.18	33.84
HIGH FLOW LOAD (3)		4110.65	12922.70			2489.71	7480.94
LOW AVERAGE (1)		4.60	4.79			5.58	6.16
DAYS PER YEAR (2)		317.39	320.49			331.82	331.16
LOW FLOW LOAD (3)		1459.93	1535.33			1851.72	2040.09
TOTAL ANNUAL LOAD (4)		5570.58	14458.03			4341.43	9521.03

* TDS LOAD = TOTAL DISSOLVED SOLIDS (MG/L) x DISCHARGE (CFS) x 0.002697
TSS LOAD = TOTAL SUSPENDED SEDIMENTS (MG/L) x DISCHARGE (CFS) x 0.002697

(1) HIGH AVERAGE REPRESENTS MEAN LOAD IN TONS PER DAY WITH DISCHARGE GREATER THAN OR EQUAL TO 10 CFS. LOW AVERAGE REPRESENTS MEAN LOAD IN TONS PER DAY WITH DISCHARGE LESS THAN 10 CFS.
(2) DAYS PER YEAR COMPUTED AS THE RATIO OF THE VALUE COUNT COMPUTED FOR THE HIGH OR LOW AVERAGE TO THE TOTAL VALUE COUNT FOR THE RESPECTIVE LOAD MULTIPLIED BY 365 DAYS PER YEAR.
(3) LOW AND HIGH FLOW LOADS COMPUTED AS THE PRODUCT OF DAYS PER YEAR AND THE RESPECTIVE HIGH OR LOW AVERAGE VALUE.
(4) COMPUTED AS THE SUMMATION OF LOW FLOW AND HIGH FLOW LOADS, IN TONS PER YEAR.
Notes:
Reported values for SBC1-75 and SBC2-75 on February 21, 2017 may have been affected by ice in channels.
No samples obtained during the 2021 report period.
No samples obtained during the 2024 report period.
***NA = Not analyzed

TABLE 14. 2024 MINE DISCHARGES TO BITTER CREEK

DISCHARGE POINT SITE	DATE	VOLUME DISCHARGED Million Gallons	VOLUME DISCHARGED (acre-feet)
017	1st Quarter	3.74	11.5
029		1.44	4.4
031		2.59	7.9
014		2.01	6.2
025	2nd Quarter	3.74	11.5
No Discharge	3rd Quarter		
No Discharge	4rd Quarter		
2024 Total Discharge		**13.53**	**41.5**

Discharge monitoring conducted in accordance with WYDES permit and results were below applicable dry or wet weather discharge limits.

TABLE 15. HOURLY AND DAILY PRECIPITATION

Precipitation

December 2023 **Measurement Units: in**

Day	Hr1	Hr2	Hr3	Hr4	Hr5	Hr6	Hr7	Hr8	Hr9	Hr10	Hr11	Hr12	Hr13	Hr14	Hr15	Hr16	Hr17	Hr18	Hr19	Hr20	Hr21	Hr22	Hr23	Hr24	Max	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0.03
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0.02	0.02
9	0	0	0	0	0	0	0	0	0	0.03	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0.03	0.04
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0.02	0.03
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0.01	0	0	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0.04
15	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0.01	0	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0.04
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0.01	0	0.01	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0.01	0.04
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0.01	0.01
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0.01	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02
28	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Maximum hourly value = 0.03
Maximum Daily value = 0.04
Monthly total = 0.28

TABLE 15. HOURLY AND DAILY PRECIPITATION

Precipitation

January 2024 **Measurement Units: in**

Day	Hr1	Hr2	Hr3	Hr4	Hr5	Hr6	Hr7	Hr8	Hr9	Hr10	Hr11	Hr12	Hr13	Hr14	Hr15	Hr16	Hr17	Hr18	Hr19	Hr20	Hr21	Hr22	Hr23	Hr24	Max	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0	0	0	0.05	0.05
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.04	0	0	0	0	0.04	0.06
11	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0.16	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0.16	0.19
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0.01	0.01
16	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0.04	0.04
17	0	0	0	0	0	0	0	0.11	0	0	0	0	0.01	0.02	0.01	0	0	0	0	0	0	0	0	0	0.11	0.15
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.01	0	0.02	0.03
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Maximum hourly value = 0.16
Maximum Daily value = 0.19
Monthly total = 0.54

TABLE 15. HOURLY AND DAILY PRECIPITATION

Precipitation

February 2024 **Measurement Units: in**

Day	Hr1	Hr2	Hr3	Hr4	Hr5	Hr6	Hr7	Hr8	Hr9	Hr10	Hr11	Hr12	Hr13	Hr14	Hr15	Hr16	Hr17	Hr18	Hr19	Hr20	Hr21	Hr22	Hr23	Hr24	Max	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0.02	0.05	0.05	0.02	0	0	0	0	0	0	0	0	0	0	0.02	0.02	0.01	0	0	0	0.05	0.19
4	0	0	0	0	0	0	0	0	0	0	0	0.06	0	0	0	0	0	0	0	0	0	0	0	0	0.06	0.06
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0	0.02	0.02
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0.01	0	0.03	0	0	0.01	0	0.01	0	0	0	0.03	0.09
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0.07	0.11	0.01	0.01	0	0	0	0	0	0.01	0	0.11	0.21
17	0	0	0	0	0	0	0	0	0.02	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.03	0.06
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0.02	0.02
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0.04	0.04	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0.09
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0.01	0.01
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0.01	0.01
28	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Maximum hourly value = 0.11
Maximum Daily value = 0.21
Monthly total = 0.78

TABLE 15. HOURLY AND DAILY PRECIPITATION

Precipitation

March 2024 **Measurement Units: in**

Day	Hr1	Hr2	Hr3	Hr4	Hr5	Hr6	Hr7	Hr8	Hr9	Hr10	Hr11	Hr12	Hr13	Hr14	Hr15	Hr16	Hr17	Hr18	Hr19	Hr20	Hr21	Hr22	Hr23	Hr24	Max	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.06	0.07	0.01	0.01	0	0	0	0.07	0.15
3	0	0	0	0	0	0	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0.04
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0.03	0.04
8	0	0	0	0.02	0.01	0	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0.06
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0.01	0.05	0.06	0.13	0.16	0.17	0.16	0.17	0.75
14	0.06	0.03	0.01	0.08	0.03	0.06	0.04	0	0	0.02	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0.08	0.34
15	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08	0.08
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.02	0.02
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0.01	0.01
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08	0.07	0.01	0	0	0	0	0	0.08	0.16
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0.01	0.03	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0.06
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.03	0.02	0	0	0	0	0	0	0.03	0.06

Maximum hourly value = 0.17
Maximum Daily value = 0.75
Monthly total = 1.78

TABLE 15. HOURLY AND DAILY PRECIPITATION

Precipitation

April 2024 **Measurement Units: in**

Day	Hr1	Hr2	Hr3	Hr4	Hr5	Hr6	Hr7	Hr8	Hr9	Hr10	Hr11	Hr12	Hr13	Hr14	Hr15	Hr16	Hr17	Hr18	Hr19	Hr20	Hr21	Hr22	Hr23	Hr24	Max	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0.01	0.01
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0.11	0	0	0.01	0	0	0	0	0	0	0	0	0.11	0.12
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0.04	0.06	0	0	0	0.02	0	0	0	0	0	0	0	0.06	0.12
27	0.01	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08	0.06	0	0.08	0.14
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Maximum hourly value = 0.11
Maximum Daily value = 0.14
Monthly total = 0.43

TABLE 15. HOURLY AND DAILY PRECIPITATION

Precipitation

May 2024 **Measurement Units: in**

Day	Hr1	Hr2	Hr3	Hr4	Hr5	Hr6	Hr7	Hr8	Hr9	Hr10	Hr11	Hr12	Hr13	Hr14	Hr15	Hr16	Hr17	Hr18	Hr19	Hr20	Hr21	Hr22	Hr23	Hr24	Max	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0.05	0.14	0.03	0	0	0.14	0.26
6	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.02
7	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.04	0.04	0.05
9	0.04	0.04	0.04	0.04	0.01	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0.04	0.18
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0.03	0.06	0.01	0.01	0	0	0	0	0	0	0	0	0	0.06	0.11
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0.01	0.01
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.03	0.01	0	0	0	0	0	0	0.03	0.05
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Maximum hourly value = 0.14
Maximum Daily value = 0.26
Monthly total = 0.68

TABLE 15. HOURLY AND DAILY PRECIPITATION

Precipitation

June 2024 **Measurement Units: in**

Day	Hr1	Hr2	Hr3	Hr4	Hr5	Hr6	Hr7	Hr8	Hr9	Hr10	Hr11	Hr12	Hr13	Hr14	Hr15	Hr16	Hr17	Hr18	Hr19	Hr20	Hr21	Hr22	Hr23	Hr24	Max	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0	0	0	0	0	0	0	0	0.03	0.03
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0.01	0.01
4	0	0	0.01	0.01	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.03
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0.01	0.01
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0	0	0	0	0	0	0.01	0.02
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0	0.01	0	0	0	0	0	0	0.03	0.04
30	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0.01	0.02

Maximum hourly value = 0.03
Maximum Daily value = 0.04
Monthly total = 0.16

TABLE 15. HOURLY AND DAILY PRECIPITATION

Precipitation

July 2024 **Measurement Units: in**

Day	Hr1	Hr2	Hr3	Hr4	Hr5	Hr6	Hr7	Hr8	Hr9	Hr10	Hr11	Hr12	Hr13	Hr14	Hr15	Hr16	Hr17	Hr18	Hr19	Hr20	Hr21	Hr22	Hr23	Hr24	Max	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0.05
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0.01	0.01
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0.02	0	0	0.02	0.03
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Maximum hourly value = 0.05
Maximum Daily value = 0.05
Monthly total = 0.09

TABLE 15. HOURLY AND DAILY PRECIPITATION

Precipitation

August 2024 **Measurement Units: in**

Day	Hr1	Hr2	Hr3	Hr4	Hr5	Hr6	Hr7	Hr8	Hr9	Hr10	Hr11	Hr12	Hr13	Hr14	Hr15	Hr16	Hr17	Hr18	Hr19	Hr20	Hr21	Hr22	Hr23	Hr24	Max	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.03	0	0	0	0	0.03	0.04
13	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0.06	0	0	0.06	0.11
14	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0.02	0.03	0	0	0	0	0	0	0.03	0.06
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0	0.01	0	0	0	0	0	0	0.03	0.03	0.06
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0	0	0	0.03	0.07	0.07	0.15
19	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0.02	0	0.02	0.01	0	0	0	0	0	0	0.21	0	0.02	0.04	0.01	0.02	0.04	0	0	0	0.21	0.39
26	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Maximum hourly value = 0.21
Maximum Daily value = 0.39
Monthly total = 0.83

TABLE 15. HOURLY AND DAILY PRECIPITATION

Precipitation

September 2024 **Measurement Units: in**

Day	Hr1	Hr2	Hr3	Hr4	Hr5	Hr6	Hr7	Hr8	Hr9	Hr10	Hr11	Hr12	Hr13	Hr14	Hr15	Hr16	Hr17	Hr18	Hr19	Hr20	Hr21	Hr22	Hr23	Hr24	Max	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0.06	0.25	0	0	0	0	0.01	0.04	0	0	0	0.25	0.36
4	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.01	0.01
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0	0.02	0.02
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0.04	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0.06
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0.01	0.01
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Maximum hourly value = 0.25
Maximum Daily value = 0.36
Monthly total = 0.47

TABLE 15. HOURLY AND DAILY PRECIPITATION

Precipitation

October 2024 **Measurement Units: in**

Day	Hr1	Hr2	Hr3	Hr4	Hr5	Hr6	Hr7	Hr8	Hr9	Hr10	Hr11	Hr12	Hr13	Hr14	Hr15	Hr16	Hr17	Hr18	Hr19	Hr20	Hr21	Hr22	Hr23	Hr24	Max	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0.04	0.09	0	0	0.01	0.02	0.02	0	0	0.01	0.03	0.09	0.23
18	0	0	0	0	0	0.01	0.01	0.02	0.1	0	0.01	0.03	0	0	0	0	0.01	0	0	0	0	0	0	0	0.1	0.19
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0	0	0	0	0.04	0.04
29	0	0	0.01	0.01	0	0	0	0	0.05	0.07	0	0	0.04	0.12	0.11	0	0	0	0	0	0.04	0	0	0.01	0.12	0.46
30	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Maximum hourly value = 0.12
Maximum Daily value = 0.46
Monthly total = 0.94

TABLE 15. HOURLY AND DAILY PRECIPITATION

Precipitation

November 2024 **Measurement Units: in**

Day	Hr1	Hr2	Hr3	Hr4	Hr5	Hr6	Hr7	Hr8	Hr9	Hr10	Hr11	Hr12	Hr13	Hr14	Hr15	Hr16	Hr17	Hr18	Hr19	Hr20	Hr21	Hr22	Hr23	Hr24	Max	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0.01	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.02
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0.02	0	0	0	0	0	0	0	0	0.02	0.04
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0.01	0	0	0	0	0	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0.04
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0.01	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.03
26	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0.04	0.04	0	0	0	0	0.1	0.18
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0.01	0.03	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0.03	0.05
29	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0.02	0.03
30	0	0.02	0	0	0.01	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.04

Maximum hourly value = 0.1
Maximum Daily value = 0.18
Monthly total = 0.44

TABLE 16. 2024 TOTAL DEPTH WELL MEASUREMENTS

Well ID	Measuring Point Height	Constructed Total Depth	Previous Year Total Depth Measurement	Current Year Total Depth Measurement	Date
9	0.0	250	234.98	234.88	09/25/24
21	2.1	400	[1]	[1]	[1]
22	1.8	223	216.15	216.10	08/28/24
33	1.3	130	133.62	133.60	08/28/24
37	3.9	130	123.23	123.40	09/05/24
39	2.6	90	90.50	90.50	09/05/24
40	2.7	130	126.53	126.43	08/29/24
41	1.9	82	79.98	80.00	09/05/24
58	3.0	100	102.64	102.62	09/05/24
66	2.0	288	289.80	289.75	09/25/24
68	2.1	109	[2]	[2]	[2]
71	0.0	201	200.03	200.01	09/16/24
72	0.7	224	219.26	219.15	09/10/24
73	1.8	76	77.47	77.28	09/05/24
75	1.3	402	372.72	372.72	09/16/24
76	1.6	362	339.40	339.22	09/16/24
81	1.7	280	261.13	261.22	09/17/24
85R	2.0	281	275.03	275.10	08/29/24
86	2.0	401	402.28	402.28	09/25/24
87R	2.0	228	220.58	220.52	08/29/24
89	1.9	372	373.94	373.91	08/29/24
90	1.8	230	230.68	230.48	09/05/24
91	1.3	90	87.60	87.61	09/16/24
93	1.8	80	80.19	80.19	09/10/24
96	2.0	80	79.20	79.18	08/29/24
97	1.9	84	78.55	78.50	09/23/24
99	1.5	80	78.90	78.89	09/05/24
102	1.8	85	80.51	80.52	09/23/24
104	1.6	85	80.55	80.55	09/10/24
105	1.4	89	85.57	85.67	09/10/24
107	1.7	84	81.80	81.76	09/05/24
108	1.7	320	316.97	316.85	09/16/24
110	2.0	142	138.58	138.54	09/17/24
111	2.2	255	254.52	254.50	09/10/24
112	2.0	315	315.25	315.22	08/29/24

TABLE 16. 2024 TOTAL DEPTH WELL MEASUREMENTS

Well ID	Measuring Point Height	Constructed Total Depth	Previous Year Total Depth Measurement	Current Year Total Depth Measurement	Date
113	2.8	175	177.04	177.00	08/29/24
P10MW1 CZ	2.5	451	431.10	431.12	09/24/24
P10MW1 OB	2.5	365	365.55	365.50	09/24/24
P10MW1 UB	2.5	500	493.62	493.62	09/24/24
RP-5B	1.75	183	[1]	[1]	[1]
SW1-CZ	2.2	252	252.82	252.72	09/10/24
SW1-OB	3.3	150	148.08	148.00	09/10/24
SW1-UB	2.4	290	285.98	285.87	09/10/24
SW3-CZ	2.3	112	114.77	114.85	08/29/24
SW3-OB	2.5	82	83.43	83.40	09/10/24
SW3-UB	2.5	150	152.02	152.02	08/29/24
SW4-CZ	3.2	250	249.51	249.48	08/29/24
SW4-OB	2.7	165	160.53	160.49	08/29/24
SW4-UB	2.8	300	301.16	301.20	08/29/24

[1]Wells 21 and RP5B total depths were unable to be obtained due to obstructions in the wells.
[2]Inadvertently missed Total Depth level this annual report period.

FIGURES

Figure 1. Historical Hydrograph 568094 (No. 108)
Fort Union Wells, Pit 2 Area

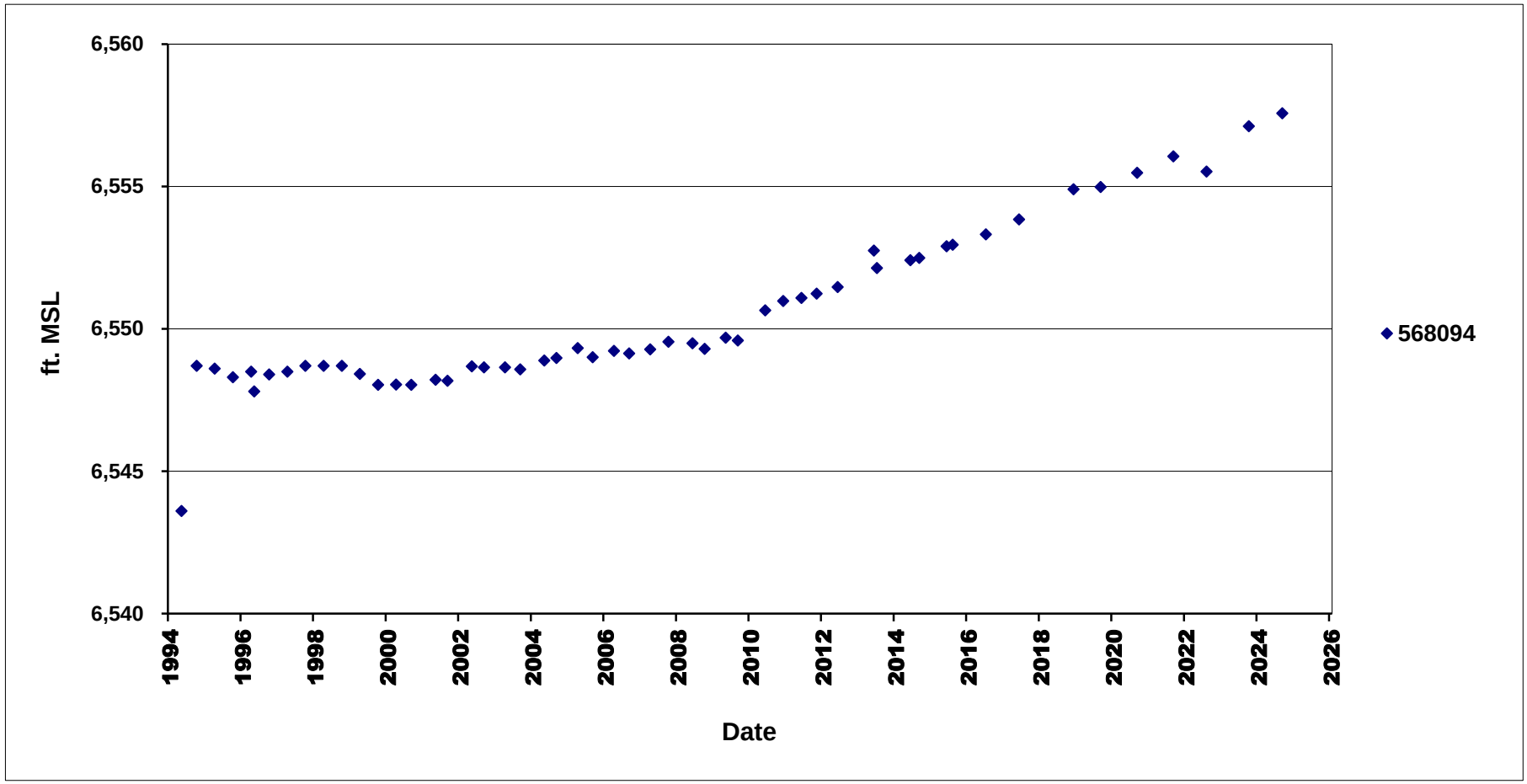


Figure 2. Historical Hydrograph
Fort Union Wells, Pit 3 Area

505986 (No. 75)
506086 (No. 76)
566194 (No. 89)
566294 (No. 90)

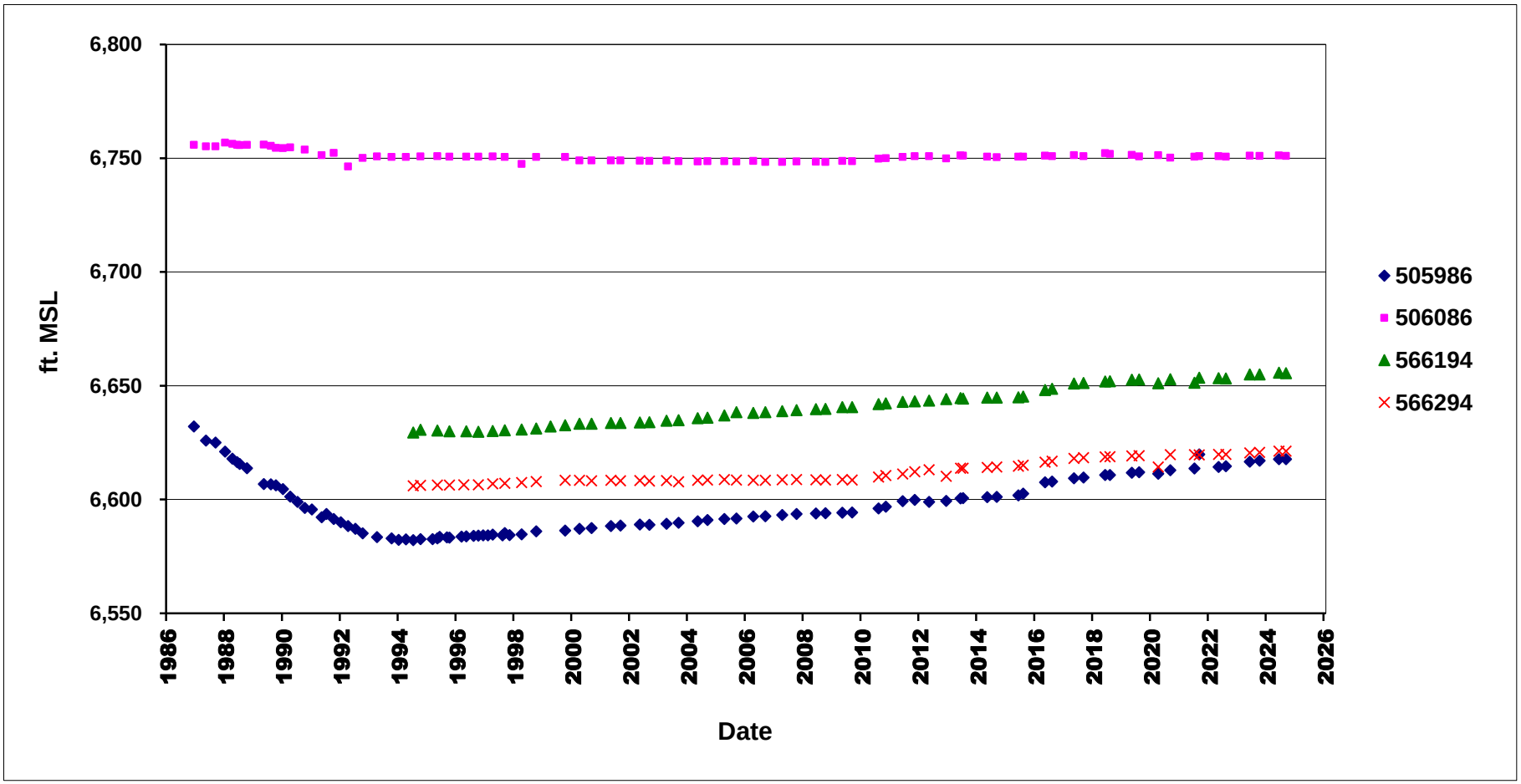


Figure 3. Historical Hydrograph
Fort Union Wells, Pit 3 Area

284280 (No. 37)
284480 (No. 39)
284580 (No. 40)
286380 (No. 58)

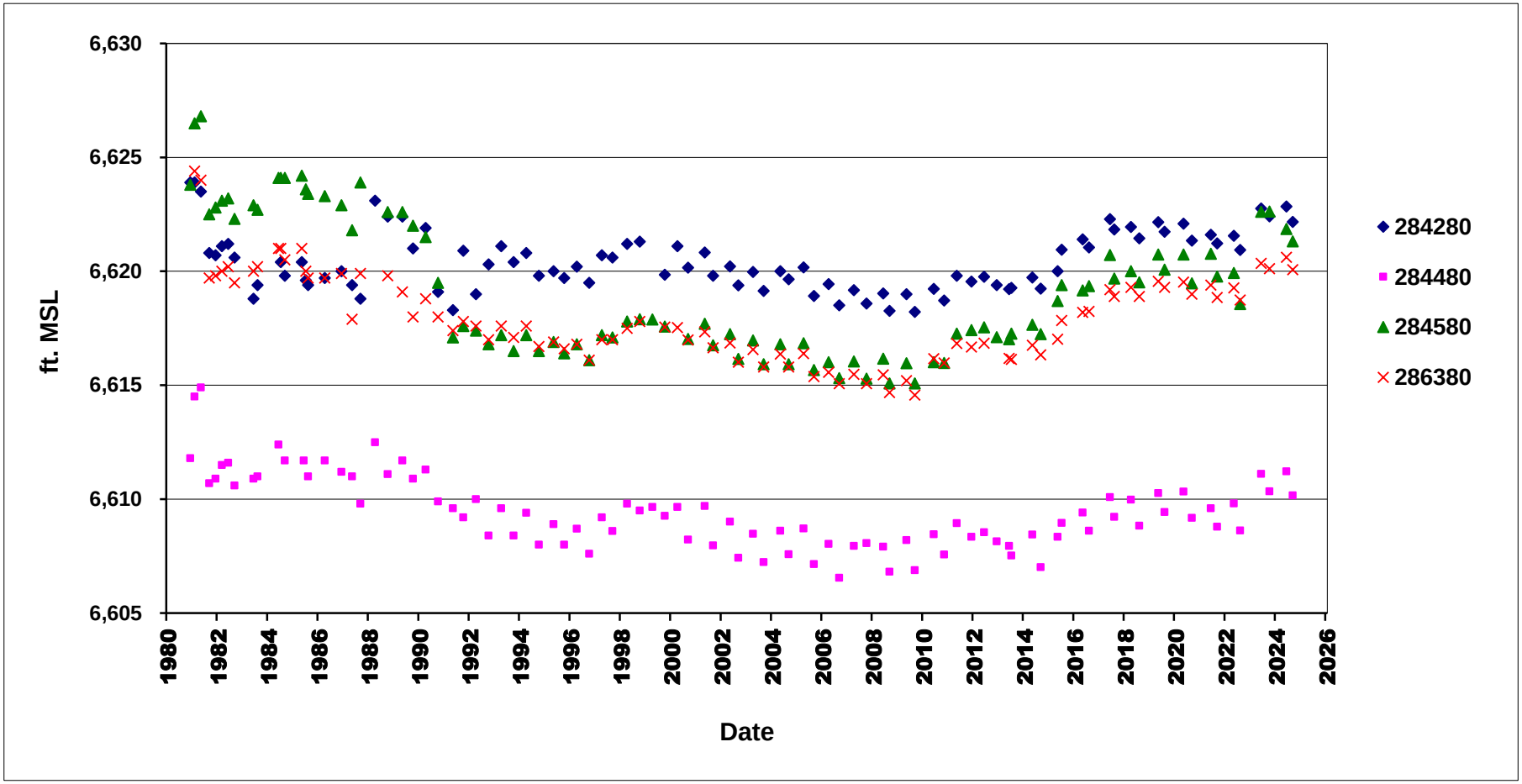


Figure 4. Historical Hydrograph 286080 (No. 55)
Fort Union Wells, Pit 3 and 4 Area

Notes: **Discontinued monitoring 2016. Current approved Table MP-23 (Revised 4/2016).**

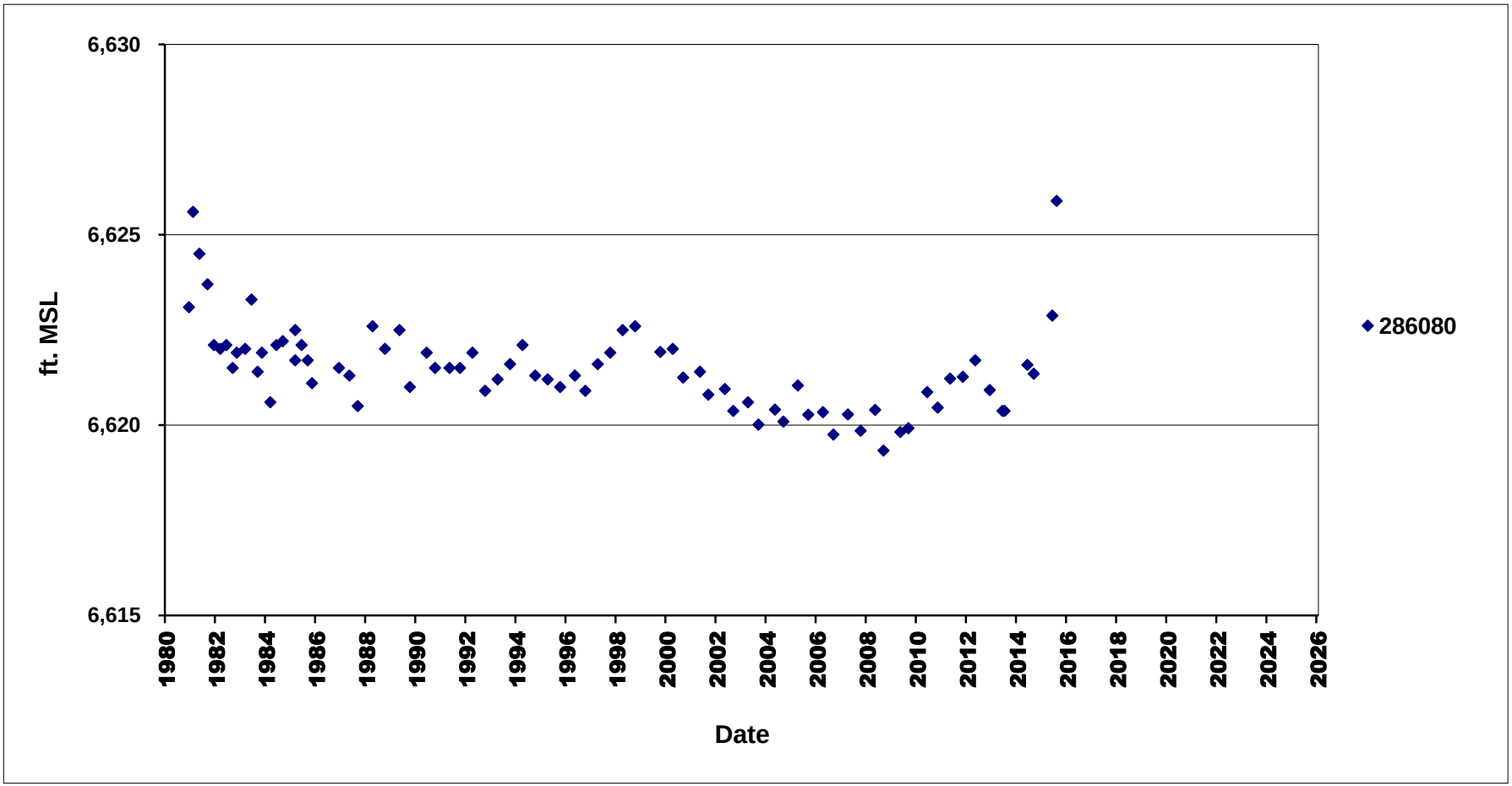


Figure 5. Historical Hydrograph
Fort Union Wells, Pit 4 Area

59374 (No. 9)

