



Peabody Western Coal Company

August 3, 2026

Ms. Amy Ryser
Western Region Office
Office of Surface Mining
Reclamation and Enforcement
P. O. Box 25065
One Federal Center, Building 41
Lakewood, CO 80225-0065

RE: Phase II Bond Release Application / Peabody Western Coal Company / Kayenta Mine Permit AZ-0001F / J19 and J21 Permanent Program Areas – Revised

Dear Ms. Ryser:

Peabody Western Coal Company (PWCC) submits to the Office of Surface Mining Reclamation and Enforcement (OSMRE) the enclosed revision to the application materials in accordance with 30 CFR 800.40 for phase II release of bond on approximately 249 acres of mined and reclaimed lands in the permanent program area of J19 and J21 at Kayenta Mine. As noted on the TE dated July 27, 2026, PWCC submits revised bond instrument and liability amount being held currently. In addition, the phone number on the public notice has been changed.

Enclosed, please find one electronic copy of the Revised Bond Release Application. PWCC understands that OSMRE will complete a preliminary application review and will provide PWCC with a response that will include details of information required so that OSMRE can deem the application complete. Once OSMRE has deemed the application complete, PWCC will submit a complete official application with signed documents to OSMRE along with any additional hard copies and electronic thumb drives OSMRE directs PWCC to provide.

Please direct any questions and correspondence to me at 928.280.7091 or by email at mshepherd2@peabodyenergy.com.

Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

Phase II Bond Release Application
J19 and J21 Coal Resource Areas, Kayenta Mine

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SECTION 1. Phase II Bond Release Supporting Information
Administrative, Permit, and Bond Summary Data

Introduction

Peabody Western Coal Company (PWCC) is requesting Phase II bond release on portions of land within the J19 and J21 areas of the Kayenta Mine. The bond release application included in this submittal contains required documentation and information to support Phase II bond release for 249 acres of mined and reclaimed lands in the permanent program areas within the J19 and J21 Coal Resource Areas (CRAs) as shown on Map 1.1. There are no proposed permanent ponds within this request while 2 permanent roads are included within this release application. Information such as public notice, affidavit of publication, bond summary, bond reduction, and copies of notification letters to the Tribes, government agencies, and utilities are included in Section 1 of the application. Information for the Phase II technical portions of the application are presented in Section 2 (Certification of Reclamation), Section 3 (Historical Revegetation and Vegetation Sampling), and Section 4 (Suspended Solids Outside of the Permit Area) of this document.

Permit and Bond Release Summary Information

The J19 and J21 CRAs are located within PWCC's Kayenta Mine. The Kayenta Mine operates under Permit AZ-0001F issued by the Office of Surface Mining Reclamation and Enforcement (OSMRE) to PWCC Kayenta Mine on October 3, 2017. The 5-year renewal application for Permit AZ-0001F was submitted to OSMRE on February 27, 2020. On June 25, 2020, OSMRE administratively delayed their decision to renew Permit AZ-0001F due to COVID-19 pandemic closures and stay-at-home orders. Coal production at the Kayenta Mine ceased on August 26, 2019; reclamation activities continue under Permit AZ-0001F.

The Kayenta Mine permit area is located approximately 18 miles south southwest of Kayenta, Arizona (USGS 7.5-minute quadrangle maps Longhouse Valley, Marsh Pass S.E, Owl Spring, Yucca Hill, and Cliff Rose Hill). The permit areas for the J19 and J21 Phase II bond release are located within the following lands of Navajo County, Arizona that are described relative to the Gila and Salt River Base Meridian as:

A total of 72.3 acres of land is located within the J19 CRA. The computer-generated centroid location is Latitude 36° 26' 58" N and Longitude 110° 18' 33" W. A total of 176.7 acres of land is located within the J21 CRA. The computer-generated centroid location is Latitude 36° 24' 55" N and Longitude 110° 17' 27" W.

The type of bond and the amount of bond filed for Kayenta Mine Permit AZ-0001F are described in Table 1.1. The portion requested for release in the J19 and J21 CRAs includes \$585,610 for Phase II. Justification for these release dollars is explained in the following section.

Table 1.1 Bond Information for Kayenta Mine.		
Bond Surety	Bond Number	Bond Amount
Liberty Mutual Insurance Company	60S003887	\$20,871,344.37
SiriusPoint America Insurance Co.	SPA150171_003	\$15,791,861.00
AXIS Insurance Company	DUA005142	\$36,471,839.00
Zurich American Insurance Company	8940860	\$17,178,247.35
Total		\$90,313,291.72

Phase II Bond Reduction Cost

PWCC is seeking a reduction in the surface stabilization bond for Phase II in the amount of \$585,610. Surface stabilization has been accomplished on 72.3 acres in J19 and 176.7 acres in J21 as documented in Sections 3 and 4 of this application. Additionally, 1.25 miles of permanent roads will be retained as shown on Map 1.1. The bond reduction amount was determined by using direct and indirect unit costs calculated for 249 acres in J19 and J21 CRAs as documented in Permit AZ-0001F, Chapter 24, Table 24-1-4. Reclamation cost estimates as of January 2024 ("worst case" or "highest liability" as approved in Permit AZ-0001F by OSMRE on January 23, 2024) were used and these rates were adjusted for inflation through July 2026. The project categories and direct costs applicable to this Phase II bond release are listed in Table 1.2 for the J19 and J21 CRAs. PWCC does not request backfilling, grading, suitable material replacement, and soil material replacement for 72.3 acres at J19 and 176.7 acres at J21 as these were included in previous Phase I application submittals to OSMRE. Similarly, no costs have been requested on the disturbed lands for the Phase III reclamation activities including

revegetation and revegetation maintenance. The combined total bond reduction direct costs shown in Table 1.2 is \$478,048.

Table 1.2. Bond Reduction of Direct Cost Associated with Surface Stabilization and Permanent Road Retention in J19 and J21.	
Project Category	Bond Reduction Amount
Surface Stabilization for 72.3 acres in J19	\$3,557
General Grading @ 20% for 72.3 acres in J19	\$61,592
Surface Ripping @ 20% for 72.3 acres in J19	\$8,153
Roads (2.81 acres/712 acres) in J19	\$35,464
Surface Stabilization for 176.7 acres in J21	\$18,936
General Grading @ 20% for 176.7 acres in J21	\$150,530
Surface Ripping @ 20% for 176.7 acres in J21	\$19,925
Roads (9.21 acres/712 acres) in J21	\$116,239
Total Direct Costs	\$414,396
Inflation January 2024 thru July 2025 (9.97%)	\$41,316
Inflation July 2025 thru July 2026 (5.39%)	\$22,336
Total Direct Cost for Surface Stabilization and Permanent Road Retention in J19 and J21	\$478,048

Table 1.3 shows the indirect costs obtained from Permit AZ-0001F; Chapter 24 that are associated with the J19 and J21 Phase I direct cost as determined in January 2024. The total indirect cost reflects inflation through July 2026 (15.36%). An inflation rate of 9.97% for January 2024 through July 2025 was determined by OSMRE in April 2024 using RS Means Historical Cost Indexes and approved in Permit AZ-0001F by OSMRE. An inflation rate of 5.39% for July 2025 through July 2026 was determined by OSMRE in February 2025 using RS Means Historical Cost Indexes for the proposed renewal of Permit AZ-0001F. The total bond reduction indirect cost shown in Table 1.3 is \$107,562.

Table 1.3. Bond Reduction on Indirect Costs Associated with Surface Stabilization and Permanent Road Retention in J19 and J21.	
Project Category	Bond Reduction Amount
Mobilization/demobilization (1.5%)	\$7,171
Contingencies (2.0%)	\$9,561
Engineering redesign fee (2.0%)	\$9,561
Contractor profit and overhead (15.0%)	\$71,708
Reclamation management fee (2.0%)	\$9,561
Total Indirect Cost	\$107,562

The total direct, indirect, tax, and 2024 to July 2026 inflation costs for Phase II bond categories in the J19 and J21 CRAs is \$585,610.

Permanent Facilities

Two (2) two-track ranch roads shown within the J19 (.29 miles) and J21 (.95 miles) release areas will continue to be used for access to monitor the J21-H sediment pond for compliance-related inspections, for reclamation maintenance, other environmental monitoring, and local access by residents and will be retained as permanent roads.

PWCC is requesting approval from OSMRE, Tribal agencies, and the local transportation committee, if applicable, to leave permanent roads for accessing residences, interior grazing areas, permanent ponds, and sites of interest. The postmining access roads, left by PWCC for the purpose of accessing the postmining lands, will be maintained in the manner that other similar residential and range access roads have been traditionally maintained prior to any mining activities. All permanent facilities proposed for retention will enhance and complement the postmining land uses.

PUBLIC NOTICE

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for bond release on a portion of the lands in the J19 and J21 Coal Resource Areas (CRAs) within the Kayenta Mine Permit AZ-0001F. PWCC is seeking a release of Phase II bond liability for a portion of the J19 and J21 areas currently under bond with Zurich American Insurance Company, Liberty Mutual Insurance Company, SiriusPoint America Insurance Co., and AXIS Insurance Company. PWCC is seeking a reduction in bond of \$585,610 under the Phase II application. The total combined bond for Kayenta Mine is \$90,313,292.

The Phase II bond release application consists of information currently contained in the AZ-0001F permit application package (PAP) approved January 17, 2017. The PAP outlines PWCC's reclamation operations on Permanent Program Lands. The total area in J19 and J21 requested for Phase II release is 249 acres. Reclamation was completed between 2016 and 2024. Reclamation activities included surface stabilization, drainage control construction, and initiation of revegetation. The Kayenta Mine permit for the release areas is under Navajo Tribal Coal Leases 14-20-0603-9910 and Hopi Tribal Coal Lease 14-20-0450-5743 and operates pursuant to Code of Federal Regulations (CFR), Title 30; Subchapter E, Part 750; Subchapter G, Parts 773 and 774; and Subchapter K, Parts 810 and 816. This notice is hereby given that:

1. The name and business address of the applicant is:

Peabody Western Coal Company
Kayenta Mine
P.O. Box 650
Kayenta, AZ 86033

2. The mine permit area is located approximately 18 miles south southwest of Kayenta, Arizona. The permit area for the Phase II bond release areas is located in USGS 7.5-minute quadrangle map "Yucca Hill" within the following lands of Navajo County, Arizona that are described relative to the Gila and Salt River Base Meridian as:

A total of 72.3 acres of land is located within the J19 CRA. The computer-generated centroid location is Latitude 36° 26' 58" N and Longitude 110° 18' 33" W. A total of 176.7 acres of land is located within the J21 CRA. The computer-generated centroid location is Latitude 36° 24' 55" N and Longitude 110° 17' 27" W.

3. Locations of where copies of the application and permit are available for public review and/or inspection are:

The Navajo Nation Minerals Department

Forest Lake Chapter House

Office of Surface Mining
Window Rock Boulevard
Window Rock, AZ 86515

Navajo Route 41
17 miles north of Pinon
Pinon, AZ 86510

Office of Surface Mining
Reclamation and Enforcement
Western Region Office
One Federal Center, Building 41
Lakewood, CO 80225-0065

Peabody Western Coal Company
Kayenta Mine
Mesa Central Warehouse Office Complex
8 miles from Hyw 160 and Rt 41 Junction
Kayenta, AZ 86033

4. The names and addresses of the OSM-WRCC representative where written comments, objections, requests for a public hearing, or requests for an informal conference may be submitted on or before 5:00 p.m., October 26, 2026, thirty (30) days after the last publication date are:

Ms. Amy Ryser
Western Region Office
Office of Surface Mining Reclamation & Enforcement
One Federal Center, Building 41
Lakewood, CO 80225-0065
WR Permitting Information Line, 1-303-236-4690

5. Interested persons may obtain more information concerning the bond release by contacting Marie Shepherd, Senior Manager Environmental for PWCC at 928.280.7091.
6. The application has been filed with OSMRE and will be acted upon pursuant to the Permanent Regulatory Program (30 CFR Parts 750 and 774) approved by the Secretary of the Interior under Title V of the Surface Mining Control and Reclamation Act of 1977.



PEABODY WESTERN

COAL COMPANY

Kayenta Mine
Highway 160, Navajo Route 41
P.O. Box 650
Kayenta, Arizona 86033
928.280.7115

August 3, 2026

Bureau of Indian Affairs
Navajo Area Office
Ms. Deborah Shirley, Regional Director
P.O. Box 1060
301 West Hill Street
Gallup, New Mexico 87305-1060

RE: Notice of Application for Phase II Bond Release; J19 and J21 Coal Resource Areas; Kayenta Mine

Dear Ms. Shirley:

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for Phase II bond release on portions of the J19 and J21 Coal Resource Areas. The release area is in the southeastern portion of the PWCC lease area. PWCC is seeking release from Phase II bond liability for those surety bonds currently held with Zurich American Insurance Company, Liberty Mutual Insurance Company, SiriusPoint America Insurance Co. and AXIS Insurance Company. The total combined bond for Kayenta Mine is \$90,313,292.

The Phase II bond release area is located within the Kayenta Mine Permanent Program permit area (AZ-0001F PAP) in the southeastern portion of the PWCC lease area. PWCC is seeking a reduction of the total J19 and J21 bond amount of \$585,610 at this time by gaining regulatory approval for release of lands described in the application from Phase II bond liability. The total area sought for release includes 249 acres of disturbed land. Approval of Phase II will allow for Phase III bond release to proceed on these areas once all requirements for this phase are met. Phase III is the final bond release step and once approved will allow for the planned return of these lands to the Navajo Nation in the future. Until that time, PWCC will continue to control and manage reclaimed lands in the release areas described.

Reclamation of the Phase II release areas which includes surface stabilization, drainage control, and initiation of vegetation establishment was completed between 2016 and 2024. All reclamation activities were conducted in accordance with the Surface Mining Control and Reclamation Act (SMCRA) and the requirements of the OSMRE Permit AZ-0001F PAP approved October 3, 2017. Reclamation activities are documented in annual reports submitted previously to OSMRE.

The application and permit are available for public review and/or inspection at:

Navajo Nation Minerals Department
Office of Surface Mining
Window Rock Boulevard
Window Rock, AZ 86515

Forest Lake Chapter House
Navajo Route 41
17 miles North of Pinon
Pinon, AZ 86510

Ms. Deborah Shirley
August 3, 2026
Page 2 of 2

Peabody Western Coal Company
Kayenta Mine
Mesa Central Warehouse Office Complex
8 Miles from Hwy 160 and Route 41 Junction
Kayenta, Arizona 86033

OSMRE Website: <https://www.osmre.gov/programs/regulating-active-coal-mines/indian-lands>

If you have questions, comments, or wish to request a hearing or informal conference regarding this bond release application, please contact:

Ms. Amy Ryser
Western Region Office
Office of Surface Mining Reclamation & Enforcement
P. O. Box 25065
One Federal Center, Building 41
Lakewood, CO 80225-0065
WR Permitting Information Line, 1-303-236-4690

Please direct your questions about this application to me at 928.280.7091 or email them to me at mshepherd2@peabodyenergy.com.

Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

C: Amy Ryser (OSMRE-WRO)



PEABODY WESTERN

COAL COMPANY

Kayenta Mine
Highway 160, Navajo Route 41
P.O. Box 650
Kayenta, Arizona 86033
928.280.7115

August 3, 2026

Bureau of Land Management
Arizona State Office
Mr. Rick Selbach
Land and Minerals Branch Chief
One North Central Ave., Suite 800
Phoenix, Arizona 85004

RE: Notice of Application for Phase II Bond Release; J19 and J21 Coal Resource Areas; Kayenta Mine

Dear Mr. Selbach:

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for Phase I bond release on portions of the J19 and J21 Coal Resource Areas. The release area is in the southeastern portion of the PWCC lease area. PWCC is seeking release from Phase II bond liability for those surety bonds currently held with Zurich American Insurance Company, Liberty Mutual Insurance Company, SiriusPoint America Insurance Co., and AXIS Insurance Company. The total combined bond for Kayenta Mine is \$90,313,292.

The Phase II bond release area is located within the Kayenta Mine Permanent Program permit area (AZ-0001F PAP) in the southeastern portion of the PWCC lease area. PWCC is seeking a reduction of the total J19 and J21 bond amount of \$585,610 at this time by gaining regulatory approval for release of lands described in the application from Phase I bond liability. The total area sought for release includes 249 acres of disturbed land. Approval of Phase II will allow for Phase III bond release to proceed on these areas once all requirements for this phase are met. Phase III is the final bond release step and once approved will allow for the planned return of these lands to the Navajo Nation in the future. Until that time, PWCC will continue to control and manage reclaimed lands in the release areas described.

Reclamation of the Phase II release areas which includes surface stabilization, drainage control, and initiation of vegetation establishment was completed between 2016 and 2024. All reclamation activities were conducted in accordance with the Surface Mining Control and Reclamation Act (SMCRA) and the requirements of the OSMRE Permit AZ-0001F PAP approved October 3, 2017. Reclamation activities are documented in annual reports submitted previously to OSMRE.

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Navajo Nation Minerals Department
Office of Surface Mining
Window Rock Boulevard
Window Rock, AZ 86515

Forest Lake Chapter House
Navajo Route 41
17 miles North of Pinon
Pinon, AZ 86510

Mr. Rick Selbach
August 3, 2026
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Peabody Western Coal Company
Kayenta Mine
Mesa Central Warehouse Office Complex
8 Miles from Hyw 160 and Route 41 Junction
Kayenta, Arizona 86033

OSMRE Website: <https://www.osmre.gov/programs/regulating-active-coal-mines/indian-lands>

If you have questions, comments, or wish to request a hearing or informal conference regarding this bond release application, please contact:

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Please direct your questions about this application to me at 928.280.7091 or email them to me at mshepherd2@peabodyenergy.com.

Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

C: Amy Ryser (OSMRE-WRO)



**PEABODY WESTERN
COAL COMPANY**
Kayenta Mine
Highway 160, Navajo Route 41
P.O. Box 650
Kayenta, Arizona 86033
928.280.7115

August 3, 2026

Chilchinbeto Chapter
Mr. Thomas Bradley, Vice President
P.O. Box 1681
Kayenta, Arizona 86033

RE: Notice of Application for Phase II Bond Release; J19 and J21 Coal Resource Areas; Kayenta Mine

Dear Mr. Bradley:

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for Phase II bond release on portions of the J19 and J21 Coal Resource Areas. The release area is in the southeastern portion of the PWCC lease area. PWCC is seeking release from Phase II bond liability for those surety bonds currently held with Zurich American Insurance Company, Liberty Mutual Insurance Company, SiriusPoint America Insurance Co., and AXIS Insurance Company. The total combined bond for Kayenta Mine is \$90,313,292.

The Phase II bond release area is located within the Kayenta Mine Permanent Program permit area (AZ-0001F PAP) in the southeastern portion of the PWCC lease area. PWCC is seeking a reduction of the total J19 and J21 bond amount of \$585,610 at this time by gaining regulatory approval for release of lands described in the application from Phase II bond liability. The total area sought for release includes 249 acres of disturbed land. Approval of Phase II will allow for Phase III bond release to proceed on these areas once all requirements for this phase are met. Phase III is the final bond release step and once approved will allow for the planned return of these lands to the Navajo Nation in the future. Until that time, PWCC will continue to control and manage reclaimed lands in the release areas described.

Reclamation of the Phase II release areas which include surface stabilization, drainage control, and initiation of vegetation establishment was completed between 2016 and 2024. All reclamation activities were conducted in accordance with the Surface Mining Control and Reclamation Act (SMCRA) and the requirements of the OSMRE Permit AZ-0001F PAP approved October 3, 2017. Reclamation activities are documented in annual reports submitted previously to OSMRE.

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Forest Lake Chapter House
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Mr. Thomas Bradley
August 3, 2026
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Please direct your questions about this application to me at 928.280.7091 or email them to me at mshepherd2@peabodyenergy.com.

Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

C: Amy Ryser (OSMRE-WRO)



PEABODY WESTERN

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Highway 160, Navajo Route 41
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August 3, 2026

Forest Lake Chapter
Mr. Loren Silver, President
P.O. Box 441
Pinon, Arizona 86510

RE: Notice of Application for Phase II Bond Release; J19 and J21 Coal Resource Areas; Kayenta Mine

Dear Mr. Silver:

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for Phase II bond release on portions of the J19 and J21 Coal Resource Areas. The release area is in the southeastern portion of the PWCC lease area. PWCC is seeking release from Phase II bond liability for those surety bonds currently held with Zurich American Insurance Company, Liberty Mutual Insurance Company, SiriusPoint America Insurance Co., and AXIS Insurance Company. The total combined bond for Kayenta Mine is \$90,313,292.

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Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

C: Amy Ryser (OSMRE-WRO)



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COAL COMPANY

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Highway 160, Navajo Route 41
P.O. Box 650
Kayenta, Arizona 86033
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August 3, 2026

The Hopi Tribe
Office of Mining and Minerals
Attn: Dr. Carrie Joseph
P.O. Box 123
Kykotsmovi, AZ 86039

RE: Notice of Application for Phase II Bond Release; J19 and J21 Coal Resource Areas; Kayenta Mine

Dear Dr. Joseph:

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for Phase II bond release on portions of the J19 and J21 Coal Resource Areas. The release area is in the southeastern portion of the PWCC lease area. PWCC is seeking release from Phase II bond liability for those surety bonds currently held with Zurich American Insurance Company, Liberty Mutual Insurance Company, SiriusPoint America Insurance Co., and AXIS Insurance Company. The total combined bond for Kayenta Mine is \$90,313,292.

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Dr. Carrie Joseph
August 3, 2026
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Please direct your questions about this application to me at 928.280.7091 or email them to me at mshepherd2@peabodyenergy.com.

Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

C: Amy Ryser (OSMRE-WRO)



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COAL COMPANY

Kayenta Mine
Highway 160, Navajo Route 41
P.O. Box 650
Kayenta, Arizona 86033
928.280.7115

August 3, 2026

Kayenta Chapter
Mr. Albert Bailey, President
P.O. Box 1088
Kayenta, Arizona 86033

RE: Notice of Application for Phase II Bond Release; J19 and J21 Coal Resource Areas; Kayenta Mine

Dear Mr. Bailey:

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for Phase II bond release on portions of the J19 and J21 Coal Resource Areas. The release area is in the southeastern portion of the PWCC lease area. PWCC is seeking release from Phase II bond liability for those surety bonds currently held with Zurich American Insurance Company, Liberty Mutual Insurance Company, SiriusPoint America Insurance Co. and AXIS Insurance Company. The total combined bond for Kayenta Mine is \$90,313,292.

The Phase II bond release area is located within the Kayenta Mine Permanent Program permit area (AZ-0001F PAP) in the southeastern portion of the PWCC lease area. PWCC is seeking a reduction of the total J19 and J21 bond amount of \$585,610 at this time by gaining regulatory approval for release of lands described in the application from Phase II bond liability. The total area sought for release includes 249 acres of disturbed land. Approval of Phase II will allow for Phase III bond release to proceed on these areas once all requirements for this phase are met. Phase III is the final bond release step and once approved will allow for the planned return of these lands to the Navajo Nation in the future. Until that time, PWCC will continue to control and manage reclaimed lands in the release areas described.

Reclamation of the Phase II release areas which include surface stabilization, drainage control, and initiation of vegetation establishment was completed between 2016 and 2024. All reclamation activities were conducted in accordance with the Surface Mining Control and Reclamation Act (SMCRA) and the requirements of the OSMRE Permit AZ-0001F PAP approved October 3, 2017. Reclamation activities are documented in annual reports submitted previously to OSMRE.