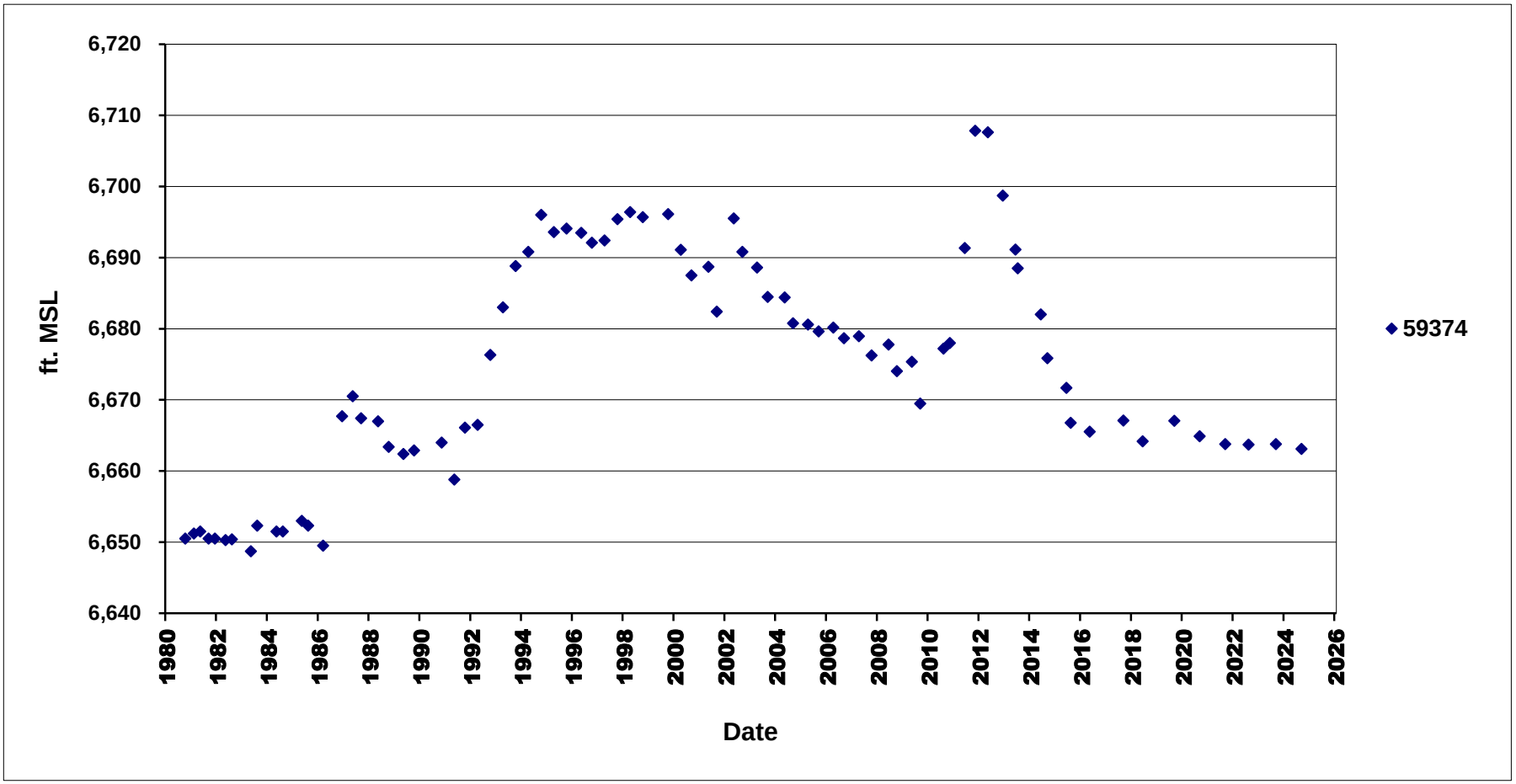


Figure 6. Historical Hydrograph 534990 (No. 86)
Fort Union Wells, Pit 9 Area

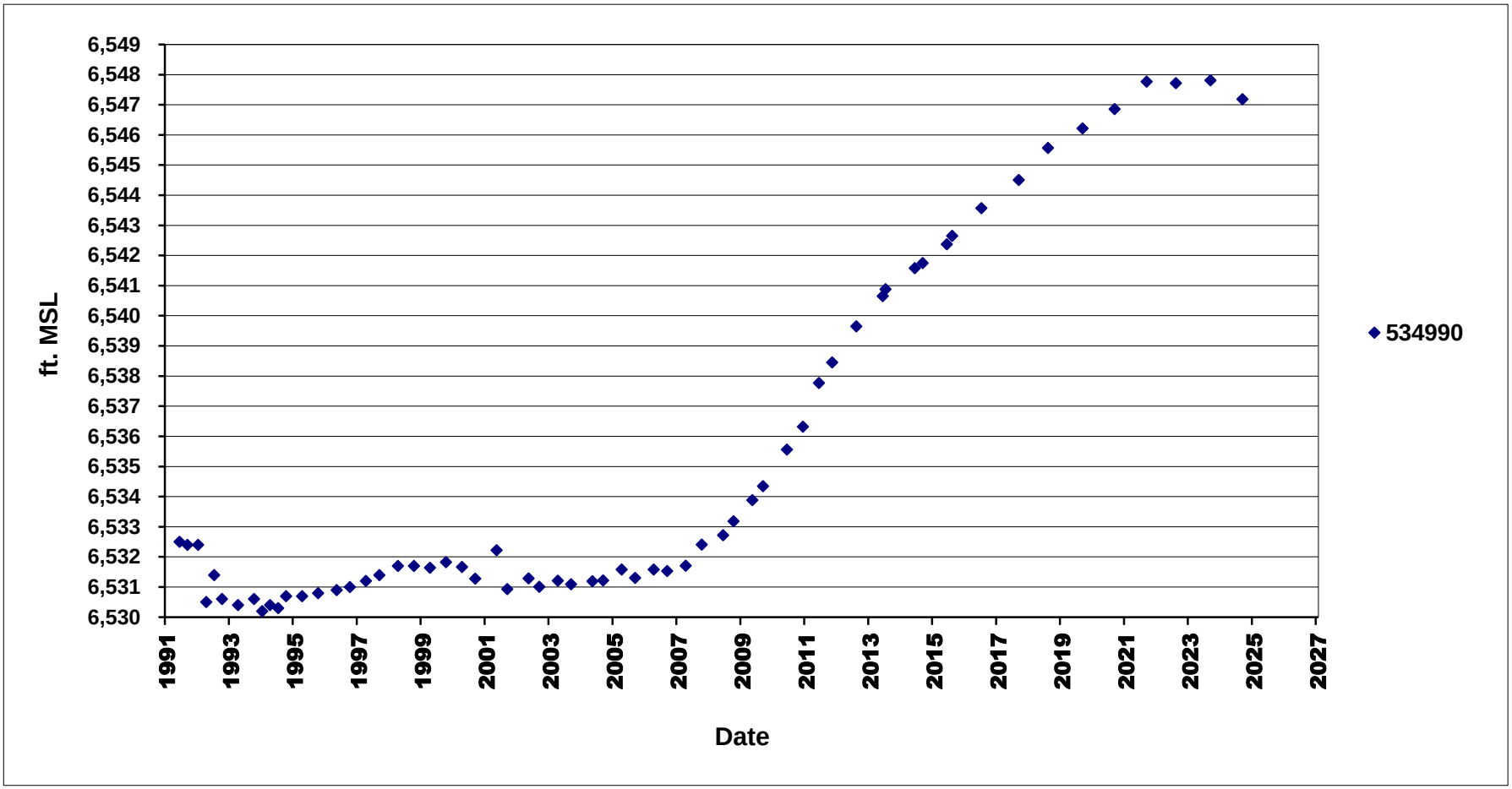


Figure 7. Historical Hydrograph
Fort Union Wells, Pit 10 Area

502586 (No. 81)
305081 (No. 65)

Notes: **Well 305081 has been dry since Sept 2008. Not presently monitored. Resume monitoring upon completion of backfill. Table MP-23 (Rev 4/2016).**

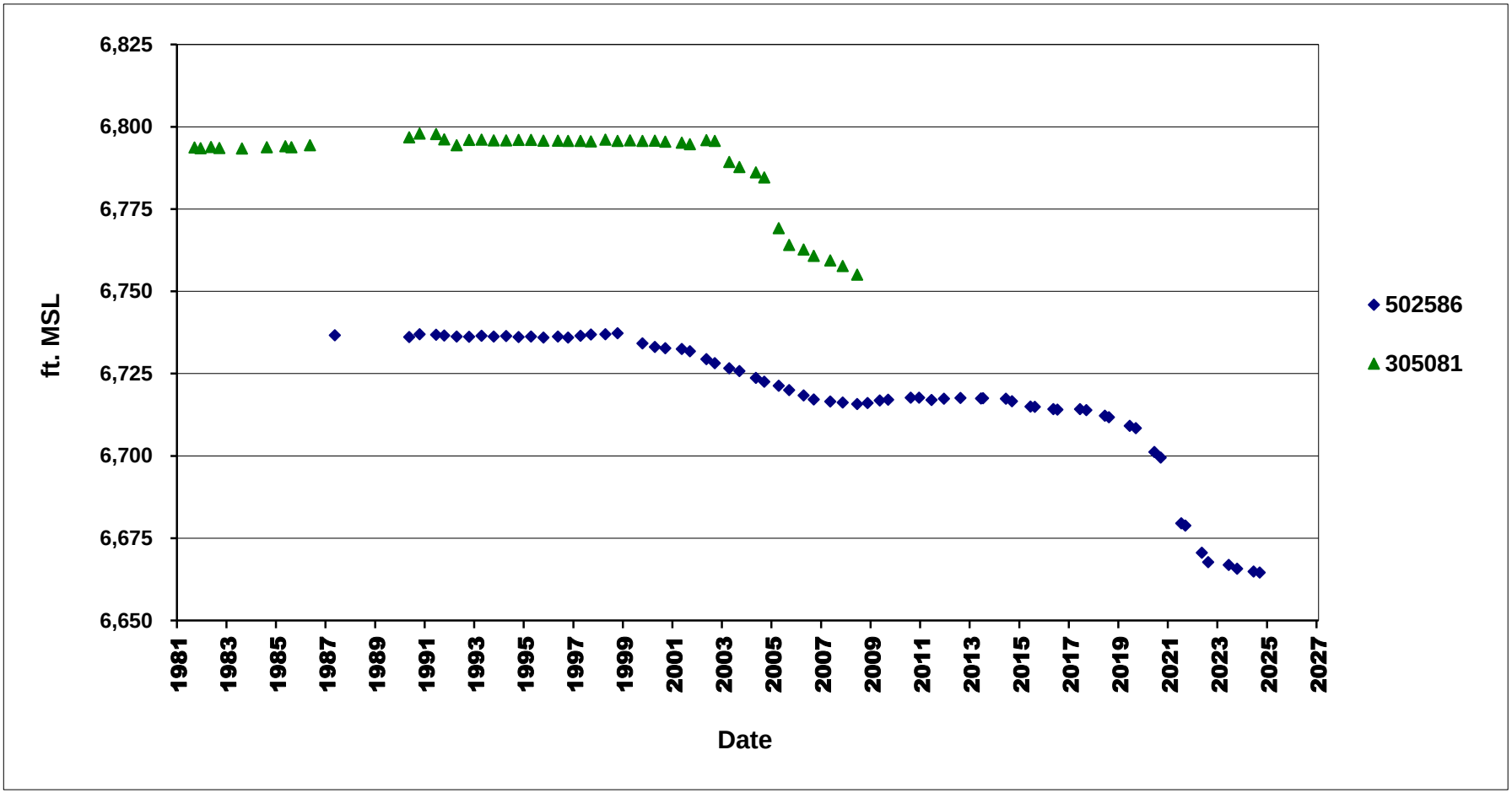


Figure 8. Historical Hydrograph
Fort Union Wells, Pit 11 Area

534890 (No. 85)
545691 (No. 87)
11205 (No. 112)
11305 (No. 113)
1108085R (85R)
1108087R (87R)

Notes: **Monitoring was discontinued after May 2009 at Wells 534890 and 545691. Both wells destroyed in 2011.**
Well 1108085R replaced 534890.
Well 1108087R replaced 545691.

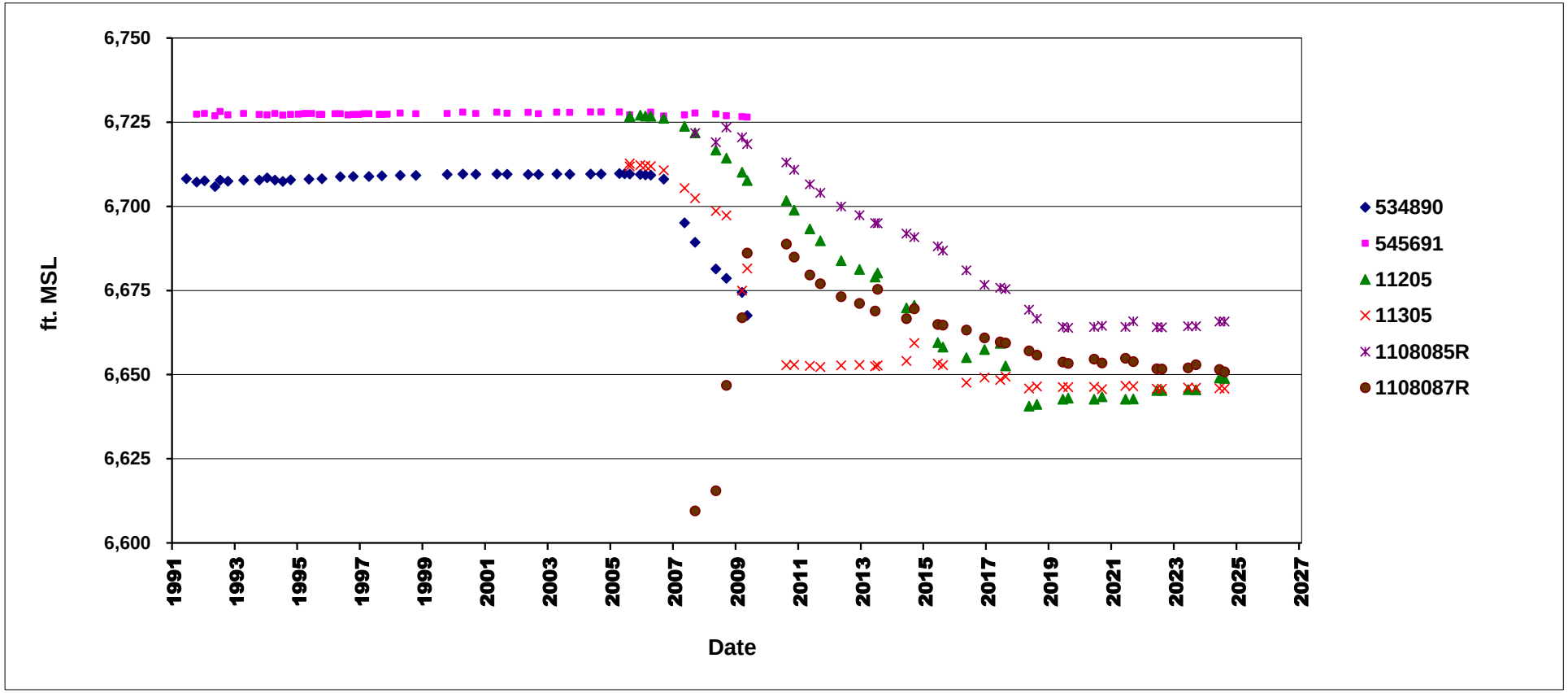


Figure 9. Historical Hydrograph
Lance Wells, Pit 5 Area

59474 (No. 24)
200478 (No. 21)
200578 (No. 22)
272380 (No. 35)

Notes: Monitoring temporarily suspended and will commence one year prior to opening Pit 5S at Well 272380. Well 59474 discontinued monitoring in 2016. Well 200478 is obstructed and no levels were obtained in 2019, 2020 and 2021. Current approved Table MP-23 (Revised 4/2016).

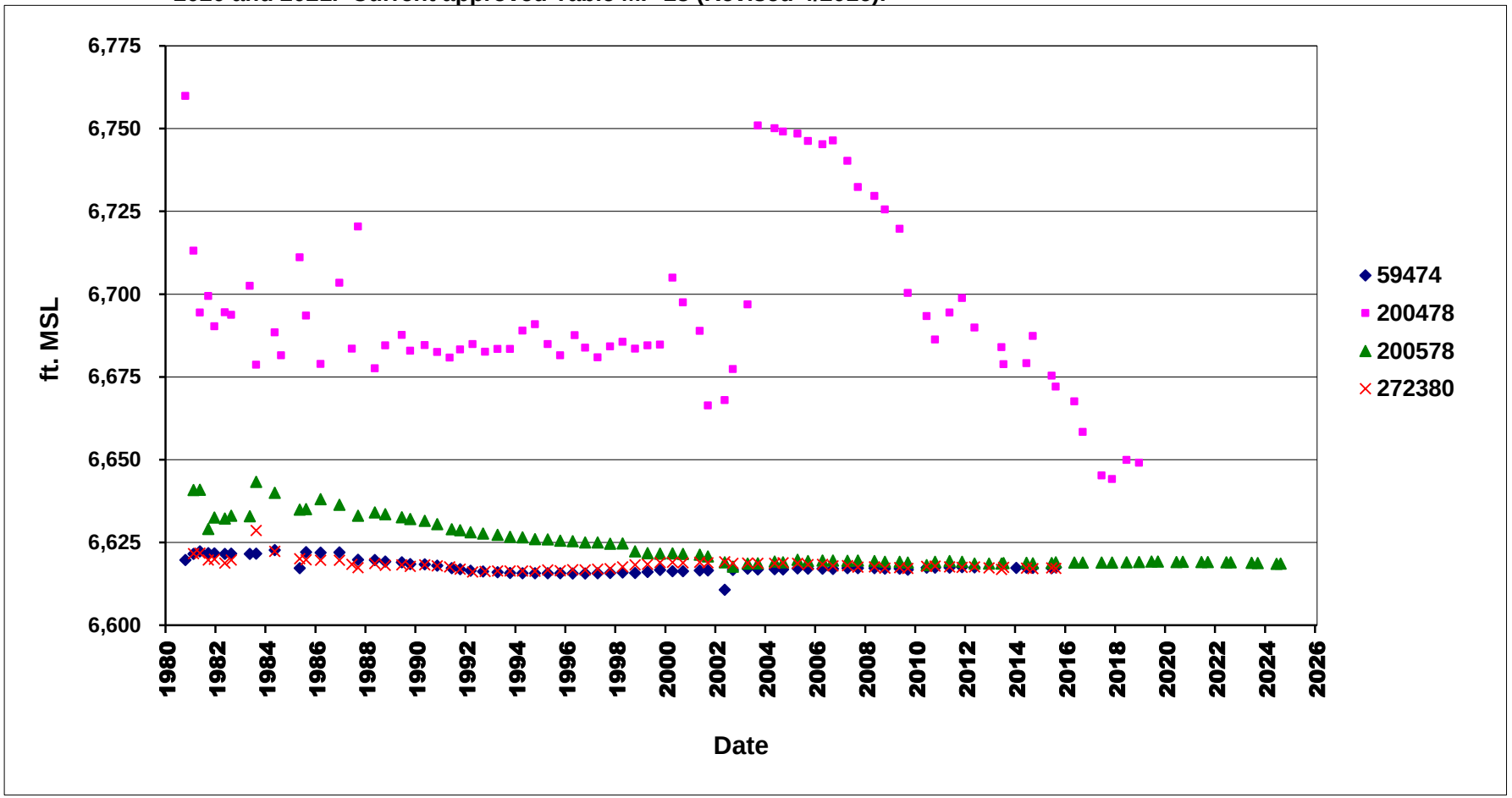


Figure 10. Historical Hydrograph
Lance Wells, Pit 5 South Area

305381 (No. 66)
272180 (No. 33)
286280 (No. 57)
286180 (No. 56)

Notes: Monitoring temporarily suspended and will commence one year prior to opening Pit 5S at Wells 286280 and 286180.
Current approved Table MP-23 (Revised 4/2016).

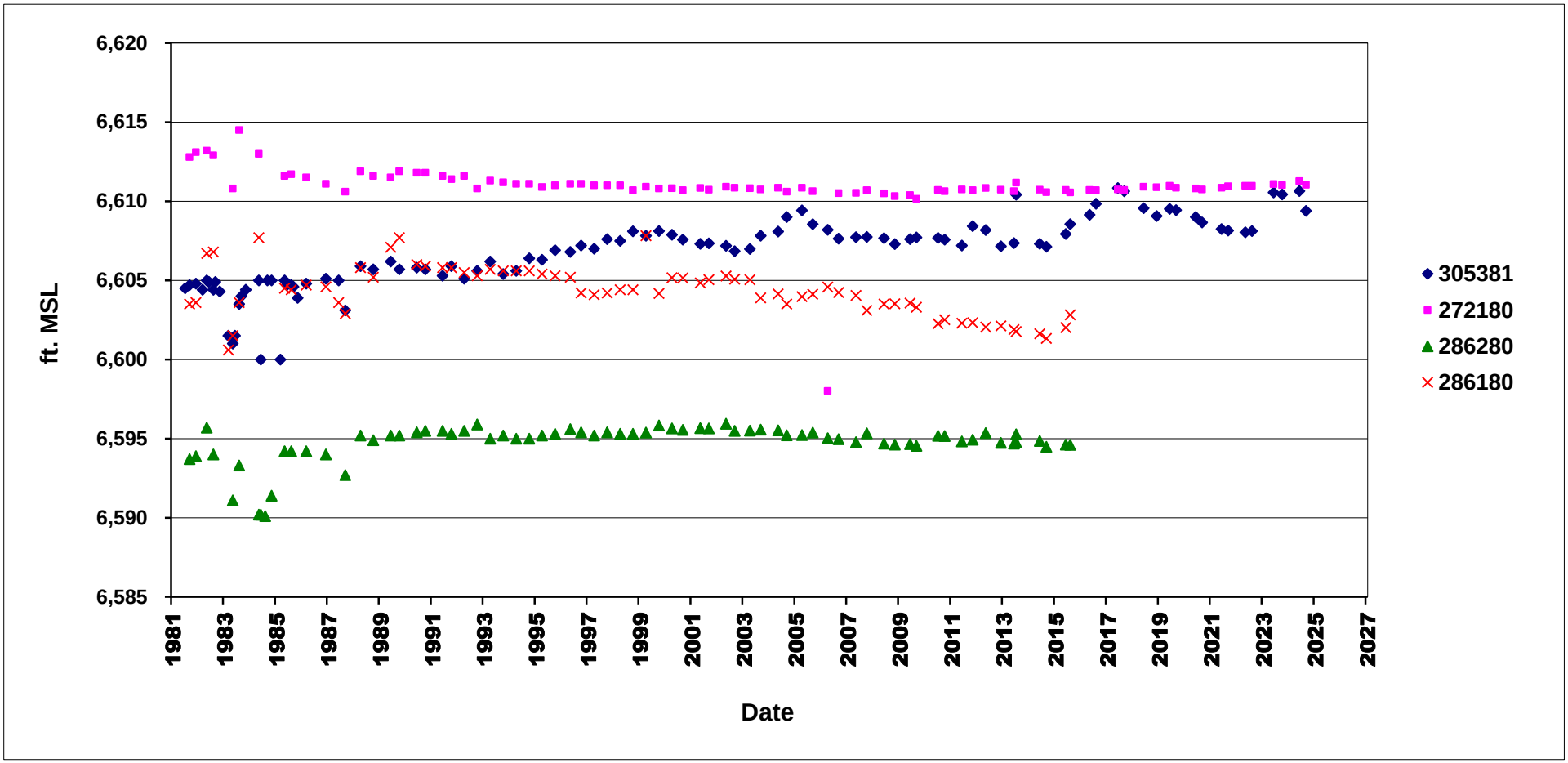


Figure 11. Historical Hydrograph
Lance Wells, Pit 6 Area

305181 (No. 68)
305281 (No. 67)

Notes: **Well 305281 - monitoring suspended in 2016, leave for stock well. Current approved Table MP-23 (Revised 4/2016).**

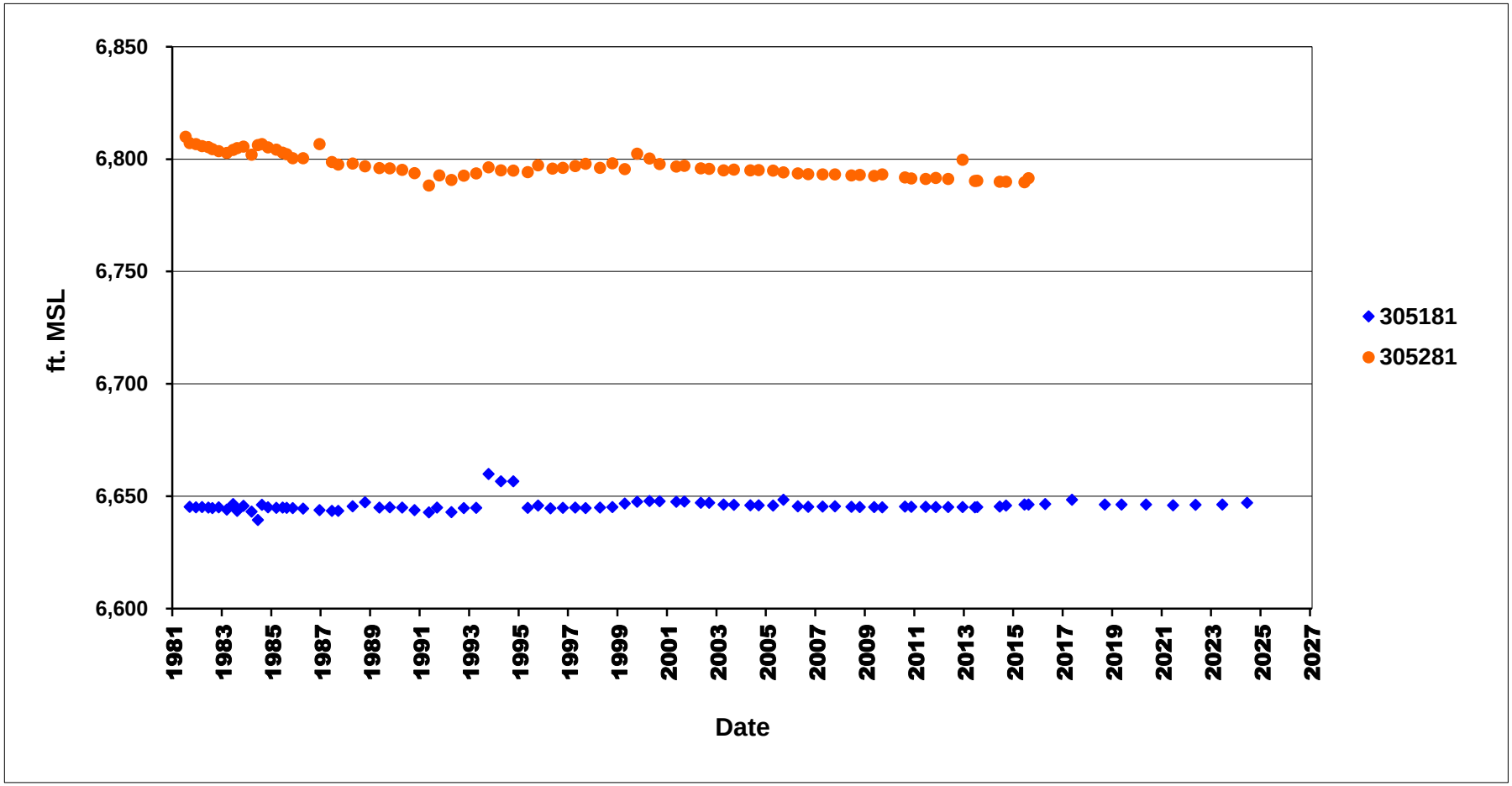


Figure 12. Historical Hydrograph
Lance Wells, Pits 7, 12 & 13 Areas

053474 (No. 1)
053574 (No. 2)
053774 (No. 4)
054774 (No. 5)

Notes: **Well 053474 was not monitored 1986 - 1989, was dry 1990 - 2001 and 2006, obstructed from 2002 - 2009. Dry or nearly dry 2010 and 2012.**
An obstruction was noted in Well 053574 in 2004. The elevations shown likely represent the obstruction. Well 054774 has always been dry except for one measurement in 2005.
Wells 053474, 053574, 053774 & 054774 are not presently monitored. Annual water level monitoring will be resumed 1 year prior to any mining activities in Pit 7, 12 or 13. Table MP-23 (Rev 4/20/16).

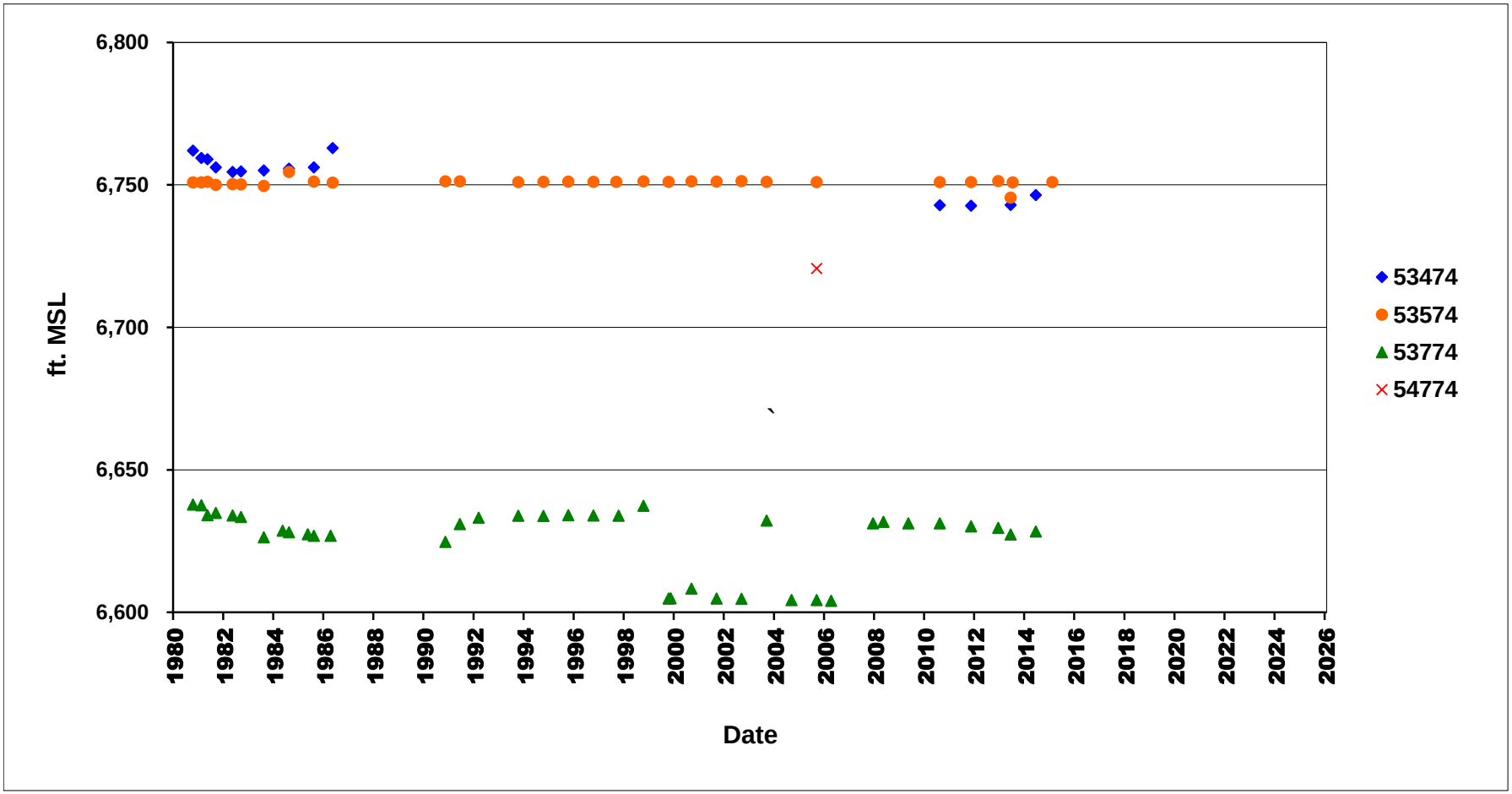


Figure 13. Historical Hydrograph
Almond Wells, Pit 8 Area

059074 (No. 8)
330682 (No. 71)
330782 (No. 72)
11105 (No. 111)

Note: **Well 330682 flowed from 1983 to 2001. Well 059074 was destroyed by mining in September 2003 and was replaced by well 11105 in 2005. Gas was observed at 11105 in 2005.**

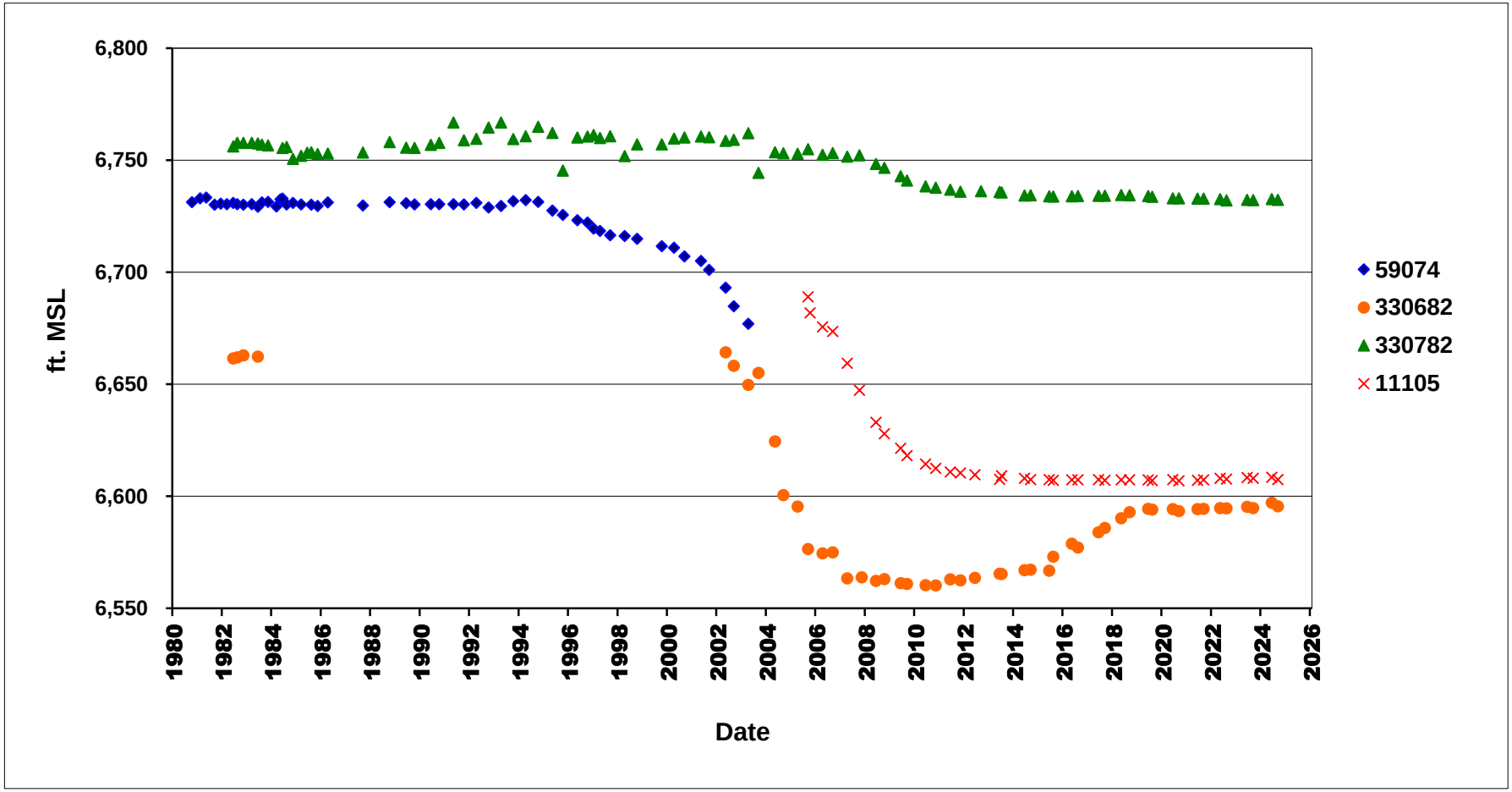


Figure 14. Historical Hydrograph
Alluvial Wells, Upgradient of Pit 3

566594 (No. 93)
566694 (No. 94)

Notes: **Well 566694 - monitoring discontinued in 2016. Current approved Table MP-23 (Revised 4/2016).**

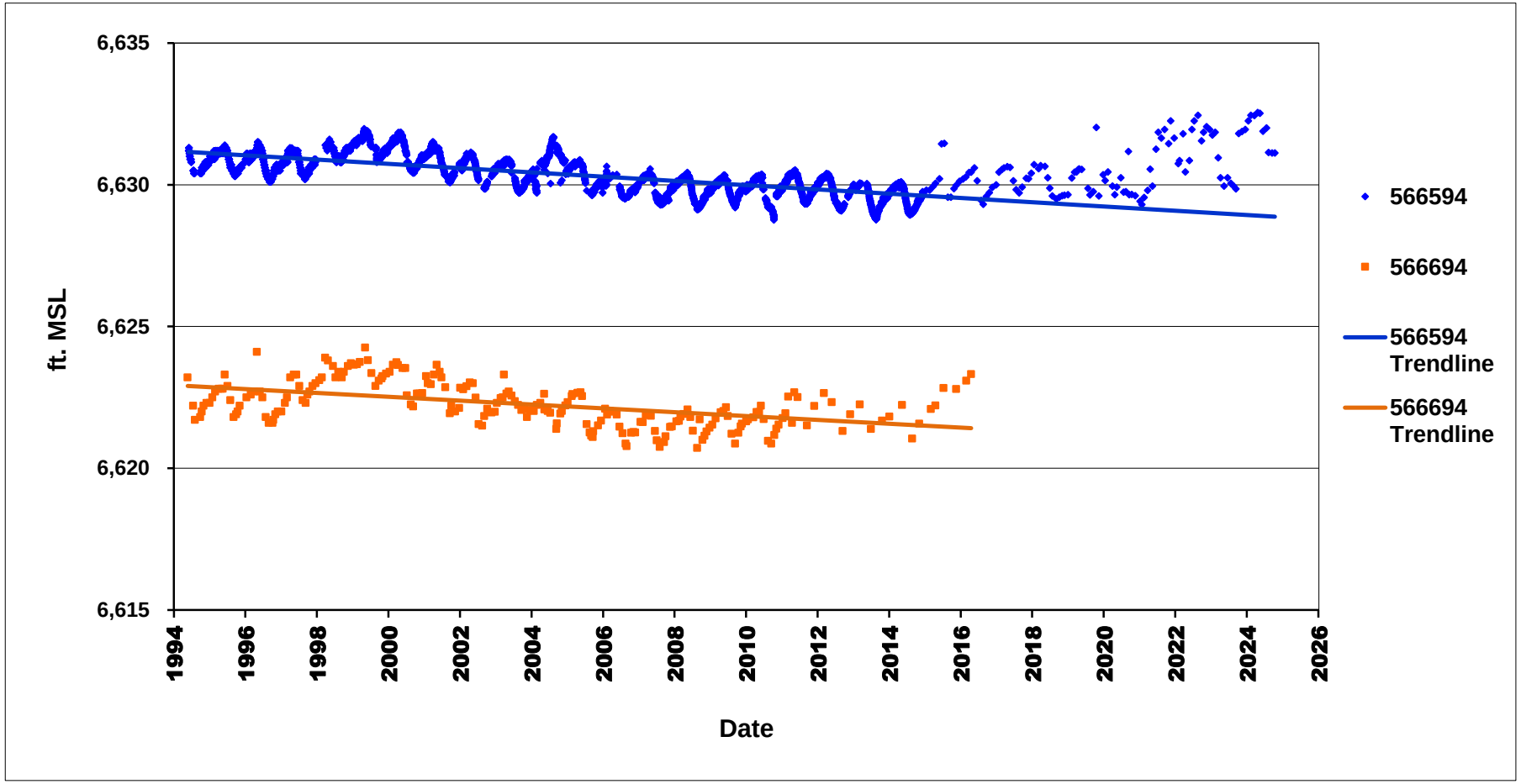


Figure 15. Historical Hydrograph
Alluvial Wells, Adjacent to Pit 3

284680 (No. 41)
285280 (No. 47)
285780 (No. 52)

Notes: **Wells 285280 and 285780 - monitoring discontinued 2016. Current approved Table MP-23 (Revised 4/2016).**

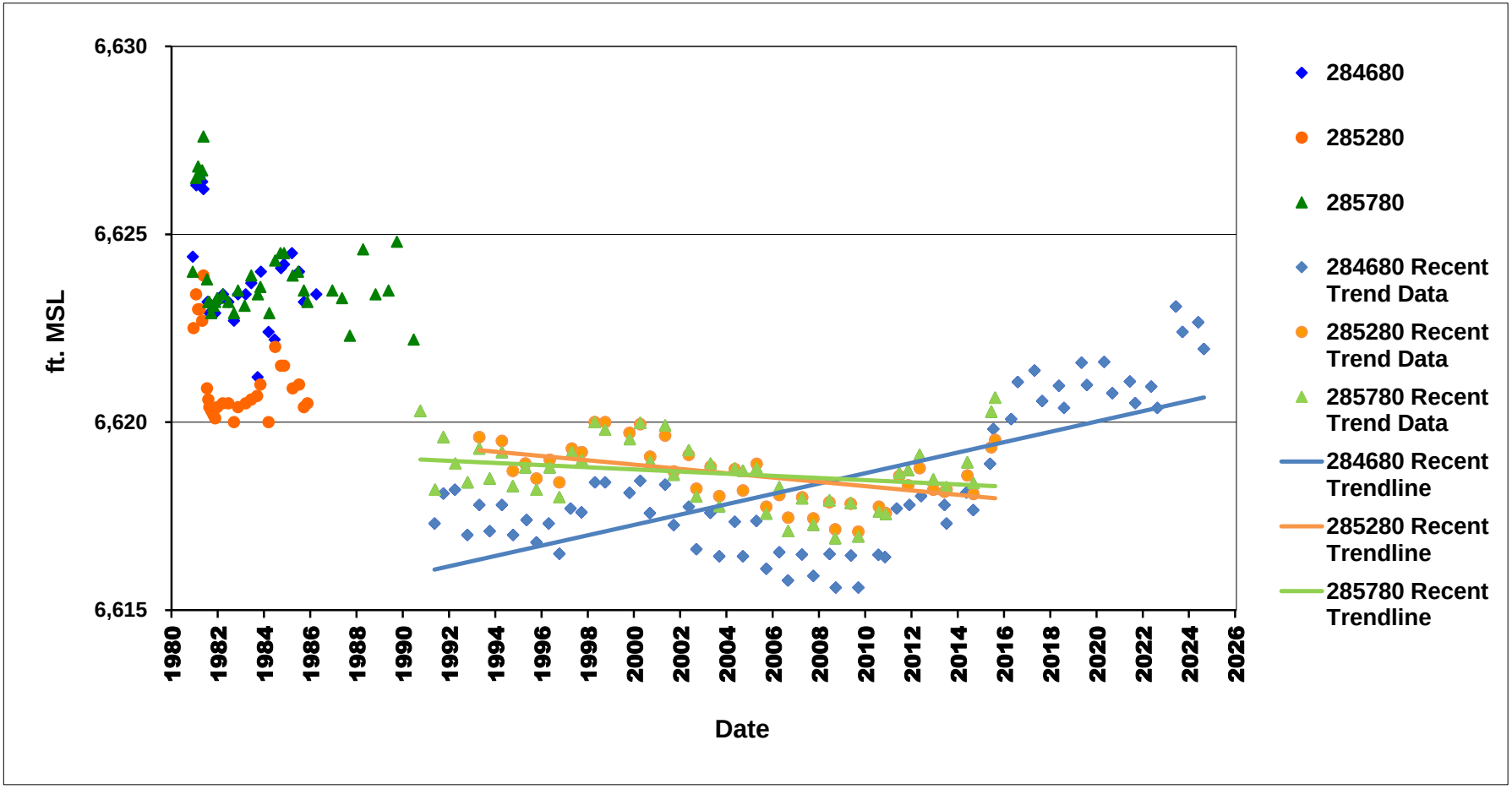


Figure 16. Historical Hydrograph
Alluvial Wells, Down-Valley of Pit 3

566794 (No. 95)
566894 (No. 96)
566994 (No. 97)
567094 (No. 98)

Notes: **Wells 566794 and 567094 - monitoring discontinued in 2016. Current approved Table MP-23 (Revised 4/2016).**

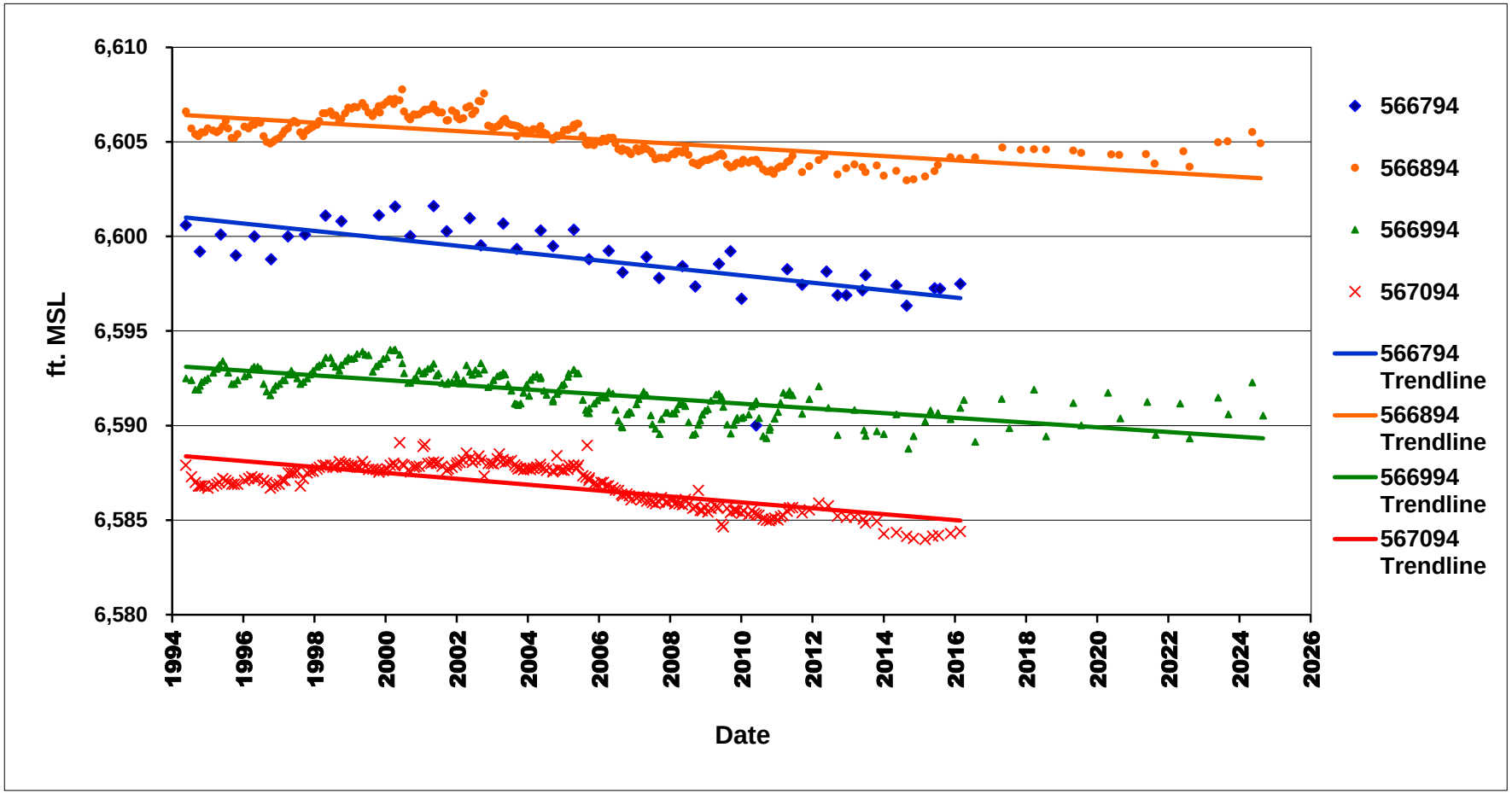


Figure 17. Historical Hydrograph
Alluvial Wells, Up-Valley of Pit 2

567194 (No. 99)
567994 (No. 107)

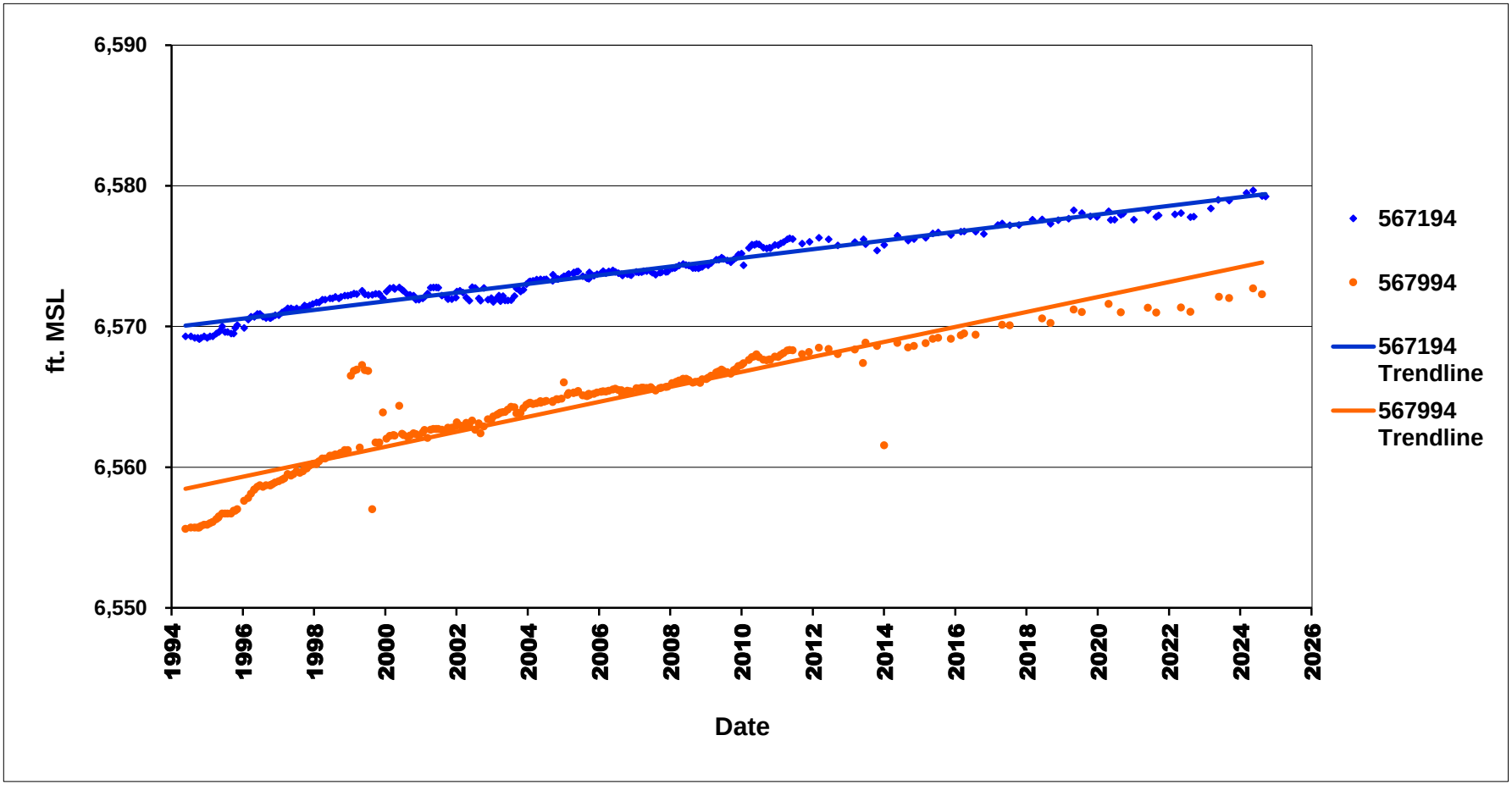


Figure 18. Historical Hydrograph
Alluvial Wells, Adjacent to Pit 2

455485 (No. 74)
455585 (No. 73)
567394 (No. 101)
567894 (No. 106)

Notes: **Monitoring discontinued in 2016 for Wells 455485, 567394 and 567894. Current approved Table MP-23 (Revised 4/2016).**

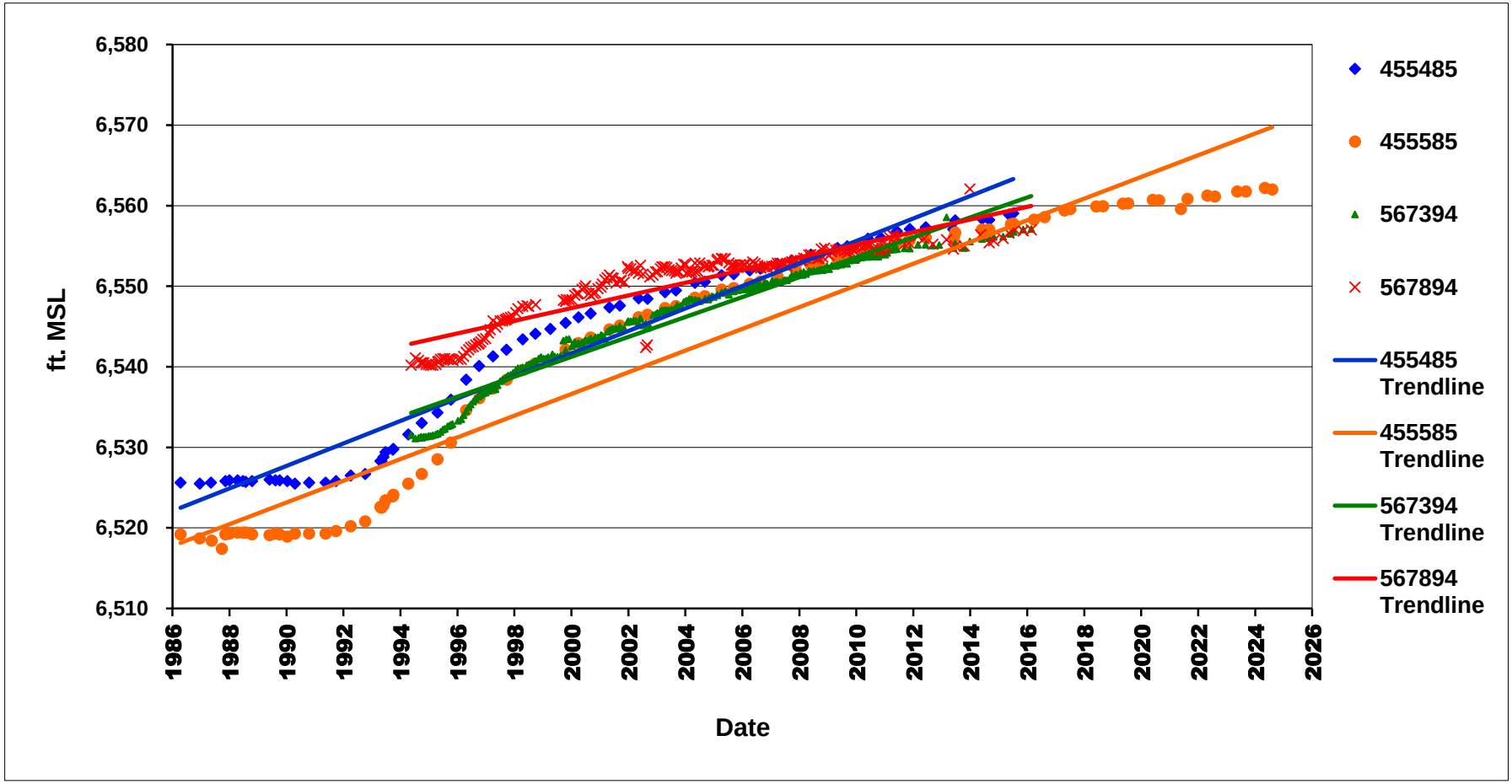


Figure 19. Historical Hydrograph
Alluvial Wells, Down-Valley of Pit 2

567494 (No. 102)
567694 (No. 104)
567794 (No. 105)

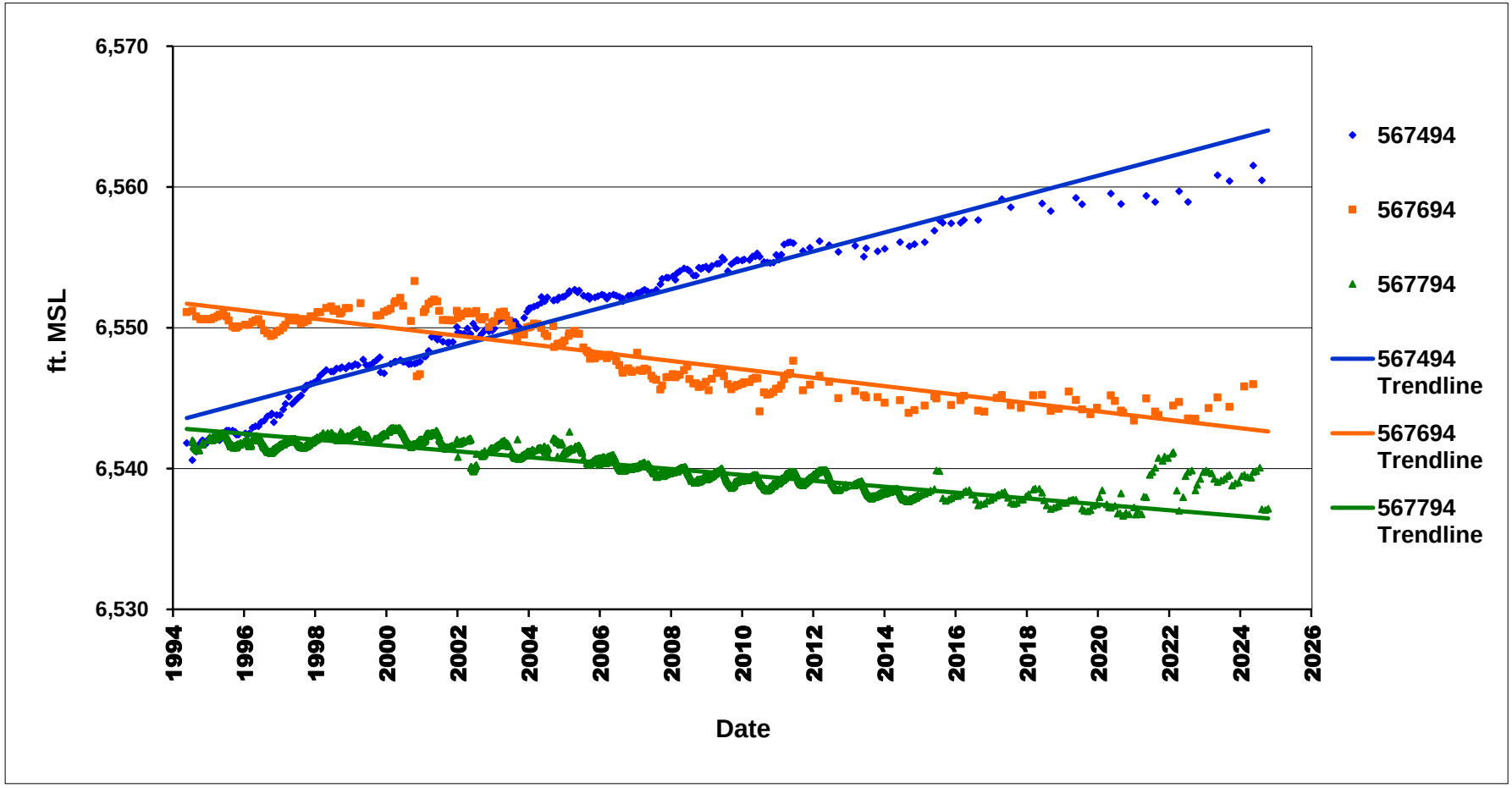


Figure 19a. Historical Hydrograph
Almond Wells, Adjacent to Pit 14 (Central)

Notes: All elevations above 6,990 (monitoring point elevation) for SW1-UB represent flowing conditions.