The application and permit are available for public review and/or inspection at:

Navajo Nation Minerals Department
Office of Surface Mining
Window Rock Boulevard
Window Rock, AZ 86515

Forest Lake Chapter House
Navajo Route 41
17 miles North of Pinon
Pinon, AZ 86510

Mr. Albert Bailey
August 3, 2026
Page 2 of 2

Peabody Western Coal Company
Kayenta Mine
Mesa Central Warehouse Office Complex
8 Miles from 160 and Route 41 Junction
Kayenta, Arizona 86033

OSMRE Website: <https://www.osmre.gov/programs/regulating-active-coal-mines/indian-lands>

If you have questions, comments, or wish to request a hearing or informal conference regarding this bond release application, please contact:

Ms. Amy Ryser
Western Region Office
Office of Surface Mining Reclamation & Enforcement
P. O. Box 25065
One Federal Center, Building 41
Lakewood, CO 80225-0065
WR Permitting Information Line, 1-303-236-4690

Please direct your questions about this application to me at 928.280.7091 or email them to me at mshepherd2@peabodyenergy.com.

Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

C: Amy Ryser (OSMRE-WRO)



PEABODY WESTERN

COAL COMPANY

Kayenta Mine
Highway 160, Navajo Route 41
P.O. Box 650
Kayenta, Arizona 86033
928.280.7115

August 3, 2026

Navajo Nation
Minerals Department
Mr. Bryan R. Benally
P.O. Box 1910
Window Rock, AZ 86515

RE: Notice of Application for Phase II Bond Release; J19 and J21 Coal Resource Areas; Kayenta Mine

Dear Mr. Benally:

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for Phase II bond release on portions of the J19 and J21 Coal Resource Areas. The release area is in the southeastern portion of the PWCC lease area. PWCC is seeking release from Phase II bond liability for those surety bonds currently held with Zurich American Insurance Company, Liberty Mutual Insurance Company, SiriusPoint America Insurance Co. and AXIS Insurance Company. The total combined bond for Kayenta Mine is \$90,313,292.

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Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

C: Amy Ryser (OSMRE-WRO)



**PEABODY WESTERN
COAL COMPANY**
Kayenta Mine
Highway 160, Navajo Route 41
P.O. Box 650
Kayenta, Arizona 86033
928.280.7115

August 3, 2026

Navajo Tribal Utility Authority
Mr. Walter W. Haase, P.E., General Manager
P.O. Box 170
Fort Defiance, Arizona 86504-0170

RE: Notice of Application for Phase II Bond Release; J19 and J21 Coal Resource Areas; Kayenta Mine

Dear Mr. Haase:

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for Phase II bond release on portions of the J19 and J21 Coal Resource Areas. The release area is in the southeastern portion of the PWCC lease area. PWCC is seeking release from Phase II bond liability for those surety bonds currently held with Zurich American Insurance Company, Liberty Mutual Insurance Company, SiriusPoint America Insurance Co. and AXIS Insurance Company. The total combined bond for Kayenta Mine is \$90,313,292.

The Phase II bond release area is located within the Kayenta Mine Permanent Program permit area (AZ-0001F PAP) in the southeastern portion of the PWCC lease area. PWCC is seeking a reduction of the total J19 and J21 bond amount of \$585,610 at this time by gaining regulatory approval for release of lands described in the application from Phase II bond liability. The total area sought for release includes 249 acres of disturbed land. Approval of Phase II will allow for Phase III bond release to proceed on these areas once all requirements for this phase are met. Phase III is the final bond release step and once approved will allow for the planned return of these lands to the Navajo Nation in the future. Until that time, PWCC will continue to control and manage reclaimed lands in the release areas described.

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Mr. Walter W. Haase
August 3, 2026
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Office of Surface Mining Reclamation & Enforcement
P. O. Box 25065
One Federal Center, Building 41
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Please direct your questions about this application to me at 928.280.7091 or email them to me at mshepherd2@peabodyenergy.com.

Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

C: Amy Ryser (OSMRE-WRO)



**PEABODY WESTERN
COAL COMPANY**
Kayenta Mine
Highway 160, Navajo Route 41
P.O. Box 650
Kayenta, Arizona 86033
928.280.7115

August 3, 2026

Shonto Chapter
Ms. Marsha Greyeyes, President
P. O. Box 7800
Shonto, AZ 86054

RE: Notice of Application for Phase II Bond Release; J19 and J21 Coal Resource Areas; Kayenta Mine

Dear Ms. Greyeyes:

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for Phase II bond release on portions of the J19 and J21 Coal Resource Areas. The release area is in the southeastern portion of the PWCC lease area. PWCC is seeking release from Phase II bond liability for those surety bonds currently held with Zurich American Insurance Company, Liberty Mutual Insurance Company, SiriusPoint America Insurance Co. and AXIS Insurance Company. The total combined bond for Kayenta Mine is \$90,313,292.

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Ms. Marsha Greyeyes
August 3, 2026
Page 2 of 2

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Please direct your questions about this application to me at 928.280.7091 or email them to me at mshepherd2@peabodyenergy.com.

Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

C: Amy Ryser (OSMRE-WRO)



Kayenta Complex
PO Box 650
Kayenta, Arizona USA 86033

J19/J21 Phase II Bond Release
Map 1.1
Permanent Program
Bonded Area Summary

Produced by
Gary Altsisi
Professional
Engineer

Map design by
Deep Southwest Enterprises

July 17, 2026
Revision

1 Inch = 500 Feet



Total Proposed 2026
Phase II Bond Release - 249 Acres

Legend

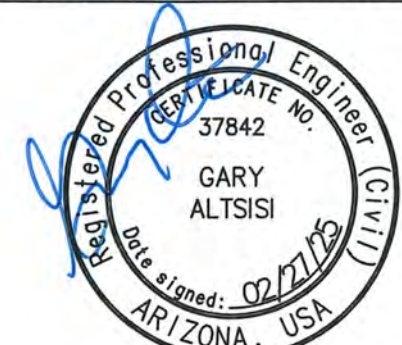
- J19 Proposed Phase II Bond Release - 72.3 acres
- J21 Proposed Phase II Bond Release - 176.7 acres
- Approved Phase II Bond Release
- Unreleased Permanent Program Areas
- J19 Ranch Road - 0.29 mile
- J21 Ranch Road - 0.95 mile



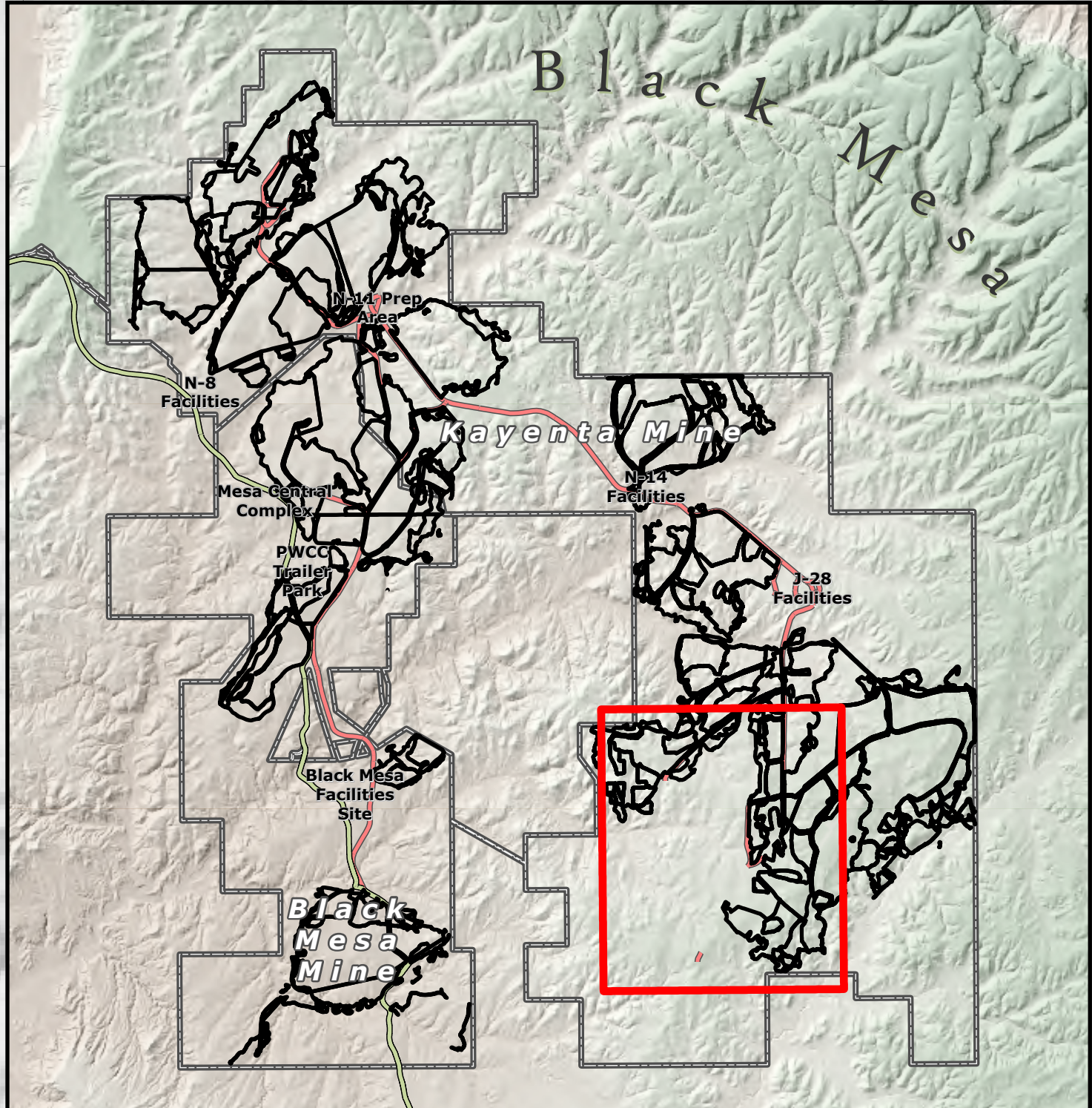
Other Features

- Major Wash
- PWCC Permit Boundary
- Ponds

ENGINEER'S CERTIFICATION



Gary Altsisi
ARIZONA P.E. 37842



J21 Proposed
Phase II Release Area
176.7 ac

Sources: Esri, Vantor, Airbus DS, USGS, NASA, GEBCO, N Robinson, NCEAS, NLS, OS, NMA, Geodatasysteem, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap, and the GIS user community

ATTACHMENT 2.1

CERTIFICATION

PEABODY WESTERN COAL COMPANY
KAYENTA MINE, J19 and J21 COAL RESOURCE AREAS, PHASE II BOND RELEASE APPLICATION
NAVAJO COUNTY, ARIZONA

I HEREBY CERTIFY that, to the best of my knowledge and belief, all applicable reclamation activities described in the attached Phase II Bond Release Application, dated July 21, 2026, have been accomplished in accordance with the reclamation requirements of the Act, the regulatory program, and the approved reclamation plan contained in the AZ-0001F Permit. The bond release parcel is free from enforcement actions.

Peabody Western Coal Company - Kayenta Mine

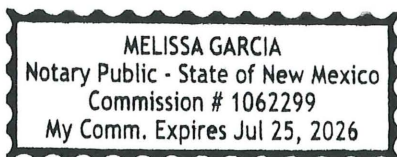
By: _____

Seth Puls
General Manager - Kayenta Mine

STATE OF NEW MEXICO

MCKINLEY COUNTY

Signed or attested before me this 21st day of July 2026, by Seth Puls, General Manager - Kayenta Mine owned by Peabody Western Coal Company, a Delaware Corporation, on behalf of said Kayenta Mine.



M. Garcia

Notary Public

My commission expires:

July 25, 2026

SECTION 3 - PHASE II BOND RELEASE SUPPORTING INFORMATION

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Map 3.2	J19/J21 Bond Release Phase II Vegetation Sampling Locations

INTRODUCTION

The Phase II Bond Release information contained in this section includes historical revegetation information and results and analysis of vegetation sampling in support of the application. The Phase I bond release for the Reclaimed Liability Release Areas (RLRA) is included in Sections 1 and 2 of this application.

HISTORICAL REVEGETATION

Revegetation activities for the J19/J21 RLRA included in this application were conducted mainly during the years 2016 through 2024. Details of revegetation procedures and applied seed mixtures for initial seeding and reseeding have been previously reported to the regulatory authority in annual monitoring reports. This information and supporting maps are contained in the Minesoil Reconstruction and Revegetation Activities Report, Black Mesa and Kayenta Mines for the years 1996 through 1999 as well as in Tab 2 of the Reclamation Status and Monitoring Report, Black Mesa and Kayenta Mines for the years 2000 through 2019. Revegetation procedures are summarized as follows. Upon completion of soil replacement, sites were deep ripped and then contour furrow disked to aid in surface stabilization and seedbed preparation. The sites were then seeded during the next available seeding season using the approved permanent seed mixture and appropriate seeding practices. Following seeding the sites were mulched with native grass hay at two tons per acre and then crimped to anchor the mulch. Map 3.1 shows the permanent program revegetation areas by year of seeding included in this Phase II application.

PHASE II VEGETATION SAMPLING

The sampling methods and results presented in the application address the requirements for Phase II bond release. Sampling methods are consistent with approved vegetation baseline and monitoring study methods for the Kayenta Mine as outlined in the AZ-0001F PAP, Chapter 9, Attachment 2. These methods have been used for all sampling at Kayenta Mine.

The Guideline to Bond Release Procedures for Permanent Programs Lands, Indian Programs Branch, Western Region Office of Surface Mining Reclamation and Enforcement (2017) states that the operator must demonstrate for Phase II bond release that "the reclaimed plant community is successfully established in accordance with 30 CFR 816.111 and the approved PAP." 30 CFR 816.111 states that the vegetative cover must be:

1. Diverse, effective, and permanent;
2. Comprised of species native to the area, or of introduced species where desirable and necessary to achieve the approved postmining land use and approved by the regulatory authority;

3. At least equal in extent of cover to the natural vegetation of the area; and
4. Capable of stabilizing the soil surface from erosion.

This section includes the discussion of the first three requirements. The fourth requirement, sediment loss and erosion discussion is detailed in Section 4 of this application.

Phase II bond release requires statistically valid methods and random sampling of reclaimed and reference areas and comparison of the sampling results for these two areas. For purposes of permanent program vegetative cover evaluations, the J7, N7/8, and N14 sagebrush reference areas (SBRAs) determine the cover success standard. A minimum of 20 samples were collected in the RLRA and 15 samples in the SBRAs. An additional two permanent transect locations were sampled within the RLRA to show trends over time and were included with the RLRA data presented here. Sample adequacy was calculated from first-hit foliar vegetation cover sample values using the following formula:

$$N_{min} = \frac{t^2 * s^2}{d^2 * \bar{x}^2}$$

where:

N_{min} = minimum number of samples required

t = one-tailed t-value with n-1 degrees of freedom

s^2 = sample variance (n-1 degrees of freedom)

d = 0.1 (level of precision or desired detectable reduction)

$\bar{x}$ = sample mean

The vegetation sampling locations (RLRA & SBRA) are shown on Map 3.2. The vegetation data included in this application were collected in fall 2025 in the RLRA and SBRAs. Vegetation cover data were subjected to hypothesis testing as described in the PAP. Total first-hit live foliar vegetation data minus noxious weeds (Arizona or Navajo Nation A- or B-listed) were used for this evaluation.

VEGETATION DATA SUMMARY

Data summaries for the vegetation monitoring studies supporting this liability release application are presented in this section and summarized in Table 3.1. Noxious weeds (Arizona or Navajo Nation A- or B-listed) were removed from the vegetation cover data used for vegetation analysis but not removed from ground cover data used for sediment loss and erosion evaluations discussed in Section 4 of this application. Raw data for all datasets are presented in Appendix 3.1 (RLRA) and Appendix 3.2 (SBRAs).

SECTION 3 - PHASE II BOND RELEASE SUPPORTING INFORMATION

Table 3.1: Summary Statistics for the J19/J21 RLRA and J7, N7/8, and N14 SBRA

Site ID	Foliar Vegetation Cover ¹	Ground Cover ^{1,2}	Grass Cover	Forb Cover	Shrub/Subshrub Cover	Tree Cover	Total Species Present
Phase II RLRA							
J19/J21 RLRA	19.05	70.82	11.00	1.18	6.86	0.00	55
Sagebrush Reference Areas							
J7 SBRA	17.80	45.67	10.73	0.40	6.67	0.00	17
N7/8 SBRA	18.54	80.87	3.61	0.13	11.87	2.93	20
N14 SBRA	23.13	63.53	7.60	0.00	13.67	1.87	18

¹ Noxious weeds listed as A- or B-list by Arizona and Navajo Nation were removed from foliar vegetation totals.

² Ground cover includes vegetation cover plus standing dead, litter, and rock.

Sample Adequacy

A summary of sample adequacy calculations for vegetation cover in the J19/J21 RLRA as well as the J7, N7/8, and N14 SBRA is presented in Table 3.2. Adequate samples were obtained in all sample areas.

Table 3.2: Sample Adequacy Calculations for the J19/J21 RLRA and J7, N7/8, and N14 SBRA

Site ID	Sample Size	t-statistic	Mean	Standard Deviation	Minimum Sample Size
Phase II RLRA					
J19/J21 RLRA	22	1.323	19.05	6.71	22
Sagebrush Reference Areas					
J7 SBRA	15	1.345	17.80	3.59	8
N7/8 SBRA	15	1.345	18.54	4.72	12
N14 SBRA	15	1.345	23.13	4.19	6

RLRA Cover

Vegetation cover averaged 19.05% and total ground cover averaged 70.82% in the J19/J21 RLRA (Table 3.1). Litter cover averaged 35.68% and rock cover averaged 11.09% (Appendix 3.1). The perennial grass component comprised most of the total vegetation cover with an average cover of 10.64% (55.9% of the relative cover). However, the most dominant species was fourwing saltbush (*Atriplex canescens*) which contributed 32.7% of the total relative vegetation cover.

Russian wildrye (*Elymus junceus*), an introduced perennial grass in the seed mixture, contributed another 14.5% of the relative cover and western wheatgrass (*Agropyron smithii*), a native perennial grass in the seed mixture contributed 13.6%. Five other native perennial cool season grasses, two other introduced perennial cool season grasses, and six native perennial warm season grasses also contributed to the cover data. Additionally, five shrubs and subshrubs, including fourwing saltbush,

contributed 36.0% of the total relative vegetation cover and three forbs contributed 6.2% of the total relative vegetation cover.

SBRA Cover

Average vegetation cover ranged from 17.80% in the J7 SBRA to 23.13% in the N14 SBRA (Table 3.1) and averaged 19.82% across all three reference areas. Average ground cover ranged from 45.67% in the J7 SBRA to 80.87% in the N7/8 SBRA with an average of 63.36%.

Litter cover ranged from 15.20% in the J7 SBRA to 31.00% in the N7/8 SBRA (Appendix 3.2) with an average of 23.22%. Rock cover was a large component of the ground cover in the N7/8 SBRA at 18.53% but the other SBRAs had little or no rock.

Shrubs and subshrubs comprised an average of 53.5% of the relative cover across all three SBRAs and were the largest component of the vegetation cover in the N7/8 and N14 SBRAs and the second largest component in the J7 SBRA. The most common species in the N7/8 and N14 SBRAs was big sagebrush (*Artemisia tridentata*) which contributed an average of 41.3% of the relative cover in these two reference areas and 32.5% across all three reference areas. There was also a significant contribution from fourwing saltbush and Greene's rabbitbrush (*Chrysothamnus Greenei*) in the J7 and N7/8 SBRAs.

Native perennial grasses were the largest component of the vegetation cover in the J7 SBRA and the second largest component in reference areas N7/8 and N14 SBRAs. Native perennial grasses comprised 37.5% of the relative vegetation cover on average. Blue grama (*Bouteloua gracilis*) was the most commonly encountered grass species in all three SBRAs and averaged 21.1% of the relative cover across all three SBRAs.

Species Diversity

Species diversity is measured by recording all species occurring within one meter on either side of each vegetation cover transect. The total number of species observed along all RLRA transects was 55 species in 2025 (Table 3.1). Of these 21 were grasses, 18 were forbs, and 16 were woody species (subshrubs, shrubs, cactus, and trees). The total number of species observed in the SBRAs ranged from 17 species in the J7 SBRA to 20 species in the N7/8 SBRA and averaged 18.33 species across all three SBRAs.

RLRA REVEGETATION SUCCESS CHARACTERIZATION

The data collected in the J19/J21 RLRA demonstrates that it has developed vegetation cover that meets the requirements for Phase II bond release. An effective, diverse, and permanent vegetative cover has been established that is consistent with the post-mining land use. The vegetation cover

on the RLRA is comparable to that observed on the SBRAs and it is anticipated that this RLRA is on the way to achieving the goals of final bond release when it reaches that stage of maturity.

Vegetation Cover

Foliar cover in the J19/J21 RLRA was greater than that observed in the J7 and N7/8 SBRAs and less than that observed in the N14 SBRA (Figure 3.1). Ground cover in the J19/J21 RLRA was greater than that observed in the J7 and N14 SBRAs and less than that observed in the N7/8 SBRA (Figure 3.1). The foliar cover from the RLRA was greater than 90% of the average SBRA when subjected to hypothesis testing using the methods detailed in the PAP (Table 3.3).

Figure 3.1: Foliar and Ground Cover (Mean $\pm$ Standard Error) in the RLRA and SBRAs

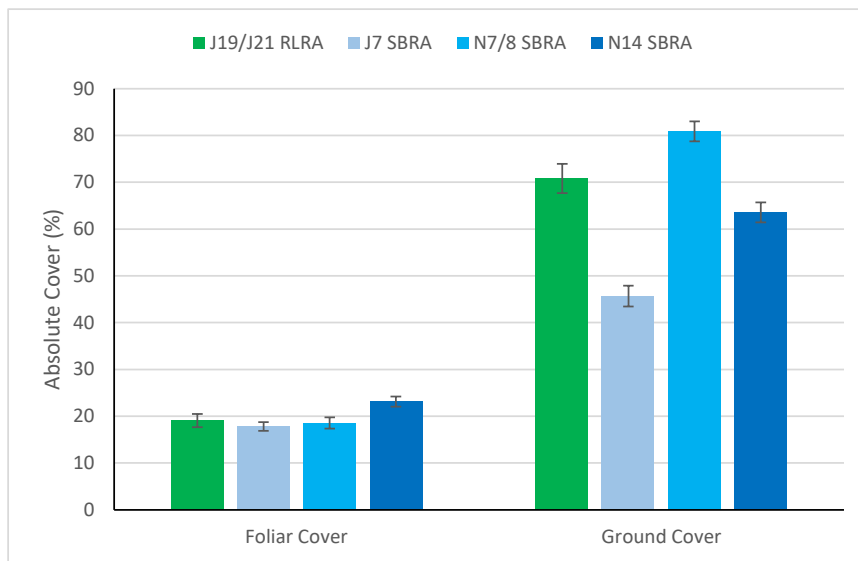


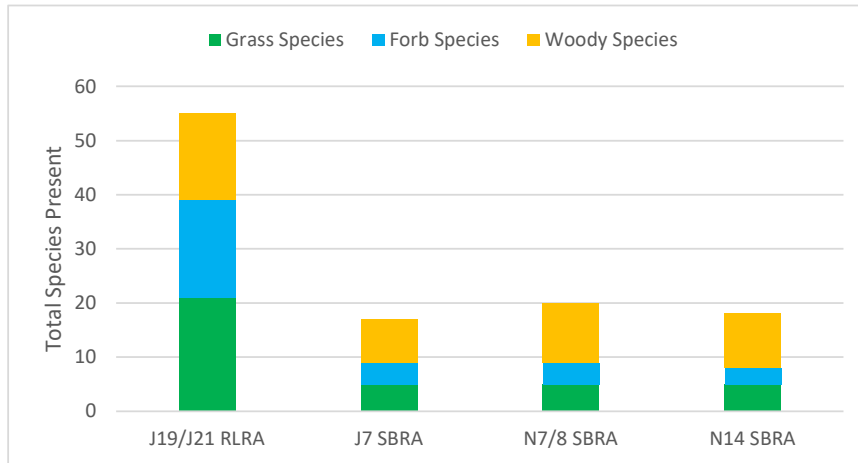
Table 3.3: Hypothesis Testing Results for J19/J21 RLRA

Site ID	RLRA Mean	90% SBRA Mean	t-statistic	t-test value	Reclamation Pass?
J19/J21 RLRA	19.05	17.84	-1.313	0.78	Yes

Species Diversity

The total species diversity in the J19/J21 RLRA was greater than all three SBRAs (Figure 3.2). As with the vegetation cover data, the species composition of the RLRA included more grasses than woody species and the SBRAs included more woody species than grasses. Given that this RLRA is only at the Phase II stage of bond release, there is ample evidence to suggest that the RLRA will meet Phase III standards in the future.