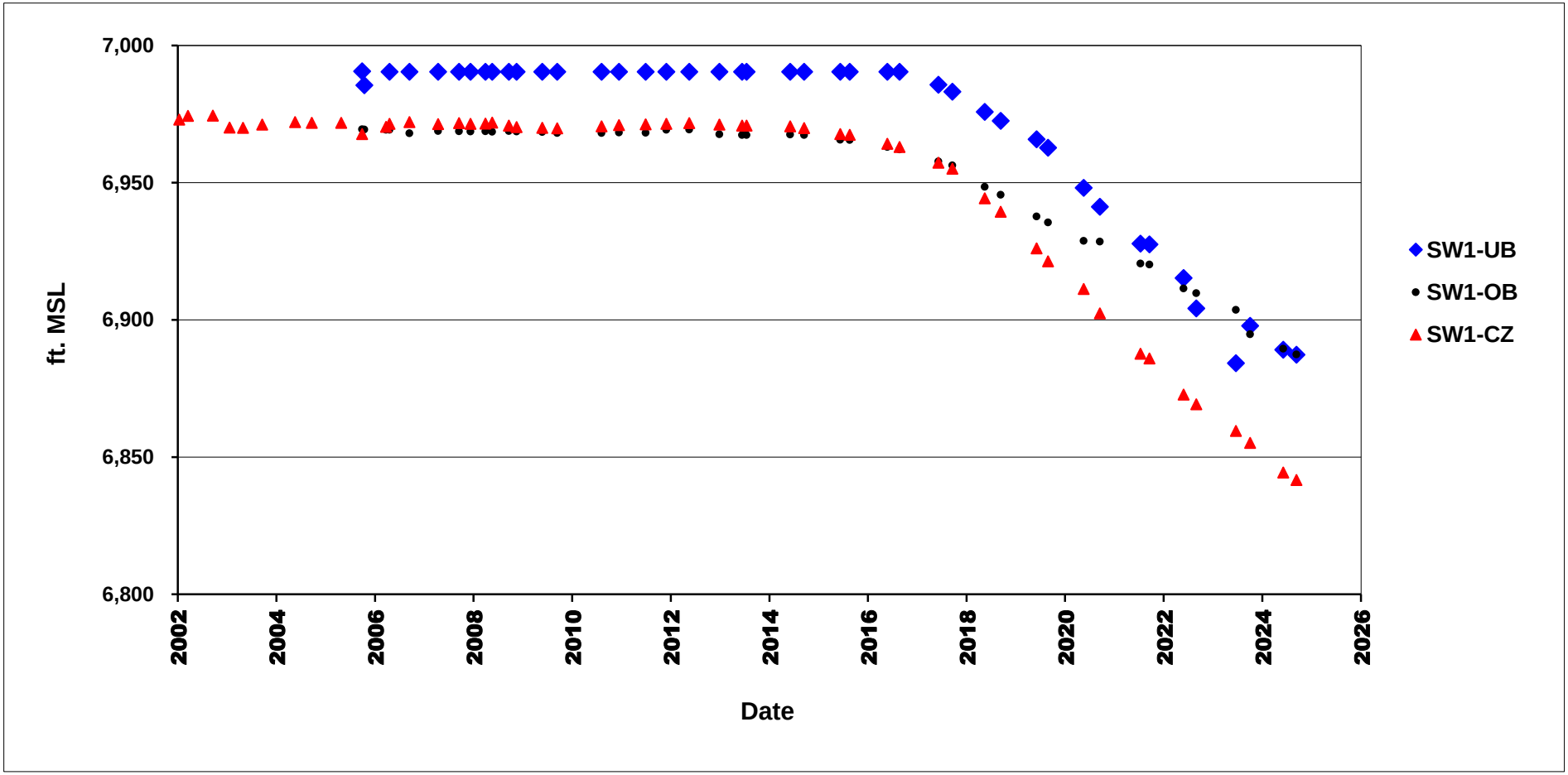


Figure 19b. Historical Hydrograph
Almond Wells, Adjacent to Pit 14 (Southwest)

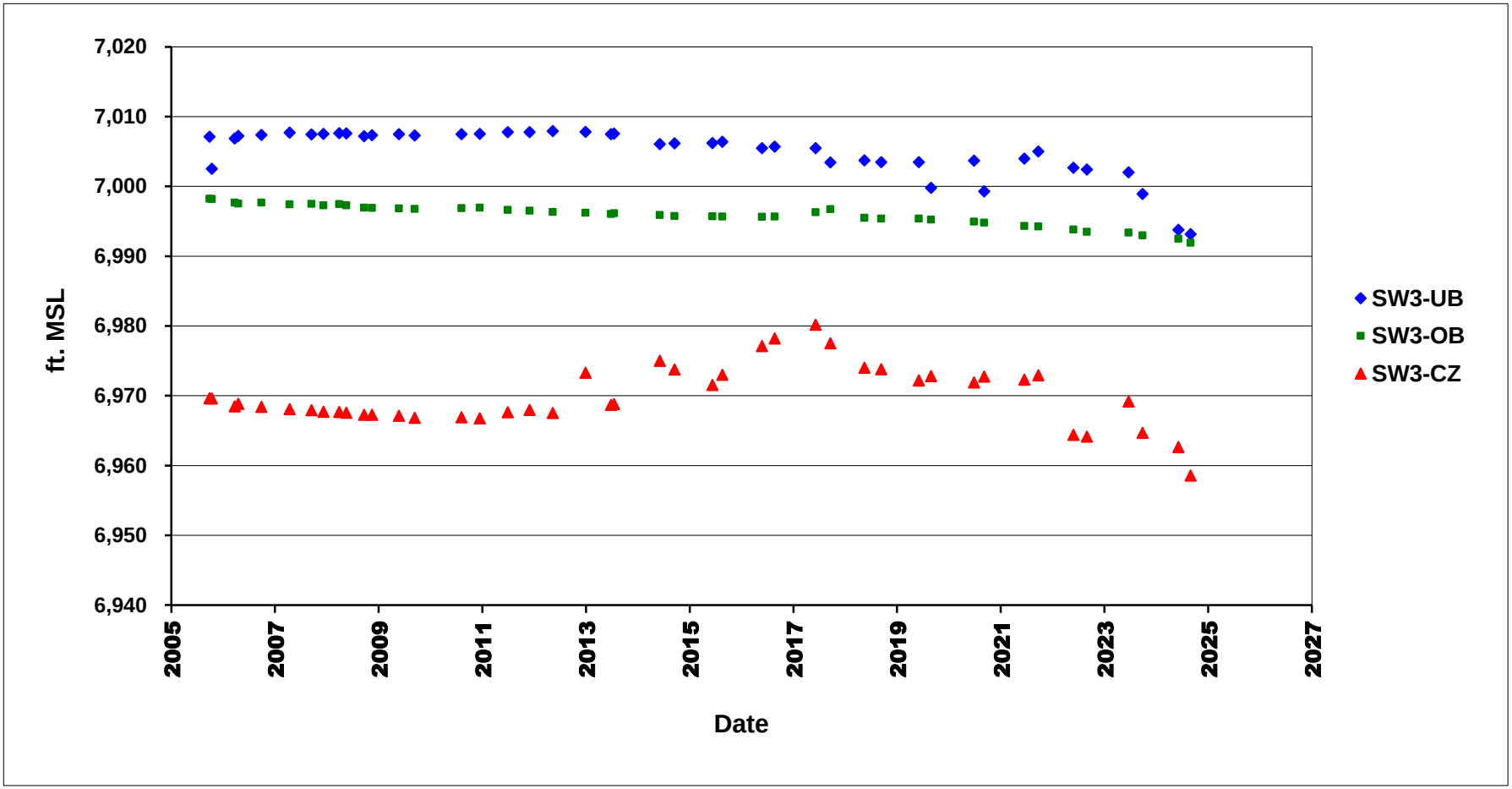


Figure 20a. Water Elevation At 566594 (QAL) - #93 Versus Streamflow At SBC1-75

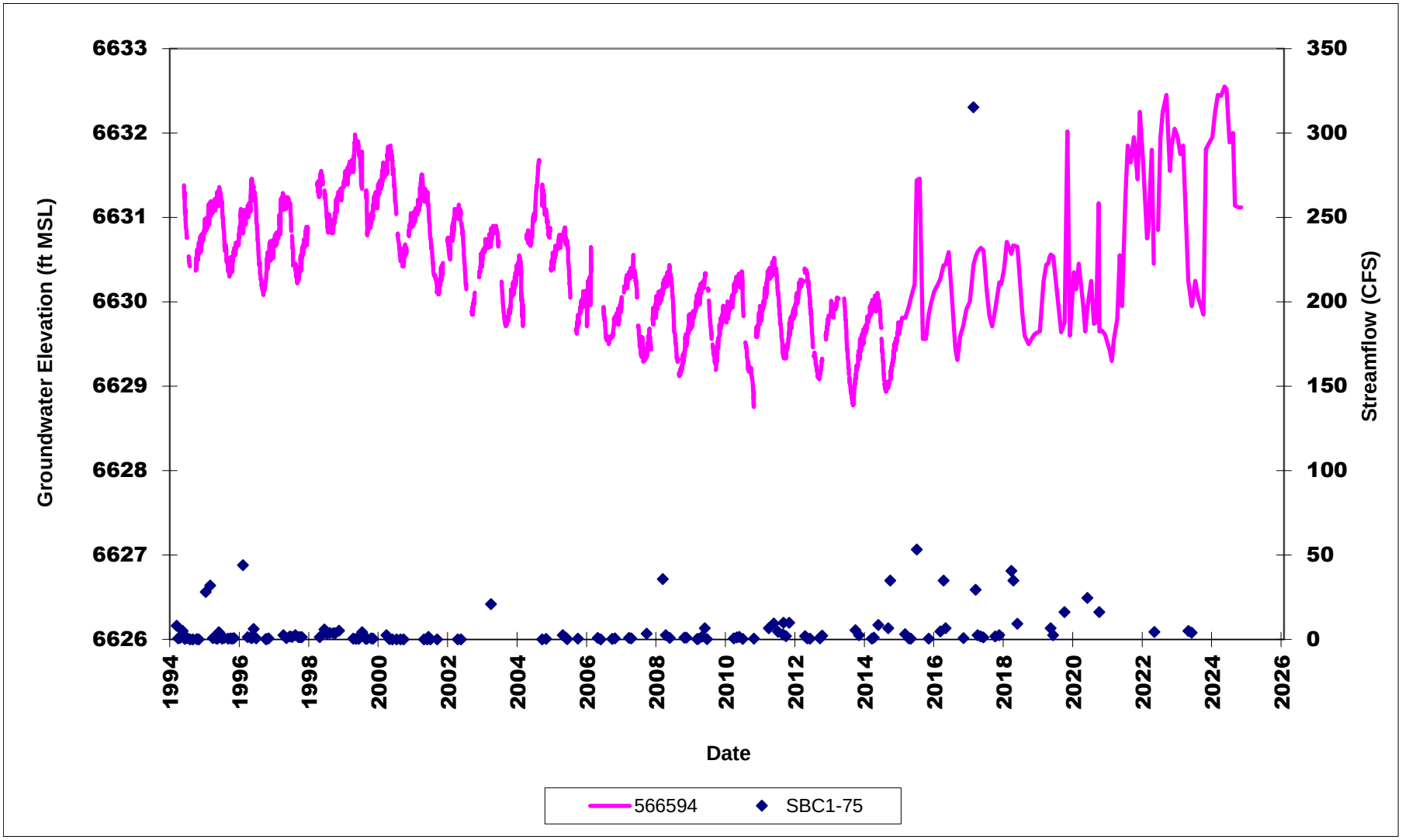


Figure 20b. Water Elevation At 567794 (QAL) - #105 Versus Streamflow At SBC2-75

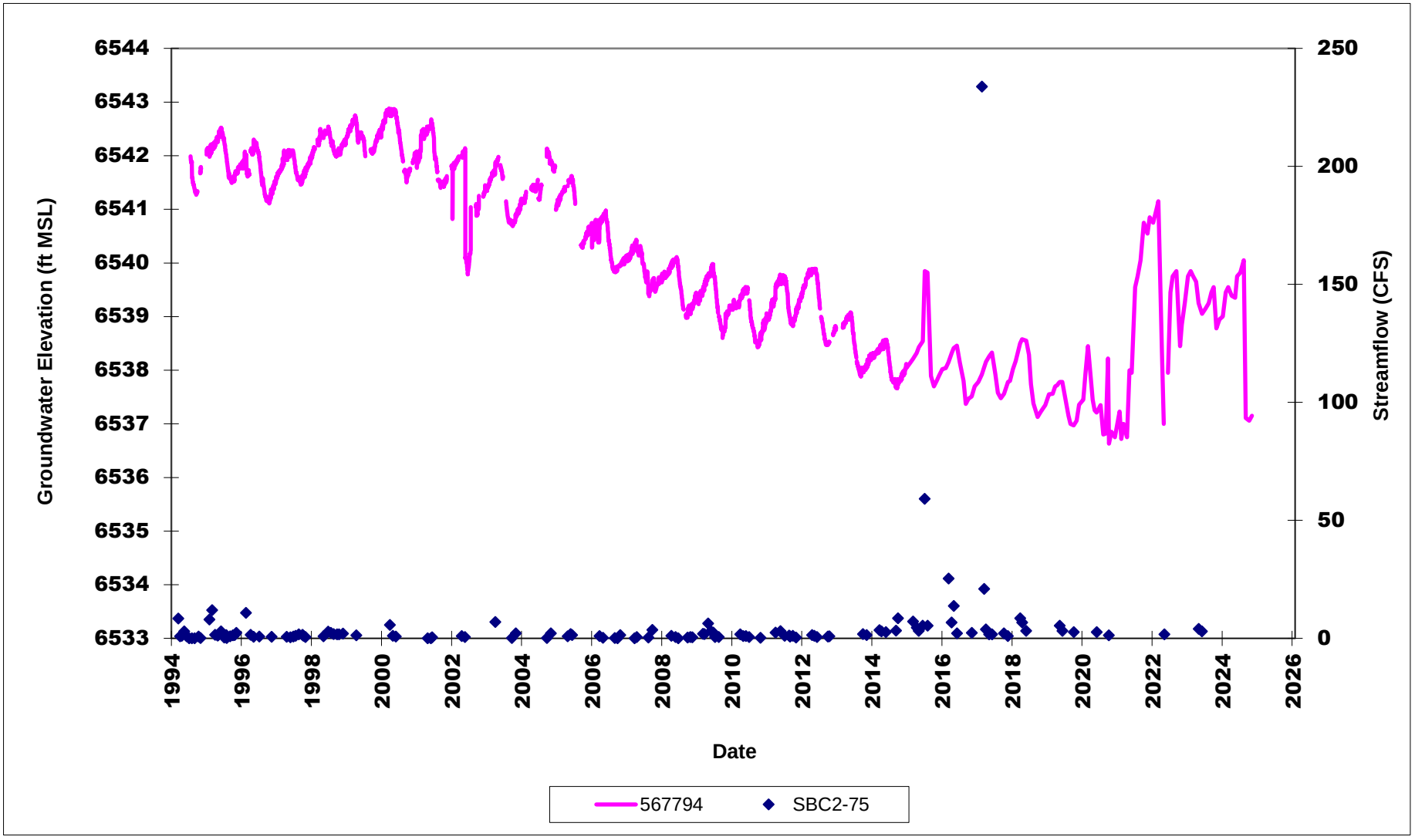


Figure 21. Historical Hydrograph
Spoil Wells, Pit 2 Area

510086 (No. 79)
520287 (No. 84)
568198 (No. 109)
568298 (N0. 110)

Notes: **Well 568198 was completed as a replacement for Well 520287.**
Well 568298 was completed as a replacement for Well 510086.
Monitoring discontinued in 2016 for Well 568198. Current approved Table MP-23 (Revised 4/2016).

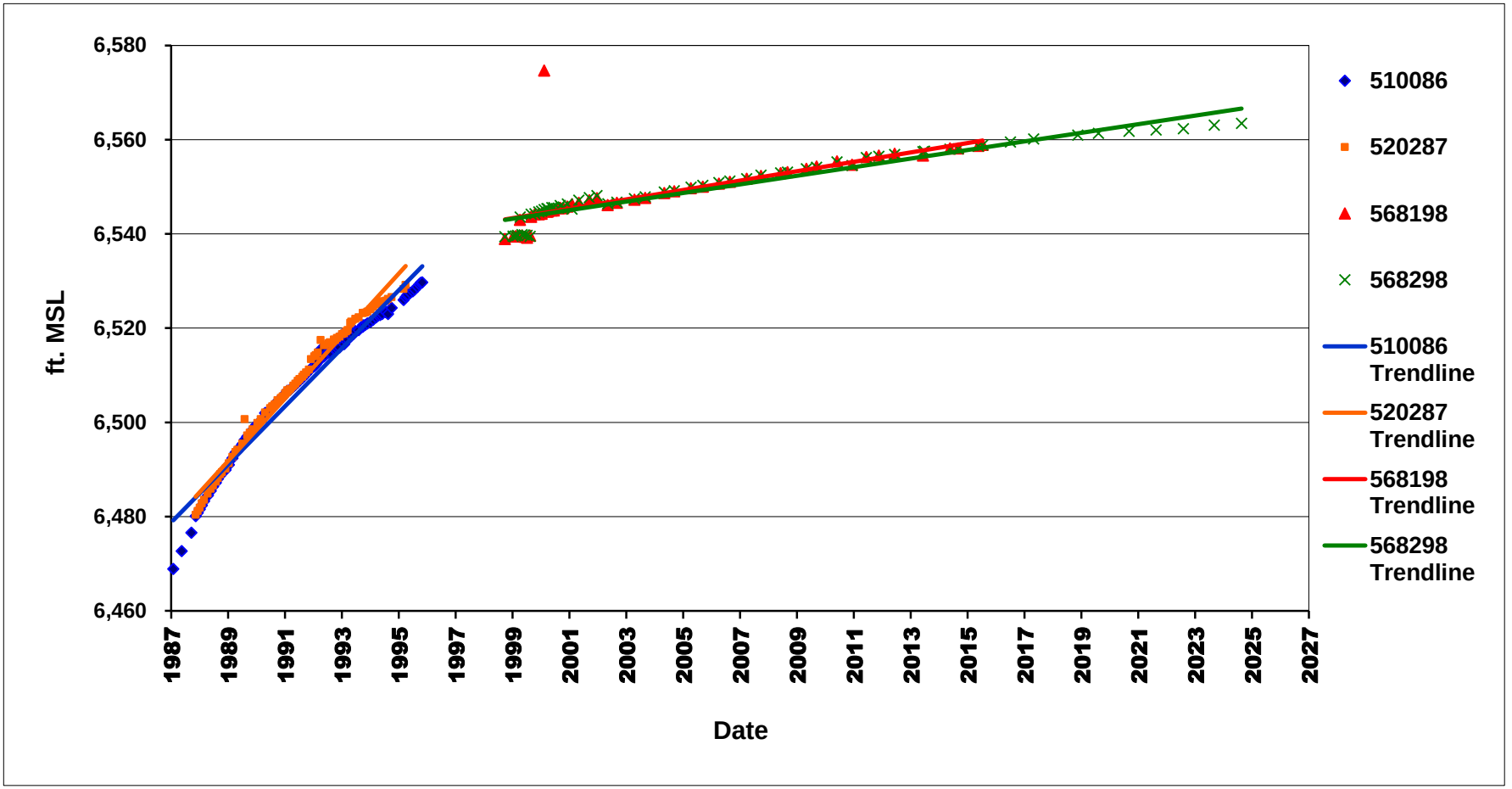
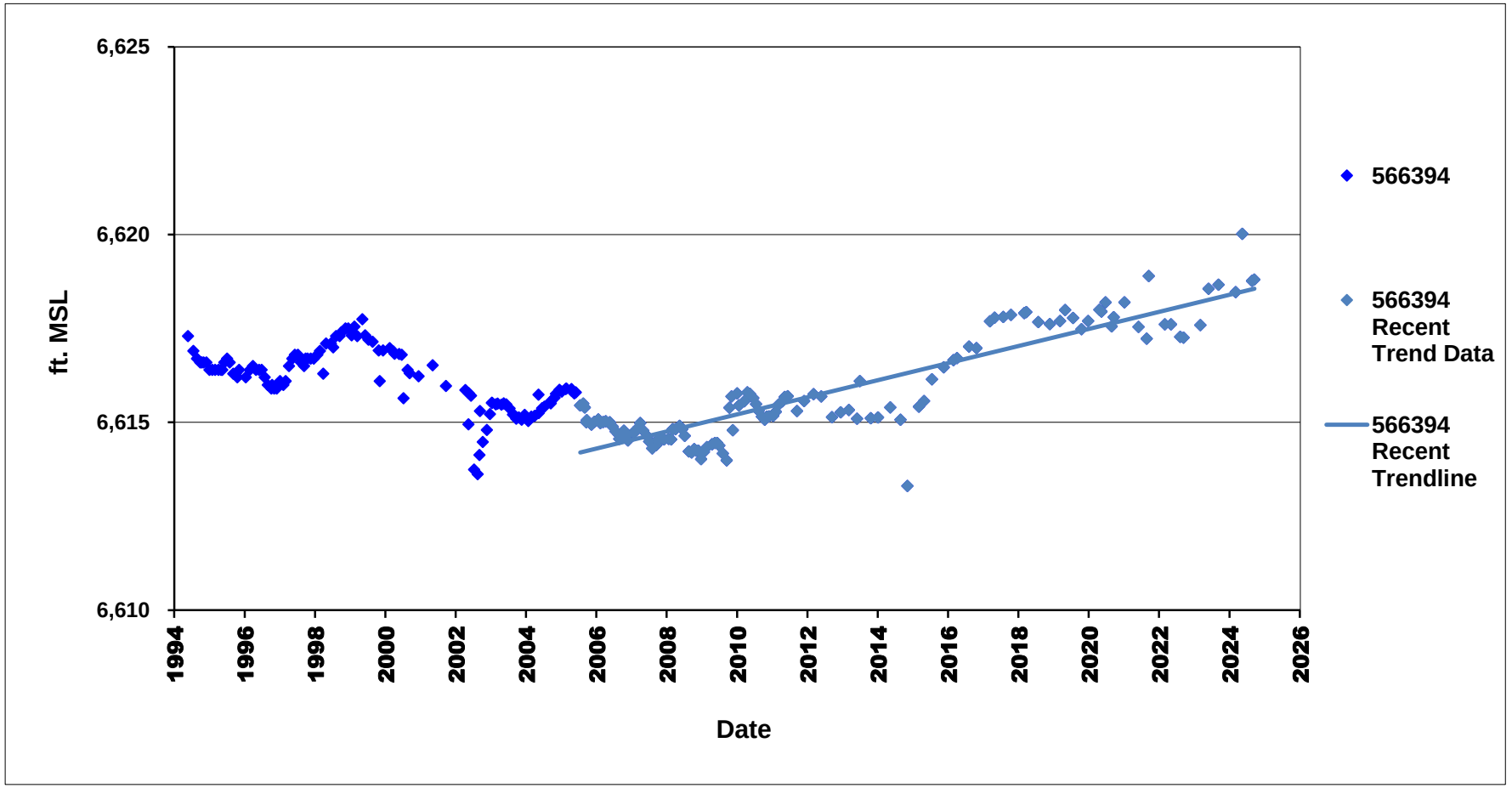
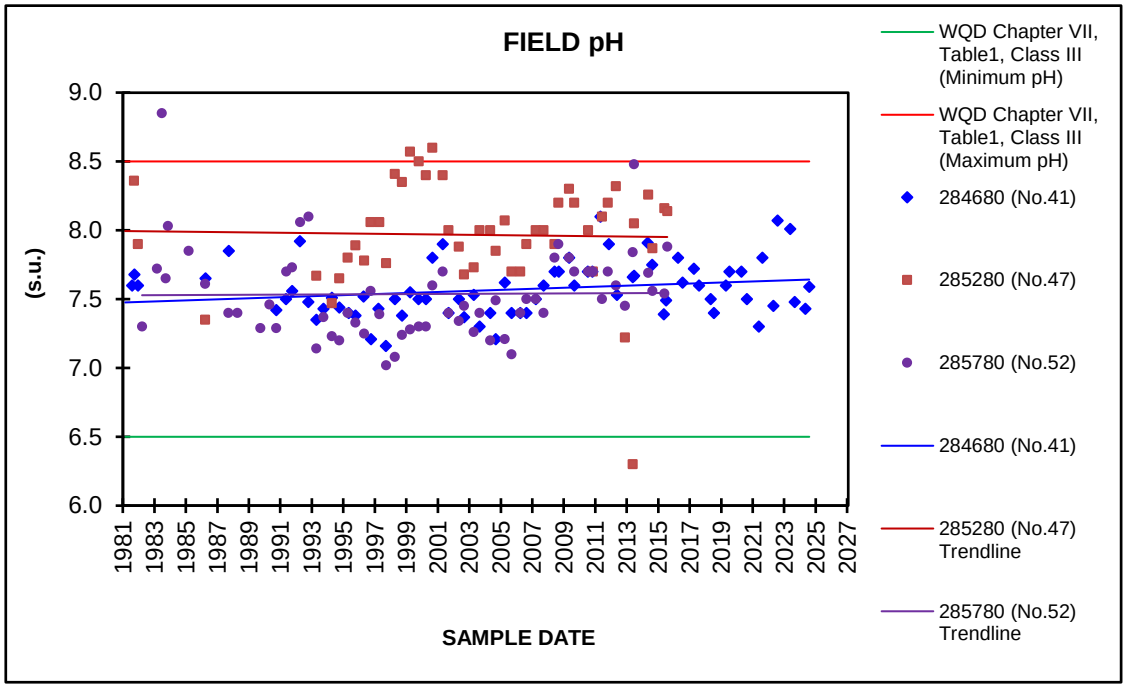
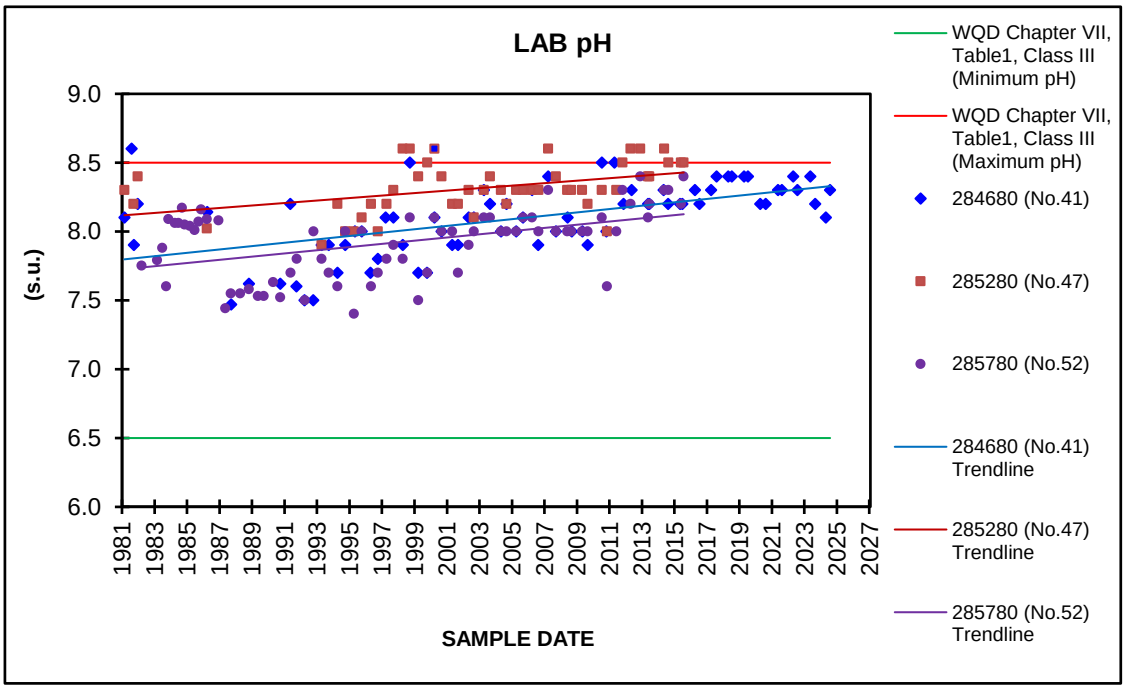


Figure 22. Historical Hydrograph
Spoil Well Pit 3 Area

566394 (No. 91)

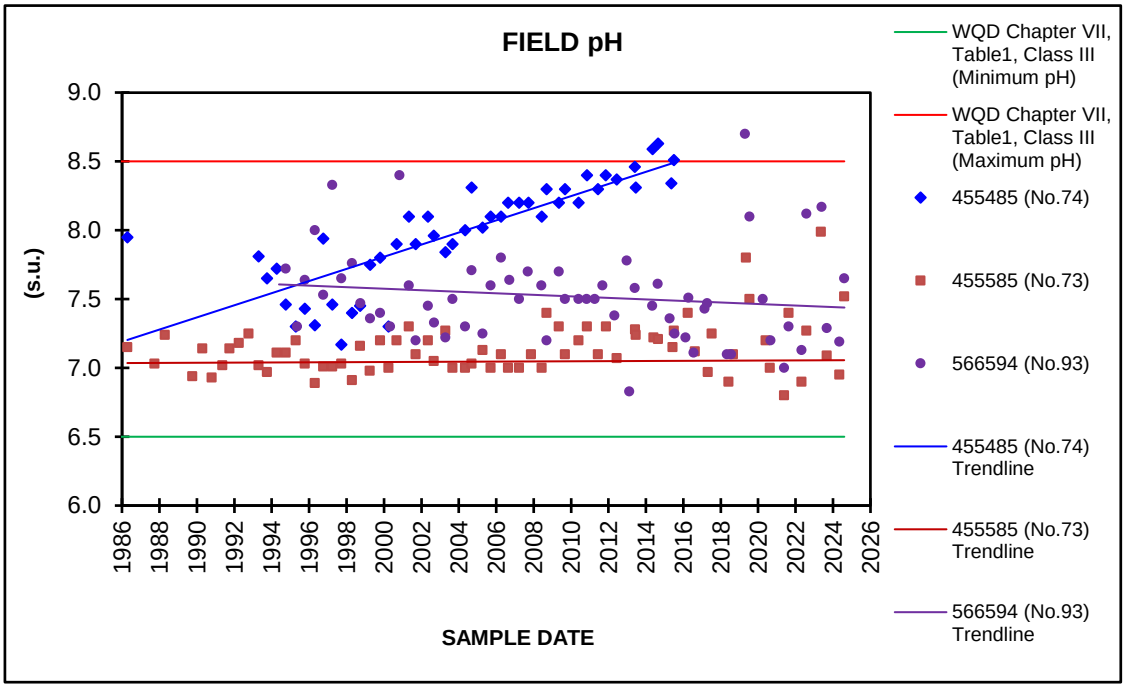


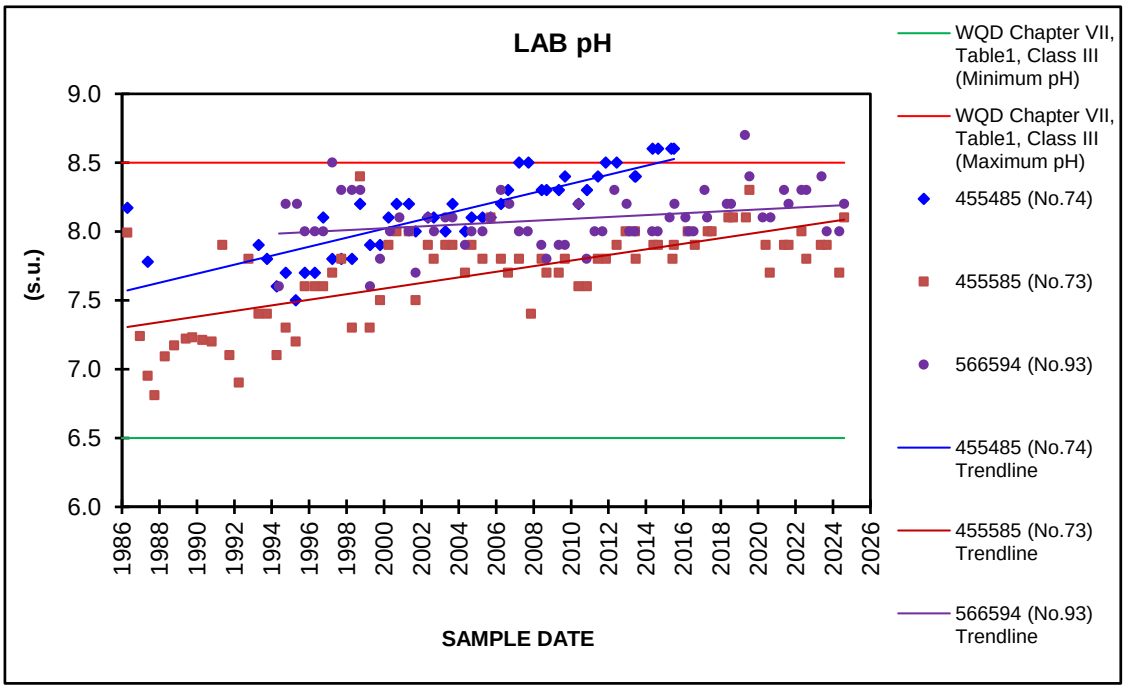




Note: All three of these wells are near Pit 3.
Monitoring discontinued in 2016 for Wells 285280 and 285780.
Current approved Table MP-23 (Revised 4/2016).