Figure 3.2: Total Number of Species Observed Along Transects in the RLRA and SBRA



Utility for Post-Mining Land Use

Most of the vegetation cover (84.5% of the relative cover) observed in the J19/J21 RLRA reflects approved seed mixtures. Seed mixtures were formulated to provide good forage production, nutrient levels, and palatability for all classes of livestock and a variety of wildlife. While no production data were collected as a part of Phase II sampling, an average of 79.2% of the relative vegetation cover in the RLRA was comprised of species known to have high palatability for livestock, with another 16.5% of the cover made up of species with medium forage palatability.

The dominant grass species in the RLRA were Russian wildrye and western wheatgrass which combined comprised 28.2% of the relative cover. Russian wildrye has a very long season of use and high digestibility through much of the year (Cook et al. 1977). It retains good nutrient qualities as standing hay in the winter. Russian wildrye also exhibits good regrowth and recovery after grazing and when spring moisture and summer rains are likely. These qualities make this grass a valuable species throughout the year and compliment the other reclamation species in the PWCC grazing management program. Western wheatgrass is highly palatable and offers the greatest utility when green in the spring, dropping off significantly as the grass matures (Cook et al. 1977). Western wheatgrass matures later than other cool season grasses extending the forage season. Five other native and cultivated wheatgrasses (*Agropyron* spp.) compliment these dominant grasses contributing an additional 15.0% of the relative vegetation cover.

Warm season native grasses are also found throughout the RLRA and contributed an average of 10.0% of the relative vegetation cover. All warm season grasses present in the RLRA's have good forage qualities during the growing season and blue grama maintains these qualities after the growing season (Cook et al. 1977). Blue grama has the greatest palatability, forage quality, and utility of the warm season grasses observed. Alkali sacaton (*Sporobolus airoides*) is a significant producer

but has its greatest utility early in the season when green and palatable. Galleta (*Hilaria jamesii*) has a good presence in the reclaimed lands and during its green growing period, forage value is good but drops off quickly after maturity (Stubbendieck et al. 1982).

Many of the shrubs and forbs offer forage nutrition that compliments the grass dominated communities and aid in balancing the overall forage nutritional quality. Fourwing saltbush, the dominant species throughout the RLRA, is an excellent source of nutrients for all classes of livestock throughout the year (Cook et al. 1977). It provides valuable forage and browse to livestock and wildlife in the summer and into the fall and winter. Also, while not a native species, the commonly occurring annual species, kochia, can be a significant contributor to annual production during wetter springs and in the fall. This species is used by livestock, particularly when green, and has good nutrient qualities (Cook et al. 1977).

Trends over Time

Since 1992, PWCC has installed 144 permanent vegetation monitoring transects throughout the reclaimed areas on the mine to evaluate reclamation success over time. Two of these transects are within the J19/J21 RLRA (Map 3.2). While these two sample points are not a statistically adequate sample, they can provide a general trend over more than one year for the area. Cover data for these transects is presented in Table 3.4 and production data is presented in Table 3.5.

Between 2023 and 2025 each of these permanent transects was monitored six times. They were all monitored in both the spring and fall to evaluate both cool season and warm season species development. The average SBRA cover collected in the same season was compared to the permanent transect sample data to evaluate progress. Of the six seasons, the average cover of the RLRA permanent transects was greater than 90% of the average for the reference areas in four instances (Table 3.4). Production data are not collected from the SBRA; however, the J19/J21 RLRA permanent transects average production was greater than the Phase III standard in five of the last six monitoring events (Table 3.5).

Table 3.4: Permanent Transect Foliar Cover Data for J19/J21 RLRA (2023-2025)

Permanent Transect	2023		2024		2025	
	Spring	Fall	Spring	Fall	Spring	Fall
P121	25	45	32	19	12	14
P122	31	50	51	17	16	36
Average	28.0	47.5	41.5	18.0	14.0	25.0
SBRA Average	17.4	28.2	23.5	23.1	17.9	20.6

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Table 3.5: Permanent Transect Production Data for J19/J21 RLRA (2023-2025)

Permanent Transect	2023		2024		2025	
	Spring	Fall	Spring	Fall	Spring	Fall
P121	360	1060	420	704	266	268
P122	357	1814	540	720	185	197
Average	358.9	1436.8	480.1	712.1	225.2	232.5
Phase III Standard	696.5	581.4	273.2	178.4	61.5	4.7

LITERATURE CITED

- Cook, C.W., R.D. Child, and L.L. Larson. 1977. Digestible Protein in Range Forages as an Index to Nutrient Content and Animal Response. Colorado State University Range Science Department Series No. 29.
- Stubbendieck, J., S.L. Hatch, K.J. Kjar. 1982. North American Range Plants. University of Nebraska Press, Lincoln, Nebraska.

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Appendix 3.1

RLRA Raw Data

J19/J21 RLRA Cover Data - 2025

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																													
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	P121	P122								
						1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd								
NATIVE ANNUAL & BIENNIAL FORBS																																			
Eriogonum cernuum	0.00	9.09	0.00	0.00	0.00			P		P																									
TOTAL NATIVE ANN. & BIEN. FORBS	0.00	9.09	0.00	0.00	0.00			P		P																									
INTRODUCED ANNUAL & BIENNIAL FORBS																																			
Halogeton glomeratus	0.00	4.55	0.00	0.00	0.00				P																										
Kochia scoparia	0.23	68.18	1.19	0.23	1.14		P	P	P			1	P		P	P	P	P		P			P	P	4	P	P								
Salsola iberica	0.41	54.55	2.15	0.41	2.06			P	1	P		P			P	P	P	5		P		1	2	P		P	P								
TOTAL INTRO. ANN. & BIEN. FORBS	0.64	77.27	3.34	0.64	3.20		P	P	1	P		1	P		P	P	P	5		P		1	2	P	4	P	P								
INTRODUCED ANNUAL GRASSES																																			
Bromus japonicus	0.00	4.55	0.00	0.00	0.00																		P												
Bromus tectorum	0.36	31.82	1.91	0.36	1.83			P	P			1								P			P	3	4		P								
TOTAL INTRODUCED ANNUAL GRASSES	0.36	36.36	1.91	0.36	1.83			P	P			1								P			P	3	4		P								
NATIVE PERENNIAL FORBS																																			
Eriogonum alatum	0.00	4.55	0.00	0.00	0.00			P																											
Gaillardia aristata	0.00	9.09	0.00	0.00	0.00			P	P																										
Lesquerella intermedia	0.00	4.55	0.00	0.00	0.00					P																									
Leucelene ericoides	0.00	9.09	0.00	0.00	0.00									P		P																			
Linum lewisii	0.00	4.55	0.00	0.00	0.00				P																										
Mirabilis multiflora	0.00	4.55	0.00	0.00	0.00					P																									
Penstemon palmeri	0.00	13.64	0.00	0.00	0.00			P		P								P																	
Ratibida columnaris	0.00	9.09	0.00	0.00	0.00				P						P																				
Sphaeralcea ambigua	0.00	9.09	0.00	0.00	0.00			P		P																									
Sphaeralcea coccinea	0.00	18.18	0.00	0.00	0.00			P					P				P			P															
Thelesperma megapotamicum	0.00	4.55	0.00	0.00	0.00			P																											
Thelesperma subnudum	0.00	4.55	0.00	0.00	0.00			P																											
TOTAL NATIVE PERENNIAL FORBS	0.00	45.45	0.00	0.00	0.00			P	P	P			P	P	P	P	P			P															
INTRODUCED PERENNIAL FORBS																																			
Onobrychis viciifolia	0.55	27.27	2.86	0.55	2.75		P	1	P	11					P								P												
Sanguisorba minor	0.00	22.73	0.00	0.00	0.00			P	P						P			P					P	P											
TOTAL INTRO. PERENNIAL FORBS	0.55	31.82	2.86	0.55	2.75		P	1	P	11					P			P					P												
NATIVE PERENNIAL GRASSES (cool)																																			
Agropyron dasystachyum	1.14	86.36	5.97	1.23	6.18		P	P	2	2	P	2	1	P	5	P	1	1	2		2	2		1	3	P	P	2	1						
Agropyron smithii	2.59	95.45	13.60	2.64	13.27	P		4	2	7	1	P	5	2	3	1	P	5	5	P			4	4	5	3	1	5							
Agropyron spicatum	0.91	68.18	4.77	1.05	5.26			2					1	1	1	P	3	2	6	1			1	1	P	P	2								
Agropyron trachycaulum	0.23	36.36	1.19	0.23	1.14				P	P					1	P		1		1	P				2										
Elymus canadensis	0.00	4.55	0.00	0.00	0.00											P																			
Oryzopsis hymenoides	0.09	54.55	0.48	0.09	0.46		P		1	P	P	P						1	P			P		P	P	P	P								
Sitanion hystrix	0.41	45.45	2.15	0.50	2.52				1		P		P	1	P	2	1	P		P			4	1				1							
Stipa comata	0.00	4.55	0.00	0.00	0.00					P																									
TOTAL NATIVE PERENNIAL GRASSES (c)	5.36	100.00	28.16	5.73	28.83	P	6	6	9	1	P	7	4	1	4	8	5	4	1	15	6	3	2	1	4	1	6	1	7	7	5	2	1	8	1
NATIVE PERENNIAL GRASSES (warm)																																			
Aristida purpurea	0.05	4.55	0.24	0.05	0.23													1																	
Bouteloua curtipendula	0.00	9.09	0.00	0.00	0.00											P	P																		
Bouteloua gracilis	0.82	81.82	4.30	0.95	4.81	P		1	P	P	P	1	3	2	P	P	P	1	2	P			1	1			2	P	P	3	3	1			
Buchloe dactyloides	0.05	27.27	0.24	0.05	0.23								P	P		P		1									P								
Hilaria jamesii	0.50	72.73	2.63	0.55	2.75	2	1	3	P	P		1	1	P	1	1	P	P	1							P	P	P		P	1				
Sporobolus airoides	0.36	54.55	1.91	0.36	1.83	P		P		P			3	1	1		P	P								P	P	1	P		2				
Sporobolus cryptandrus	0.14	36.36	0.72	0.14	0.69							1	1	P		P		P				P	P				1	1							
TOTAL NATIVE PERENNIAL GRASSES (w)	1.91	86.36	10.02	2.09	10.53	2	1	4	P	P	P	2	8	3	2	1	P	1	4	1			P	1	1			3	2	3	6	1			

Continued on the next page

J19/J21 RLRA - 2025 (Continued)

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																																											
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	P121	P122																						
						1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd																				
INTRODUCED PERENNIAL GRASSES (cool)																																																	
Agropyron desertorum	0.00	4.55	0.00	0.00	0.00																				P																								
Agropyron elongatum	0.32	22.73	1.67	0.32	1.60							1	1			2	1		2																														
Agropyron intermedium	0.27	36.36	1.43	0.27	1.37			1	1			P	P		P	P	1	P				3	1																										
Elymus junceus	2.77	86.36	14.56	3.00	15.10	8	1	2		P		7	2	2	4	P	1	1	1	9	6	2		1	2	1	4	3	4	5																			
TOTAL INTRO. PERENNIAL GRASSES (c)	3.36	90.91	17.66	3.59	18.08	8	1	2	1	1		7	3	3	4	P	3	2	1	9	8	2		4	2	2	4	3	4	5																			
NATIVE SUBSHRUBS																																																	
Artemisia frigida	0.18	18.18	0.95	0.18	0.92				2		1					P					1																												
Ceratoides lanata	0.00	40.91	0.00	0.00	0.00	P			P	P		P	P											P			P	P																					
Gutierrezia sarothrae	0.05	40.91	0.24	0.09	0.46	P	P				P	P	P			P	P				1	1																											
Senecio douglasii var. longilobus	0.00	4.55	0.00	0.00	0.00				P																																								
TOTAL NATIVE SUBSHRUBS	0.23	68.18	1.19	0.27	1.37	P	P	2	P	1	P	P	P	P		P	P				2	1				P		P	P																				
INTRODUCED SUBSHRUBS																																																	
Kochia prostrata	0.00	13.64	0.00	0.00	0.00	P								P						P																													
TOTAL INTRO. SUBSHRUBS	0.00	13.64	0.00	0.00	0.00	P								P						P																													
NATIVE SHRUBS																																																	
Artemisia tridentata	0.36	22.73	1.91	0.36	1.83		P	P		1				P																																			
Atriplex canescens	6.23	100.00	32.70	6.23	31.35	1	4	P	5	P	11	4	4	12	10	21	5	P	2	9	14	5	4	2	2	5	17																						
Atriplex confertifolia	0.00	4.55	0.00	0.00	0.00						P																																						
Chrysothamnus nauseosus	0.00	13.64	0.00	0.00	0.00					P					P																																		
Cowania mexicana	0.00	9.09	0.00	0.00	0.00			P		P																																							
Ephedra viridis	0.05	4.55	0.24	0.05	0.23			1																																									
Lycium pallidum	0.00	4.55	0.00	0.00	0.00			P																																									
Purshia tridentata	0.00	4.55	0.00	0.00	0.00			P																																									
Shepherdia rotundifolia	0.00	9.09	0.00	0.00	0.00			P		P																																							
Yucca baccata	0.00	4.55	0.00	0.00	0.00			P		P																																							
TOTAL NATIVE SHRUBS	6.64	100.00	34.84	6.64	33.41	1	4	1	5	1	11	4	4	12	10	21	5	P	2	9	21	5	4	2	2	5	17																						
NATIVE TREES																																																	
Pinus edulis	0.00	4.55	0.00	0.00	0.00			P																																									
TOTAL NATIVE TREES	0.00	4.55	0.00	0.00	0.00			P																																									
Standing dead	5.00	90.91		5.00		10	8		4		4	4	10	4	3	10	5	3	10	6	6	3	3	2	2	2	11																						
Litter	35.68	100.00		35.68		35	12	8	35	6	40	43	47	33	35	46	33	47	53	57	32	54	45	19	50	24	31																						
Bare ground	29.18	100.00		29.18		41	58	5	33	8	22	32	27	31	16	14	36	25	20	17	29	27	37	58	28	57	21																						
Rock	11.09	77.27		11.09		3	6	76	12	73	7		2	6	30	2		12	3	1	5		2		3	1																							
TOTALS	100.00		100.00	100.82	100.00	100	2	100	0	100	0	100	1	100	0	100	0	100	0	100	3	100	3	100	0	100	0	100	2																				
TOTAL VEGETATION COVER	19.05	s=(6.71)		19.86	s=(7.13)	11	2	16	0	11	0	16	1	13	0	27	0	21	1	14	0	26	0	16	0	28	2	26	0	13	0	14	0	19	3	28	3	16	3	15	0	19	0	20	0	14	1	36	2
GROUND COVER (Veg+Litter+St.Dead+Rock)	70.82	s=(14.68)		71.64	s=(14.83)	59	2	42	0	95	0	67	1	92	0	78	0	68	1	73	0	69	0	84	0	86	2	64	0	75	0	80	0	83	3	71	3	73	3	63	0	42	0	72	0	43	1	79	2
Allowable Vegetation Cover	19.05	s=(6.71)				11.0	16.0	11.0	16.0	13.0	27.0	21.0	14.0	26.0	16.0	28.0	26.0	13.0	14.0	19.0	28.0	16.0	15.0	19.0	20.0	14.0	36.0																						
SPECIES DENSITY (# of species/100 sq.m.)	14.50	s=(5.96)				9	13	33	20	21	9	17	18	13	19	18	18	13	5	12	9	7	12	15	13	12	13																						

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Appendix 3.2

Sagebrush Reference Area Raw Data

J7 Sagebrush Reference Area

N7/8 Sagebrush Reference Area

N14 Sagebrush Reference Area

J7 SBRA - 2025

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover															
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
						1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	
NATIVE ANNUAL & BIENNIAL FORBS																					
Chenopodium leptophyllum	0.20	86.67	1.12	0.20	1.12	P	P	P	P		1	P	P	P		P	1	P	1	P	
TOTAL NATIVE ANN. & BIEN. FORBS	0.20	86.67	1.12	0.20	1.12	P	P	P	P		1	P	P	P		P	1	P	1	P	
INTRODUCED ANNUAL & BIENNIAL FORBS																					
Chenopodium album	0.13	66.67	0.75	0.13	0.75	1	P	P			P	1				P	P	P	P	P	
TOTAL INTRO. ANN. & BIEN. FORBS	0.13	66.67	0.75	0.13	0.75	1	P	P			P	1				P	P	P	P	P	
NATIVE PERENNIAL FORBS																					
Leucelene ericoides	0.07	53.33	0.37	0.07	0.37			P	P	P		P	1	P			P			P	
Sphaeralcea coccinea	0.00	53.33	0.00	0.00	0.00	P		P	P		P	P		P	P				P		
TOTAL NATIVE PERENNIAL FORBS	0.07	80.00	0.37	0.07	0.37	P		P	P	P	P	P	1	P	P		P		P	P	
NATIVE PERENNIAL GRASSES (cool)																					
Oryzopsis hymenoides	0.00	26.67	0.00	0.00	0.00			P					P	P	P						
Sitanion hystrix	2.67	100.00	14.98	2.67	14.93	2	4	5	2	3	4	2	P	2	3	4	5	P	4	P	
Stipa comata	0.00	13.33	0.00	0.00	0.00								P	P							
TOTAL NATIVE PERENNIAL GRASSES (c)	2.67	100.00	14.98	2.67	14.93	2	4	5	2	3	4	2	P	2	3	4	5	P	4	P	
NATIVE PERENNIAL GRASSES (warm)																					
Bouteloua gracilis	4.80	100.00	26.97	4.87	27.24	4	4	6	9	6	8	1	P	P	1	2	11	7	3	6	5
Hilaria jamesii	3.27	86.67	18.35	3.27	18.28	3	4	1	P	5	3	12			1	1	1	5	3	10	
TOTAL NATIVE PERENNIAL GRASSES (w)	8.07	100.00	45.32	8.13	45.52	7	8	7	9	11	11	13	P	P	1	3	12	8	8	9	15
NATIVE SUBSHRUBS																					
Ceratoides lanata	0.40	33.33	2.25	0.40	2.24			P					4	2	P				P		
Chrysothamnus greenei	3.13	100.00	17.60	3.13	17.54	P	6	6	1	P	7	P	7	5	5	2	P	3	3	2	
Gutierrezia sarothrae	0.00	53.33	0.00	0.00	0.00		P	P		P			P	P	P	P	P				
TOTAL NATIVE SUBSHRUBS	3.53	100.00	19.85	3.53	19.78	P	6	6	1	P	7	P	11	7	5	2	P	3	3	2	
NATIVE SHRUBS																					
Artemisia tridentata	2.67	100.00	14.98	2.67	14.93	2	5	P	3	5	P	2	6	1	2	2	1	7	3	1	
Atriplex canescens	0.47	53.33	2.62	0.47	2.61		P	1	1				1	2		1	P		1		
TOTAL NATIVE SHRUBS	3.13	100.00	17.60	3.13	17.54	2	5	1	4	5	P	2	7	3	2	3	1	7	4	1	
SUCCULENTS																					
Coryphantha vivipara	0.00	6.67	0.00	0.00	0.00												P				
Opuntia phaeacantha	0.00	20.00	0.00	0.00	0.00	P												P		P	
Opuntia whipplei	0.00	6.67	0.00	0.00	0.00														P		
TOTAL SUCCULENTS	0.00	33.33	0.00	0.00	0.00	P											P	P	P	P	
LICHEN/FUNGUS																					
Lichen spp.	0.27	93.33	1.50	0.27	1.49	P	P	P	P	P	1	P	2	P	1		P	P	P	P	
TOTAL LICHEN	0.27	93.33	1.50	0.27	1.49	P	P	P	P	P	1	P	2	P	1		P	P	P	P	
Standing dead	11.80	100.00		11.80		15	14	7	14	9	8	25	8	10	9	10	11	16	13	8	
Litter	15.20	100.00		15.20		19	18	5	17	9	13	21	9	10	13	22	20	18	13	21	
Bare ground	54.33	100.00		54.33		54	45	69	53	62	55	36	55	67	64	47	54	48	53	53	
Rock	0.60	20.00		0.60						1			7	1							
TOTALS	100.00		100.00	100.07	100.00	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 1	100 0	100 0	100 0	100 0	100 0	100 0	
TOTAL VEGETATION COVER	17.80	s=(3.59)		17.87	s=(3.48)	12 0	23 0	19 0	16 0	19 0	23 0	18 0	19 0	12 1	13 0	21 0	15 0	18 0	21 0	18 0	
GROUND COVER (Veg+Litter+St.Dead+Rock)	45.67	s=(8.67)		45.73	s=(8.56)	46 0	55 0	31 0	47 0	38 0	45 0	64 0	45 0	33 1	36 0	53 0	46 0	52 0	47 0	47 0	
Allowable Vegetation Cover	17.80	s=(3.59)				12.0	23.0	19.0	16.0	19.0	23.0	18.0	19.0	12.0	13.0	21.0	15.0	18.0	21.0	18.0	
SPECIES DENSITY (# of species/100 sq.m.)	10.53	s=(1.68)				10	10	14	10	8	9	10	12	13	10	9	12	9	12	10	