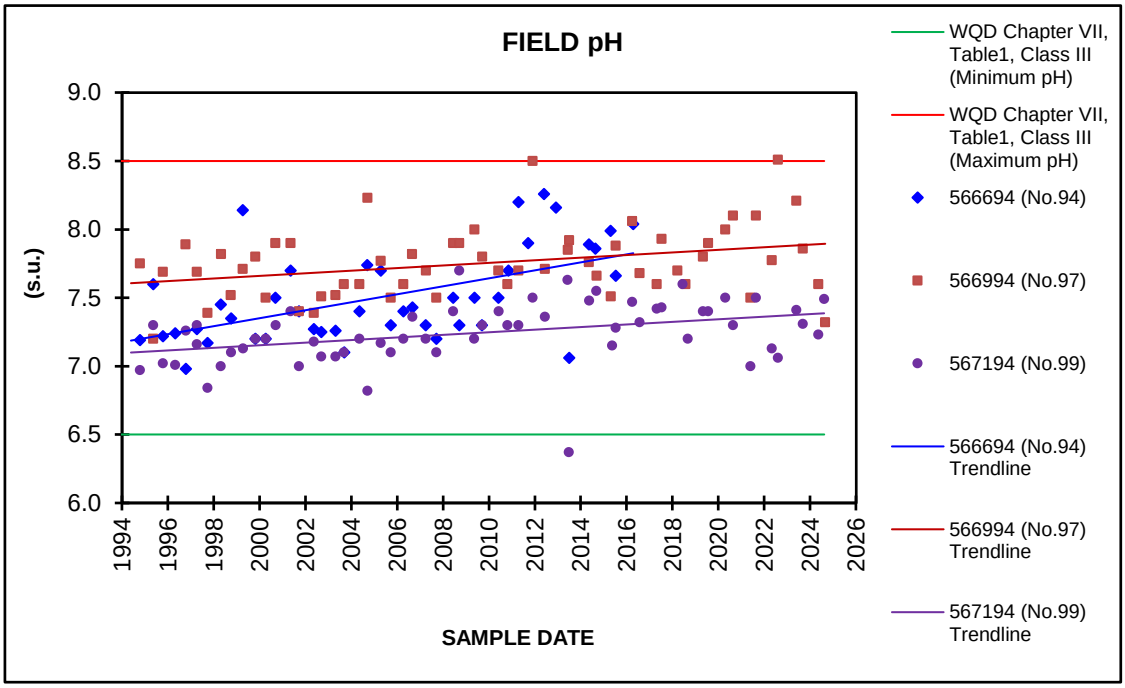
Figure 23. Field & Lab pH Values In Bitter Creek Alluvial Wells

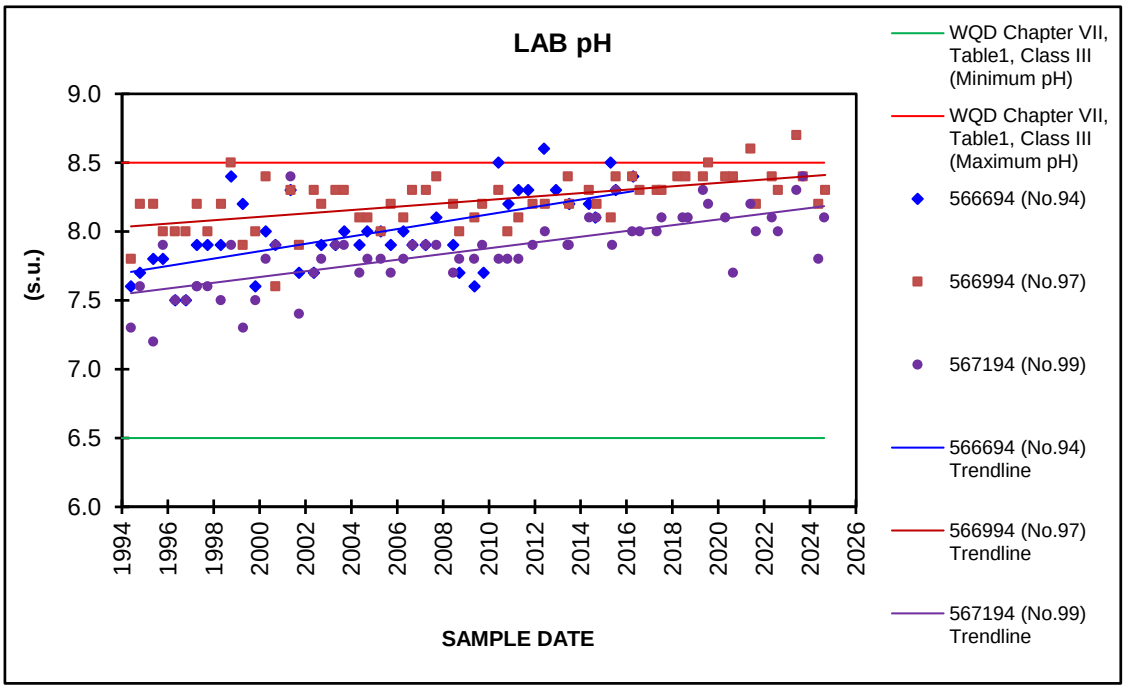




Note: 455485 and 455585 are near Pit 2. 566594 is in the farthest up-valley location. Monitoring discontinued in 2016 for Well 455485. Current approved Table MP-23 (Revised 4/2016).

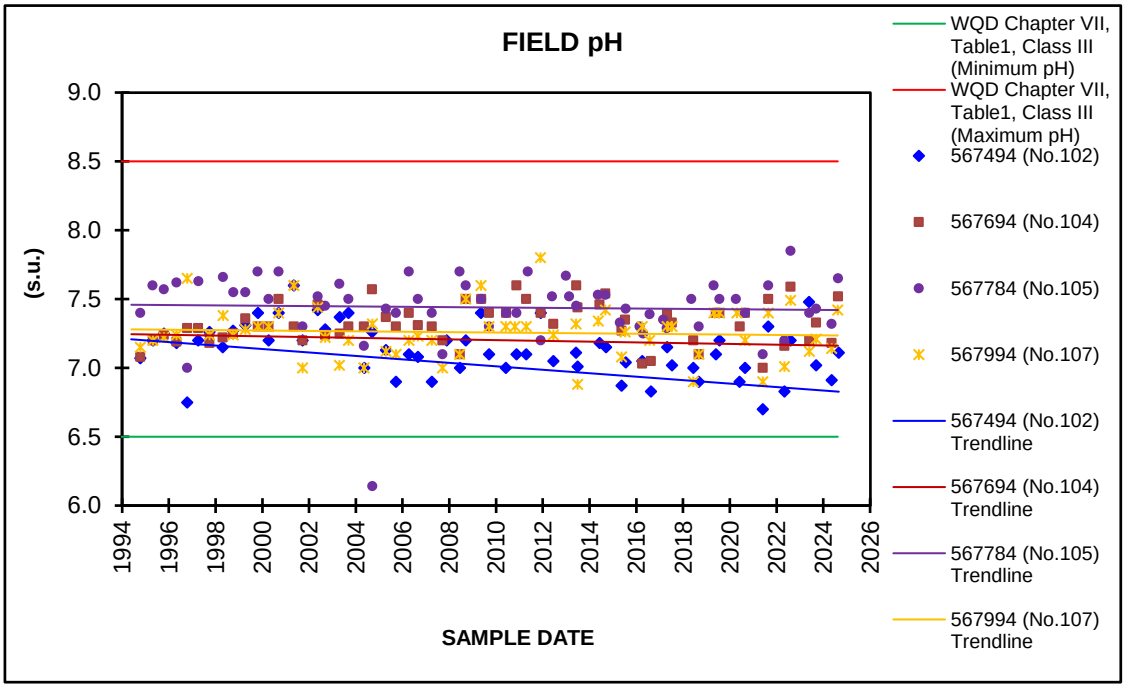
Figure 24. Field & Lab pH Values In Bitter Creek Alluvial Wells

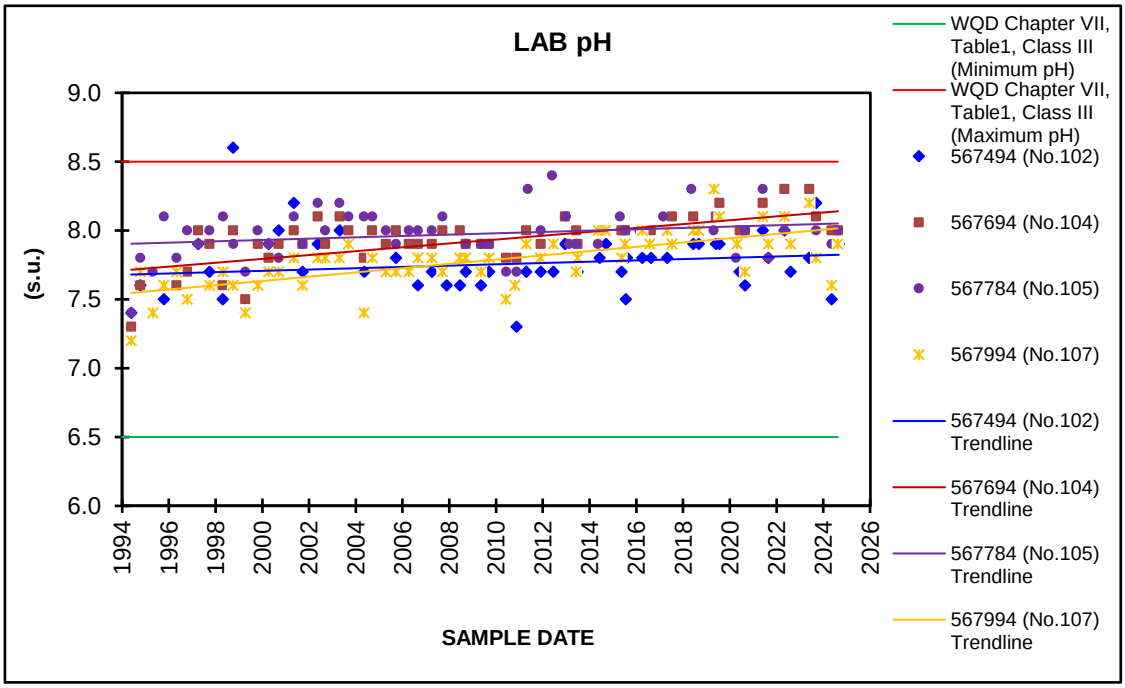




Note: 566694 is near Pit 3; 566994 is near Pit 5S and 567194 is near Pit 2. Monitoring discontinued in 2016 for Well 566694. Current approved Table MP-23 (Revised 4/2016).

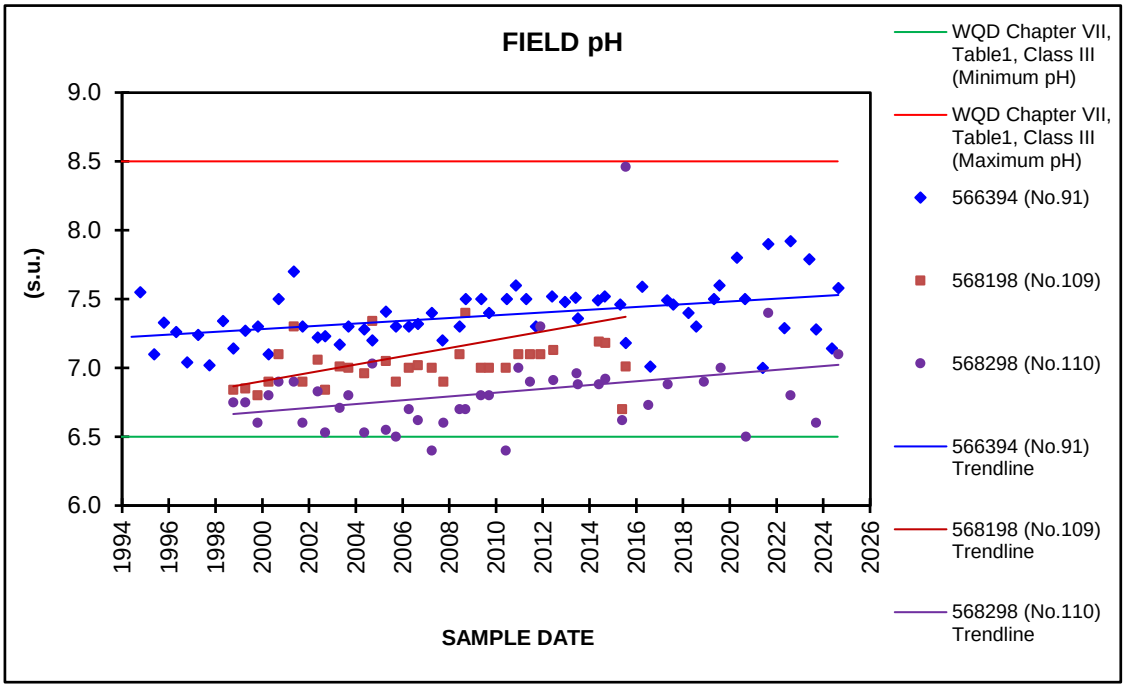
Figure 25. Field & Lab pH Values In Bitter Creek Alluvial Wells

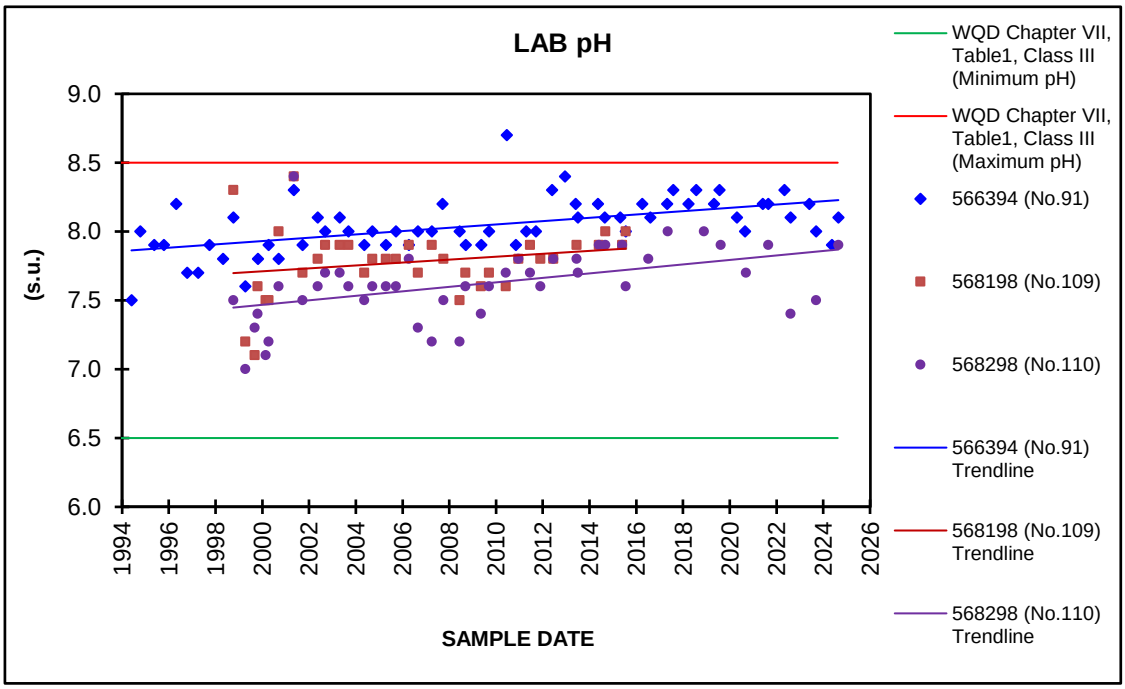




Note: 567494 and 567994 are near Pit 2, 567694 is down-valley of Pit 2, and 567794 is in the farthest down-valley location.

Figure 26. Field & Lab pH Values In Bitter Creek Alluvial Wells





Note: 566394 is near Pit 3; 568198 and 568298 are are near Pit 2. Monitoring discontinued in 2016 for Well 568198. Current approved Table MP-23 (Revised 4/2016).

Figure 27. Field & Lab pH Values In Spoils Wells

Figure 28. Historical Water Quality
Total Dissolved Solids (mg/l)
Bitter Creek Alluvial Wells

284680 (No. 41)
285280 (No. 47)
285780 (No. 52)

Note: All three of these wells are near Pit 3.
Monitoring discontinued in 2016 for Wells 285280 and 285780. Current approved Table MP-23 (Revised 4/2016).

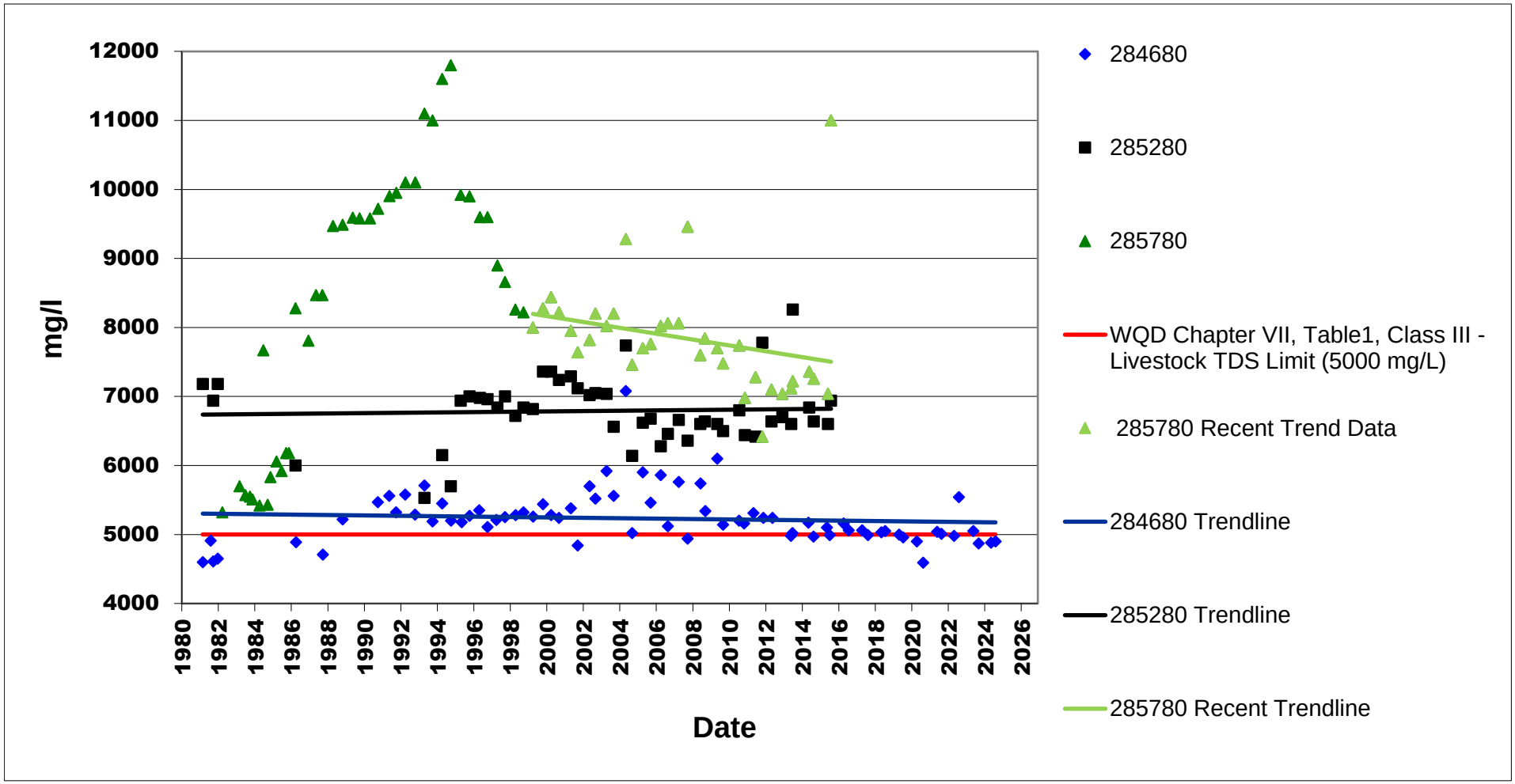


Figure 29. Historical Water Quality
Total Dissolved Solids (mg/l)
Bitter Creek Alluvial Wells

455485 (No. 74)
455585 (No. 73)
566594 (No. 93)

Note: 455485 and 455585 are near Pit 2. 566594 is in the farthest up-valley location.
Monitoring discontinued in 2016 for Well 455485. Current approved Table MP-23 (Revised 4/2016).

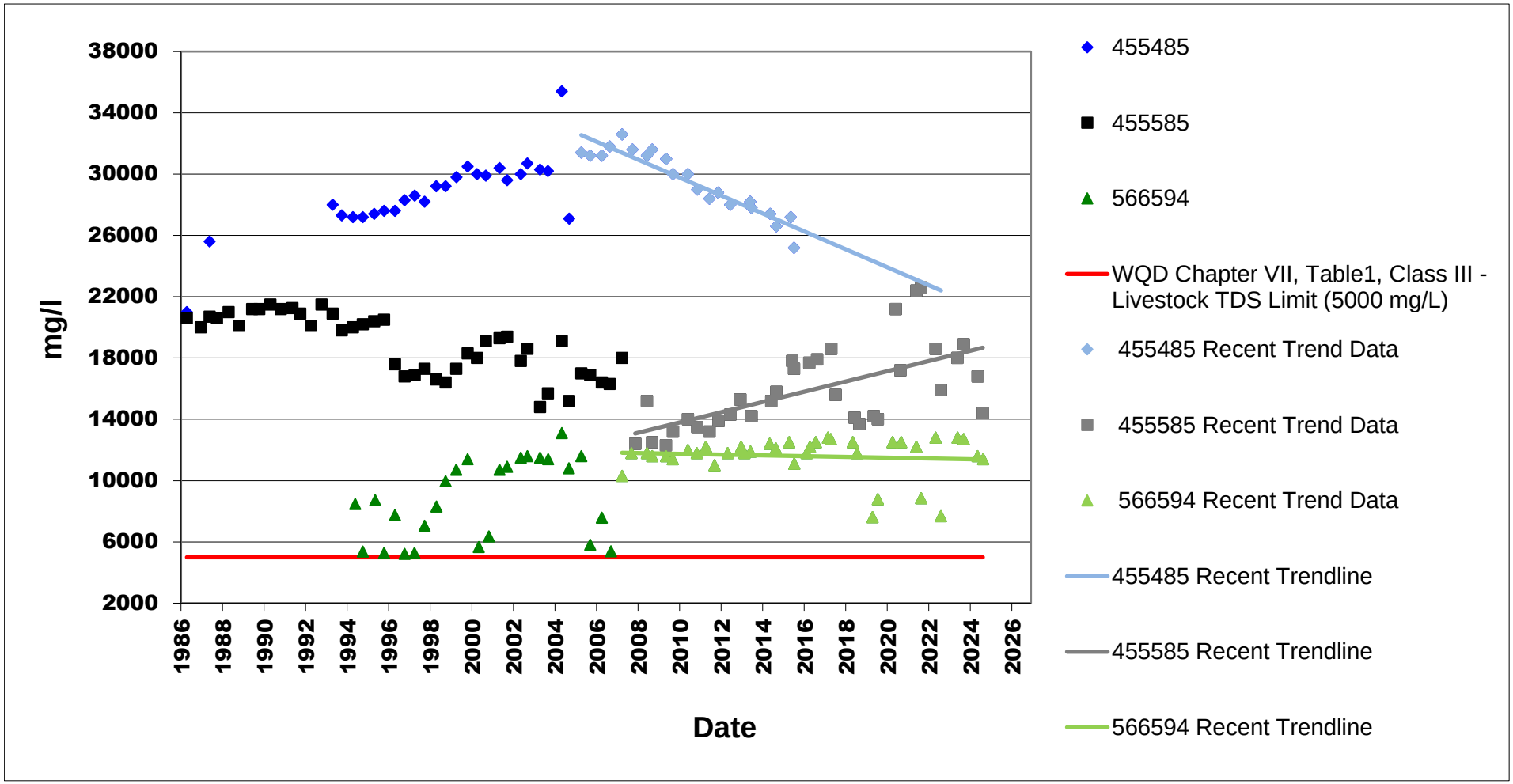


Figure 30. Historical Water Quality
Total Dissolved Solids (mg/l)
Bitter Creek Alluvial Wells

566694 (No. 94)
566994 (No. 97)
567194 (No. 99)

Note: 566694 is near Pit 3; 566994 is near Pit 5S and 567194 is near Pit 2.
Monitoring discontinued in 2016 for Well 566694. Current approved Table MP-23 (Revised 4/2016).

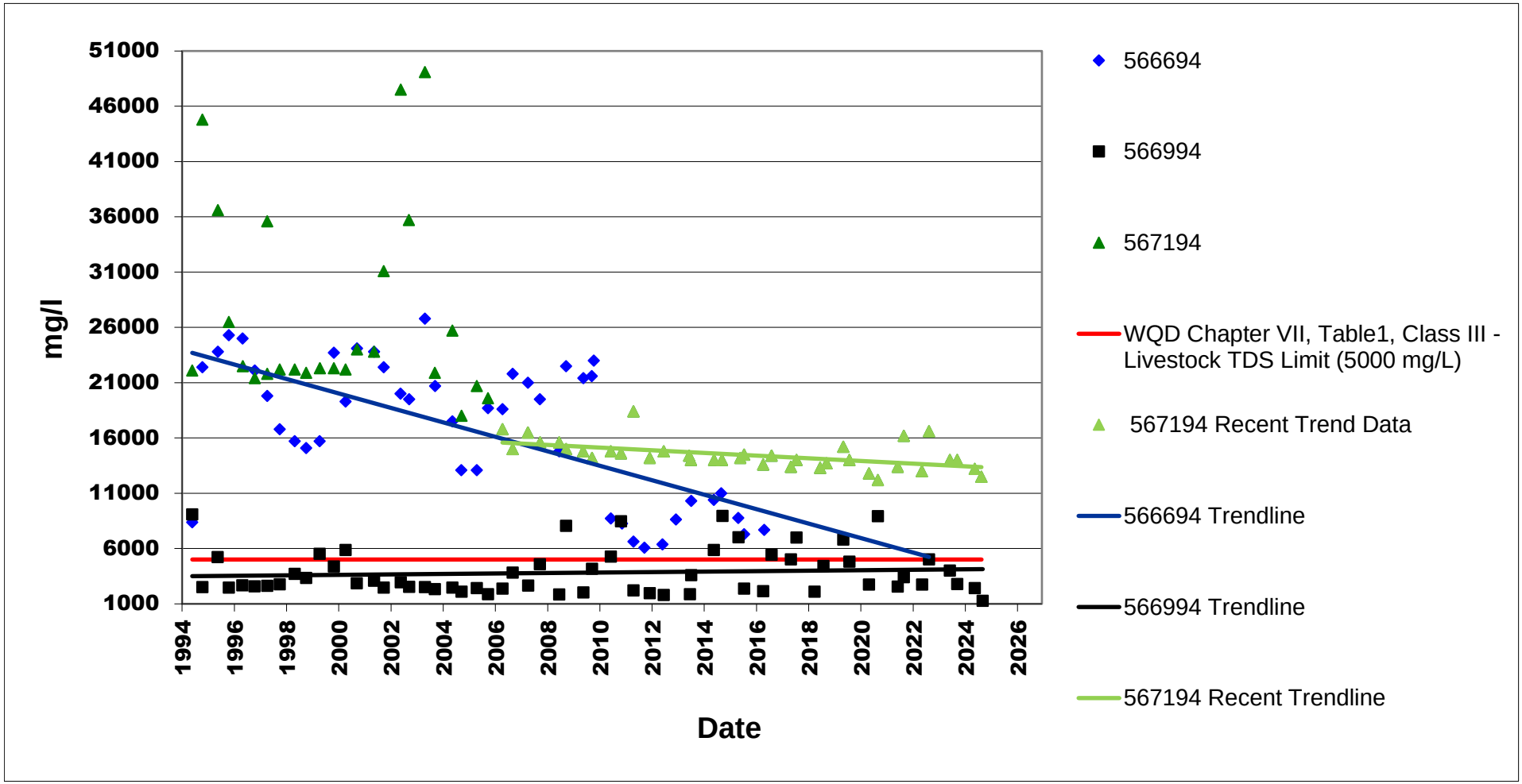


Figure 31. Historical Water Quality
Total Dissolved Solids (mg/l)
Bitter Creek Alluvial Wells

567494 (No. 102)
567694 (No. 104)
567794 (No. 105)
567994 (No. 107)

Note: 567494 and 567994 are near Pit 2, 567694 is down-valley of Pit 2, and 567794 is in the farthest down-valley location.

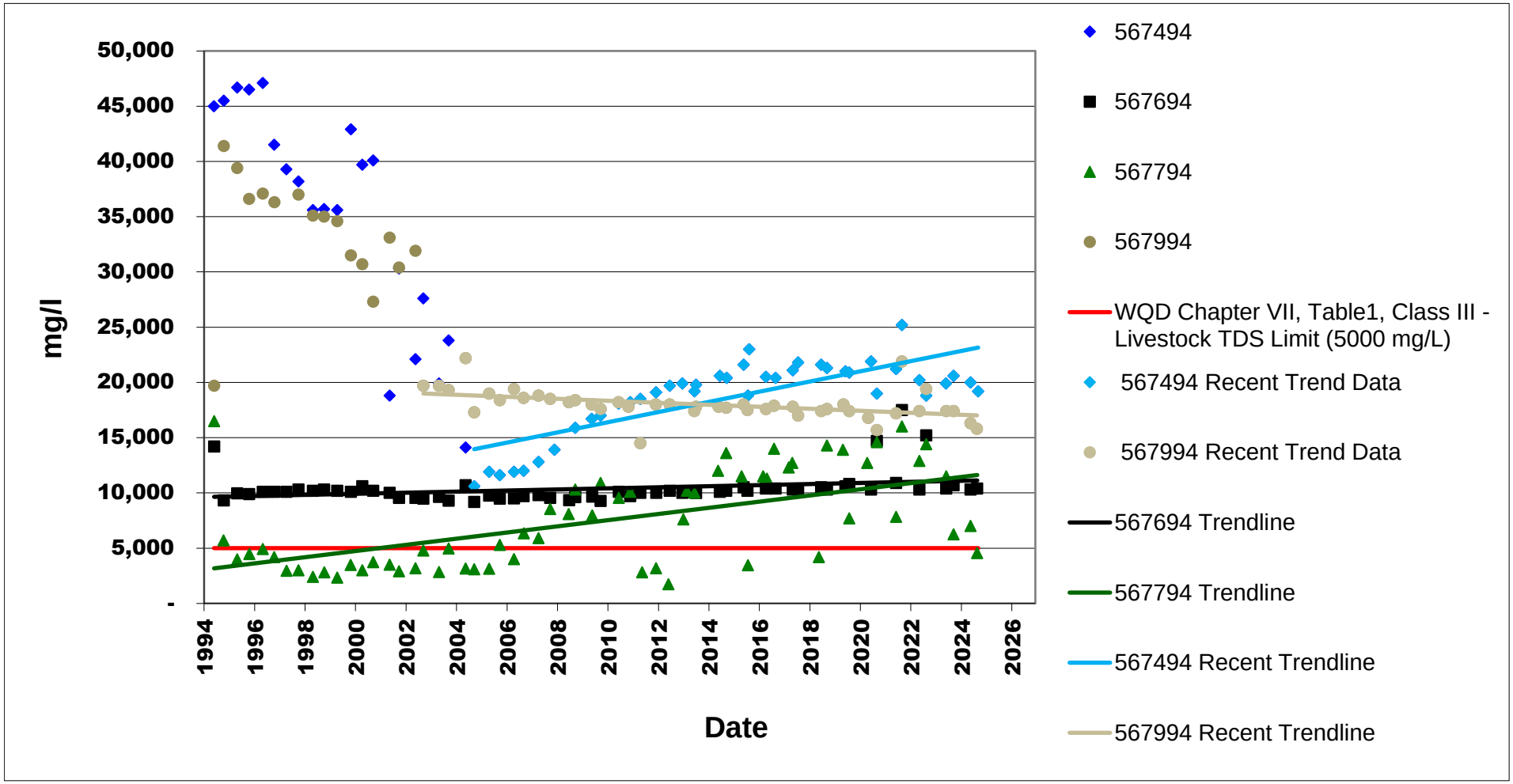


Figure 32. Historical Water Quality
Total Dissolved Solids (mg/l)
Spoils Wells

566394 (No. 91)
568198 (No. 109)
568298 (No. 110)

Note: 566394 is near Pit 3; 568198 and 568298 are are near Pit 2.
Monitoring discontinued in 2016 for Well 568198. Current approved Table MP-23 (Revised 4/2016).

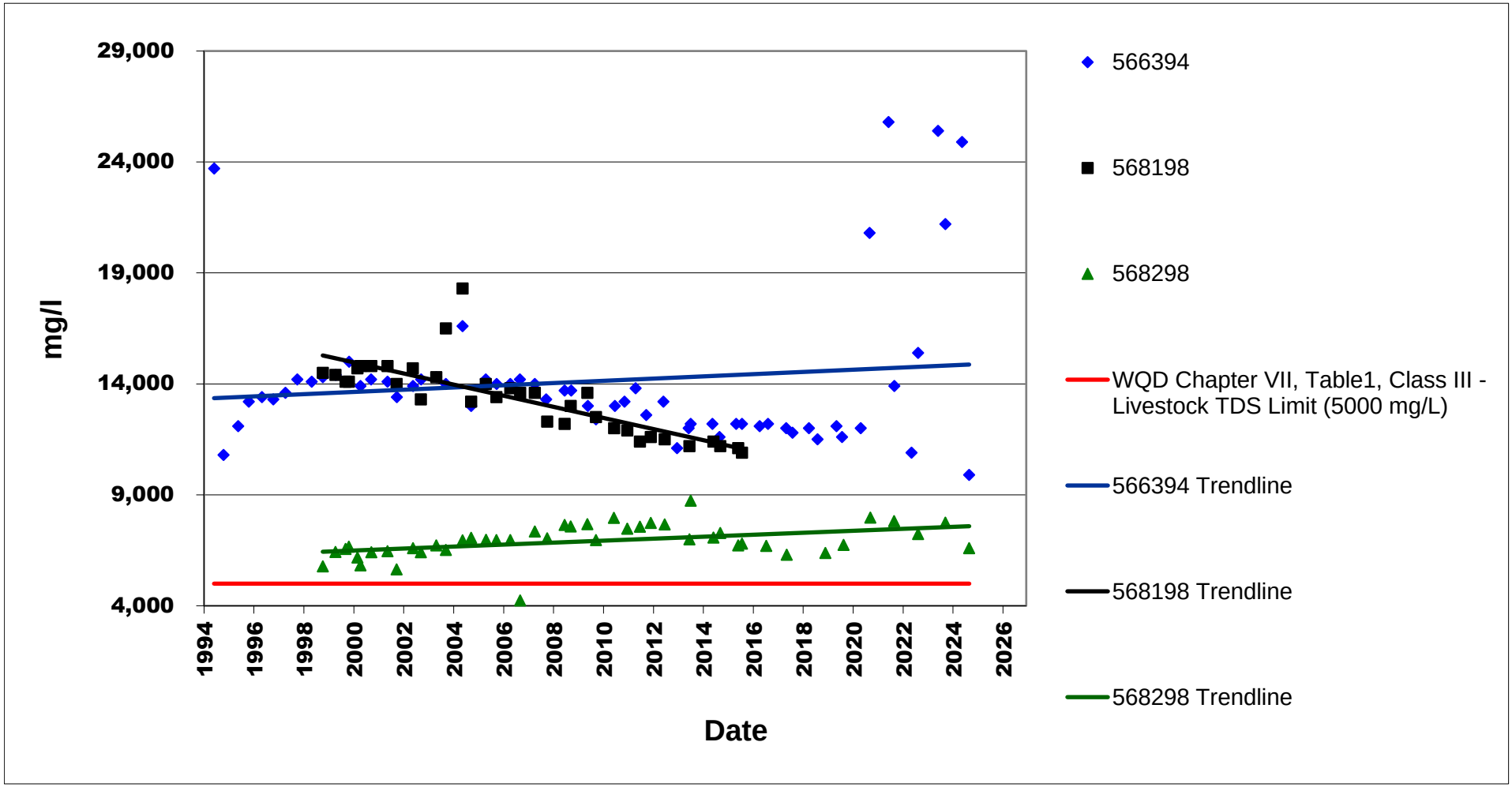


Figure 33. Historical Water Quality
Dissolved Iron (mg/l)
Bitter Creek Alluvial Wells

284680 (No. 41)
285280 (No. 47)
285780 (No. 52)

Note: All three of these wells are near Pit 3.

Monitoring discontinued in 2016 for Wells 285280 and 285780. Current approved Table MP-23 (Revised 4/2016).

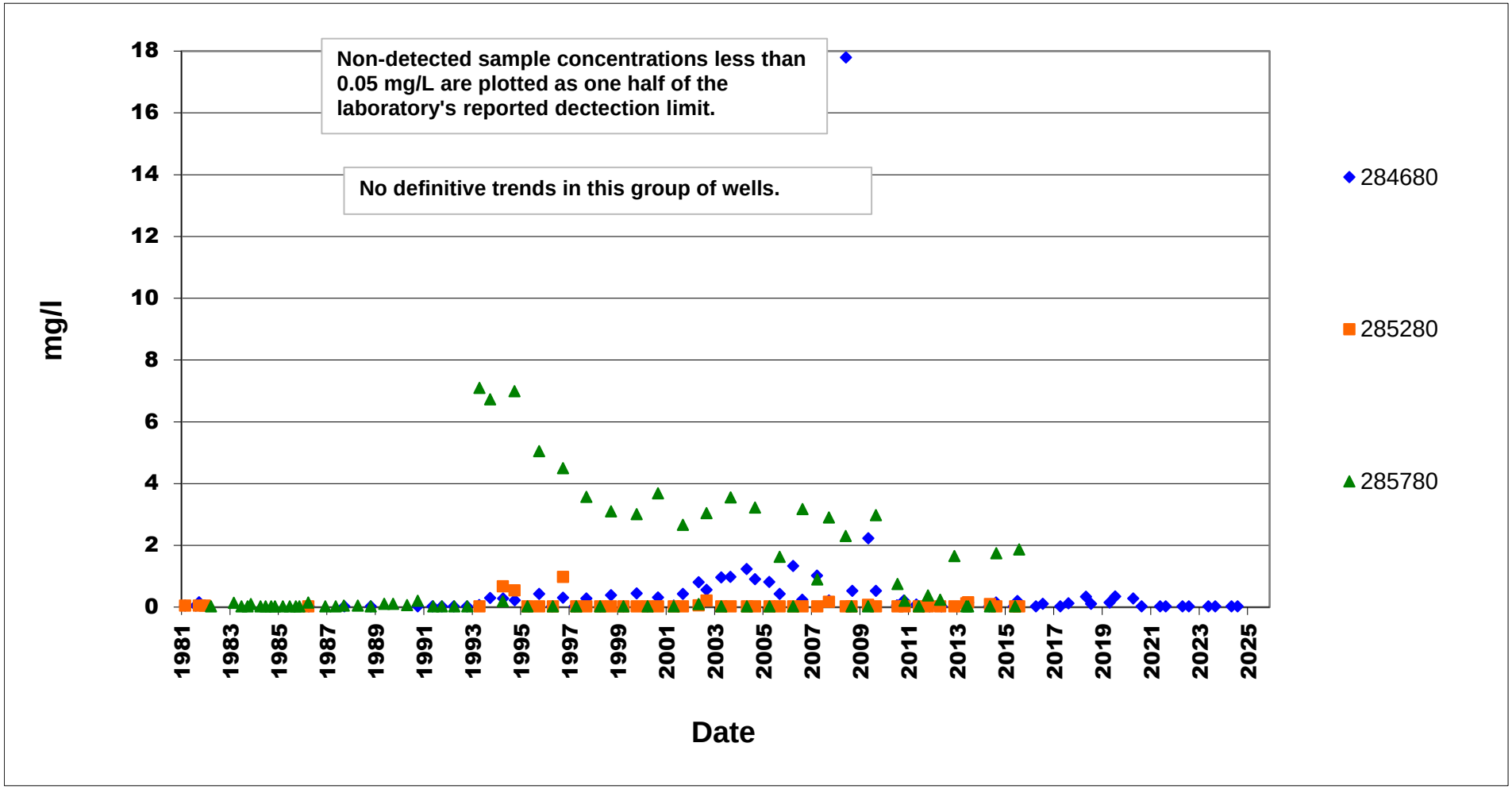


Figure 34. Historical Water Quality
Dissolved Iron (mg/l)
Bitter Creek Alluvial Wells

455485 (No. 74)
455585 (No. 73)
566594 (No. 93)

Note: 455485 and 455585 are near Pit 2. 566594 is in the farthest up-valley location.
Monitoring discontinued in 2016 for Well 455485. Current approved Table MP-23 (Revised 4/2016).

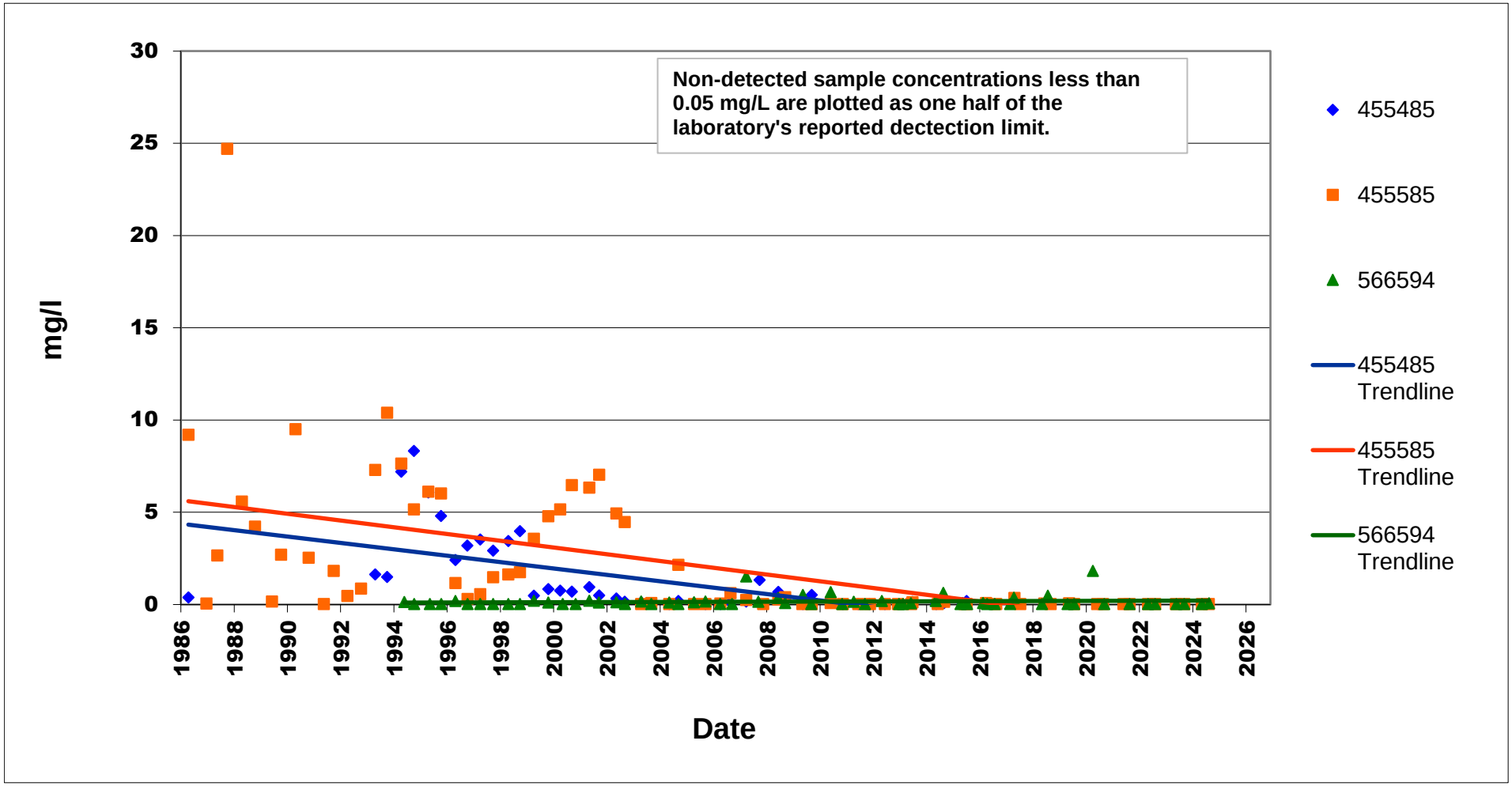


Figure 35. Historical Water Quality
Dissolved Iron (mg/l)
Bitter Creek Alluvial Wells

566694 (No. 94)
566994 (No. 97)
567194 (No. 99)

Note: 566694 is near Pit 3; 566994 is near Pit 5S and 567194 is near Pit 2.
Monitoring discontinued in 2016 for Well 566694. Current approved Table MP-23 (Revised 4/2016).

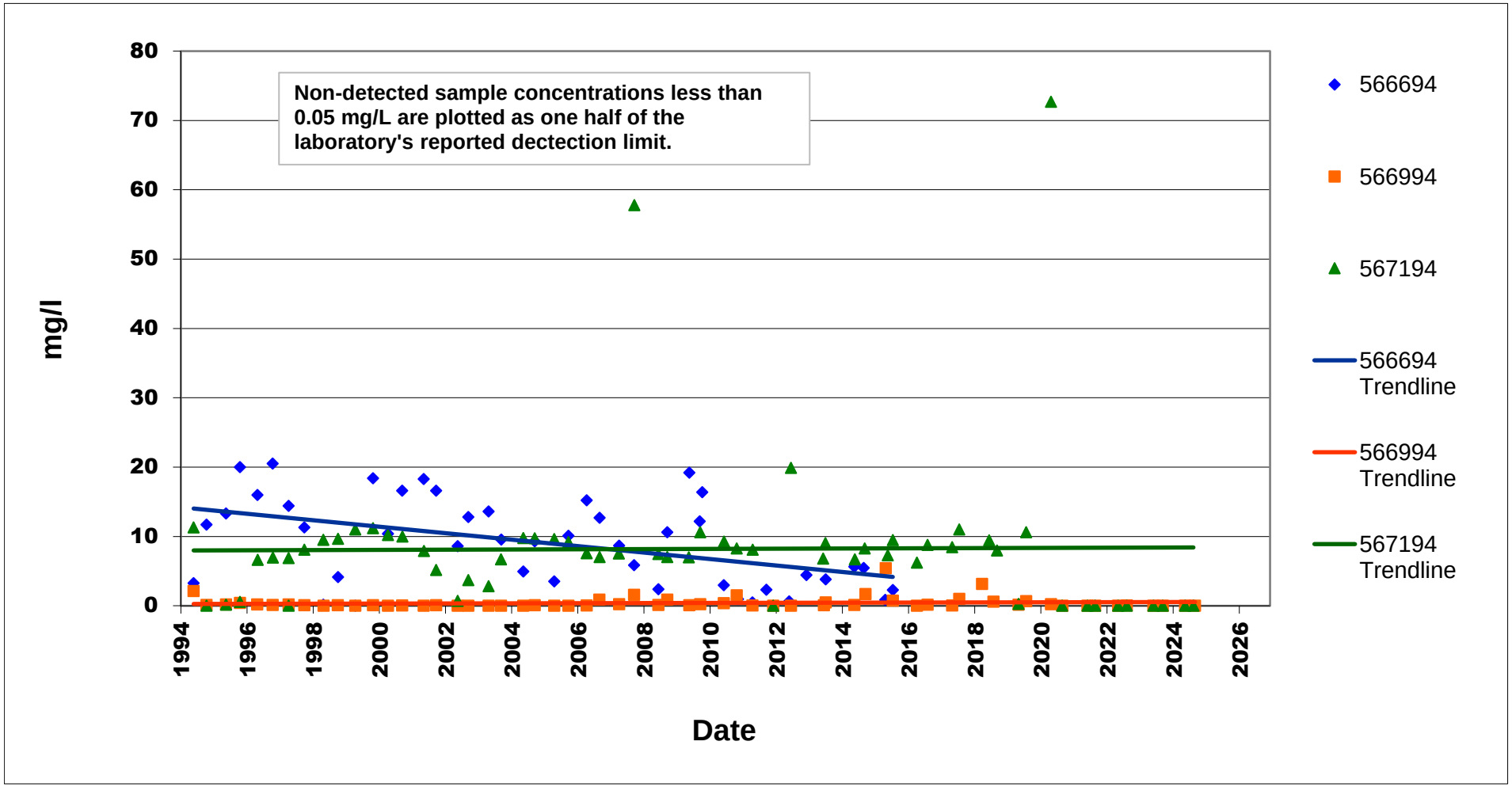


Figure 36. Historical Water Quality
Dissolved Iron (mg/l)
Bitter Creek Alluvial Wells

567494 (No. 102)
567694 (No. 104)
567794 (No. 105)
567994 (No. 107)

Note: 567494 and 567994 are near Pit 2, 567694 is down-valley of Pit 2, and 567794 is in the farthest down-valley location.

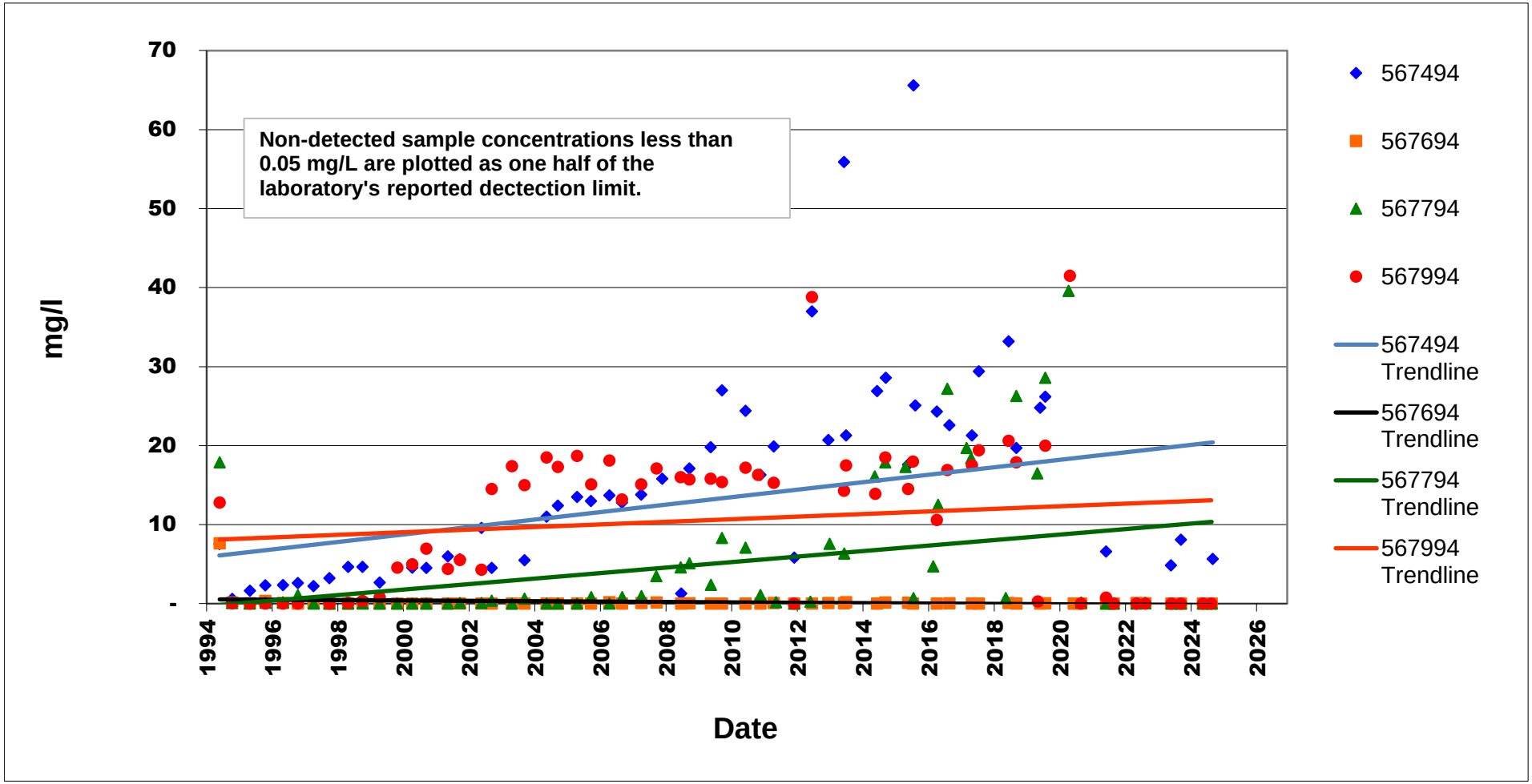


Figure 37. Historical Water Quality
Dissolved Iron (mg/l)
Spoils Wells

566394 (No. 91)
568198 (No. 109)
568298 (No. 110)

Note: 566394 is near Pit 3; 568198 and 568298 are are near Pit 2.

Monitoring discontinued in 2016 for Well 568198. Current approved Table MP-23 (Revised 4/2016).

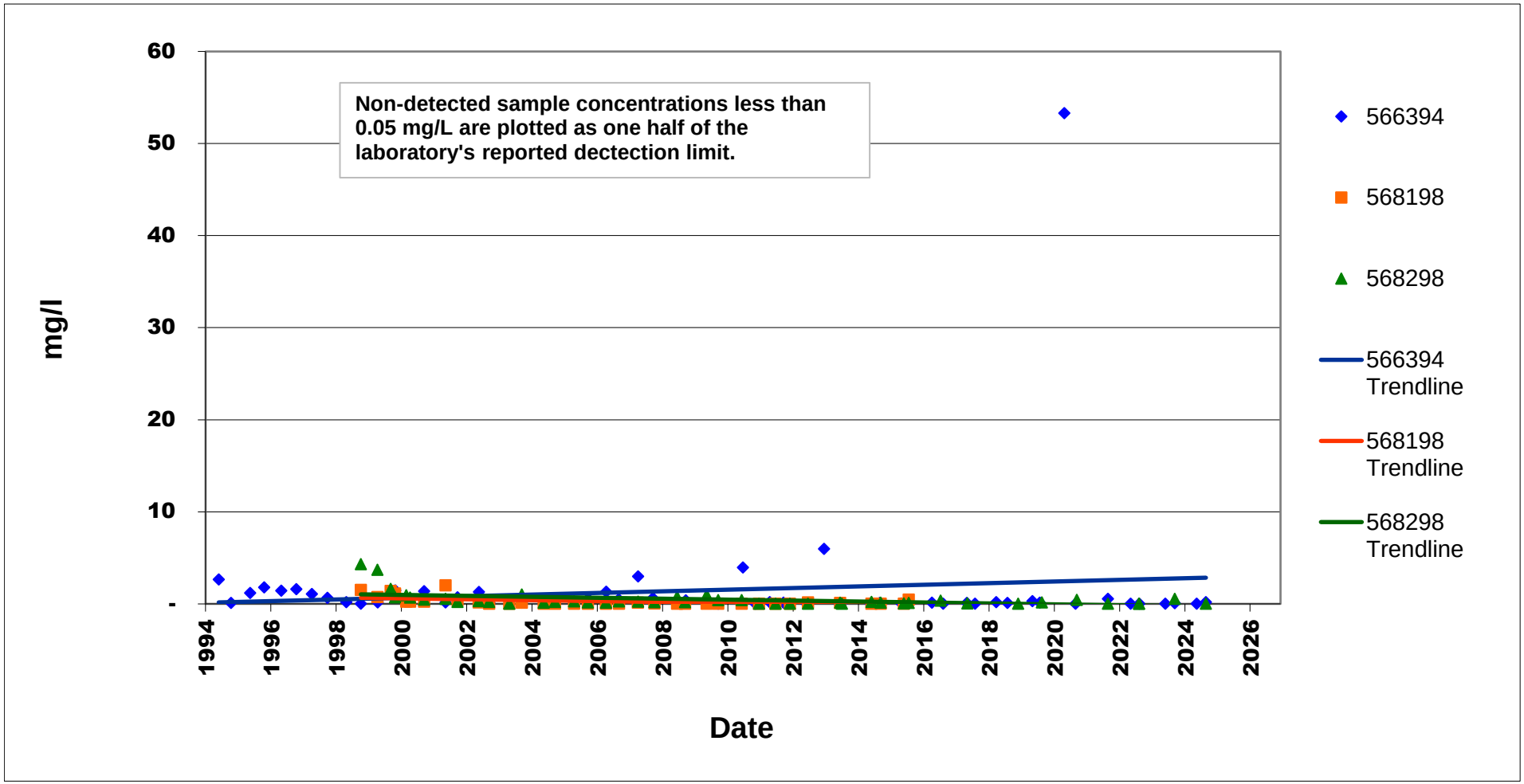


Figure 38. Historical Water Quality
Total Iron (mg/l)
Bitter Creek Alluvial Wells

284680 (No. 41)
285280 (No. 47)
285780 (No. 52)

Note: All three of these wells are near Pit 3.

Monitoring discontinued in 2016 for Wells 285280 and 285780. Current approved Table MP-23 (Revised 4/2016).

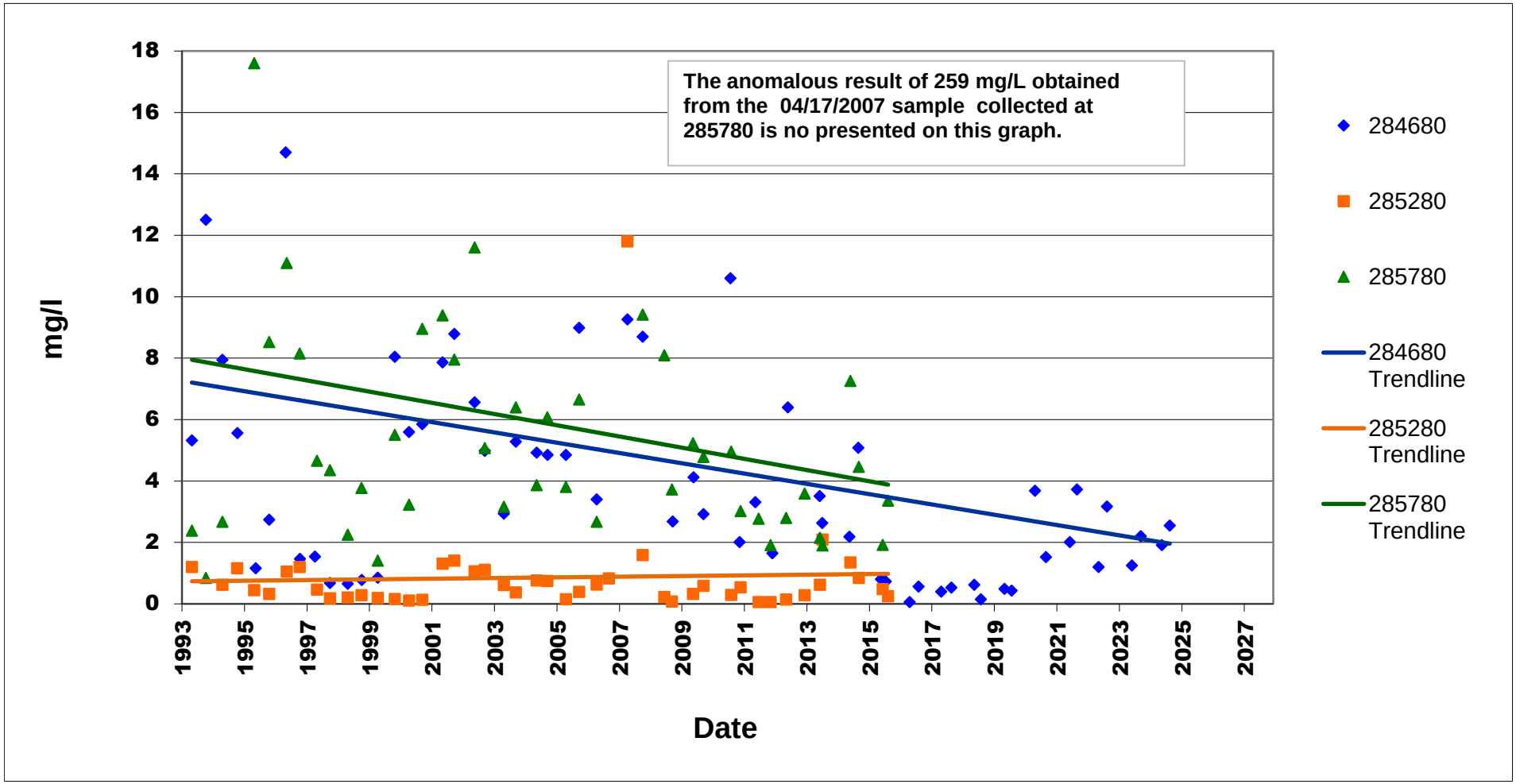


Figure 39. Historical Water Quality
Total Iron (mg/l)
Bitter Creek Alluvial Wells

455485 (No. 74)
455585 (No. 73)
566594 (No. 93)

Note: 455485 and 455585 are near Pit 2. 566594 is in the farthest up-valley location.
Monitoring discontinued in 2016 for Well 455485. Current approved Table MP-23 (Revised 4/2016).

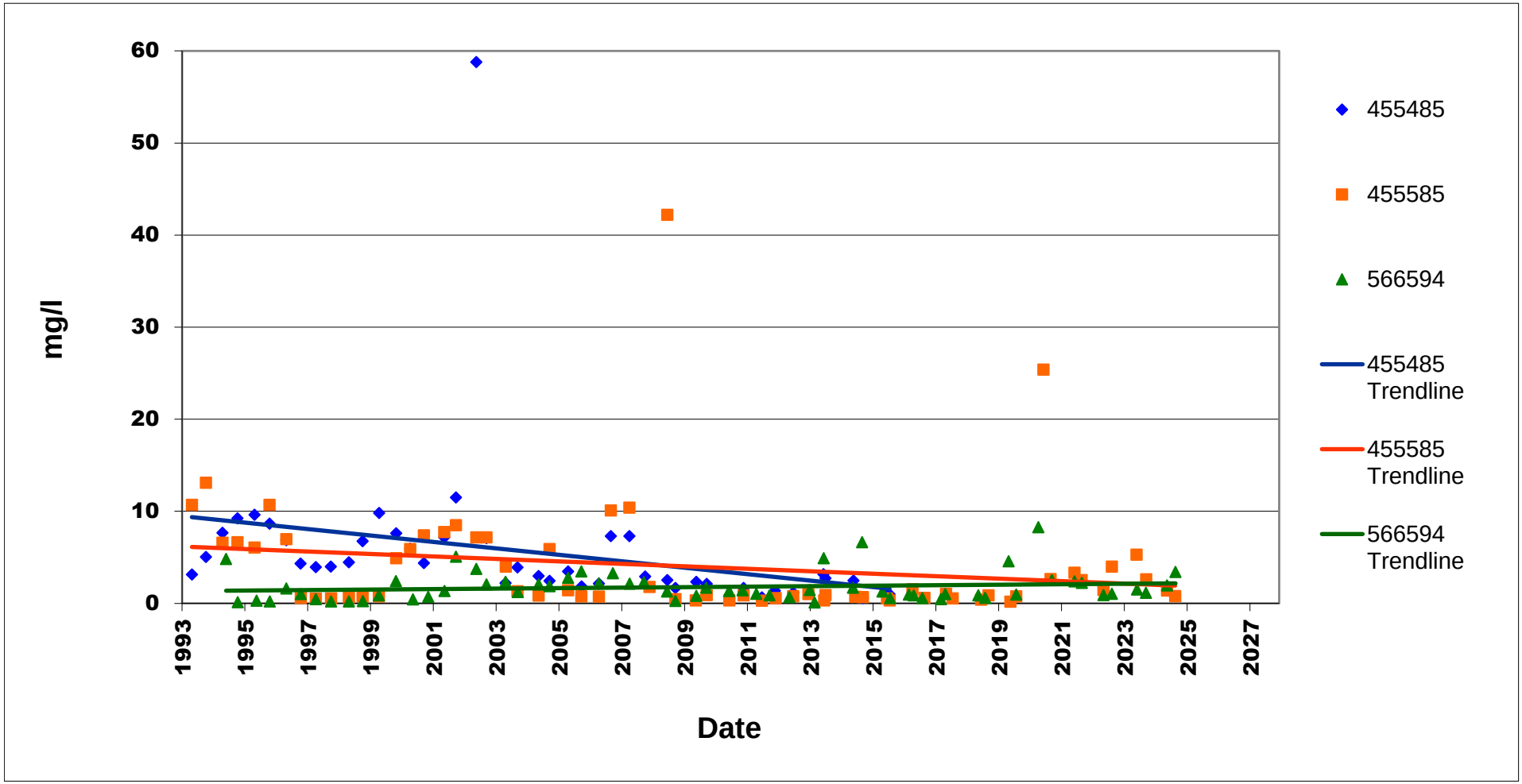


Figure 40. Historical Water Quality
Total Iron (mg/l)
Bitter Creek Alluvial Wells

566694 (No. 94)
566994 (No. 97)
567194 (No. 99)

Note: **566694 is near Pit 3; 566994 is near Pit 5S and 567194 is near Pit 2.**

Monitoring discontinued in 2016 for Well 566694. Current approved Table MP-23 (Revised 4/2016).