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																													
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
						1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd
NATIVE PERENNIAL FORBS																																			
Heterotheca villosa var. foliosa	0.00	13.33	0.00	0.00	0.00																						P		P						
Leucelene ericoides	0.00	66.67	0.00	0.00	0.00	P		P		P		P		P		P		P		P		P				P	P		P						
Sphaeralcea coccinea	0.07	86.67	0.36	0.07	0.34	P		P		P		P		P		P		P		P				1		P	P		P		P				
Stanleya pinnata	0.07	33.33	0.36	0.07	0.34	P		1		P				P		P		P		P															
TOTAL NATIVE PERENNIAL FORBS	0.13	86.67	0.72	0.13	0.69	P		1		P		P		P		P		P		P		P		1		P		P		P					
NATIVE PERENNIAL GRASSES (cool)																																			
Oryzopsis hymenoides	0.67	100.00	3.60	0.80	4.14	P	1	1		1		1		P		P		P		1		1		2		1		1		1		P		P 1	
Sitanion hystrix	0.87	86.67	4.71	0.94	4.86	P	1	1		P		1		2		2				P		P		1		1				P		4		1	
Stipa comata	0.00	13.33	0.00	0.00	0.00																					P			P						
TOTAL NATIVE PERENNIAL GRASSES (c)	1.54	100.00	8.31	1.74	9.00	P	2	2		1		2.1		2		2		P		1		1		3		2		1		1		4		1 1	
NATIVE PERENNIAL GRASSES (warm)																																			
Bouteloua gracilis	1.27	93.33	6.83	1.40	7.24	P				P		P		2	1	2		P		1		P		2		3		2		P		4		3 1	
Hilaria jamesii	0.80	86.67	4.31	0.80	4.14	P				2		P		P		P		3		P		4		1				P		2		P			
TOTAL NATIVE PERENNIAL GRASSES (w)	2.07	93.33	11.15	2.20	11.38	P				2		P		2	1	2		3		1		4		3		3		2		2		4		3 1	
NATIVE SUBSHRUBS																																			
Ceratoides lanata	0.00	13.33	0.00	0.00	0.00	P																				P									
Chrysothamnus depressus	0.00	13.33	0.00	0.00	0.00			P					P																						
Chrysothamnus greenei	1.93	86.67	10.43	2.13	11.03			2	1	4	1	P	1	2		8		1				P		4		4		P		P		P		4	
Gutierrezia sarothrae	1.93	100.00	10.43	2.07	10.69	P	1	2		3	1	1		2		1		2		4		4		1		2		1		1		P		5	
TOTAL NATIVE SUBSHRUBS	3.87	100.00	20.86	4.20	21.72	P	1	4	1	7	2	1	1	4		9		3		4		4		5		6		1		1		P		9	
NATIVE SHRUBS																																			
Artemisia tridentata	4.67	93.33	25.17	4.80	24.82	5		11				5		9	1	2		6		2		2	1	3		1		3		8		5		8	
Atriplex canescens	3.13	93.33	16.90	3.13	16.20	3		2		1		7		2				P		P		4		13		1		8		P		3		3	
Ephedra viridis	0.00	13.33	0.00	0.00	0.00	P										P																			
Lycium pallidum	0.07	20.00	0.36	0.07	0.34					1														P				P							
TOTAL NATIVE SHRUBS	7.87	100.00	42.43	8.00	41.37	8		13		2		12		11	1	2		6		2		6	1	16		2		11		8		8		11	
NATIVE TREES																																			
Juniperus osteosperma	0.20	26.67	1.08	0.20	1.03			2				P						P								1									
Pinus edulis	2.73	93.33	14.74	2.73	14.13	5		P		6		4		3		4		2		2		4		1				2		4		3		1	
TOTAL NATIVE TREES	2.93	100.00	15.82	2.93	15.17	5		2		6		4		3		4		2		2		4		1		1		2		4		3		1	
SUCCULENTS																																			
Opuntia polyacantha	0.13	13.33	0.72	0.13	0.69							1		1																					
TOTAL SUCCULENTS	0.13	13.33	0.72	0.13	0.69							1		1																					
Standing dead	12.80	100.00		12.80		14		11		13		14		12		3		8		11		14		22		14		21		8		10		17	
Litter	31.00	100.00		31.00		38		26		31		34		38		38		18		38		29		27		23		27		28		46		24	
Bare ground	19.13	100.00		19.13		26		35		15		25		23		22		12		15		9		18		32		10		10		12		23	
Rock	18.53	100.00		18.53		9		6		23		7		4		18		48		26		29		5		16		25		38		13		11	
TOTALS	100.01		100.00	100.81	100.00	100	3	100	1	100	2	100	1	100	2	100	0	100	0	100	0	100	1	100	0	100	0	100	0	100	0	100	0	100 2	
TOTAL VEGETATION COVER	18.54	s=(4.72)		19.34	s=(4.97)	13	3	22	1	18	2	20	1	23	2	19	0	14	0	10	0	19	1	28	0	15	0	17	0	16	0	19	0	25 2	
GROUND COVER (Veg+Litter+St.Dead+Rock)	80.87	s=(8.21)		81.67	s=(7.92)	74	3	65	1	85	2	75	1	77	2	78	0	88	0	85	0	91	1	82	0	68	0	90	0	90	0	88	0	77 2	
Allowable Vegetation Cover	18.54	s=(4.72)				13.0		22.0		18.0		20.1		23.0		19.0		14.0		10.0		19.0		28.0		15.0		17.0		16.0		19.0		25.0	
SPECIES DENSITY (# of species/100 sq.m.)	11.47	s=(1.3)				13		12		12		13		13		9		12		10		11		12		11		12		12		11		9	

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover														
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
						1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd
NATIVE ANNUAL & BIENNIAL FORBS																				
Machaeranthera canescens	0.00	6.67	0.00	0.00	0.00			P												
TOTAL NATIVE ANN. & BIEN. FORBS	0.00	6.67	0.00	0.00	0.00			P												
NATIVE PERENNIAL FORBS																				
Leucelene ericoides	0.00	20.00	0.00	0.00	0.00	P								P				P		
Sphaeralcea coccinea	0.00	20.00	0.00	0.00	0.00	P								P						P
TOTAL NATIVE PERENNIAL FORBS	0.00	26.67	0.00	0.00	0.00	P								P				P		P
NATIVE PERENNIAL GRASSES (cool)																				
Oryzopsis hymenoides	0.07	6.67	0.29	0.07	0.27									1						
Sitanion hystrix	0.73	100.00	3.17	0.87	3.54	1	P	1	2	1	P	1	1 1	P	P	2	2 1	P	P	P
Stipa comata	0.00	6.67	0.00	0.00	0.00															P
TOTAL NATIVE PERENNIAL GRASSES (c)	0.80	100.00	3.46	0.93	3.81	1	P	1	2	1	P	1	1 1	1	P	2	2 1	P	P	P
NATIVE PERENNIAL GRASSES (warm)																				
Bouteloua gracilis	6.80	100.00	29.39	7.73	31.61	7	2 3	4 1	4 2	6	9 1	7	11 2	10 2	3 1	10	9 2	7	5	8
Hilaria jamesii	0.00	13.33	0.00	0.00	0.00	P														P
TOTAL NATIVE PERENNIAL GRASSES (w)	6.80	100.00	29.39	7.73	31.61	7	2 3	4 1	4 2	6	9 1	7	11 2	10 2	3 1	10	9 2	7	5	8
NATIVE SUBSHRUBS																				
Chrysothamnus Greenei	0.00	66.67	0.00	0.00	0.00				P	P	P	P	P	P		P	P	P		P
Gutierrezia sarothrae	0.40	93.33	1.73	0.40	1.63	3	P	P	P	P	P	P	P	1	P	P	P	1	1	P
TOTAL NATIVE SUBSHRUBS	0.40	100.00	1.73	0.40	1.63	3	P	P	P	P	P	P	P	1	P	P	P	1	1	P
NATIVE SHRUBS																				
Artemisia tridentata	13.27	100.00	57.35	13.53	55.31	9	15	17	10 1	15	15	9	7	18	17 2	7	14	10	25	11 1
Atriplex canescens	0.00	6.67	0.00	0.00	0.00						P									
Chrysothamnus nauseosus	0.00	6.67	0.00	0.00	0.00														P	
TOTAL NATIVE SHRUBS	13.27	100.00	57.35	13.53	55.31	9	15	17	10 1	15	15	9	7	18	17 2	7	14	10	25	11 1
NATIVE TREES																				
Juniperus osteosperma	0.00	6.67	0.00	0.00	0.00								P							
Pinus edulis	1.87	80.00	8.07	1.87	7.63	1	2	P	5	1	P		4	1	6	3			1	4
TOTAL NATIVE TREES	1.87	80.00	8.07	1.87	7.63	1	2	P	5	1	P		4	1	6	3			1	4
SUCCULENTS																				
Opuntia macrorhiza	0.00	13.33	0.00	0.00	0.00							P						P		
Opuntia phaeacantha	0.00	6.67	0.00	0.00	0.00											P				
Opuntia whipplei	0.00	6.67	0.00	0.00	0.00					P										
TOTAL SUCCULENTS	0.00	26.67	0.00	0.00	0.00					P		P				P		P		
LICHEN/FUNGUS																				
Lichen spp.	0.40	93.33	1.73	0.47	1.91	1	2 1		P	P	P	1	P	1	P	P	P	P	P	1
TOTAL LICHEN	0.40	93.33	1.73	0.47	1.91	1	2 1		P	P	P	1	P	1	P	P	P	P	P	1
Standing dead	16.40	100.00		16.40		13	20	21	10	16	18	18	22	21	10	11	17	17	20	12
Litter	23.47	100.00		23.47		28	19	27	28	20	26	18	25	21	19	20	25	22	30	24
Bare ground	36.47	100.00		36.47		37	40	30	41	41	32	46	30	26	45	47	32	43	18	39
Rock	0.13	13.33		0.13													1			1
TOTALS	100.00		100.00	101.40	100.00	100 0	100 4	100 1	100 3	100 0	100 1	100 0	100 3	100 2	100 3	100 0	100 3	100 0	100 0	100 1
TOTAL VEGETATION COVER	23.13	s=(4.19)		24.47	s=(4.56)	21 0	19 3	22 1	21 3	23 0	24 1	17 0	23 3	31 2	26 3	22 0	25 3	18 0	32 0	23 1
GROUND COVER (Veg+Litter+St.Dead+Rock)	63.53	s=(8.25)		64.93	s=(8.45)	63 0	60 4	70 1	59 3	59 0	68 1	54 0	70 3	74 2	55 3	53 0	68 3	57 0	82 0	61 1
Allowable Vegetation Cover	23.13	s=(4.19)				21.0	19.0	22.0	21.0	23.0	24.0	17.0	23.0	31.0	26.0	22.0	25.0	18.0	32.0	23.0
SPECIES DENSITY (# of species/100 sq.m.)	7.53	s=(1.41)				9	6	6	7	8	8	6	8	10	6	8	6	8	7	10

AZM

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226

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176

304

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PLANT SPECIES	AVERAGE COVER	FREQUENCY	RELATIVE VEGETATION COVER	AVERAGE COVER-ALL	RELATIVE VEGETATION COVER-ALL																		
						Percent Foliar Cover																	
						1	2	3	4	5	6	7	8	9	10	11	12	13	14				
	(%)	(%)	(%)	(%)	(%)	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd		
INTRODUCED PERENNIAL GRASSES (cool)																							
Agropyron desertorum	0.00	4.55	0.00	0.00	0.00																		
Agropyron elongatum	0.32	22.73	1.67	0.32	1.60																		
Agropyron intermedium	0.27	36.36	1.43	0.27	1.37																		
Elymus junceus	2.77	86.36	14.56	3.00	15.10	8	1	2															
TOTAL INTRO. PERENNIAL GRASSES (c)	3.36	90.91	17.66	3.59	18.08	8	1	2	1	1		7	3	3	4	P	3	2	1		9		
NATIVE SUBSHRUBS																							
Artemisia frigida	0.18	18.18	0.95	0.18	0.92																		
Ceratoides lanata	0.00	40.91	0.00	0.00	0.00	P																	
Gutierrezia sarothrae	0.05	40.91	0.24	0.09	0.46	P		P															
Senecio douglasii var. longilobus	0.00	4.55	0.00	0.00	0.00																		
TOTAL NATIVE SUBSHRUBS	0.23	68.18	1.19	0.27	1.37	P	P	2	P	1	P	P	P	P		P	P						
INTRODUCED SUBSHRUBS																							
Kochia prostrata	0.00	13.64	0.00	0.00	0.00	P																	
TOTAL INTRO. SUBSHRUBS	0.00	13.64	0.00	0.00	0.00	P																	
NATIVE SHRUBS																							
Artemisia tridentata	0.36	22.73	1.91	0.36	1.83		P	P		1				P									
Atriplex canescens	6.23	100.00	32.70	6.23	31.35	1	4	P	5	P	11	4	4	12	10	21	5	P		2			
Atriplex confertifolia	0.00	4.55	0.00	0.00	0.00																		
Chrysothamnus nauseosus	0.00	13.64	0.00	0.00	0.00			P		P					P								
Cowania mexicana	0.00	9.09	0.00	0.00	0.00			P		P													
Ephedra viridis	0.05	4.55	0.24	0.05	0.23			1															
Lycium pallidum	0.00	4.55	0.00	0.00	0.00			P															
Purshia tridentata	0.00	4.55	0.00	0.00	0.00			P															
Shepherdia rotundifolia	0.00	9.09	0.00	0.00	0.00			P		P													
Yucca baccata	0.00	4.55	0.00	0.00	0.00			P		P													
TOTAL NATIVE SHRUBS	6.64	100.00	34.84	6.64	33.41	1	4	1	5	1	11	4	4	12	10	21	5	P		2			
NATIVE TREES																							
Pinus edulis	0.00	4.55	0.00	0.00	0.00				P														
TOTAL NATIVE TREES	0.00	4.55	0.00	0.00	0.00				P														
Standing dead	5.00	90.91		5.00		10	8		4		4	4	10	4	3	10	5	3		10			
Litter	35.68	100.00		35.68		35	12	8	35	6	40	43	47	33	35	46	33	47		53			
Bare ground	29.18	100.00		29.18		41	58	5	33	8	22	32	27	31	16	14	36	25		20			
Rock	11.09	77.27		11.09		3	6	76	12	73	7		2	6	30	2		12		3			
TOTALS	100.00		100.00	100.82	100.00	100	2	100	0	100	0	100	1	100	0	100	2	100	0	100			
TOTAL VEGETATION COVER	19.05	s=(6.71)		19.86	s=(7.13)	11	2	16	0	11	0	16	1	13	0	27	0	21	1	14	0		
GROUND COVER (Veg+Litter+St.Dead+Rock)	70.82	s=(14.68)		71.64	s=(14.83)	59	2	42	0	95	0	67	1	92	0	78	0	68	1	73	0		
Allowable Vegetation Cover	19.05	s=(6.71)				11.0	16.0	11.0	16.0	13.0	27.0	21.0	14.0	26.0	16.0	28.0	26.0	13.0		14.			
SPECIES DENSITY (# of species/100 sq.m.)	14.50	s=(5.96)				9	13	33	20	21	9	17	18	13	19	18	18	13		5			

7

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RB

RB

RB

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4	15	16	17	18	19	20	P121	P122	
2 ^{no}	1 st 2 ^{no}	1 st 2 ^{no}	1 st 2 ^{no}	1 st 2 ^{no}	1 st 2 ^{no}	1 st 2 ^{no}	1 st 2 ^{no}	1 st 2 ^{no}	
	2					P			
	6 2		3 1 2	1 1	4	3	4	5	
	8 2		4 2	2	4	3	4	5	
		1							
		1 1			P		P	P	
		2 1			P		P	P	
	P								
	P								
	9	7 14	5	4	2	2	5	17	
	9	21	5	4	2	2	5	17	
	6 57 17 1	6 32 29 5	3 54 27	3 45 37	2 19 58 2	2 50 28	2 24 57 3	11 31 21 1	
0	100 3	100 3	100 3	100 0	100 0	100 0	100 1	100 2	
0	19 3	28 3	16 3	15 0	19 0	20 0	14 1	36 2	
0	83 3	71 3	73 3	63 0	42 0	72 0	43 1	79 2	
.0	19.0	28.0	16.0	15.0	19.0	20.0	14.0	36.0	
	12	9	7	12	15	13	12	13	

AZM

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																	
						1	2	3	4	5	6	7	8	9	10	11	12	13	14				
						1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd		
NATIVE ANNUAL & BIENNIAL FORBS																							
Chenopodium leptophyllum	0.20	86.67	1.12	0.20	1.12	P	P	P	P		1	P	P	P		P	1	P	1				
TOTAL NATIVE ANN. & BIEN. FORBS	0.20	86.67	1.12	0.20	1.12	P	P	P	P		1	P	P	P		P	1	P	1				
INTRODUCED ANNUAL & BIENNIAL FORBS																							
Chenopodium album	0.13	66.67	0.75	0.13	0.75	1	P	P			P	1				P	P	P	P				
TOTAL INTRO. ANN. & BIEN. FORBS	0.13	66.67	0.75	0.13	0.75	1	P	P			P	1				P	P	P	P				
NATIVE PERENNIAL FORBS																							
Leucelene ericoides	0.07	53.33	0.37	0.07	0.37			P	P	P		P	1	P				P					
Sphaeralcea coccinea	0.00	53.33	0.00	0.00	0.00	P		P	P		P	P		P	P							P	
TOTAL NATIVE PERENNIAL FORBS	0.07	80.00	0.37	0.07	0.37	P		P	P	P	P	P	1	P	P			P				P	
NATIVE PERENNIAL GRASSES (cool)																							
Oryzopsis hymenoides	0.00	26.67	0.00	0.00	0.00			P					P	P	P								
Sitanion hystrix	2.67	100.00	14.98	2.67	14.93	2	4	5	2	3	4	2	P	P	2	3	4	5	P			4	
Stipa comata	0.00	13.33	0.00	0.00	0.00								P	P									
TOTAL NATIVE PERENNIAL GRASSES (c)	2.67	100.00	14.98	2.67	14.93	2	4	5	2	3	4	2	P	2	3	4	5	P				4	
NATIVE PERENNIAL GRASSES (warm)																							
Bouteloua gracilis	4.80	100.00	26.97	4.87	27.24	4	4	6	9	6	8	1	P	P	1	2	11	7	3			6	
Hilaria jamesii	3.27	86.67	18.35	3.27	18.28	3	4	1	P	5	3	12			1	1	1	1	5			3	
TOTAL NATIVE PERENNIAL GRASSES (w)	8.07	100.00	45.32	8.13	45.52	7	8	7	9	11	11	13	P	P	1	3	12	8	8			9	
NATIVE SUBSHRUBS																							
Ceratoides lanata	0.40	33.33	2.25	0.40	2.24			P					4	2	P							P	
Chrysothamnus greenei	3.13	100.00	17.60	3.13	17.54	P	6	6	1	P	7	P	7	5	5	2	P	3				3	
Gutierrezia sarothrae	0.00	53.33	0.00	0.00	0.00		P	P		P			P	P	P	P	P	P					
TOTAL NATIVE SUBSHRUBS	3.53	100.00	19.85	3.53	19.78	P	6	6	1	P	7	P	11	7	5	2	P	3				3	
NATIVE SHRUBS																							
Artemisia tridentata	2.67	100.00	14.98	2.67	14.93	2	5	P	3	5	P	2	6	1	2	2	1	7	3			1	
Atriplex canescens	0.47	53.33	2.62	0.47	2.61		P	1	1				1	2		1	P					1	
TOTAL NATIVE SHRUBS	3.13	100.00	17.60	3.13	17.54	2	5	1	4	5	P	2	7	3	2	3	1	7	4			4	
SUCCULENTS																							
Coryphantha vivipara	0.00	6.67	0.00	0.00	0.00													P					
Opuntia phaeacantha	0.00	20.00	0.00	0.00	0.00	P													P				
Opuntia whipplei	0.00	6.67	0.00	0.00	0.00																	P	
TOTAL SUCCULENTS	0.00	33.33	0.00	0.00	0.00	P																P	
LICHEN/FUNGUS																							
Lichen spp.	0.27	93.33	1.50	0.27	1.49	P	P	P	P	P	1	P	2	P	1			P	P			P	
TOTAL LICHEN	0.27	93.33	1.50	0.27	1.49	P	P	P	P	P	1	P	2	P	1			P	P			P	
Standing dead	11.80	100.00		11.80		15	14	7	14	9	8	25	8	10	9	10	11	16	13				
Litter	15.20	100.00		15.20		19	18	5	17	9	13	21	9	10	13	22	20	18	13				
Bare ground	54.33	100.00		54.33		54	45	69	53	62	55	36	55	67	64	47	54	48	53				
Rock	0.60	20.00		0.60						1			7	1									
TOTALS	100.00		100.00	100.07	100.00	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 1	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100	
TOTAL VEGETATION COVER	17.80	s=(3.59)		17.87	s=(3.48)	12 0	23 0	19 0	16 0	19 0	23 0	18 0	19 0	12 1	13 0	21 0	15 0	18 0	21				
GROUND COVER (Veg+Litter+St.Dead+Rock)	45.67	s=(8.67)		45.73	s=(8.56)	46 0	55 0	31 0	47 0	38 0	45 0	64 0	45 0	33 1	36 0	53 0	46 0	52 0	47				
Allowable Vegetation Cover	17.80	s=(3.59)				12.0	23.0	19.0	16.0	19.0	23.0	18.0	19.0	12.0	13.0	21.0	15.0	18.0	21.				
SPECIES DENSITY (# of species/100 sq.m.)	10.53	s=(1.68)				10	10	14	10	8	9	10	12	13	10	9	12	9	12			12	

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4	15	
2 ¹⁰⁰	1 st	2 ¹⁰⁰
	P	
	P	
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	P	
	P	
	P	
	P	
	5	
	10	
	15	
	2	
	2	
	1	
	1	
	P	
	P	
	P	
	P	
	8	
	21	
	53	
0	100	0
0	18	0
0	47	0
.0	18.0	
2	10	

AZM

280

123

104

329

323

248

137

238

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185

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160

270

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INITIALS

RB

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																	
						1	2	3	4	5	6	7	8	9	10	11	12	13	14				
						1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd		
NATIVE PERENNIAL FORBS																							
Heterotheca villosa var. foliosa	0.00	13.33	0.00	0.00	0.00													P	P				
Leucelene ericoides	0.00	66.67	0.00	0.00	0.00	P	P	P	P	P		P	P		P		P	P			P		
Sphaeralcea coccinea	0.07	86.67	0.36	0.07	0.34	P	P	P	P	P		P	P	P	P	1	P	P	P			P	
Stanleya pinnata	0.07	33.33	0.36	0.07	0.34	P	1	P				P		P									
TOTAL NATIVE PERENNIAL FORBS	0.13	86.67	0.72	0.13	0.69	P	1	P	P	P		P	P	P	P	1	P	P	P			P	
NATIVE PERENNIAL GRASSES (cool)																							
Oryzopsis hymenoides	0.67	100.00	3.60	0.80	4.14	P	1	1	1	P	P	P	1	1	2	1	1	1				P	
Sitanion hystrix	0.87	86.67	4.71	0.94	4.86	P	1	1	P	1	2	2		P	P	1	1		P			P	
Stipa comata	0.00	13.33	0.00	0.00	0.00											P						P	
TOTAL NATIVE PERENNIAL GRASSES (c)	1.54	100.00	8.31	1.74	9.00	P	2	2	1	2.1	2	2	P	1	1	3	2	1	1			4	
NATIVE PERENNIAL GRASSES (warm)																							
Bouteloua gracilis	1.27	93.33	6.83	1.40	7.24	P			P	P	2	1	2	P	1	P	2	3	2			P	
Hilaria jamesii	0.80	86.67	4.31	0.80	4.14	P			2	P	P	P	3	P	4	1		P	2			P	
TOTAL NATIVE PERENNIAL GRASSES (w)	2.07	93.33	11.15	2.20	11.38	P			2	P	2	1	2	3	1	4	3	3	2			4	
NATIVE SUBSHRUBS																							
Ceratoides lanata	0.00	13.33	0.00	0.00	0.00	P											P						
Chrysothamnus depressus	0.00	13.33	0.00	0.00	0.00		P				P												
Chrysothamnus greenei	1.93	86.67	10.43	2.13	11.03		2	1	4	1	P	1	2	8	1		P	4	4	P	P	P	
Gutierrezia sarothrae	1.93	100.00	10.43	2.07	10.69	P	1	2	3	1	1	2	1	2	4	4	1	2	1	1		P	
TOTAL NATIVE SUBSHRUBS	3.87	100.00	20.86	4.20	21.72	P	1	4	1	7	2	1	1	4	9	3	4	4	5	6	1	1	P
NATIVE SHRUBS																							
Artemisia tridentata	4.67	93.33	25.17	4.80	24.82	5	11			5	9	1	2	6	2	2	1	3	1	3		8	
Atriplex canescens	3.13	93.33	16.90	3.13	16.20	3	2	1		7	2		P	P	P	4	13	1	8	P		3	
Ephedra viridis	0.00	13.33	0.00	0.00	0.00	P						P											
Lycium pallidum	0.07	20.00	0.36	0.07	0.34			1								P		P					
TOTAL NATIVE SHRUBS	7.87	100.00	42.43	8.00	41.37	8	13	2	12	11	1	2	6	2	6	1	16	2	11			8	
NATIVE TREES																							
Juniperus osteosperma	0.20	26.67	1.08	0.20	1.03		2		P				P					1					
Pinus edulis	2.73	93.33	14.74	2.73	14.13	5	P	6	4	3	4		2	2	4	1			2			4	
TOTAL NATIVE TREES	2.93	100.00	15.82	2.93	15.17	5	2	6	4	3	4		2	2	4	1		1	2			3	
SUCCULENTS																							
Opuntia polyacantha	0.13	13.33	0.72	0.13	0.69				1	1													
TOTAL SUCCULENTS	0.13	13.33	0.72	0.13	0.69				1	1													
Standing dead	12.80	100.00		12.80		14	11	13	14	12	3	8	11	14	22	14	21	8				10	
Litter	31.00	100.00		31.00		38	26	31	34	38	38	18	38	29	27	23	27	28				46	
Bare ground	19.13	100.00		19.13		26	35	15	25	23	22	12	15	9	18	32	10	10				12	
Rock	18.53	100.00		18.53		9	6	23	7	4	18	48	26	29	5	16	25	38				13	
TOTALS	100.01		100.00	100.81	100.00	100	3	100	1	100	2	100	0	100	0	100	0	100	0	100	0	100	
TOTAL VEGETATION COVER	18.54	s=(4.72)		19.34	s=(4.97)	13	3	22	1	18	2	20	1	23	2	19	0	14	0	10	0	19	
GROUND COVER (Veg+Litter+St.Dead+Rock)	80.87	s=(8.21)		81.67	s=(7.92)	74	3	65	1	85	2	75	1	77	2	78	0	88	0	85	0	91	
Allowable Vegetation Cover	18.54	s=(4.72)				13.0	22.0	18.0	20.1	23.0	19.0	14.0	10.0	19.0	28.0	15.0	17.0	16.0	19				
SPECIES DENSITY (# of species/100 sq.m.)	11.47	s=(1.3)				13	12	12	13	13	9	12	10	11	12	11	12	12				11	

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4	15	
2 ^{no}	1 st	2 ^{no}
	P	1
	1	
	1	1
	3	1
	P	
	3	1
	4	
	5	
	9	
	8	
	3	
	11	
	1	
	1	
	17	
	24	
	23	
	11	
0	100	2
0	25	2
0	77	2
.0	25.0	
1	9	

AZM

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INITIALS

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover															
						1	2	3	4	5	6	7	8	9	10	11	12	13	14		
						1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	1 st 2 nd	
NATIVE ANNUAL & BIENNIAL FORBS																					
Machaeranthera canescens	0.00	6.67	0.00	0.00	0.00			P													
TOTAL NATIVE ANN. & BIEN. FORBS	0.00	6.67	0.00	0.00	0.00			P													
NATIVE PERENNIAL FORBS																					
Leucelene ericoides	0.00	20.00	0.00	0.00	0.00	P							P					P			
Sphaeralcea coccinea	0.00	20.00	0.00	0.00	0.00	P							P								
TOTAL NATIVE PERENNIAL FORBS	0.00	26.67	0.00	0.00	0.00	P							P					P			
NATIVE PERENNIAL GRASSES (cool)																					
Oryzopsis hymenoides	0.07	6.67	0.29	0.07	0.27								1								
Sitanion hystrix	0.73	100.00	3.17	0.87	3.54	1	P	1	2	1	P	1	1 1	P	P	2	2 1	P		P	
Stipa comata	0.00	6.67	0.00	0.00	0.00																
TOTAL NATIVE PERENNIAL GRASSES (c)	0.80	100.00	3.46	0.93	3.81	1	P	1	2	1	P	1	1 1	1	P	2	2 1	P		P	
NATIVE PERENNIAL GRASSES (warm)																					
Bouteloua gracilis	6.80	100.00	29.39	7.73	31.61	7	2 3	4 1	4 2	6	9 1	7	11 2	10 2	3 1	10	9 2	7		5	
Hilaria jamesii	0.00	13.33	0.00	0.00	0.00	P															
TOTAL NATIVE PERENNIAL GRASSES (w)	6.80	100.00	29.39	7.73	31.61	7	2 3	4 1	4 2	6	9 1	7	11 2	10 2	3 1	10	9 2	7		5	
NATIVE SUBSHRUBS																					
Chrysothamnus Greenei	0.00	66.67	0.00	0.00	0.00				P	P	P	P	P	P		P	P	P	P		
Gutierrezia sarothrae	0.40	93.33	1.73	0.40	1.63	3	P	P	P	P	P	P	P	1	P	P	P	P	1	1	
TOTAL NATIVE SUBSHRUBS	0.40	100.00	1.73	0.40	1.63	3	P	P	P	P	P	P	P	1	P	P	P	P	1	1	
NATIVE SHRUBS																					
Artemisia tridentata	13.27	100.00	57.35	13.53	55.31	9	15	17	10 1	15	15	9	7	18	17 2	7	14	10		25	
Atriplex canescens	0.00	6.67	0.00	0.00	0.00						P										
Chrysothamnus nauseosus	0.00	6.67	0.00	0.00	0.00															P	
TOTAL NATIVE SHRUBS	13.27	100.00	57.35	13.53	55.31	9	15	17	10 1	15	15	9	7	18	17 2	7	14	10		25	
NATIVE TREES																					
Juniperus osteosperma	0.00	6.67	0.00	0.00	0.00								P								
Pinus edulis	1.87	80.00	8.07	1.87	7.63	1	2	P	5	1	P		4	1	6	3				1	
TOTAL NATIVE TREES	1.87	80.00	8.07	1.87	7.63	1	2	P	5	1	P		4	1	6	3				1	
SUCCULENTS																					
Opuntia macrorhiza	0.00	13.33	0.00	0.00	0.00							P							P		
Opuntia phaeacantha	0.00	6.67	0.00	0.00	0.00											P					
Opuntia whipplei	0.00	6.67	0.00	0.00	0.00					P											
TOTAL SUCCULENTS	0.00	26.67	0.00	0.00	0.00					P		P				P			P		
LICHEN/FUNGUS																					
Lichen spp.	0.40	93.33	1.73	0.47	1.91	1	2 1		P	P	P	1	P	1	P	P	P	P	P	P	
TOTAL LICHEN	0.40	93.33	1.73	0.47	1.91	1	2 1		P	P	P	1	P	1	P	P	P	P	P	P	
Standing dead	16.40	100.00		16.40		13	20	21	10	16	18	18	22	21	10	11	17	17		20	
Litter	23.47	100.00		23.47		28	19	27	28	20	26	18	25	21	19	20	25	22		30	
Bare ground	36.47	100.00		36.47		37	40	30	41	41	32	46	30	26	45	47	32	43		18	
Rock	0.13	13.33		0.13													1				
TOTALS	100.00		100.00	101.40	100.00	100 0	100 4	100 1	100 3	100 0	100 1	100 0	100 3	100 2	100 3	100 0	100 3	100 0	100 3	100	
TOTAL VEGETATION COVER	23.13	s=(4.19)		24.47	s=(4.56)	21 0	19 3	22 1	21 3	23 0	24 1	17 0	23 3	31 2	26 3	22 0	25 3	18 0		32	
GROUND COVER (Veg+Litter+St.Dead+Rock)	63.53	s=(8.25)		64.93	s=(8.45)	63 0	60 4	70 1	59 3	59 0	68 1	54 0	70 3	74 2	55 3	53 0	68 3	57 0		82	
Allowable Vegetation Cover	23.13	s=(4.19)				21.0	19.0	22.0	21.0	23.0	24.0	17.0	23.0	31.0	26.0	22.0	25.0	18.0		32	
SPECIES DENSITY (# of species/100 sq.m.)	7.53	s=(1.41)				9	6	6	7	8	8	6	8	10	6	8	6	8		7	

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3 AT
125 091125

4	15	
2 ^{no}	1 st	2 ^{no}
	P	
	P	
	P	
	P	
	P	
	8	
	P	
	8	
	P	
	P	
	P	
	11	1
	11	1
	4	
	4	
	1	
	1	
	12	
	24	
	39	
	1	
0	100	1
0	23	1
0	61	1
.0	23.0	
	10	

Step 1: Raw Data

Enter raw data below. (If the reclamation data includes more than 40 samples and/or reference data includes more than 20 samples in each area, you will need to manually adjust future steps)

Transect ID	Reclamation Data	J7 Reference Data		N7/8 Reference Data		N14 Reference Data	
		Raw	90%	Raw	90%	Raw	90%
1	11.0	12	10.8	13	11.7	21	18.9
2	16.0	23	20.7	22	19.8	19	17.1
3	11.0	19	17.1	18	16.2	22	19.8
4	16.0	16	14.4	20.1	18.09	21	18.9
5	13.0	19	17.1	23	20.7	23	20.7
6	27.0	23	20.7	19	17.1	24	21.6
7	21.0	18	16.2	14	12.6	17	15.3
8	14.0	19	17.1	10	9	23	20.7
9	26.0	12	10.8	19	17.1	31	27.9
10	16.0	13	11.7	28	25.2	26	23.4
11	28.0	21	18.9	15	13.5	22	19.8
12	26.0	15	13.5	17	15.3	25	22.5
13	13.0	18	16.2	16	14.4	18	16.2
14	14.0	21	18.9	19	17.1	32	28.8
15	19.0	18	16.2	25	22.5	23	20.7
16	28.0						
17	16.0						
18	15.0						
19	19.0						
20	20.0						
21	14.0						
22	36.0						
23							
24							
25							
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37							
38							
39							

Transect ID	Data to be Used in T-Test
Rec1	11.0
Rec2	16.0
Rec3	11.0
Rec4	16.0
Rec5	13.0
Rec6	27.0
Rec7	21.0
Rec8	14.0
Rec9	26.0
Rec10	16.0
Rec11	28.0
Rec12	26.0
Rec13	13.0
Rec14	14.0
Rec15	19.0
Rec16	28.0
Rec17	16.0
Rec18	15.0
Rec19	19.0
Rec20	20.0
Rec21	14.0
Rec22	36.0
Rec23	
Rec24	
Rec25	
Rec26	
Rec27	
Rec28	
Rec29	
Rec30	
Rec31	
Rec32	
Rec33	
Rec34	
Rec35	
Rec36	
Rec37	
Rec38	
Rec39	
Rec40	

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Mean	19.0	17.8	16.0	18.5	16.7	23.1	20.8
N	22	15	15	15	15	15	15
Variance	45.00	12.89	10.44	22.29	18.05	17.55	14.22
St Dev	6.71	3.59	3.23	4.72	4.25	4.19	3.77
SE	1.43	0.93	0.83	1.22	1.10	1.08	0.97

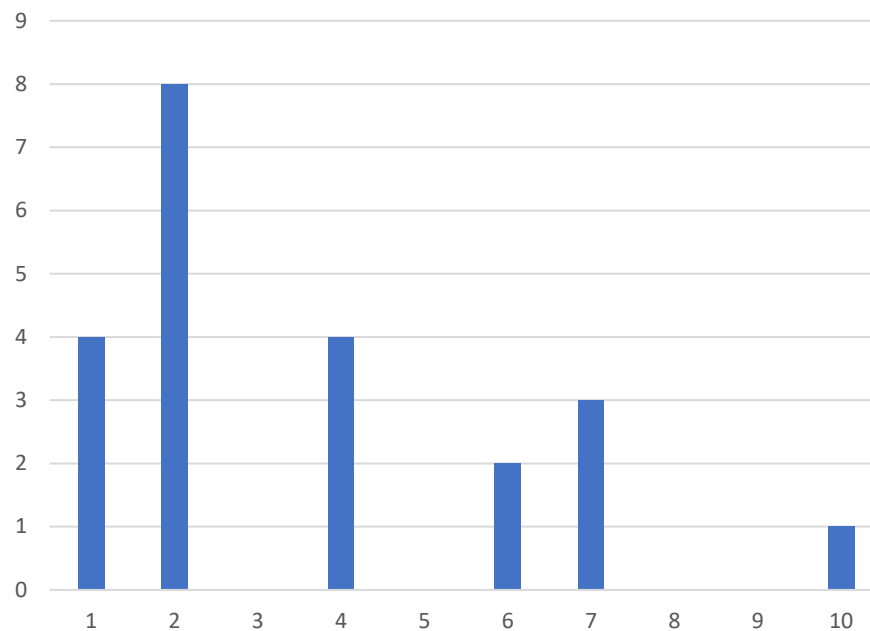
	Raw	90%
Pooled Variance	17.58	14.24
Pooled Stdev	4.19	3.77
Pooled Mean	19.82	17.84
Pooled N	45	45

Step 2a: Distribution Normality - Reclamation

Proceed to Step 2b: Distribution Normality - Reference

Group	Max	###	Group	Range Top	Count	Does the distribution look like a bell curve?
1	Min	###	1	13.5	4	
2	Range	###	2	16.0	8	Select the correct value in the cell below.
1	Split Qty	2.5	3	18.5	0	
2	Groups	10	4	21.0	4	
1			5	23.5	0	
7			6	26.0	2	
4			7	28.5	3	Yes
2			8	31.0	0	
6			9	33.5	0	
2			10	36.0	1	

Distribution Histogram



If the distribution looks generally like a bell curve, then this assumption is met. Select the correct value in the cell below.

Transect ID

J7-1

J7-2

J7-3

J7-4

J7-5

J7-6

J7-7

J7-8

J7-9

J7-10

J7-11

J7-12

J7-13

J7-14

J7-15

J7-16

J7-17

J7-18

J7-19

J7-20

J7-21

J7-22

J7-23

J7-24

J7-25

J7-26

J7-27

J7-28

J7-29

J7-30

N7/8-1

N7/8-2

N7/8-3

N7/8-4

N7/8-5

N7/8-6

N7/8-7

N7/8-8

N7/8-9

N7/8-10

N7/8-11

N7/8-12
N7/8-13
N7/8-14
N7/8-15
N7/8-16
N7/8-17
N7/8-18
N7/8-19
N7/8-20
N7/8-21
N7/8-22
N7/8-23
N7/8-24
N7/8-25
N7/8-26
N7/8-27
N7/8-28
N7/8-29
N7/8-30
N14-1
N14-2
N14-3
N14-4
N14-5
N14-6
N14-7
N14-8
N14-9
N14-10
N14-11
N14-12
N14-13
N14-14
N14-15
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N14-18
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N14-25
N14-26
N14-27
N14-28

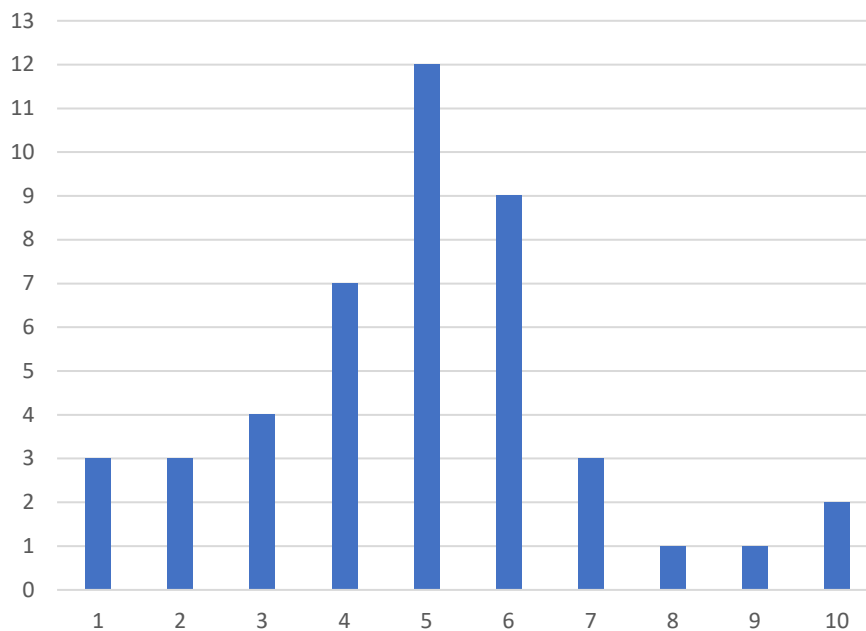
N14-29
N14-30

Step 2: Distribution Normality

Proceed to Step 3A: Sample Adequacy Test

Data to be Used in T-Test	Group	Max	###	Group	Range Top	Count	Does the distribution look like a bell curve? Select the correct value in the cell below.
10.8	1	Min	9.0	1	11.0	3	
20.7	6	Range	###	2	13.0	3	
17.1	5	Split Qty	2.0	3	14.9	4	
14.4	3	Groups	10	4	16.9	7	
17.1	5			5	18.9	12	
20.7	6			6	20.9	9	Yes
16.2	4			7	22.9	3	
17.1	5			8	24.8	1	
10.8	1			9	26.8	1	
11.7	2			10	28.8	2	
18.9	5						
13.5	3						
16.2	4						
18.9	5						
16.2	4						

Distribution Histogram



If the distribution looks generally like a bell curve, then this assumption is met. Select the correct value in the cell below.

11.7	2
19.8	6
16.2	4
18.1	5
20.7	6
17.1	5
12.6	2
9.0	1
17.1	5
25.2	9
13.5	3

[illegible]

|

Step 3A: Sample Adequacy

Proceed to Step 4: Levene's Test for Homogeneity of Variance

Mean =	19.0	16.0	16.7	20.8
Stdev =	6.7	3.2	4.2	3.8
n =	22	15	15	15
df =	21	14	14	14
t Critical Value =	1.323	1.345	1.345	1.345
d =	0.1	0.1	0.1	0.1
alpha =	0.1	0.1	0.1	0.1
Nmin =	22	7	12	6
Adequate Sample?	Yes	Yes	Yes	Yes

Transect ID	Reclamation	J7 Ref	N7/8 Ref	N14 Ref
1	11	10.8	11.7	18.9
2	16	20.7	19.8	17.1
3	11	17.1	16.2	19.8
4	16	14.4	18.09	18.9
5	13	17.1	20.7	20.7
6	27	20.7	17.1	21.6
7	21	16.2	12.6	15.3
8	14	17.1	9	20.7
9	26	10.8	17.1	27.9
10	16	11.7	25.2	23.4
11	28	18.9	13.5	19.8
12	26	13.5	15.3	22.5
13	13	16.2	14.4	16.2
14	14	18.9	17.1	28.8
15	19	16.2	22.5	20.7
16	28			
17	16			
18	15			
19	19			
20	20			
21	14			
22	36			
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34				

Procedural

Reclamat

n=

Transect
ID

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Step 3B: Reverse Mann-Whitney Test

Proceed to Step 4: Levene's Test for Homogeneity of Variance

Reclamation Area		Reference Area	Combined Data	
22		45	n = 67	
Raw Reclamation Data	90% of raw Reference Data	Sort ID	Copy Raw Reclamation Values (Yellow) into yellow space (Paste Special) in this column. Copy "90% of Raw Reference Data" (Green) into green space in this column then Sort columns AO&AP ascending together by column AP	Rank Values numerically If equal values occur, use mean rank for all equal values
11.0	10.8	Rec		
16.0	20.7	Rec		
11.0	17.1	Rec		
16.0	14.4	Rec		
13.0	17.1	Rec		
27.0	20.7	Rec		
21.0	16.2	Rec		
14.0	17.1	Rec		
26.0	10.8	Rec		
16.0	11.7	Rec		
28.0	18.9	Rec		
26.0	13.5	Rec		
13.0	16.2	Rec		
14.0	18.9	Rec		
19.0	16.2	Rec		
28.0		Rec		
16.0		Rec		
15.0		Rec		
19.0		Rec		
20.0		Rec		
14.0		Rec		
36.0		Rec		
		Rec		
		Rec		
		Rec		
		Rec		

Step 4: Levene's Test for Homogeneity of Variance

Proceed to Step 5: ANOVA

Transect ID	Raw Reclamation Data	Absolute Deviation (Z)
1	11.0	8.0454545
2	16.0	3.0454545
3	11.0	8.0454545
4	16.0	3.0454545
5	13.0	6.0454545
6	27.0	7.9545455
7	21.0	1.9545455
8	14.0	5.0454545
9	26.0	6.9545455
10	16.0	3.0454545
11	28.0	8.9545455
12	26.0	6.9545455
13	13.0	6.0454545
14	14.0	5.0454545
15	19.0	0.0454545
16	28.0	8.9545455
17	16.0	3.0454545
18	15.0	4.0454545
19	19.0	0.0454545
20	20.0	0.9545455
21	14.0	5.0454545
22	36.0	16.954545
23		
24		
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[illegible]

Homogeneity of Variance		
Step 5: T-Test		
Transect ID	90% Reference Data	Absolute Deviation (Z)
1	10.8	7.042
2	20.7	2.858
3	17.1	0.742
4	14.4	3.442
5	17.1	0.742
6	20.7	2.858
7	16.2	1.642
8	17.1	0.742
9	10.8	7.042
10	11.7	6.142
11	18.9	1.058
12	13.5	4.342
13	16.2	1.642
14	18.9	1.058
15	16.2	1.642
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31	11.7	6.142
32	19.8	1.958
33	16.2	1.642
34	18.1	0.248
35	20.7	2.858
36	17.1	0.742
37	12.6	5.242
38	9.0	8.842
39	17.1	0.742
40	25.2	7.358
41	13.5	4.342

Step 5: T-Test		
Reclamation Passes! No Additional Sta		
Reclamation		
n =	22	
Mean =	19.05	
Variance =	45.00	
St Dev =	6.71	
Classic T-Test with Satterthwaite Adjustment		
	Classic T-Test	
T-Test Value=		0.78
df =	65	28
Critical Value t=	-1.295	-1.313
Reclamation Pass:	N/A	Yes

42	15.3	2.542
43	14.4	3.442
44	17.1	0.742
45	22.5	4.658
46		
47		
48		
49		
50		
51		
52		
53		
54		
55		
56		
57		
58		
59		
60		
61	18.9	1.058
62	17.1	0.742
63	19.8	1.958
64	18.9	1.058
65	20.7	2.858
66	21.6	3.758
67	15.3	2.542
68	20.7	2.858
69	27.9	10.058
70	23.4	5.558
71	19.8	1.958
72	22.5	4.658
73	16.2	1.642
74	28.8	10.958
75	20.7	2.858
76		
77		
78		
79		
80		
81		
82		
83		
84		
85		
86		
87		
88		

89		
90		
mean = 17.84		
Zref = 3.311467		
Stdev Zref = 2.64		
2.66		
-2.654		
2.654		
No		

Statistics Required!	
90% Reference	
45	
17.84	
14.24	
3.77	
Reverse Null T-Test with Satterthwaite Adjustment	
65	28
1.295	1.313
N/A	N/A