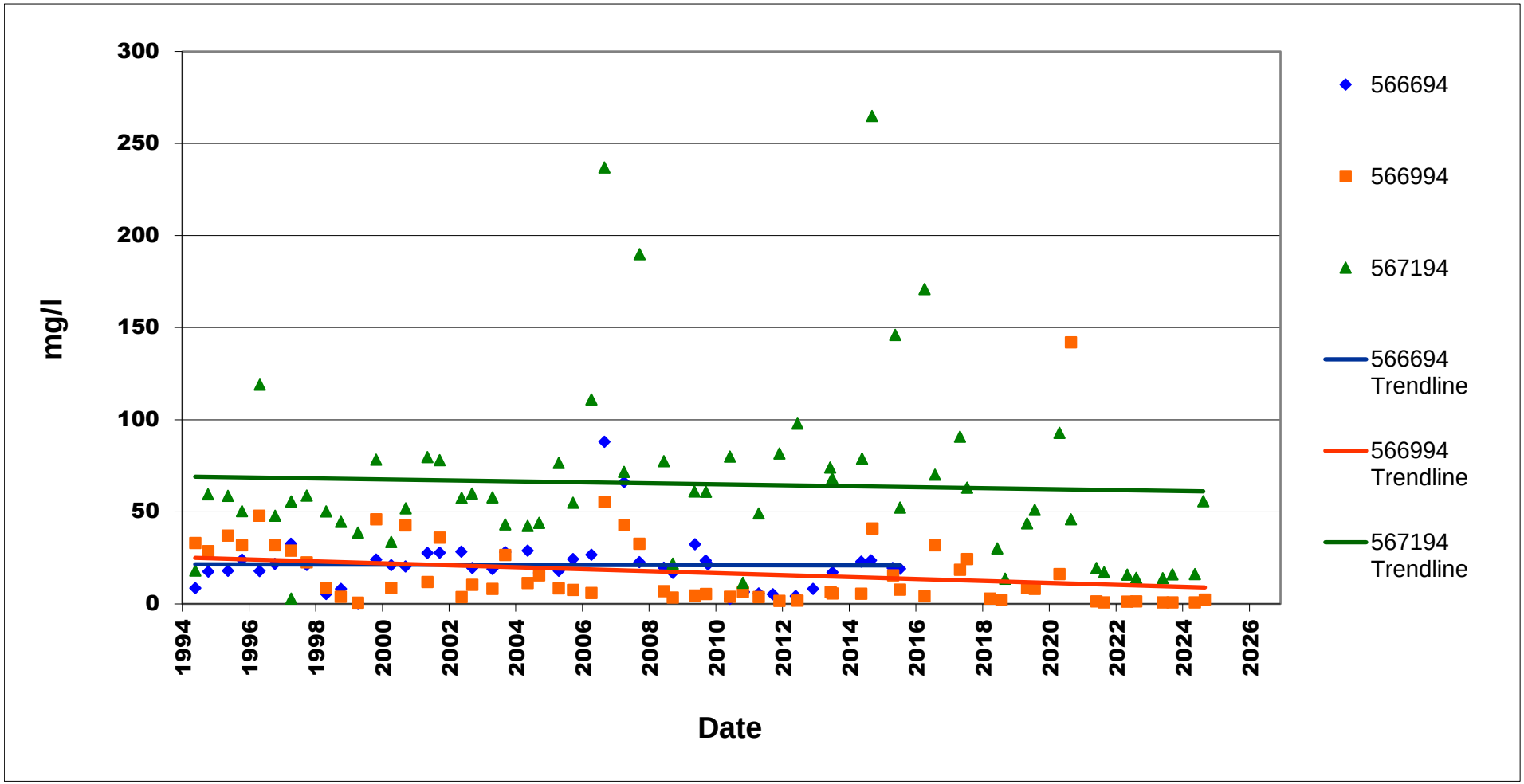


Figure 41. Historical Water Quality
Total Iron (mg/l)
Bitter Creek Alluvial Wells

567494 (No. 102)
567694 (No. 104)
567794 (No. 105)
567994 (No. 107)

Note: 567494 and 567994 are near Pit 2, 567694 is down-valley of Pit 2, and 567794 is in the farthest down-valley location.

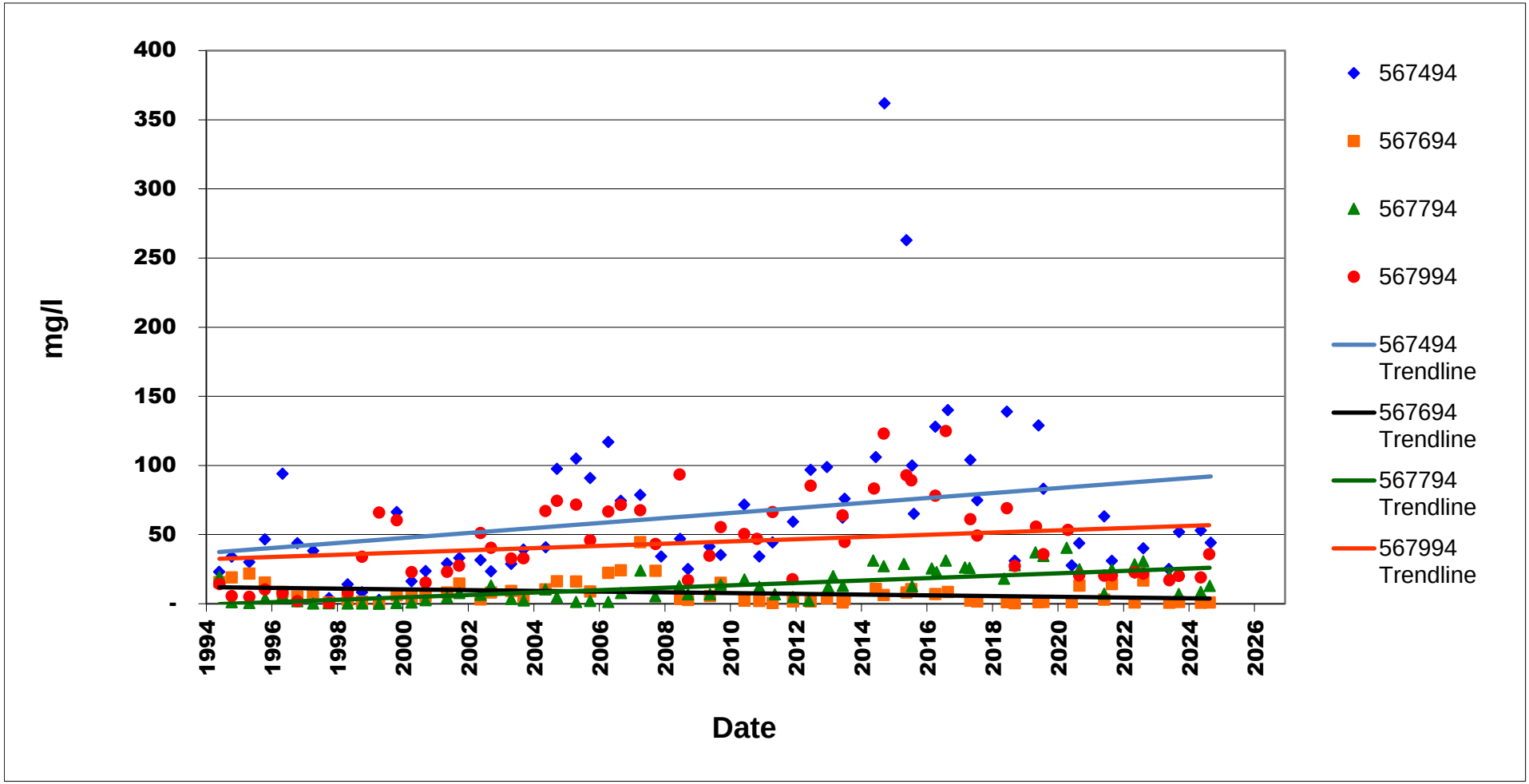


Figure 42. Historical Water Quality
Total Iron (mg/l)
Spoils Wells

566394 (No. 91)
568198 (No. 109)
568298 (No. 110)

Note: 566394 is near Pit 3; 568198 and 568298 are are near Pit 2.

Monitoring discontinued in 2016 for Well 568198. Current approved Table MP-23 (Revised 4/2016).

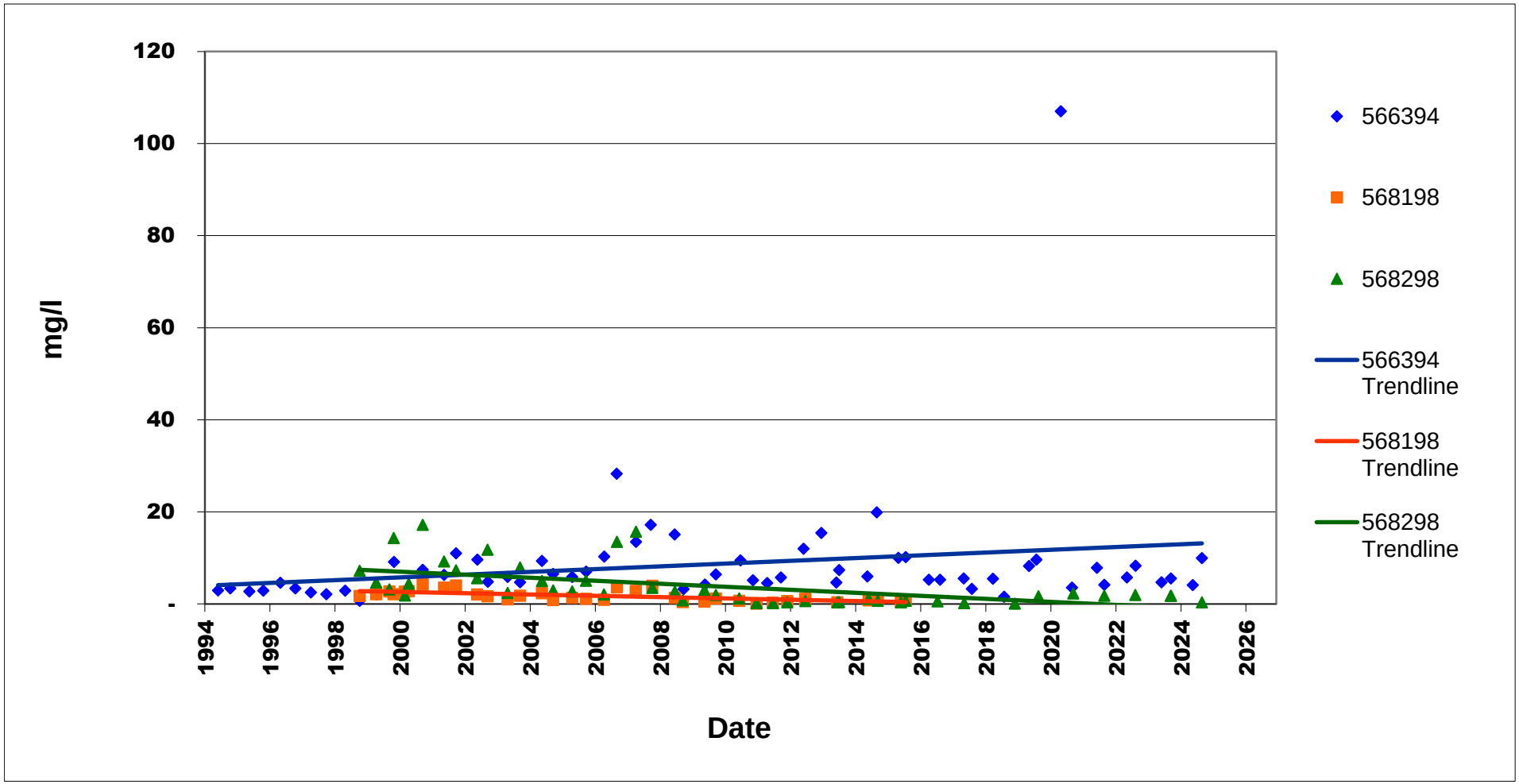
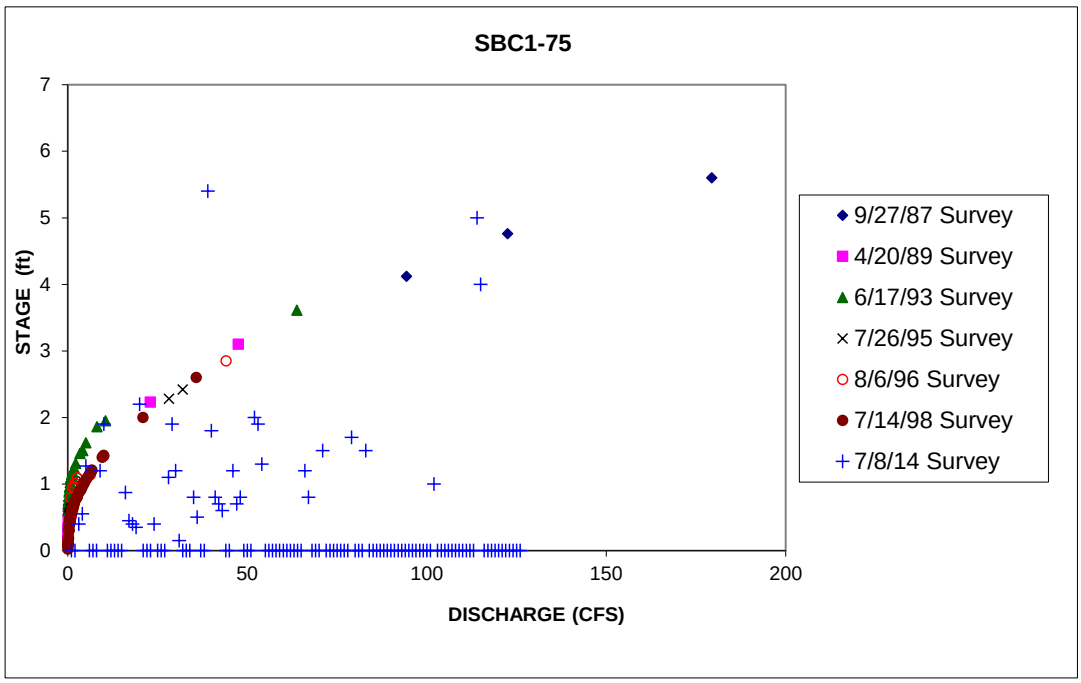
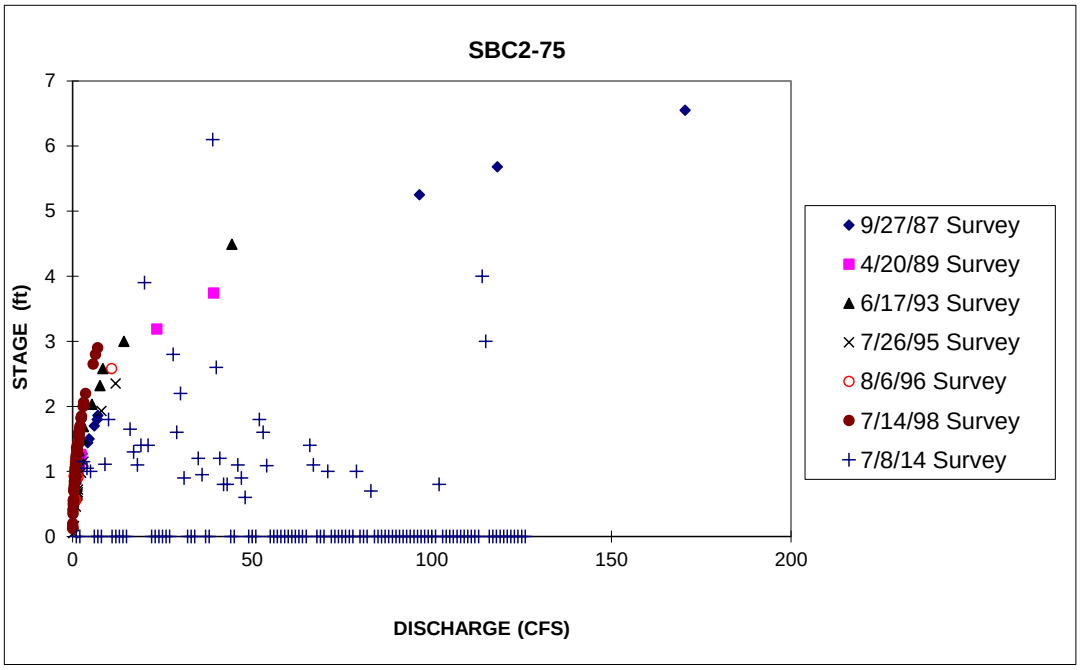


Figure 43. Stage Discharge Relationships at Bitter Creek Sites





**No discharge values for SBC1-75 and SBC2-75 during 2024 report period.*

FIGURE 44. BITTER CREEK STREAMFLOW HYDROGRAPH FOR SBC1-75 AND SBC2-75

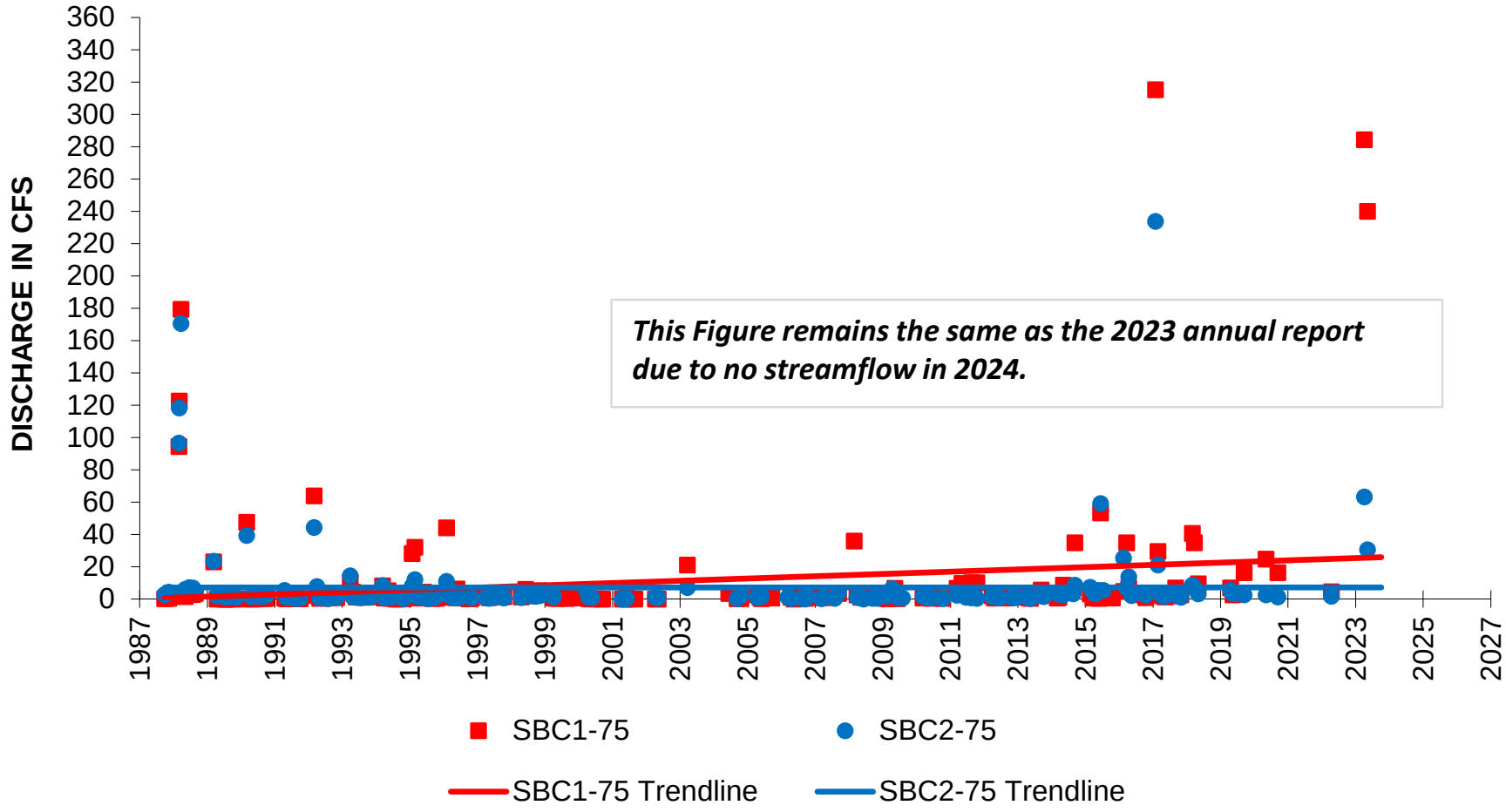


FIGURE 45. TOTAL SUSPENDED SOLIDS CONCENTRATIONS AT SBC1-75 VS SBC2-75

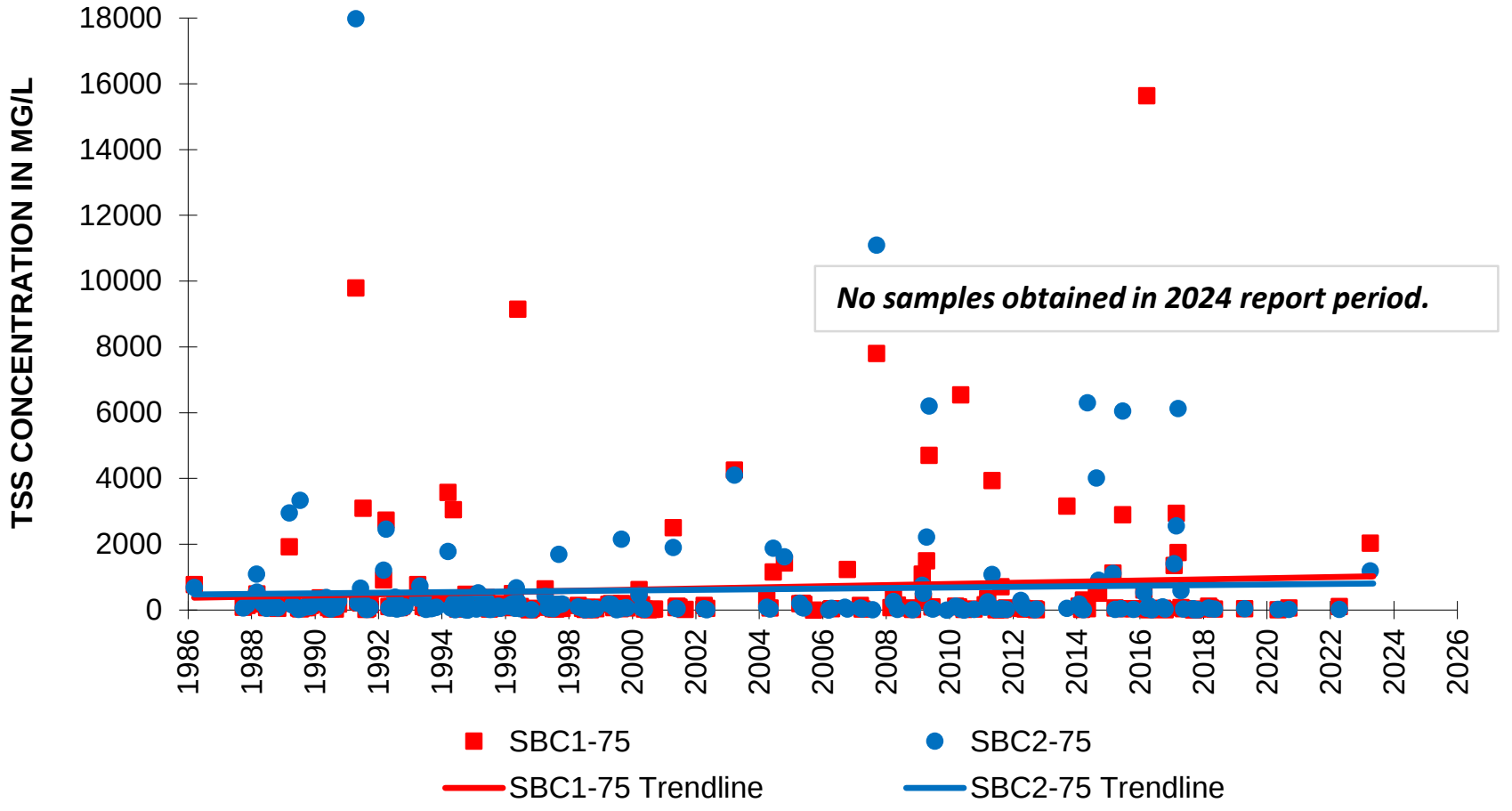
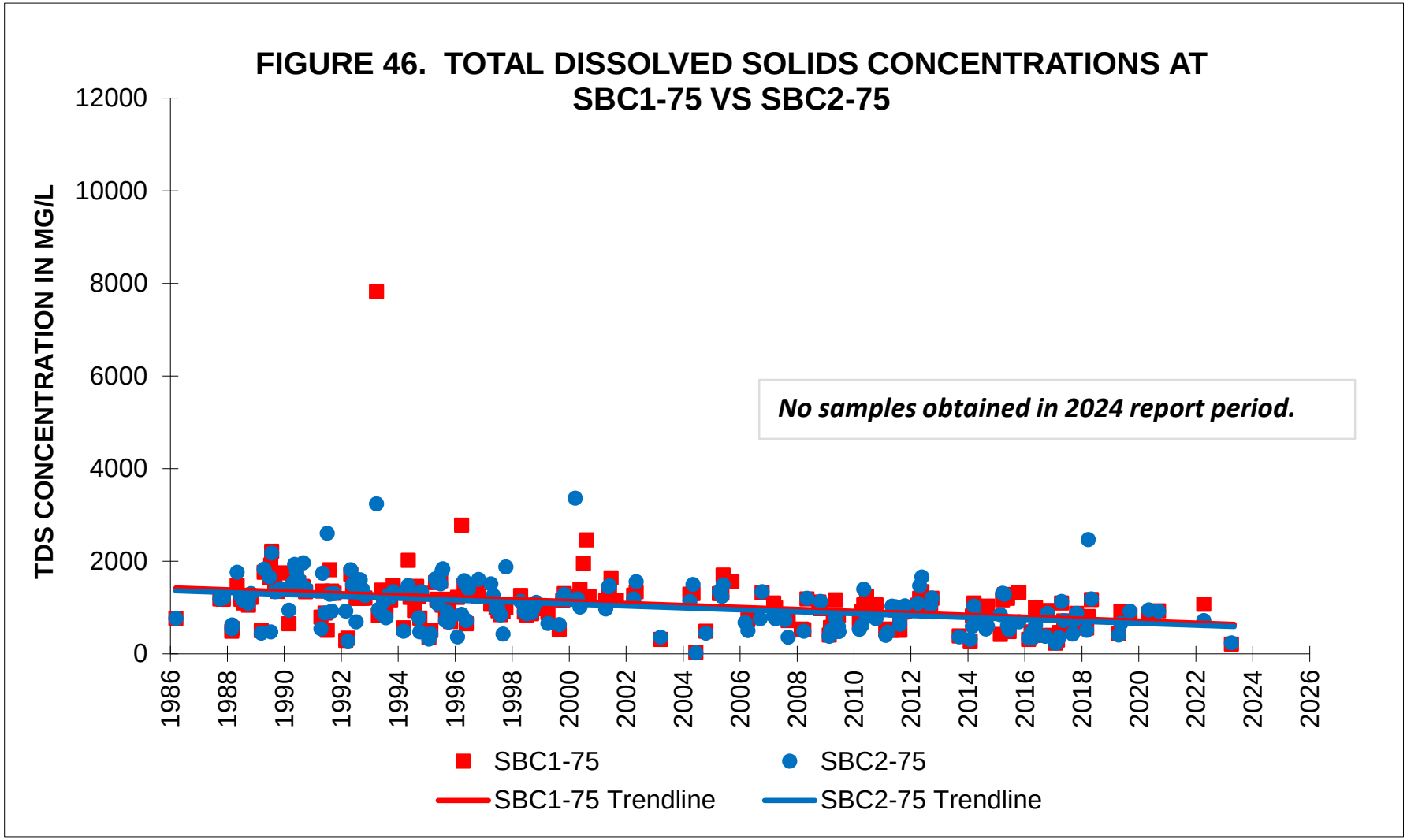


FIGURE 46. TOTAL DISSOLVED SOLIDS CONCENTRATIONS AT SBC1-75 VS SBC2-75



APPENDICES

APPENDIX A

2014 CROSS SECTION SURVEYS

SBC1-75

Worksheet for SBC1-75 Elev=6630.50.fm8

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.00270	ft/ft
Normal Depth	1.25	ft

Section Definitions

Station (ft)	Elevation (ft)
0+00	6641.60
0+19	6641.45
0+21	6640.90
0+30	6637.10
0+33	6636.25
0+39	6631.55
0+43	6631.33
0+45	6630.97
0+46	6630.86
0+47	6630.64
0+48	6630.29
0+49	6630.44
0+49	6630.70
0+51	6631.01
0+53	6631.33
0+58	6631.38
0+61	6632.08
0+63	6633.06
0+64	6634.70
0+70	6635.77
0+87	6634.92
0+97	6635.57
1+09	6637.85
1+21	6641.76

Roughness Segment Definitions

Worksheet for SBC1-75 Elev=6630.50.fm8

Input Data

(0+00, 6641.60)	(0+19, 6641.45)	0.072
(0+19, 6641.45)	(0+33, 6636.25)	0.070
(0+33, 6636.25)	(0+45, 6630.97)	0.050
(0+45, 6630.97)	(0+51, 6631.01)	0.035
(0+51, 6631.01)	(0+58, 6631.38)	0.050
(0+58, 6631.38)	(0+64, 6634.70)	0.050
(0+64, 6634.70)	(0+70, 6635.77)	0.070
(0+70, 6635.77)	(0+97, 6635.57)	0.050
(0+97, 6635.57)	(1+21, 6641.76)	0.070

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Discharge		7.63	ft^3/s
Elevation Range	6630.29 to 6641.76 ft		
Flow Area		8.02	ft^2
Wetted Perimeter		19.05	ft
Hydraulic Radius		0.42	ft
Top Width		18.80	ft
Normal Depth		1.25	ft
Critical Depth		0.77	ft
Critical Slope		0.04541	ft/ft
Velocity		0.95	ft/s
Velocity Head		0.01	ft
Specific Energy		1.26	ft
Froude Number		0.26	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

Worksheet for SBC1-75 Elev=6630.50.fm8

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.25	ft
Critical Depth	0.77	ft
Channel Slope	0.00270	ft/ft
Critical Slope	0.04541	ft/ft

Cross Section for SBC1-75 Elev=6630.50.fm8

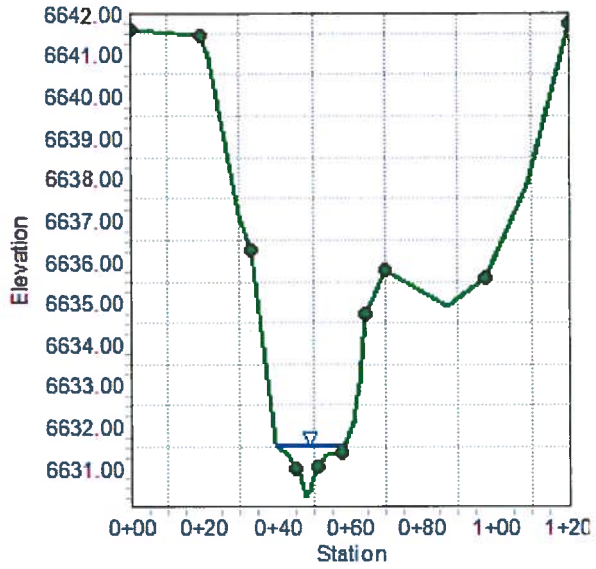
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.00270	ft/ft
Normal Depth	1.25	ft
Discharge	7.63	ft^3/s

Cross Section Image



Rating Table for SBC1-75 Elev=6630.50.fm8

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.00270	ft/ft
Normal Depth	1.25	ft

Section Definitions

Station (ft)	Elevation (ft)
0+00	6641.60
0+19	6641.45
0+21	6640.90
0+30	6637.10
0+33	6636.25
0+39	6631.55
0+43	6631.33
0+45	6630.97
0+46	6630.86
0+47	6630.64
0+48	6630.29
0+49	6630.44
0+49	6630.70
0+51	6631.01
0+53	6631.33
0+58	6631.38
0+61	6632.08
0+63	6633.06
0+64	6634.70
0+70	6635.77
0+87	6634.92
0+97	6635.57
1+09	6637.85
1+21	6641.76

Roughness Segment Definitions

Rating Table for SBC1-75 Elev=6630.50.fm8

Input Data

6630.50	0.09	0.50
6630.60	0.24	0.65
6630.70	0.49	0.79
6630.80	0.82	0.87
6630.90	1.27	0.93
6631.00	1.86	0.97
6631.10	2.54	0.98
6631.20	3.42	1.01
6631.30	4.54	1.05
6631.40	4.77	0.85
6631.50	6.73	0.92
6631.60	9.33	1.02
6631.70	12.56	1.13
6631.80	16.20	1.23
6631.90	20.22	1.33
6632.00	24.62	1.42
6632.10	29.46	1.50
6632.20	34.88	1.60
6632.30	40.68	1.69
6632.40	46.84	1.77
6632.50	53.35	1.85
6632.60	60.20	1.93
6632.70	67.40	2.01
6632.80	74.93	2.08
6632.90	82.80	2.15
6633.00	90.99	2.22
6633.10	99.56	2.29
6633.20	108.52	2.36
6633.30	117.79	2.42
6633.40	127.38	2.49
6633.50	137.28	2.55
6633.60	147.49	2.61
6633.70	158.01	2.67
6633.80	168.83	2.73
6633.90	179.95	2.79
6634.00	191.37	2.84
6634.10	203.09	2.90