0.562457

Critical Values of t				
df	t _{.005}	t _{.10}	t _{.90}	t _{.995}
1	-63.657	-3.078	3.078	63.657
2	-9.925	-1.886	1.886	9.925
3	-5.841	-1.638	1.638	5.841
4	-4.604	-1.533	1.533	4.604
5	-4.032	-1.476	1.476	4.032
6	-3.707	-1.44	1.44	3.707
7	-3.499	-1.415	1.415	3.499
8	-3.355	-1.397	1.397	3.355
9	-3.25	-1.383	1.383	3.25
10	-3.169	-1.372	1.372	3.169
11	-3.106	-1.363	1.363	3.106
12	-3.055	-1.356	1.356	3.055
13	-3.012	-1.35	1.35	3.012
14	-2.977	-1.345	1.345	2.977
15	-2.947	-1.341	1.341	2.947
16	-2.921	-1.337	1.337	2.921
17	-2.898	-1.333	1.333	2.898
18	-2.878	-1.33	1.33	2.878
19	-2.861	-1.328	1.328	2.861
20	-2.845	-1.325	1.325	2.845
21	-2.831	-1.323	1.323	2.831
22	-2.819	-1.321	1.321	2.819
23	-2.807	-1.319	1.319	2.807
24	-2.797	-1.318	1.318	2.797
25	-2.787	-1.316	1.316	2.787
26	-2.779	-1.315	1.315	2.779
27	-2.771	-1.314	1.314	2.771
28	-2.763	-1.313	1.313	2.763
29	-2.756	-1.311	1.311	2.756
30	-2.75	-1.31	1.31	2.75
31	-2.744	-1.309	1.309	2.744
32	-2.738	-1.309	1.309	2.738
33	-2.733	-1.308	1.308	2.733
34	-2.728	-1.307	1.307	2.728
35	-2.724	-1.306	1.306	2.724
36	-2.719	-1.306	1.306	2.719
37	-2.715	-1.305	1.305	2.715
38	-2.712	-1.304	1.304	2.712
39	-2.708	-1.304	1.304	2.708
40	-2.704	-1.303	1.303	2.704
41	-2.701	-1.303	1.303	2.701

Critical Values for Shapiro Francia Normality Test (W)	
n	$\alpha=0.01$
1	0.919
2	0.919
3	0.919
4	0.919
5	0.919
6	0.919
7	0.919
8	0.919
9	0.919
10	0.919
11	0.919
12	0.919
13	0.919
14	0.919
15	0.919
16	0.919
17	0.919
18	0.919
19	0.919
20	0.919
21	0.919
22	0.919
23	0.919
24	0.919
25	0.919
26	0.919
27	0.919
28	0.919
29	0.919
30	0.919
31	0.919
32	0.919
33	0.919
34	0.919
35	0.919
36	0.935
37	0.935
38	0.935
39	0.935
40	0.935
41	0.935

42	-2.698	-1.302	1.302	2.698
43	-2.695	-1.302	1.302	2.695
44	-2.692	-1.301	1.301	2.692
45	-2.69	-1.301	1.301	2.69
46	-2.687	-1.3	1.3	2.687
47	-2.685	-1.3	1.3	2.685
48	-2.682	-1.299	1.299	2.682
49	-2.68	-1.299	1.299	2.68
50	-2.678	-1.299	1.299	2.678
51	-2.676	-1.298	1.298	2.676
52	-2.674	-1.298	1.298	2.674
53	-2.672	-1.298	1.298	2.672
54	-2.67	-1.297	1.297	2.67
55	-2.668	-1.297	1.297	2.668
56	-2.667	-1.297	1.297	2.667
57	-2.665	-1.297	1.297	2.665
58	-2.663	-1.296	1.296	2.663
59	-2.662	-1.296	1.296	2.662
60	-2.66	-1.296	1.296	2.66
61	-2.659	-1.296	1.296	2.659
62	-2.657	-1.295	1.295	2.657
63	-2.656	-1.295	1.295	2.656
64	-2.655	-1.295	1.295	2.655
65	-2.654	-1.295	1.295	2.654
66	-2.652	-1.295	1.295	2.652
67	-2.651	-1.294	1.294	2.651
68	-2.65	-1.294	1.294	2.65
69	-2.649	-1.294	1.294	2.649
70	-2.648	-1.294	1.294	2.648
71	-2.647	-1.294	1.294	2.647
72	-2.646	-1.293	1.293	2.646
73	-2.645	-1.293	1.293	2.645
74	-2.644	-1.293	1.293	2.644
75	-2.643	-1.293	1.293	2.643
76	-2.642	-1.293	1.293	2.642
77	-2.641	-1.293	1.293	2.641
78	-2.64	-1.292	1.292	2.64
79	-2.64	-1.292	1.292	2.64
80	-2.639	-1.292	1.292	2.639
81	-2.638	-1.292	1.292	2.638
82	-2.637	-1.292	1.292	2.637
83	-2.636	-1.292	1.292	2.636
84	-2.636	-1.292	1.292	2.636
85	-2.635	-1.292	1.292	2.635
86	-2.634	-1.291	1.291	2.634
87	-2.634	-1.291	1.291	2.634

42	0.935
43	0.935
44	0.935
45	0.935
46	0.935
47	0.935
48	0.935
49	0.935
50	0.935

88	-2.633	-1.291	1.291	2.633
89	-2.632	-1.291	1.291	2.632
90	-2.632	-1.291	1.291	2.632
91	-2.631	-1.291	1.291	2.631
92	-2.63	-1.291	1.291	2.63
93	-2.63	-1.291	1.291	2.63
94	-2.629	-1.291	1.291	2.629
95	-2.629	-1.291	1.291	2.629
96	-2.628	-1.29	1.29	2.628
97	-2.627	-1.29	1.29	2.627
98	-2.627	-1.29	1.29	2.627
99	-2.626	-1.29	1.29	2.626
100	-2.626	-1.29	1.29	2.626
Infinity	-2.576	-1.282	1.282	2.576

Yes
No

Mann-Whitney		Reference Sample Size										
Sample Size		10	11	12	13	14	15	16	17	18	19	20
	10	122	128	135	141	147	153	160	166	172	178	184
	11	139	146	153	160	167	173	180	187	194	201	207
	12	158	165	172	180	187	197	202	209	216	224	231
	13	177	185	193	201	209	217	224	232	240	248	256
	14	197	206	214	223	231	240	248	257	265	273	282
	15	218	227	236	246	255	264	273	282	291	300	309
	16	241	250	260	269	279	289	298	308	317	327	336
	17	264	274	284	294	305	315	325	335	345	355	365
	18	288	299	309	320	331	342	352	363	374	384	395
	19	313	325	336	347	358	370	381	392	403	415	426
	20	339	351	363	375	387	399	410	422	434	446	458

z-Table	
z	1.28
d	0.1



Kayenta Complex
PO Box 650
Kayenta, Arizona USA 86033

J19/J21 Phase II Bond Release
Map 3.1
Revegetation
History

Produced by
Gary Altsisi
Professional
Engineer

Map design by
Deep Southwest Enterprises

July 16, 2026
Revision

1 Inch = 500 Feet



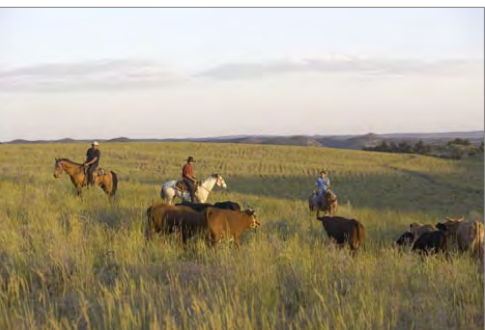
Legend

Proposed Phase II Bond Release Area - 249 acres
 Reseeded Areas

Seeding Years

2003	2009	2017	2021
2006	2012	2018	2022
2008	2016	2019	2023

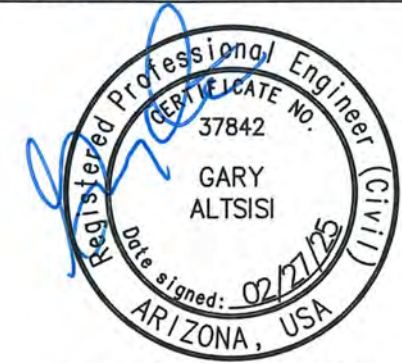
2015 Seeding Year 2015 Reseeding Year



Other Features

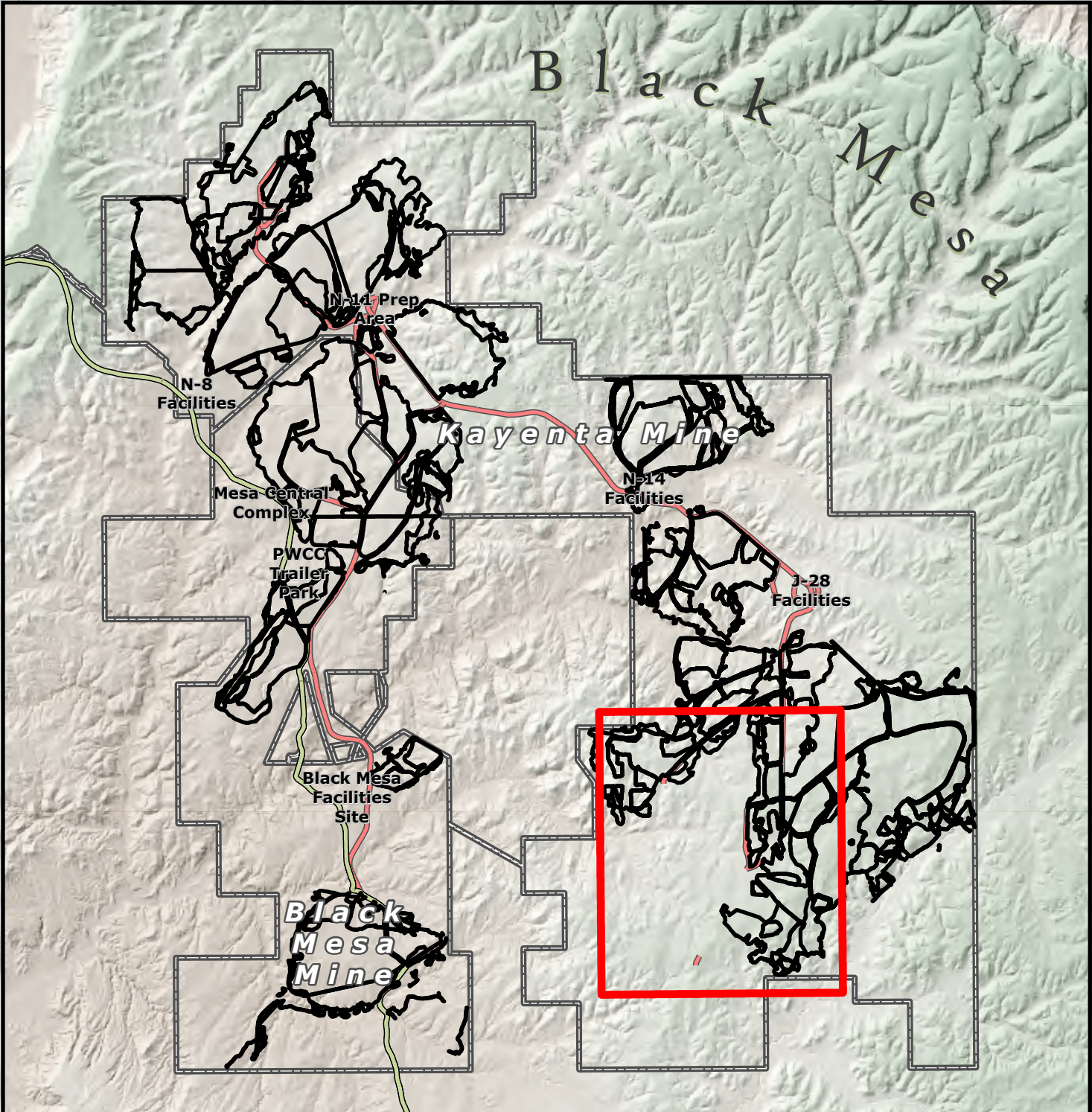
Major Wash
 PWCC Permit Boundary

ENGINEER'S CERTIFICATION



EXPIRES: 09/30/2026

Gary Altsisi
ARIZONA P.E. 37842



J21 Proposed
Phase II Release Area
176.7 ac

J19 Proposed
Phase II Release Area
72.3 ac

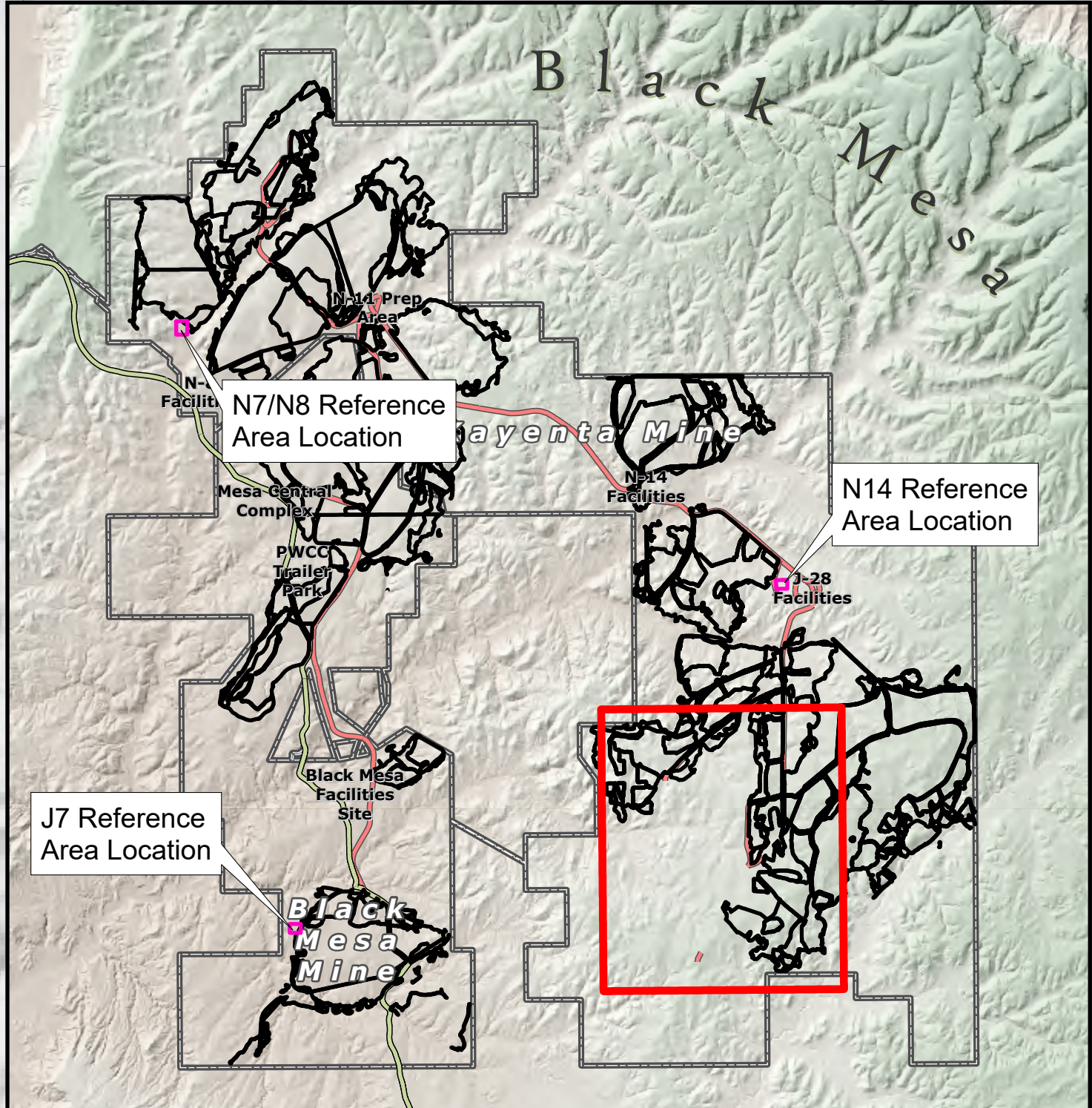
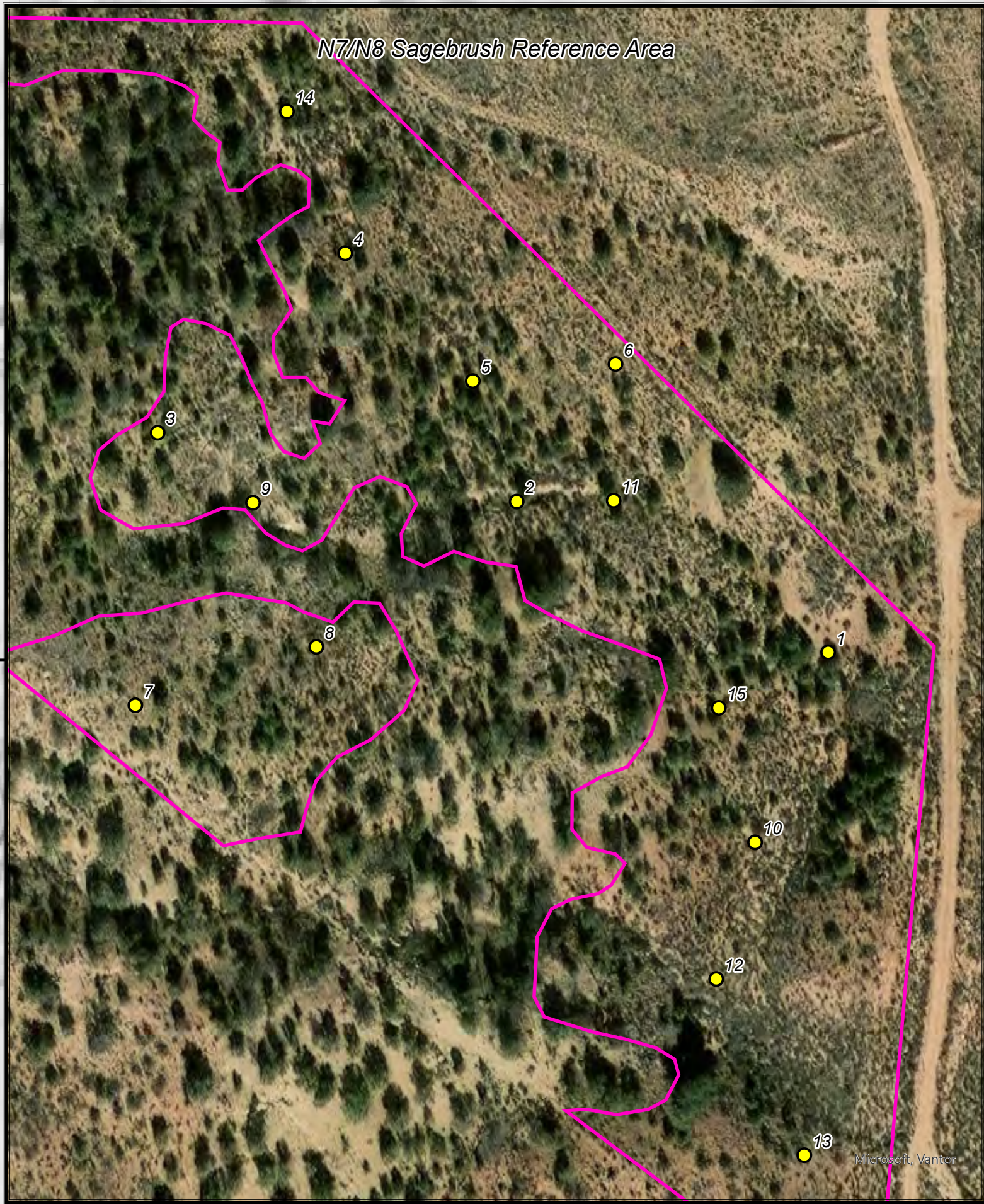
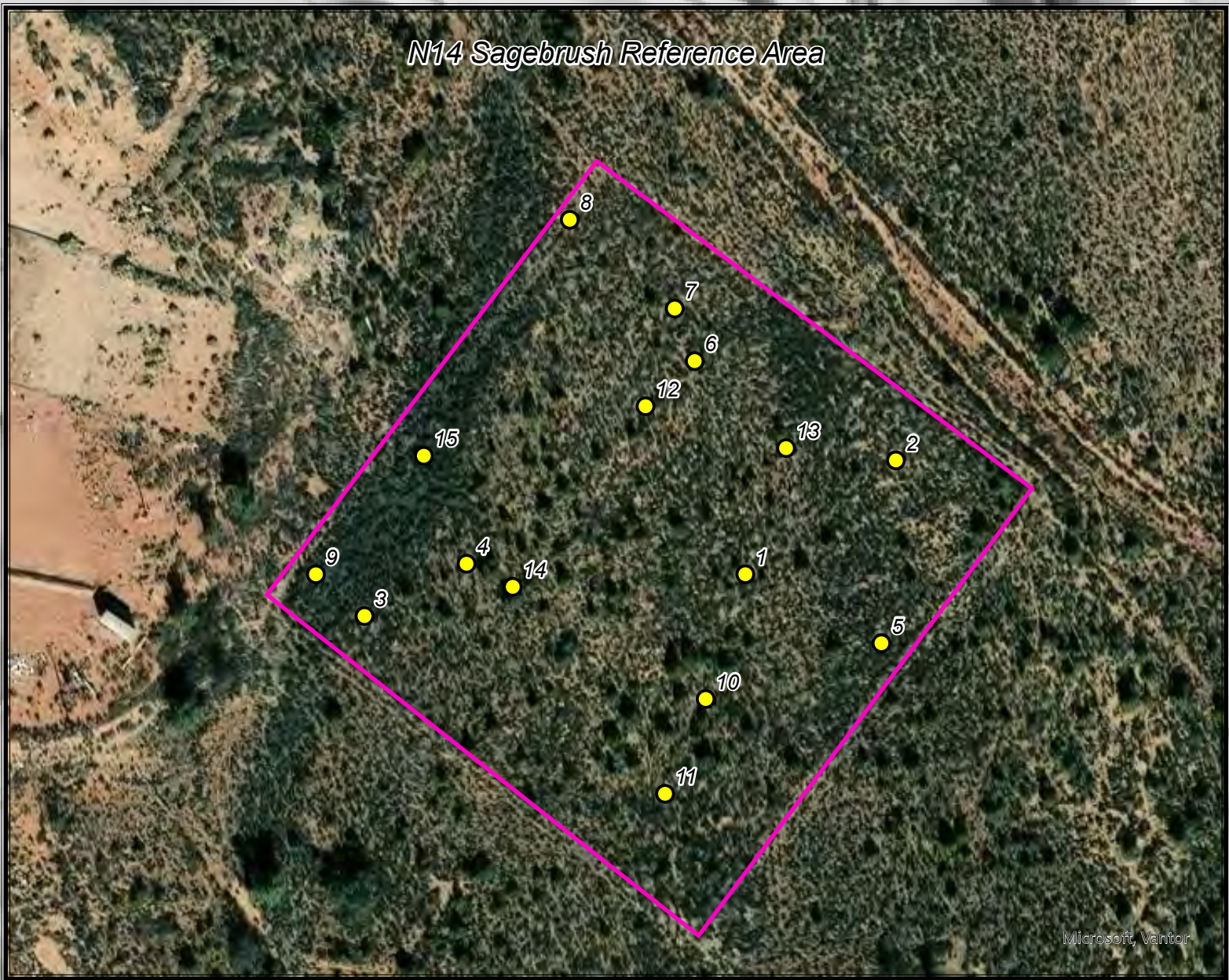
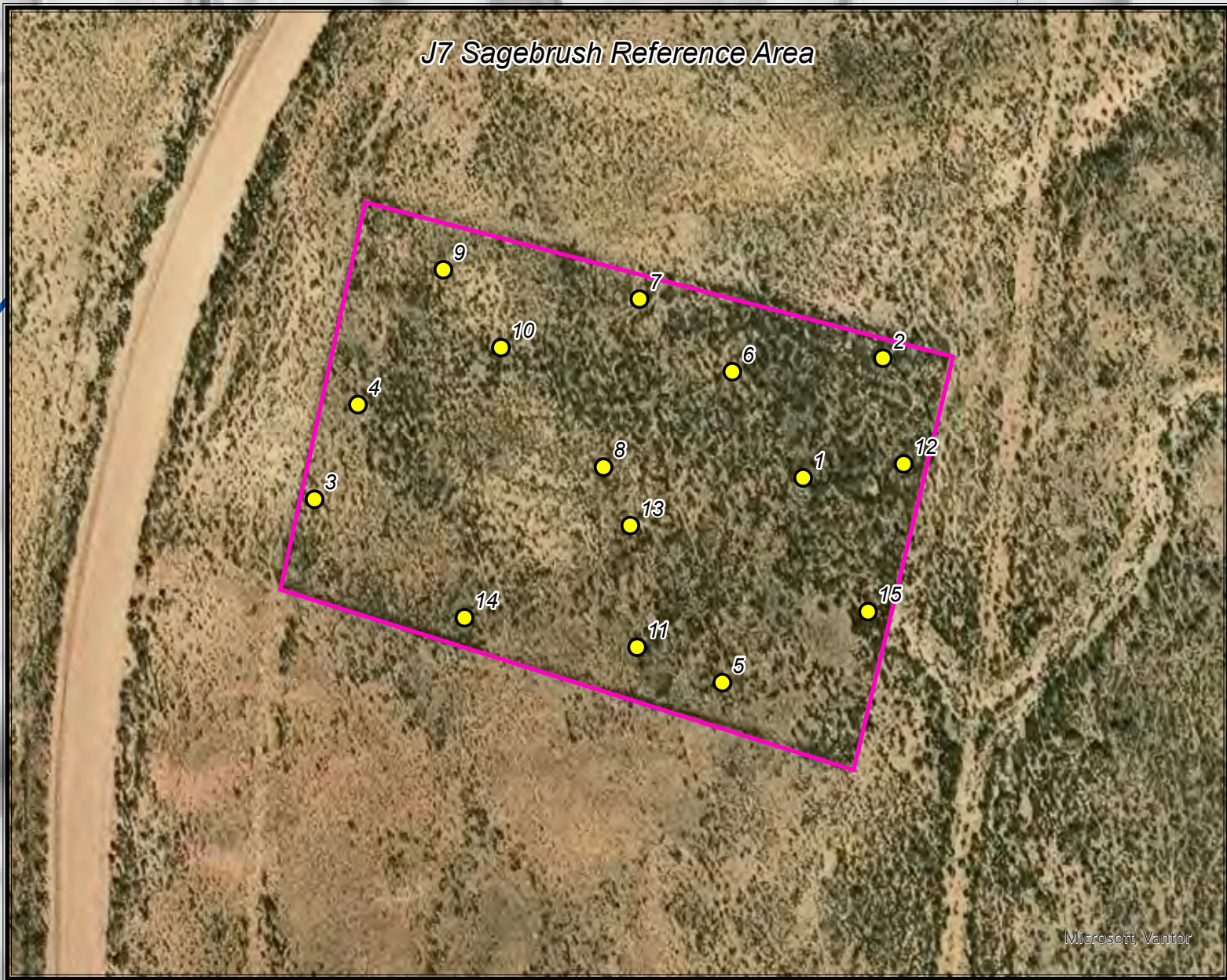
Sources: Esri, Vantor, Airbus DS, USGS, NASA, GEBCO, N Robinson, NCEAS, NLS, OS, NMA, Geodatasysteem, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap, and the GIS user community

ENGINEER'S CERTIFICATION



EXPIRES: 09/30/2026

Gary Altsisi
ARIZONA P.E. 37842



Kayenta Complex
PO Box 650
Kayenta, Arizona USA 86033

J19/J21 Phase II Bond Release

Map 3.2

Vegetation

Sample Locations

Produced by
Gary Altsisi
Professional
Engineer

Map design by
Deep Southwest Enterprises

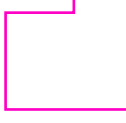
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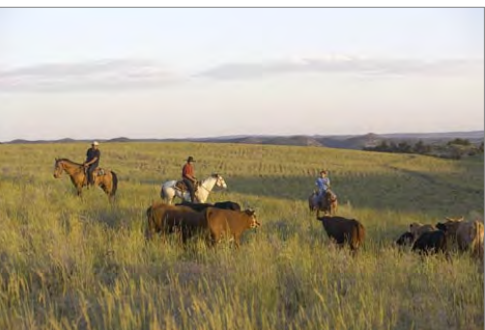
1 Inch = 500 Feet



Legend

- Permanent Transect
- Random Transects
- Reference Area Samples

-  Proposed Phase II Bond Release Area - 249 acres
-  Reference Areas



Other Features

-  Major Wash
-  PWCC Permit Boundary

Sources: Esri, Vantor, Airbus DS, USGS, NASA, GEBCO, N Robinson, NCEAS, NLS, OS, NMA, Geodatasysteem, Rijkswaterstaat, GSA, Geoland, EMA, Infarmap, and the GIS user community

Phase II Bond Release Application
J19/J21 Coal Resource Areas (CRA), Kayenta Mine

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Section 4. Phase II Bond Release Supporting Information

Suspended Solids Outside of the Permit Area

Introduction

Beginning in the early 1980's, Peabody Western Coal Company (PWCC) collected numerous measurements of suspended solids (Total Suspended Solids - TSS) in runoff events at sites established on the main washes and at small watersheds located on both reclaimed and un-mined areas within the leasehold. TSS values collected in runoff from runoff plots and small flumes contributed to the development of a surface water model (EASI) used to predict runoff and sediment loads from both un-mined and reclaimed mined lands at the Kayenta Mine. The following sections summarize the development of the EASI model and reference recent EASI modeling reports for reclaimed parcels adjacent to or within the Phase II parcels subject to this Phase II application (J19/J21). Comparisons of measured and predicted sediment discharges and TSS concentrations collected at main channel monitoring sites, small un-mined watersheds, and in small, reclaimed parcels located within the Black Mesa and Kayenta Mines are also summarized. Based on the following discussions, PWCC is confident that runoff from these parcels will not contribute additional suspended solids to stream flow outside the permit area.

EASI Model Development

PWCC initiated a Small Watershed Study (SWS) monitoring program on Black Mesa in 1985, and continued monitoring through 1992. Details regarding study objectives and monitoring associated with the study are provided in Attachment 4 in Chapter 16, Hydrologic Monitoring Program in the AZ-0001F Permit Application Package (PAP). Several small watersheds located within reclaimed and undisturbed areas were instrumented with supercritical flow flumes and continuous flow recorders for collecting runoff, sediment (TSS) and water quality data. Rainfall data were collected using Belfort automated tipping bucket rain gauges located at the centroids of each watershed and direct reading rain gauges set up at various locations within each watershed. Total overland runoff and sediment yield data for individual storm events were collected from hill slopes in each watershed using runoff plots. Small flumes were also installed downstream of the plots and were instrumented with continuous stage recorders and automated samplers to measure runoff rates and TSS concentrations during runoff events. In addition, runoff rates and TSS concentrations were collected at sites located in the main channels (e.g., Moenkopi Wash) over many years as part of historic monitoring commitments contained in the Hydrologic Monitoring Program during the 1980s into the mid-1990s. The data results were utilized to calibrate the physically based runoff and sediment yield model

named EASI (Erosion And Sediment Impacts - Zevenbergen et al., 1990; WET, 1990). EASI has been used to support Termination of Jurisdiction (TOJ) applications for mined areas reclaimed under the initial program rules (30 CFR Part 715) and bond release applications for mined areas reclaimed under the permanent program rules (30 CFR Part 816). The modeling results were used to support the first TOJ application submitted for the Kayenta Complex in March 1994 for the N-1/N-2 and J27 interim program reclaimed areas (PWCC, 1994). The 1994 TOJ application included the final report for the modeling project completed in August of 1993 (RCE, 1993).

The model was calibrated and verified using a two-step process and site-specific data collected as part of the Small Watershed Study. The EASI model was first calibrated and validated using total runoff volumes and sediment yields measured in the runoff plots along with rainfall data, followed by simulation of actual runoff hydrographs and corresponding sediment concentrations collected from the flumes considering measured storm durations and intensities. Soils and vegetative cover data measured in each plot and at select points in each watershed were also used in the model development process. Parameters that influence the model's predictions of runoff and sediment were calculated from observed data or estimated through model testing. Other theoretical parameters such as rainfall interception storage and Manning's "n" were estimated based on previous experience in the application of EASI at other surface mines in the Colorado Plateau region (WET, 1990).

EASI Model Sensitivity Analysis. The 1993 report provides a discussion of the influence of several key input parameters on its ability to duplicate measured hillslope and channel responses. Runoff and sediment yields (TSS) predicted by EASI are controlled by the short-duration, high-intensity rainfall events common to the area. The model tends to underpredict runoff and sediment yield response for small rainfall events (< 0.1 inches), especially on hillslopes where antecedent moisture, looseness of surface soils, wind and temperature can vary appreciably. For larger events, the small watershed study runoff plot and flume data were in good agreement with EASI model predictions based on the calibration and validation process utilized for optimizing model inputs.

The sensitivity of the EASI model to several input parameters was performed after completing the calibration and validation work. The analysis evaluated calibrated values for soil hydraulic conductivity, total ground cover, and both overland flow (hillslope) and channel flow detachment coefficients (erosion) by varying the input parameter values by percentages. Model response to these variations was evaluated on a unit runoff (inches) and sediment yield (tons/acre) basis at both hillslope and watershed scales. The analysis indicates runoff is not appreciably affected by cover at either a hillslope or watershed scale. For larger events, rainfall intensities are far

higher than infiltration rates.

However, sediment yield from pre-mining and reclaimed hillslopes is highly sensitive to total ground cover and less sensitive to infiltration (hydraulic conductivity) and erosion (detachment coefficients). On a watershed scale, the differences between pre-mine and reclaimed sediment yield are less pronounced because channel sediment transport processes dominate at the watershed outlet.

Many of the required EASI model input parameters used for modeling runoff and sediment yield from watersheds at the Kayenta Mine were developed during the calibration and validation process because direct measurements were difficult to obtain and not readily available. However, percent ground cover values for modeling un-mined and reclaimed areas are based on field measurements of vegetative ground cover, litter and rock. These values are measured directly in the field and are required for demonstrating successful establishment of vegetation growth in the reclaimed parcels subject to this Phase II bond release application. Because predictions of sediment yields (including TSS concentrations) using EASI are sensitive to values of total ground cover, and are readily available, it follows that measurements of total ground cover in reclaimed areas may be used to indicate whether reclaimed areas are generating sediment yields, expressed as tons/acre on a unit basis or as individual TSS concentrations (mg/L), that may result in appreciable contributions of suspended solids to streamflow outside the permit area.

Table 4.1 presents average total ground cover used in previous EASI models to predict sediment yields in numerous reclaimed areas throughout the leasehold and provides a general description of the reclaimed areas modeled, drainage area, and average total ground cover used for modeling purposes. The values range from 38.2 percent to 65.6 percent. Of note, the EASI models that were developed for all reclaimed areas listed predicted average annual sediment yields less than or equal to pre-mining conditions. Importantly, the processes that dominate the sediment yield predictions involve sediment transport in channels, not erosion from hill slopes. Measurements of total ground cover during the Fall of 2025 in the J19/J21 reclaimed parcels subject to this application averaged 70.82 percent (see Table 3.1 in Section 3.0). Accordingly, absent application of the EASI model to these parcels, the average total ground cover values indicate average annual sediment yields from these areas will be less than or equal to conditions that were present prior to mining these parcels.

Table 4.1. Total Ground Cover Values for Reclaimed Conditions used in Previous EASI Sediment Models			
Reclaimed Area Modeled	Model Date (Month-Year)	Drainage Area (acres)	Total Ground Cover ¹ (percent)
N1/N2	Aug-93	2732.5	41.2
J27	Aug-93	178.9	43.9
N7/N8	Jul-01	946.0	53.9
N14	Jul-08	1580.6	46.5
J21-D/J21-E	Aug-08	68.9	65.6
J16-E/J16-F	Aug-08	148.5	61.0
N6-C/N6-D/N6-F	Aug-08	280.9	38.2
J7-CD/J7-E/J7-F	Aug-08	99.8	48.5
J21-A	Apr-09	111.2	52.7
N6-G	Apr-09	37.9	55.6
J7-K/J7-M	Jun-09	37.3	55.2
N5-D/N5-E	Aug-09	28.3	48.9
J1/N6 and N6 East Central	Sep-09	1533.3	46.2
J21	Sep-10	2832.0	59.4
J7-A/J7-B1/J7-G/J7-H/J7-I/J7-J/J7-R/J7-R1	Feb-11	440.0	55.2
J19	Sep-11	943.4	55.8
J3	Nov-12	95.5	39.9
J7	Nov-12	1194.7	48.7
Total Drainage Area Modeled =		13289.7	
¹ Total Ground Cover = Vegetation Ground Cover + Litter + Rock			

Following the 1994 TOJ application submittal, sixteen additional EASI models were developed for reclaimed parcels located within the Kayenta and Black Mesa Mines, including reclaimed watersheds upstream of temporary sediment ponds that were permitted as outfalls in the Kayenta Complex NPDES Permit No. NN-0022179. As of 2016, a total of 13,289.7 acres of reclaimed areas had been modeled using EASI. The combined total of topsoiled and seeded areas at both mines at the end of 2016 was 15,584 acres, of which approximately 85 percent were modeled using EASI. The following sections discuss EASI models that have been developed proximate to the J19/J21 reclaimed parcels subject to this application.

J1/N6 EASI Sediment Yield Model. Attachment 4.1 contains an EASI model report entitled "Surface Water Modeling of the Reclaimed Parcels at Black Mesa Complex J1/N6 and N6 East Central Coal Resource Areas" (Ayres, 2009) for reclaimed areas situated south of the N11 reclaimed parcels. The results indicate average annual runoff (0.28 inches) generated from reclaimed hill slopes and low-order channels is less than pre-mining conditions (0.42 inches).

The difference is attributed to the creation of several internal draining impoundments in the eastern portion of the N6 post-mining landscape. Reclamation methods including BMPs (e.g., vegetative cover) utilized in the N11 reclaimed parcels were like those evaluated in the J1/N6 EASI model. In addition, physical properties of the reclaimed watersheds within the J1/N6 areas, including mean channel slope, drainage density and mean hillslope gradients were similar to pre-mining conditions.

J-19 EASI Sediment Yield Model. Attachment 4.2 contains the EASI model entitled "Surface Water Modeling of Reclaimed Parcels at the J19 Coal Resource Area, Kayenta Complex" (Ayres, 2011). The model results indicate post-mine (reclaimed parcels) average annual sediment yields are about 29 percent less than pre-mine levels. Hill slope and sub-watershed erosion rates, which are significant for sustaining postmining land use, are 9 percent higher for the reclaimed landscape, yet are comparable to pre-mine levels and are less than 1.0 ton/acre/year. The reduction of sediment yield is due to comparable hill slope erosion combined with channel erosion control measures for the post-mine landscape.

Total Suspended Solids

Soils replaced within the J19/J21 reclaimed parcels, naturally occurring soils in surrounding undisturbed areas within the leasehold overall and in the arid/semiarid Southwest typically lack cohesion. Un-mined stream channels within and adjacent to the Kayenta Mine and PWCC leasehold consist of steep sided, deeply incised arroyos with loosely consolidated channel banks and fine-grained sand bed channels. Figure 4.1 from Blatt, Middleton, and Murray (1972) shows these types of soils (unconsolidated clays, silts and fine-grained sands) are easiest to keep in suspension. The gray band shown in Figure 4.1 represents the flow velocity ranges necessary to keep particle types and sizes in suspension. Above the gray band are the velocities necessary to erode or entrain soil particles, whereas velocities below the gray band would be insufficient to transport the particles and deposition would occur. The bandwidths for the clay and silt particle sizes are quite wide because considerably higher velocities are necessary to erode consolidated and cohesive clays and silts. For the unconsolidated non-cohesive silts, clays and fine-grained sands found on the leasehold, velocities of less than 2 feet/second will erode and keep the particles in suspension. Typical flow velocities measured historically in the stream channels on the leasehold including Dinnebito Wash (sites CG34 and SW34) and the main channels along Yucca Flat Wash, Coal Mine Wash, and Moenkopi Wash where monitoring sites SW155, SW25, and SW26 are located, respectively, range from 8 to 12 feet/second.

In the semiarid Southwest, much of the precipitation is effective in terms of producing runoff. Most of the rainfall occurs in short duration, very high intensity storms that rapidly overcome soil infiltration and generate larger amounts of runoff. Total annual rainfall on the PWCC leasehold ranges from 6 to 12 inches. Figure 4.2, from Langbein and Schumm (1958), shows the relationship of annual sediment yield to effective annual precipitation and cover in the U.S. Note the highest annual sediment yields occur where there is a combination of approximately 12 inches of effective precipitation and desert/shrub type cover. Both factors are consistent for the leasehold and for the undisturbed areas adjacent to the J19/J21 reclaimed parcels. Because of the soil and rainfall characteristics and the vegetative cover for this geomorphic region, stream flows on the leasehold more closely approximate debris flows than they do stream flows.

Suspended Solids Outside of the Permit Area

Section 2.0, Comparisons with Measured Sediment Transport in both EASI model reports provided in Attachments 4.1 (Ayres, 2009) and 4.2 (Ayres, 2011) contain a discussion of measured sediment discharge and total suspended sediment (TSS) concentrations along with EASI-model derived sediment discharge and TSS concentrations. Measured values were collected over many years at main channel stream monitoring sites and at Small Watershed Study (SWS) flumes. Each EASI model report compares predicted values for sediment discharge and TSS concentrations for reclaimed areas modeled with measured values based on data plots (see Figures 2.1 and 2.2 in each model report). Overlap of model predictions for both pre- and post-mine conditions with measured data strongly indicate EASI model predictions are representative and reasonable. In addition, the plots indicate sediment loads and concentrations are dependent on the channel sediment transport capacity for small un-mined and reclaimed channels as well as larger channels draining larger basins. Channel sources of sediment in the semi-arid environment of the leasehold are virtually unlimited. Accordingly, channel transport capacity and channel-derived sediment limits and governs sediment discharge and TSS concentrations from the small tributaries and large sand-bed channels (e.g., Moenkopi Wash).

Section 2.2 of each EASI model report (Attachments 4.1 and 4.2) also discusses statistical analysis of the sediment discharge and sediment concentration plots provided in Figures 2.1 and 2.2. The analysis involved applying non-parametric statistics to determine if channels in reclaimed areas have similar sediment transport characteristics as background (un-mined) channels. The analysis showed data collected at un-mined SWS flumes can be combined with the main channel monitoring site data, and that sediment is being conveyed at or near capacity. In addition, reclaimed channel sediment discharge and TSS concentrations show the same characteristics of the data collected at un-mined SWS flumes and main channel monitoring sites even though the flow ranges are lower. The

data plots and statistical analysis indicate that channel flows within and adjacent to the leasehold achieve the sediment transport capacity of the channel regardless of whether they are located within reclaimed areas or in small and large basins that drain background watersheds not impacted by surface coal mining activities. Accordingly, runoff from any of the reclaimed parcels located within the J19/J21 parcels subject to this Phase II bond release application are not contributing additional suspended solids (TSS) to streamflow outside the permit area.

Alluvial Valley Floors

Chapter 17, Protection of the Hydrologic Balance in the AZ-0001F PAP provides a summary of early investigations of the existence of alluvial valley floors (AVFs) within or adjacent to the leasehold. The findings clearly indicate there are no AVFs within or adjacent to the leasehold.

Surface and Subsurface Water Pollution

The regulations set forth under 30 CFR Parts 780 and 816 require operators to minimize impacts to the prevailing hydrologic balance. PWCC conducted mining and reclamation activities at the J19/J21 reclaimed parcels subject to this Phase II bond release application in accordance with plans and procedures approved by the Office of Surface Mining Reclamation and Enforcement (OSMRE) as provided in the PAP for Surface Mining Permit AZ-0001F, many of which were developed in order to ensure impacts to the hydrologic balance in the vicinity were minimized. The changes to ground water (subsurface) are largely based on long term monitoring of ground water in monitoring wells completed in the Wepo Formation and adjacent alluvial deposits along Moenkopi Wash and Coal Mine Wash. Changes to surface water (surface) are based on long term monitoring of runoff at stream sites located on Moenkopi Wash and Coal Mine Wash. Changes in water chemistry discussed above cover decades of monitoring in many cases and are within magnitudes and ranges representative of naturally occurring or background values. In summary, no pollution of surface or subsurface sources of water has been found within or adjacent to the subject reclaimed J19/J21 parcels shown on Map 1.1.

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- Ayres Associates, 2009. "Surface Water Modeling of the Reclaimed Parcels at Black Mesa Complex J1/N6 and N6 East Central Coal Resource Areas", Prepared for Peabody Western Coal Company.
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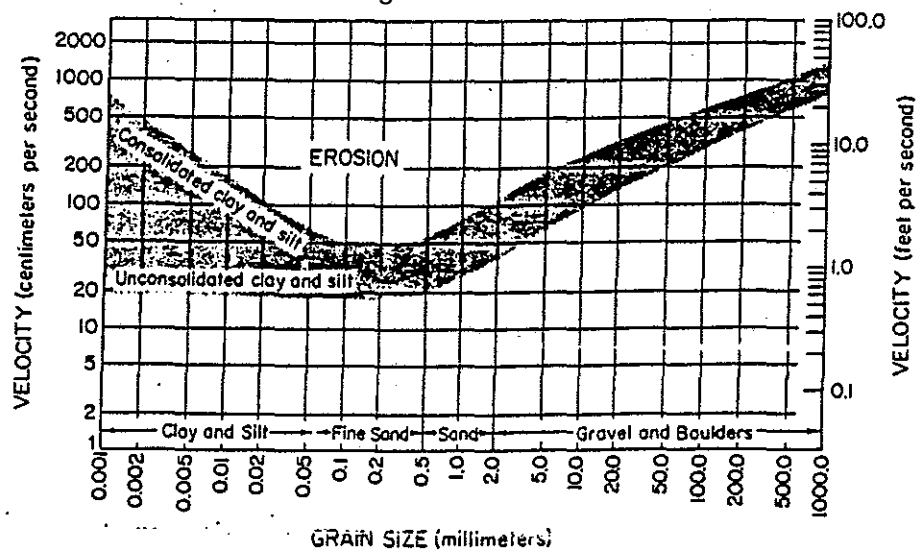
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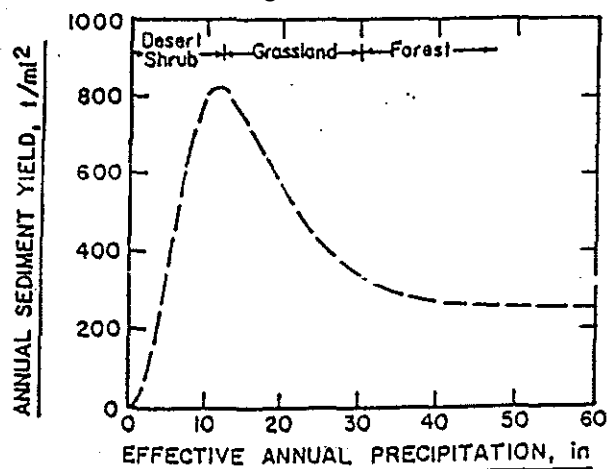
Figure 4.1



Hjulstrom's diagram, showing critical velocity for movement of quartz grains on a plane bed at a water depth of one meter, as modified by Sundborg (1956). The shaded area indicates the scatter of experimental data. There are very few reliable data in the clay and silt region.