Rating Table for SBC1-75 Elev=6630.50.fm8

Input Data

		Coefficient
6634.20	215.11	2.95
6634.30	227.42	3.00
6634.40	240.03	3.05
6634.50	252.94	3.11
6634.60	266.14	3.15
6634.70	279.64	3.20
6634.80	288.72	3.20
6634.90	298.15	3.20
6635.00	291.43	3.02
6635.10	285.27	2.85
6635.20	283.13	2.72
6635.30	284.22	2.61
6635.40	288.02	2.54
6635.50	294.18	2.47
6635.60	303.16	2.43
6635.70	315.32	2.41
6635.80	331.44	2.42
6635.90	354.62	2.47
6636.00	378.43	2.52
6636.10	402.88	2.57
6636.20	427.97	2.61
6636.30	452.63	2.66
6636.40	476.83	2.69
6636.50	501.63	2.72
6636.60	527.02	2.75
6636.70	553.01	2.79
6636.80	579.61	2.82
6636.90	606.81	2.85
6637.00	634.62	2.88
6637.10	663.05	2.91
6637.20	693.59	2.94
6637.30	724.75	2.98
6637.40	756.52	3.01
6637.50	788.90	3.05
6637.60	821.89	3.08
6637.70	855.49	3.12
6637.80	889.71	3.15

Rating Table for SBC1-75 Elev=6630.50.fm8

Input Data

		Coefficient
6637.90	925.56	3.18
6638.00	963.06	3.22
6638.10	1001.18	3.26
6638.20	1039.92	3.30
6638.30	1079.28	3.34
6638.40	1119.25	3.37
6638.50	1159.84	3.41
6638.60	1201.04	3.44
6638.70	1242.86	3.48
6638.80	1285.29	3.51
6638.90	1328.33	3.55
6639.00	1371.98	3.58
6639.10	1416.25	3.62
6639.20	1461.12	3.65
6639.30	1506.60	3.68
6639.40	1552.70	3.71
6639.50	1599.40	3.75
6639.60	1646.71	3.78
6639.70	1694.63	3.81
6639.80	1743.16	3.84
6639.90	1792.30	3.87
6640.00	1842.05	3.90
6640.10	1892.42	3.93
6640.20	1943.39	3.96
6640.30	1994.97	3.99
6640.40	2047.16	4.02
6640.50	2099.96	4.05
6640.60	2153.38	4.08
6640.70	2207.41	4.10
6640.80	2262.05	4.13
6640.90	2317.31	4.16
6641.00	2369.99	4.18
6641.10	2423.31	4.20
6641.20	2477.27	4.22
6641.30	2531.87	4.25
6641.40	2587.11	4.27

Rating Table for SBC1-75 Elev=6630.50.fm8

Input Data

		Coefficient
6641.50	2508.17	4.07

Water Surface Elevation (ft)	Discharge (ft³/s)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
6630.50	0.09	0.50	0.18	1.66	1.61
6630.60	0.24	0.65	0.37	2.32	2.23
6630.70	0.49	0.79	0.62	2.92	2.80
6630.80	0.82	0.87	0.94	3.80	3.65
6630.90	1.27	0.93	1.36	4.93	4.76
6631.00	1.86	0.97	1.91	6.35	6.17
6631.10	2.54	0.98	2.59	7.64	7.44
6631.20	3.42	1.01	3.40	8.94	8.73
6631.30	4.54	1.05	4.33	10.24	10.01
6631.40	4.77	0.85	5.60	16.10	15.86
6631.50	6.73	0.92	7.29	18.21	17.96
6631.60	9.33	1.02	9.17	19.60	19.31
6631.70	12.56	1.13	11.13	20.26	19.93
6631.80	16.20	1.23	13.16	20.92	20.55
6631.90	20.22	1.33	15.24	21.58	21.17
6632.00	24.62	1.42	17.39	22.24	21.78
6632.10	29.46	1.50	19.60	22.84	22.34
6632.20	34.88	1.60	21.85	23.20	22.64
6632.30	40.68	1.69	24.13	23.57	22.95
6632.40	46.84	1.77	26.44	23.94	23.26
6632.50	53.35	1.85	28.78	24.30	23.56
6632.60	60.20	1.93	31.15	24.67	23.87
6632.70	67.40	2.01	33.55	25.03	24.18
6632.80	74.93	2.08	35.99	25.40	24.48
6632.90	82.80	2.15	38.45	25.77	24.79
6633.00	90.99	2.22	40.94	26.13	25.10
6633.10	99.56	2.29	43.47	26.48	25.38
6633.20	108.52	2.36	46.02	26.80	25.63
6633.30	117.79	2.42	48.59	27.12	25.88

Rating Table for SBC1-75 Elev=6630.50.fm8

Input Data

Water Surface Elevation (ft)	Discharge (ft³/s)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
6633.40	127.38	2.49	51.19	27.45	26.13
6633.50	137.28	2.55	53.82	27.77	26.38
6633.60	147.49	2.61	56.47	28.09	26.63
6633.70	158.01	2.67	59.15	28.41	26.89
6633.80	168.83	2.73	61.85	28.73	27.14
6633.90	179.95	2.79	64.58	29.05	27.39
6634.00	191.37	2.84	67.33	29.37	27.64
6634.10	203.09	2.90	70.10	29.70	27.89
6634.20	215.11	2.95	72.90	30.02	28.14
6634.30	227.42	3.00	75.73	30.34	28.39
6634.40	240.03	3.05	78.58	30.66	28.64
6634.50	252.94	3.11	81.46	30.98	28.89
6634.60	266.14	3.15	84.36	31.30	29.15
6634.70	279.64	3.20	87.29	31.62	29.40
6634.80	288.72	3.20	90.26	32.31	30.04
6634.90	298.15	3.20	93.30	32.99	30.68
6635.00	291.43	3.02	96.51	36.57	34.21
6635.10	285.27	2.85	100.15	40.87	38.47
6635.20	283.13	2.72	104.21	45.18	42.72
6635.30	284.22	2.61	108.69	49.48	46.98
6635.40	288.02	2.54	113.60	53.79	51.24
6635.50	294.18	2.47	118.94	58.09	55.49
6635.60	303.16	2.43	124.69	62.06	59.41
6635.70	315.32	2.41	130.79	65.25	62.55
6635.80	331.44	2.42	137.19	67.69	64.94
6635.90	354.62	2.47	143.72	68.37	65.58
6636.00	378.43	2.52	150.31	69.06	66.22
6636.10	402.88	2.57	156.96	69.74	66.86
6636.20	427.97	2.61	163.68	70.42	67.50
6636.30	452.63	2.66	170.47	71.22	68.27
6636.40	476.83	2.69	177.34	72.15	69.17
6636.50	501.63	2.72	184.30	73.07	70.07
6636.60	527.02	2.75	191.35	74.00	70.98
6636.70	553.01	2.79	198.49	74.93	71.88
6636.80	579.61	2.82	205.73	75.85	72.78
6636.90	606.81	2.85	213.05	76.78	73.69
6637.00	634.62	2.88	220.47	77.70	74.59

Rating Table for SBC1-75 Elev=6630.50.fm8

Input Data

Water Surface Elevation (ft)	Discharge (ft³/s)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
6637.10	663.05	2.91	227.97	78.63	75.49
6637.20	693.59	2.94	235.55	79.38	76.21
6637.30	724.75	2.98	243.21	80.12	76.92
6637.40	756.52	3.01	250.94	80.87	77.64
6637.50	788.90	3.05	258.74	81.62	78.36
6637.60	821.89	3.08	266.61	82.37	79.07
6637.70	855.49	3.12	274.55	83.11	79.79
6637.80	889.71	3.15	282.57	83.86	80.50
6637.90	925.56	3.18	290.65	84.51	81.12
6638.00	963.06	3.22	298.79	85.06	81.63
6638.10	1001.18	3.26	306.98	85.62	82.15
6638.20	1039.92	3.30	315.22	86.17	82.66
6638.30	1079.28	3.34	323.51	86.72	83.17
6638.40	1119.25	3.37	331.85	87.27	83.69
6638.50	1159.84	3.41	340.25	87.83	84.20
6638.60	1201.04	3.44	348.69	88.38	84.72
6638.70	1242.86	3.48	357.19	88.93	85.23
6638.80	1285.29	3.51	365.74	89.48	85.74
6638.90	1328.33	3.55	374.34	90.04	86.26
6639.00	1371.98	3.58	382.99	90.59	86.77
6639.10	1416.25	3.62	391.69	91.14	87.28
6639.20	1461.12	3.65	400.45	91.69	87.80
6639.30	1506.60	3.68	409.25	92.25	88.31
6639.40	1552.70	3.71	418.11	92.80	88.83
6639.50	1599.40	3.75	427.02	93.35	89.34
6639.60	1646.71	3.78	435.98	93.90	89.85
6639.70	1694.63	3.81	444.99	94.45	90.37
6639.80	1743.16	3.84	454.05	95.01	90.88
6639.90	1792.30	3.87	463.17	95.56	91.40
6640.00	1842.05	3.90	472.33	96.11	91.91
6640.10	1892.42	3.93	481.55	96.66	92.42
6640.20	1943.39	3.96	490.82	97.22	92.94
6640.30	1994.97	3.99	500.14	97.77	93.45
6640.40	2047.16	4.02	509.51	98.32	93.97
6640.50	2099.96	4.05	518.93	98.87	94.48
6640.60	2153.38	4.08	528.40	99.43	94.99
6640.70	2207.41	4.10	537.93	99.98	95.51

Rating Table for SBC1-75 Elev=6630.50.fm8

Input Data

Water Surface Elevation (ft)	Discharge (ft³/s)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
6640.80	2262.05	4.13	547.50	100.53	96.02
6640.90	2317.31	4.16	557.13	101.08	96.54
6641.00	2369.99	4.18	566.82	101.79	97.21
6641.10	2423.31	4.20	576.57	102.50	97.89
6641.20	2477.27	4.22	586.40	103.21	98.57
6641.30	2531.87	4.25	596.29	103.92	99.25
6641.40	2587.11	4.27	606.25	104.62	99.93
6641.50	2508.17	4.07	616.43	111.58	106.87

SBC2-75

Worksheet for Irregular Section - SBC2-75 Elev=6551.0

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.00260	ft/ft
Normal Depth	11.72	ft

Section Definitions

Station (ft)	Elevation (ft)
0+00	6563.74
0+17	6563.70
0+21	6563.21
0+25	6561.99
0+32	6559.23
0+36	6557.46
0+40	6555.51
0+42	6554.83
0+44	6554.37
0+46	6553.01
0+48	6552.21
0+49	6550.87
0+50	6550.80
0+51	6550.92
0+53	6553.09
0+56	6554.27
0+60	6555.09
0+63	6556.05
0+67	6557.69
0+70	6559.26
0+73	6560.89
0+78	6561.79
0+86	6562.76

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 6563.74)	(0+21, 6563.21)	0.072
(0+21, 6563.21)	(0+48, 6552.21)	0.045

Worksheet for Irregular Section - SBC2-75 Elev=6551.0

Input Data

Start Station	Ending Station	Roughness Coefficient
(0+48, 6552.21)	(0+53, 6553.09)	0.035
(0+53, 6553.09)	(0+70, 6559.26)	0.045
(0+70, 6559.26)	(0+86, 6562.76)	0.072

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Discharge		1237.02	ft^3/s
Elevation Range	6550.80 to 6563.74 ft		
Flow Area		305.26	ft^2
Wetted Perimeter		66.69	ft
Hydraulic Radius		4.58	ft
Top Width		61.43	ft
Normal Depth		11.72	ft
Critical Depth		7.51	ft
Critical Slope		0.02947	ft/ft
Velocity		4.05	ft/s
Velocity Head		0.26	ft
Specific Energy		11.98	ft
Froude Number		0.32	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s

Worksheet for Irregular Section - SBC2-75 Elev=6551.0

GVF Output Data

Normal Depth	11.72	ft
Critical Depth	7.51	ft
Channel Slope	0.00260	ft/ft
Critical Slope	0.02947	ft/ft

Cross Section for Irregular Section - SBC2-75 Elev=6551.0

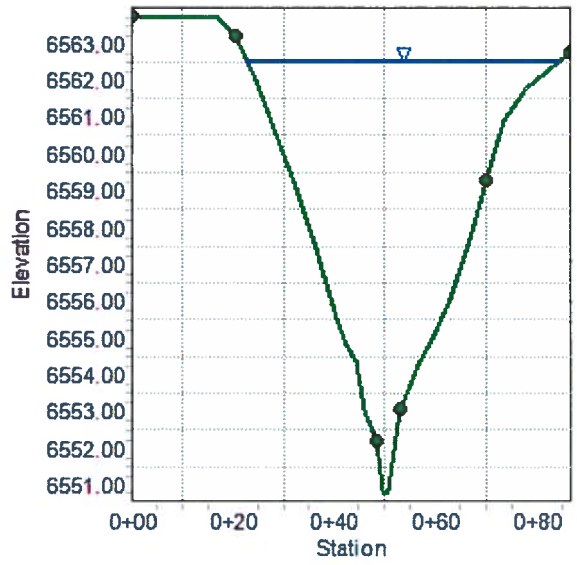
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.00260	ft/ft
Normal Depth	11.72	ft
Discharge	1237.02	ft³/s

Cross Section Image



Rating Table for Irregular Section - SBC2-75 Elev=6551.0

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.00260	ft/ft
Normal Depth	11.72	ft

Section Definitions

Station (ft)	Elevation (ft)
0+00	6563.74
0+17	6563.70
0+21	6563.21
0+25	6561.99
0+32	6559.23
0+36	6557.46
0+40	6555.51
0+42	6554.83
0+44	6554.37
0+46	6553.01
0+48	6552.21
0+49	6550.87
0+50	6550.80
0+51	6550.92
0+53	6553.09
0+56	6554.27
0+60	6555.09
0+63	6556.05
0+67	6557.69
0+70	6559.26
0+73	6560.89
0+78	6561.79
0+86	6562.76

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 6563.74)	(0+21, 6563.21)	0.072
(0+21, 6563.21)	(0+48, 6552.21)	0.045

Rating Table for Irregular Section - SBC2-75 Elev=6551.0

Input Data

Start Station	Ending Station	Roughness Coefficient
(0+48, 6552.21)	(0+53, 6553.09)	0.035
(0+53, 6553.09)	(0+70, 6559.26)	0.045
6551.40	0.93	1.06
6551.50	1.27	1.15
6551.60	1.66	1.23
6551.70	2.12	1.31
6551.80	2.63	1.38
6551.90	3.21	1.46
6552.00	3.85	1.52
6552.10	4.57	1.59
6552.20	5.35	1.65
6552.30	5.99	1.65
6552.40	6.72	1.65
6552.50	7.57	1.67
6552.60	8.54	1.69
6552.70	9.63	1.71
6552.80	10.85	1.74
6552.90	12.20	1.78
6553.00	13.69	1.81
6553.10	15.49	1.87
6553.20	17.18	1.90
6553.30	19.01	1.93
6553.40	20.98	1.97
6553.50	23.10	2.00
6553.60	25.38	2.04
6553.70	27.81	2.07
6553.80	30.40	2.11
6553.90	33.15	2.15
6554.00	36.08	2.18
6554.10	39.18	2.22
6554.20	42.45	2.26
6554.30	45.82	2.29
6554.40	49.03	2.31
6554.50	52.11	2.31
6554.60	55.49	2.31
6554.70	59.18	2.32
6554.80	63.17	2.34
6554.90	67.55	2.36
6555.00	72.27	2.38
6555.10	77.33	2.40
6555.20	82.89	2.44

Rating Table for Irregular Section - SBC2-75 Elev=6551.0

Input Data

Start Station	Ending Station	Roughness Coefficient
6555.30	88.76	2.47
6555.40	94.93	2.50
6555.50	101.43	2.54
6555.60	108.61	2.58
6555.70	116.12	2.62
6555.80	123.95	2.67
6555.90	132.08	2.71
6556.00	140.54	2.75
6556.10	149.48	2.80
6556.20	158.89	2.84
6556.30	168.63	2.89
6556.40	178.67	2.94
6556.50	189.05	2.98
6556.60	199.74	3.03
6556.70	210.77	3.07
6556.80	222.12	3.12
6556.90	233.81	3.16
6557.00	245.84	3.20
6557.10	258.21	3.24
6557.20	270.93	3.29
6557.30	283.99	3.33
6557.40	297.40	3.37
6557.50	311.09	3.41
6557.60	325.05	3.45
6557.70	339.38	3.49
6557.80	354.22	3.53
6557.90	369.44	3.56
6558.00	385.02	3.60
6558.10	400.98	3.64
6558.20	417.31	3.68
6558.30	434.03	3.72
6558.40	451.14	3.75
6558.50	468.63	3.79
6558.60	486.51	3.83
6558.70	504.79	3.87
6558.80	523.46	3.90
6558.90	542.54	3.94
6559.00	562.02	3.97
6559.10	581.90	4.01
6559.20	602.20	4.05
6559.30	621.49	4.07

Rating Table for Irregular Section - SBC2-75 Elev=6551.0

Input Data

Start Station	Ending Station	Roughness Coefficient
6559.40	639.30	4.09
6559.50	657.47	4.10
6559.60	676.00	4.12
6559.70	694.89	4.13
6559.80	714.14	4.15
6559.90	733.76	4.16
6560.00	753.74	4.18
6560.10	774.10	4.19
6560.20	794.83	4.21
6560.30	815.94	4.22
6560.40	837.42	4.24
6560.50	859.28	4.26
6560.60	881.52	4.27
6560.70	904.15	4.29
6560.80	927.17	4.31
6560.90	949.90	4.32
6561.00	967.10	4.31
6561.10	984.88	4.30
6561.20	1003.24	4.29
6561.30	1022.18	4.28
6561.40	1041.67	4.27
6561.50	1061.73	4.27
6561.60	1082.35	4.26
6561.70	1103.53	4.26
6561.80	1124.28	4.26
6561.90	1137.16	4.22
6562.00	1151.04	4.19

Water Surface Elevation (ft)	Discharge (ft³/s)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
6551.00	0.10	0.55	0.18	1.45	1.34
6551.10	0.24	0.72	0.33	1.73	1.54
6551.20	0.42	0.85	0.49	2.02	1.74
6551.30	0.65	0.96	0.68	2.30	1.94
6551.40	0.93	1.06	0.88	2.58	2.14
6551.50	1.27	1.15	1.11	2.86	2.34
6551.60	1.66	1.23	1.35	3.15	2.54

Rating Table for Irregular Section - SBC2-75 Elev=6551.0

Input Data

Water Surface Elevation (ft)	Discharge (ft³/s)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
6551.70	2.12	1.31	1.62	3.43	2.74
6551.80	2.63	1.38	1.90	3.71	2.94
6551.90	3.21	1.46	2.20	4.00	3.14
6552.00	3.85	1.52	2.53	4.28	3.34
6552.10	4.57	1.59	2.87	4.56	3.54
6552.20	5.35	1.65	3.24	4.84	3.74
6552.30	5.99	1.65	3.63	5.30	4.14
6552.40	6.72	1.65	4.06	5.78	4.56
6552.50	7.57	1.67	4.54	6.25	4.98
6552.60	8.54	1.69	5.06	6.73	5.40
6552.70	9.63	1.71	5.62	7.21	5.83
6552.80	10.85	1.74	6.22	7.68	6.25
6552.90	12.20	1.78	6.87	8.16	6.67
6553.00	13.69	1.81	7.56	8.63	7.09
6553.10	15.49	1.87	8.28	8.97	7.36
6553.20	17.18	1.90	9.04	9.43	7.76
6553.30	19.01	1.93	9.83	9.88	8.16
6553.40	20.98	1.97	10.67	10.34	8.56
6553.50	23.10	2.00	11.55	10.80	8.97
6553.60	25.38	2.04	12.46	11.25	9.37
6553.70	27.81	2.07	13.42	11.71	9.77
6553.80	30.40	2.11	14.42	12.17	10.18
6553.90	33.15	2.15	15.45	12.62	10.58
6554.00	36.08	2.18	16.53	13.08	10.98
6554.10	39.18	2.22	17.65	13.54	11.39
6554.20	42.45	2.26	18.81	13.99	11.79
6554.30	45.82	2.29	20.01	14.49	12.23
6554.40	49.03	2.31	21.26	15.13	12.83
6554.50	52.11	2.31	22.58	15.94	13.62
6554.60	55.49	2.31	23.98	16.75	14.41
6554.70	59.18	2.32	25.46	17.57	15.19
6554.80	63.17	2.34	27.02	18.38	15.98
6554.90	67.55	2.36	28.66	19.16	16.74
6555.00	72.27	2.38	30.37	19.93	17.48
6555.10	77.33	2.40	32.15	20.69	18.22
6555.20	82.89	2.44	34.01	21.38	18.88
6555.30	88.76	2.47	35.93	22.07	19.54
6555.40	94.93	2.50	37.92	22.76	20.20
6555.50	101.43	2.54	39.97	23.45	20.86
6555.60	108.61	2.58	42.08	24.03	21.39
6555.70	116.12	2.62	44.25	24.59	21.92

Rating Table for Irregular Section - SBC2-75 Elev=6551.0

Input Data

Water Surface Elevation (ft)	Discharge (ft³/s)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
6555.80	123.95	2.67	46.46	25.15	22.44
6555.90	132.08	2.71	48.74	25.72	22.97
6556.00	140.54	2.75	51.06	26.28	23.49
6556.10	149.48	2.80	53.43	26.80	23.97
6556.20	158.89	2.84	55.85	27.28	24.40
6556.30	168.63	2.89	58.31	27.76	24.84
6556.40	178.67	2.94	60.82	28.24	25.28
6556.50	189.05	2.98	63.37	28.72	25.71
6556.60	199.74	3.03	65.96	29.20	26.15
6556.70	210.77	3.07	68.60	29.68	26.58
6556.80	222.12	3.12	71.28	30.16	27.02
6556.90	233.81	3.16	74.00	30.64	27.45
6557.00	245.84	3.20	76.77	31.11	27.89
6557.10	258.21	3.24	79.58	31.59	28.32
6557.20	270.93	3.29	82.43	32.07	28.76
6557.30	283.99	3.33	85.33	32.55	29.20
6557.40	297.40	3.37	88.27	33.03	29.63
6557.50	311.09	3.41	91.26	33.52	30.08
6557.60	325.05	3.45	94.29	34.03	30.54
6557.70	339.38	3.49	97.37	34.53	31.01
6557.80	354.22	3.53	100.49	35.02	31.45
6557.90	369.44	3.56	103.66	35.50	31.89
6558.00	385.02	3.60	106.87	35.99	32.33
6558.10	400.98	3.64	110.12	36.47	32.77
6558.20	417.31	3.68	113.42	36.96	33.21
6558.30	434.03	3.72	116.77	37.44	33.65
6558.40	451.14	3.75	120.15	37.93	34.10
6558.50	468.63	3.79	123.58	38.41	34.54
6558.60	486.51	3.83	127.06	38.89	34.98
6558.70	504.79	3.87	130.58	39.38	35.42
6558.80	523.46	3.90	134.14	39.86	35.86
6558.90	542.54	3.94	137.75	40.35	36.30
6559.00	562.02	3.97	141.40	40.83	36.74
6559.10	581.90	4.01	145.10	41.32	37.18
6559.20	602.20	4.05	148.84	41.80	37.62
6559.30	621.49	4.07	152.63	42.31	38.10
6559.40	639.30	4.09	156.46	42.84	38.58
6559.50	657.47	4.10	160.34	43.36	39.07
6559.60	676.00	4.12	164.27	43.89	39.55
6559.70	694.89	4.13	168.25	44.41	40.04
6559.80	714.14	4.15	172.28	44.94	40.52

Rating Table for Irregular Section - SBC2-75 Elev=6551.0

Input Data

Water Surface Elevation (ft)	Discharge (ft³/s)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
6559.90	733.76	4.16	176.36	45.46	41.01
6560.00	753.74	4.18	180.48	45.99	41.49
6560.10	774.10	4.19	184.66	46.52	41.98
6560.20	794.83	4.21	188.88	47.04	42.46
6560.30	815.94	4.22	193.15	47.57	42.95
6560.40	837.42	4.24	197.47	48.09	43.43
6560.50	859.28	4.26	201.84	48.62	43.92
6560.60	881.52	4.27	206.25	49.14	44.40
6560.70	904.15	4.29	210.72	49.67	44.89
6560.80	927.17	4.31	215.23	50.19	45.37
6560.90	949.90	4.32	219.79	50.74	45.89
6561.00	967.10	4.31	224.42	51.53	46.65
6561.10	984.88	4.30	229.12	52.32	47.41
6561.20	1003.24	4.29	233.90	53.11	48.17
6561.30	1022.18	4.28	238.75	53.90	48.93
6561.40	1041.67	4.27	243.69	54.69	49.69
6561.50	1061.73	4.27	248.69	55.48	50.45
6561.60	1082.35	4.26	253.78	56.26	51.21
6561.70	1103.53	4.26	258.93	57.05	51.97
6561.80	1124.28	4.26	264.17	57.88	52.77
6561.90	1137.16	4.22	269.51	59.07	53.94
6562.00	1151.04	4.19	274.96	60.26	55.11

EXHIBIT

HYDROLOGY MONITORING SITES AND INSPECTION MAP

APPENDIX F –
SCOPING COMMENT RESPONSES

Black Butte Coal Company Federal Coal Lease WYW-6266 Mining Plan Modification
Environmental Impact Statement
Scoping Issue Statements and Responses

NEPA Process

Issue: Commentors made several allegations that the process that OSMRE used to complete this Environmental Impact Statement (EIS) was flawed and violated the National Environmental Policy Act of 1969 (NEPA).

Response: During an emergency, a Responsible Official of the Department can adopt alternative arrangements for projects to comply with NEPA before taking "urgently needed actions" (43 CFR 46.150). On April 23, 2025, the Council for Environmental Quality authorized the use of alternative arrangements for projects that respond to the national energy emergency, and the Department subsequently adopted alternative arrangements for qualifying projects to comply with NEPA. *See* "Alternative Arrangements for Compliance with the National Environmental Policy Act amid the National Energy Emergency," April 23, 2025. After Black Butte Coal Company (BBCC) requested use of these alternative arrangements and the Assistant Secretary for Land and Minerals Management (ASLM) approved this project for use of the alternative arrangements, the Office of Surface Mining Reclamation and Enforcement (OSMRE) issued a notice of intent (NOI) seeking comments on "the scope of the analysis in the EIS, and identification of relevant information, studies, and analyses". Comments related to the process are not relevant to the scope of the analysis and need no further response.

Issue: A commentor stated that consulting and coordinating with State and local agencies is important and that this should be done despite the accelerated EIS schedule.

Response: We agree that coordination with State and local agencies is important. The Wyoming Department of Environmental Quality (WDEQ) is a cooperating agency on this EIS. A full list of cooperating agencies is available in section 1.7. In addition, we coordinated with the Wyoming State Historic Preservation Office (SHPO) as part of our National Historic Preservation Act consolation responsibilities.

Fish and Wildlife

Issue: A commentor stated that the area around the mine has critical value for wildlife (particularly pronghorn, mule deer, elk, and sage grouse).

Response: Wildlife in the project area and potential project impacts are fully analyzed in Section 3.4 of the EIS.

Issue: A commentor stated that if mining occurs, mitigations should be required to minimize impacts on mule deer and sage grouse.

Response: Wildlife in the project area and potential project impacts, including impacts to mule deer and sage grouse, are fully analyzed in Section 3.4 of the EIS.

Issue: A commentor stated that pronghorn crucial winter habitat is located just to the north of the project on the other side of Interstate 80.

Response: Wildlife in the project area and potential project impacts, including impacts to the pronghorn, are fully analyzed in Section 3.4 of the EIS.

Recreation
Issue: A commentor stated that the area around the mine has critical value for recreation.

Response: Recreation was initially analyzed but dismissed from detailed analysis as presented in Table 1-2 of the EIS because there are no developed recreational uses in the mining plan modification area and the surrounding public lands have only limited recreational value.

Cultural Resources
Issue: A commentor stated that the area around the mine has critical value for cultural resources.

Response: Cultural resources were initially analyzed but dismissed from detailed analysis as presented in Table 1-2 of the EIS because, after consultation with the Wyoming SHPO, OSMRE determined that there were no historic properties likely to be affected by the proposed action. However, any unanticipated discoveries of archaeological or cultural remains must be reported to the Bureau of Land Management, OSMRE, and WDEQ. Furthermore, OSMRE is recommending that any mining plan modification approval by the ASLM include a special condition that the mine have a qualified archaeologist monitor mining activities at a potentially impacted site.

Public Health and Safety
Issue: A commentor stated that residents near coal-fired power plants face higher rates of cancer and asthma and have higher death rates.

Response: Potential health risks as a result of certain air pollutants emitted by coal-fired power plants are discussed in Section 3.2 – Air Quality/Greenhouse Gas. A discussion of the rates of certain health issues based on proximity to coal-fired power plants are outside the scope of the EIS.

Energy Production
Issue: A commentor questioned that the coal produced would be shipped to the Jim Bridger Power Plant or that investment should be made in coal as an energy source.

Response: Based on the information available to OSMRE at the time of this EIS, BBCM plans to sell the coal from the mining plan modification area to the Jim Bridger Power Plant. This information is included in the EIS. Comments about the merits of coal as an energy source are beyond the scope of this EIS analysis.

Issue: A commentor was concerned that the coal mine expansion would lead to electricity rate hikes for Wyoming residents.

Response: Local electricity rates are outside the scope of the EIS.

Reclamation
Issue: A commentor stated that thorough reclamation should be completed when mining activities are done to return these areas to a natural landscape.

Response: Thorough reclamation, including restoring topography and reseeding with a certified weed-free diverse seed mix of native grasses, forbs, and shrubs (as defined by existing range sites), is required by the WDEQ under BBCC's Surface Mining Control and Reclamation Act of 1977 (SMCRA) permit. Reclamation is discussed in Section 2.3.2 of the EIS.

Grazing

Issue: A commentor stated that livestock grazing does occur in the area, so the EIS must address any potential impacts to grazing because of the additional surface disturbance and it should identify any appropriate mitigation measures.

Response: We agree that livestock grazing occurs in the area and grazing is addressed at various points throughout the EIS. Mined areas would be temporarily unavailable for grazing. Thorough reclamation, including restoring topography and reseeding with a certified weed-free diverse seed mix of native grasses, forbs, and shrubs (as defined by existing range sites), is required by the WDEQ under BBCC's SMCRA permit. Following reclamation, mined lands would again be available for grazing.

Traffic

Issue: A commentor stated that the Federal mining plan modification area is close to Interstate 80 and the EIS should discuss increased truck traffic from the project.

Response: The mined coal would be shipped via rail. There would be no increase in traffic on Interstate 80 from the transport of the coal. The project is anticipated to slightly increase traffic from an increase in the number of commuters to the mine and supporting truck traffic. The mine employs 56 workers currently, though it is not in full operation, and this would increase to 110 under the Proposed Action, which is comparable the number previously employed during full operation. The rate of coal recovery under full operation would remain the same, but the duration of mining is anticipated to be extended by 6-7 years. A slight increase in commuter and truck traffic on Interstate 80 is anticipated, but a full discussion of traffic on Interstate 80 in the EIS was not included given the marginal increase.

Air Quality

Issue: A commentor stated that the EIS should address dust control measures.

Response: Air quality, including the dust control measures required in the proposed action, is adequately discussed in Section 3.2 of the EIS.

Social and Economic Resources

Issue: A commentor stated that the EIS must address the economic benefit the project will have on the State of Wyoming and the local economy as it will increase revenues through royalty payments generated from coal production, support job growth in southwestern Wyoming, and help to ensure the reliability of the grid by continuing to provide coal to the Jim Bridger Power Plant.

Response: Social and economic resources, including the impacts that the proposed project will have on Wyoming and the local economy, are adequately discussed in Section 3.7 of the EIS.