(from Blatt, Middleton and Murray, 1972)

Figure 4.2



Variation of sediment yield with climate in the United States (from Langbein and Schumm, 1958).

**SURFACE WATER MODELING OF THE RECLAIMED PARCELS AT
BLACK MESA COMPLEX J1/N6 AND N6 East Central COAL
RESOURCE AREAS**

Prepared for

**Peabody Western Coal Co.
Highway 160, Navajo Route 41
Kayenta, Arizona 86033**

AYRES
ASSOCIATES

**SURFACE WATER MODELING OF THE RECLAIMED PARCELS AT
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RESOURCE AREAS**

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September 2009

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1. RECLAIMED PARCEL MODELING

1.1 Introduction

The purpose of this project is to use a previously calibrated and validated runoff and erosion model EASI - Erosion And Sediment Impacts (Zevenbergen et al. 1990; WET 1990) for the Black Mesa and Kayenta Mines (combined as Black Mesa Complex in December 2008) to predict mean annual runoff and sediment yields from the reclaimed parcel J1/N6 and N6 East Central. Since the model for the J1/N6 Coal Resource Area (CRA) was completed in 2001, the objectives of this project are to review the completed J1/N6 model, develop a model for the neighboring N6 East Central CRA, and incorporate the newly developed N6 East Central model into the existing J1/N6 model. The response of the reclaimed parcels was evaluated relative to undisturbed (premine) conditions in the corresponding undisturbed watersheds. All soils and rainfall input to the model are to be taken from models calibrated in the previous study (RCE 1993). The input variables that were calibrated to the mine areas and used in this study include soil infiltration parameters, erodibility parameters, and the grain size distribution. Parameters that are specific to this study are vegetative canopy and ground cover percentages from data collected on site. The model serves a tool for assessing the success of reclamation efforts to protect hydrologic balance (30 CFR 715.17 and 30 CFR 816.41).

The model calibration was conducted in a previous study (RCE 1993) using data obtained from instrumented watersheds and small hillslope plots collected under natural rainfall conditions. For a detailed discussion of data collection and model calibration, please refer to the previous study (RCE 1993).

1.2 Background

The J1/N6 and N6 East Central CRA that is the focus of this project was reclaimed between 1981 and 2007. This reclaimed area is now eligible for termination of jurisdiction from the Office of Surface Mining Regulation and Enforcement (OSMRE). The fundamental purpose of this study was to quantify the expected behavior and hydrologic response of the current conditions of reclaimed areas relative to the conditions that existed prior to the occurrence of mining activities.

Runoff and sediment yield response from the reclaimed lands should be managed by implementing Best Management Practices (BMP's) in conjunction with an OSM approved sediment control plan in order to not adversely impact the prevailing hydrologic balance and to limit additional contributions of suspended sediment to streamflow or runoff outside the mine permit areas. BMP's include regrading, replacing salvaged topsoil, revegetation, and other controls such as riprapped channel bottoms, check dams, and where practicable, contour terraces. The natural watersheds on the mesa contribute significant quantities of sediment to the channel system. It is expected that the postmine condition will also produce comparable amounts of sediment without adversely impacting the hydrologic balance.

This section describes the data and procedures used to evaluate the CRA J1/N6 and N6 East Central. This area was modeled to determine the average annual hydrologic response following the completion of reclamation activities and maturation of the reclaimed area vegetation taking into account BMP's implemented as part of the reclamation process. Infiltration, runoff, and erosion processes from both hillslopes and channels within the CRA were modeled using EASI. Results were determined for concentration points at the outlets of the reclaimed watersheds. The locations of these points are shown in **Exhibit 1**. Modeling was also conducted to determine hydrologic response under premine conditions based on the topography, soils, cover, and other conditions that typified the undisturbed watersheds draining to each concentration point. **Exhibit 2** shows the modeling endpoints for the J1/N6 and N6 East Central premining watersheds.

1.3 Data

1.3.1 Soils

Soils data used for the current study (CRA J1/N6 and N6 East Central) were based on data developed from the calibration of models used in the previous study for Coal Resource Areas (CRAs) N1/N2 and J27 (RCE 1993). The composition of postmine soil in the current study is depicted along with the composition of postmine soils from the previous study in **Figure 1.1**. This figure shows that the soil composition of CRA J1/N6 and N6 East Central is very similar to soils evaluated during model calibration. Therefore, the soil properties developed in the previous study are valid for this modeling project. These properties include calibrated parameters, such as infiltration and erodibility coefficients, and measured soil size distributions. **Table 1.1** lists the premine and postmine soils data used during EASI modeling of CRA J1/N6 and N6 East Central.

1.3.2 Vegetation

Vegetative cover data representative of both pre- and postmine conditions in CRA J1/N6 and N6 East Central were supplied by PWCC. For the premine condition, land was characterized as being covered by sagebrush or pinon juniper. The spatial distribution of vegetative cover for the J1/N6 and N6 East Central CRA premine condition appears in **Figure 1.2**. Average cover properties for CRAs N1/N2 and J27 of the previous study and CRA J1/N6 and N6 East Central of the current study appear in **Table 1.2**. For the postmine condition, the reclaimed area was assigned the postmine cover type and the unmined area was assigned the same cover type as the premine condition. **Table 1.3** lists the pre- and postmine vegetative cover data used in the EASI model runs generated for the J1/N6 and N6 East Central CRA. Note that if a unit contained significant portions of both sagebrush and pinon juniper cover types, it was classified as half pinon juniper and half sagebrush.

1.3.3 Topography

Pre- and postmine topography was supplied by PWCC in the form of ArcGIS geodatabase. Basin delineations, hillslope delineations, subwatershed delineations, as well as areas, slopes, and lengths of all units of the study area were defined and calculated using ArcGIS software. **Figures 1.3 and 1.4** show the watershed delineation and numbers assigned to the basins used in the EASI model for the post- and premine conditions, respectively. Channel dimensions input to EASI were based on the topography supplied and limited field observations.

1.4 Methodology

Runoff and sediment yield in the semiarid western United States is largely governed by the occurrence of high-intensity, short-duration rainstorms of limited areal extent (Renard and Simaton 1975). Research has indicated that relatively few events may produce the greatest erosion (e.g., Hjelmfelt et al. 1986 reported that only 3 to 4% of rainfall events accounted for 50% of long-term sediment yields). Although there is perhaps a relatively limited physical basis for definition of an "average annual" runoff or sediment yield in a semiarid environment due to the extreme variability in response and importance of single infrequent events, such a term does provide a useful basis for long-term comparison between reclaimed and undisturbed conditions.

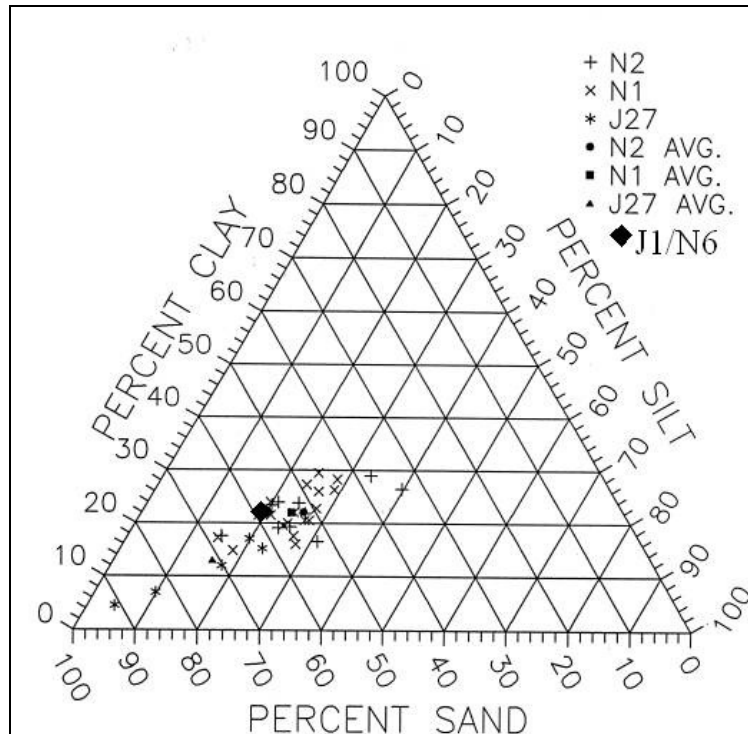


Figure 1.1. Reclaimed area soils trilinear graph.

Table 1.1. Soils Data.			
Condition	Premine	Postmine	Rock Chutes
Rainfall detachment	0.005	0.005	0
Overland flow detachment	0.44	0.44	0
Channel flow detachment	0.5	0.5	0
Initial soil moisture, %	70	70	70
Final soil moisture, %	90	90	90
Soil porosity, %	45	45	46
Temperature, *F	70	70	70
Hydraulic conductivity, in/hr	0.23	0.29	0.3
Capillary suction, in	3.7	2.6	2.6
Particle Size Distribution (all conditions)			
	Size, mm	% Finer	
	0.001	0	
	0.004	18.0	
	0.016	27.4	
	0.062	36.6	
	0.125	56.2	
	0.250	64.3	
	0.500	72.4	
	1.000	80.5	
	2.000	88.6	
	4.000	92.4	
	16.000	100	

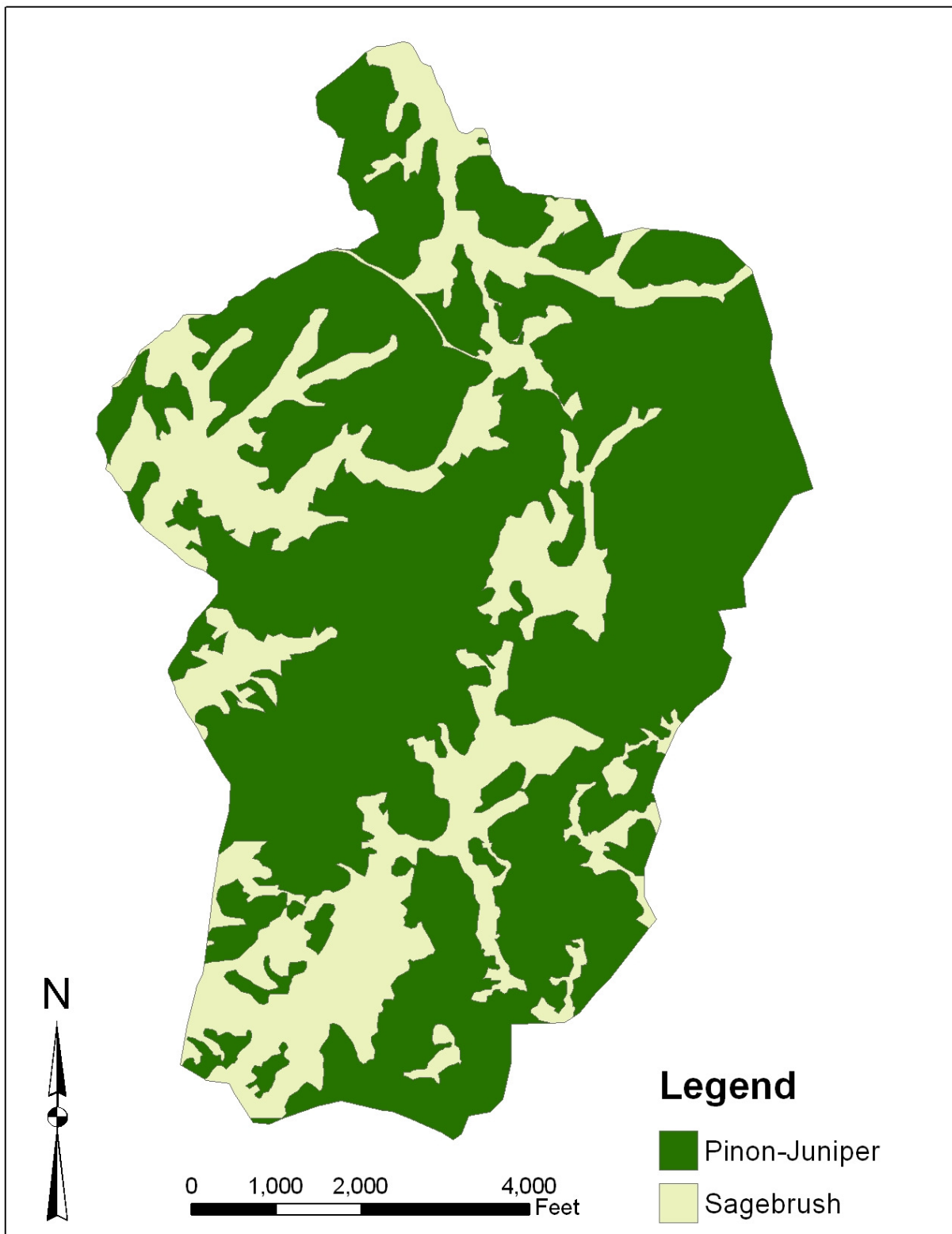


Figure 1.2. Vegetative cover for CRA J1/N6 and N6 East Central premine condition.

Table 1.2. Cover Sampling Data.								
Area	Condition	Cover Type	Nonstratified Vegetation Cover (%)	Vegetation Canopy Cover (%)	Vegetation Ground Cover (%)	Litter* (%)	Rock (%)	Total Ground Cover (%)
N1/N2	Postmine	Postmine	25.6	1.4	24.2	13.6	4.2	41.9
J1/N6	Postmine	Postmine	20.6	0.3	20.4	21.6	4.2	46.2
N1/N2/J27	Premine	Pinon Juniper	32.7	31.1	3.0	44.0	19.7	66.7
J1/N6	Premine	Pinon Juniper	16.9	14.6	2.7	18.8	17.3	38.8
N1/N2	Premine	Sagebrush	25.1	16.0	10.3	25.3	18.1	53.7
J27	Premine	Sagebrush	30.6	9.7	22.0	24.0	1.6	47.6
J1/N6	Premine	Sagebrush	12.4	1.3	11.2	24.7	2.5	38.3
*Including standing dead litter								

Table 1.3. Cover Data for J1/N6 and N6 East Central Watersheds.				
Condition	Pinon Juniper	Sagebrush	Half Pinon Juniper-Half Sagebrush	Postmine
Canopy cover, %	14.6	1.3	8.0	0.3
Ground cover, %	38.8	38.3	38.5	46.2
Canopy storage, in	0.05	0.05	0.05	0.05
Ground storage, in	0.05	0.05	0.05	0.05
Depression storage, in	0.03	0.03	0.03	0.03
Impervious area, %	0	0	0	0
Manning n	0.07	0.07	0.07	0.05

To make comparisons between reclaimed lands and associated undisturbed lands at the Black Mesa Mining Complex on the basis of average annual sediment yield, a procedure was used that considers the importance of infrequent storm events in defining sediment yield in the semiarid west. First, however, the site-specific rainfall data available for the Black Mesa Mining Complex were used to evaluate the frequency and magnitude of the measured events relative to existing predictions for rainfall depth-duration (Miller et al. 1973). The analysis of the rainfall data was performed as part of a previous study of the N1/N2 and J27 CRAs (Resource Consultants and Engineers 1993).

Comparisons between runoff and sediment yield from undisturbed and reclaimed areas in CRA J1/N6 and N6 East Central were developed for specific modeling endpoints shown in Exhibits 1 and 2. Mining and reclamation activities did not exactly replicate the topography, drainage network, or drainage areas that existed prior to mining. Consequently, direct comparisons of total runoff and sediment yield cannot be made between undisturbed and reclaimed response at a given point in a watershed. Comparisons were made on the basis of unit rates of runoff (inches) and sediment yield (tons/acre) at the various modeling computation endpoints. Although the same disturbance boundary was used to define the extent of both pre- and postmine conditions, the topographic differences that resulted after mining and reclamation occurred in the J1/N6 and N6 East Central CRA dictated that some areas would be included or excluded from the modeling. The total area modeled for premine conditions is 1499.7 acres (Exhibit 2) and for postmine conditions is 1533.3 acres (Exhibit 1).

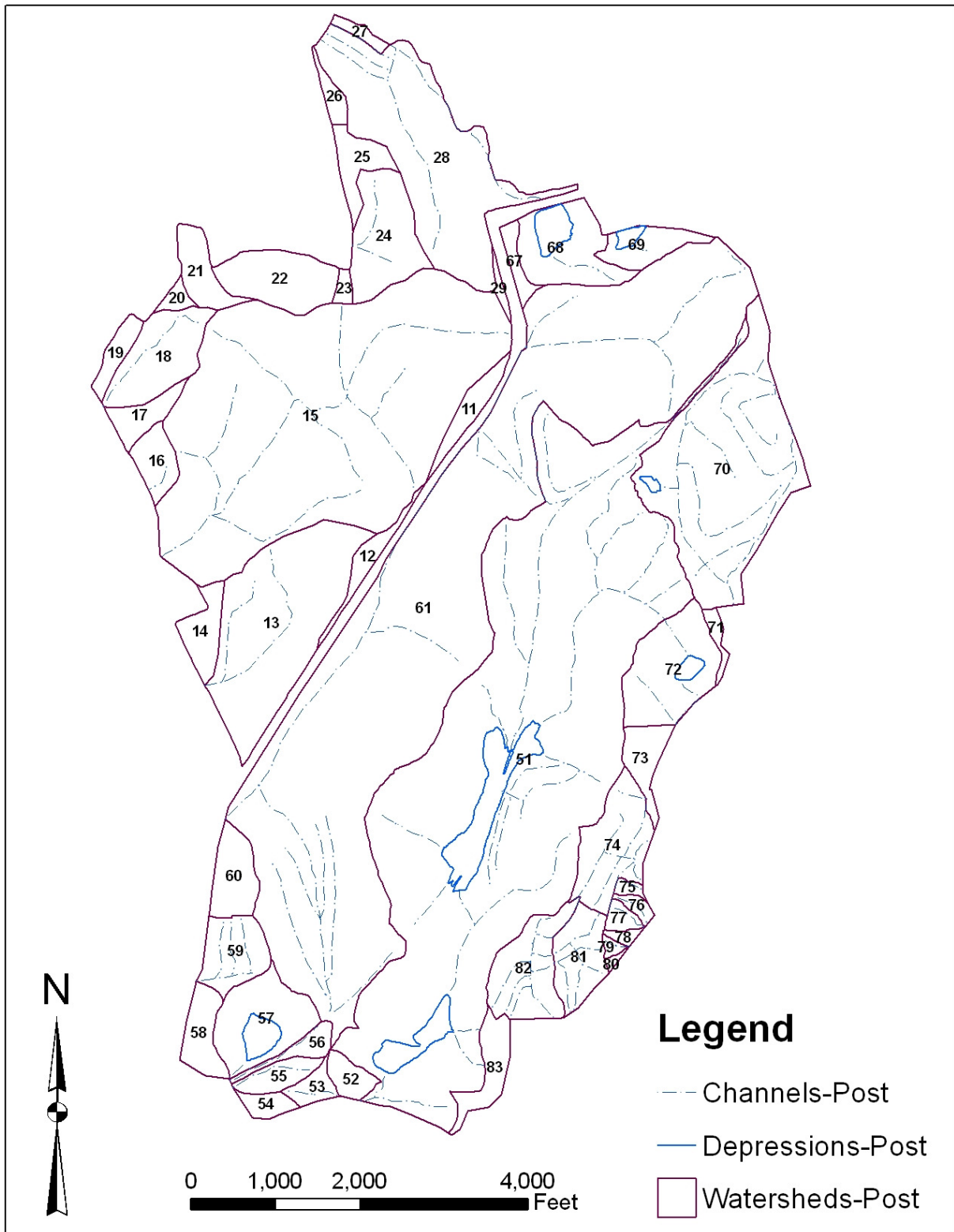


Figure 1.3. J1/N6 and N6 East Central postmine basins.

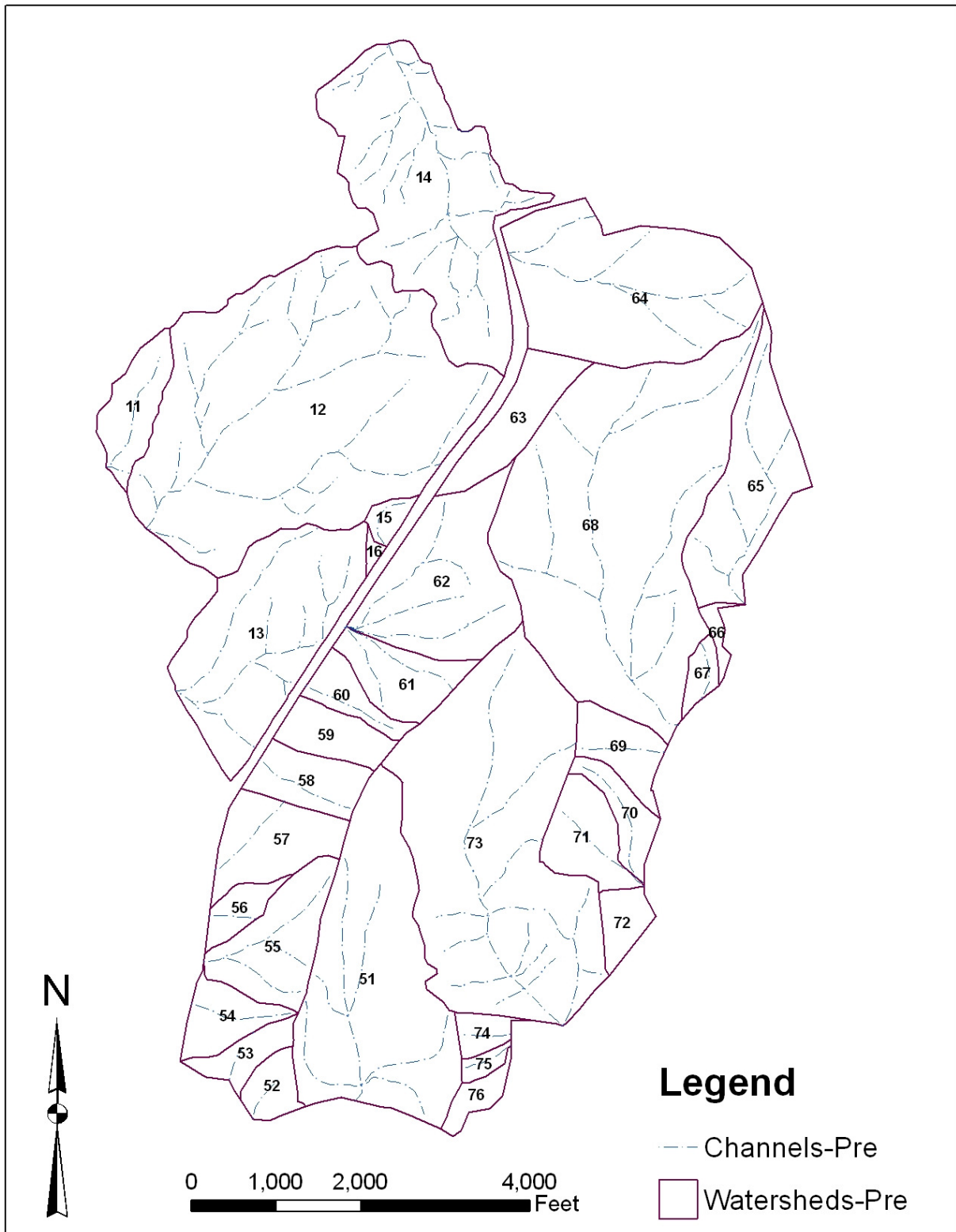


Figure 1.4. J1/N6 and N6 East Central premine basins.

1.4.1 Synthetic Rainfall

Synthetic storms of 2-, 5-, 10-, 25-, 50-, and 100-year return periods were used as input to the EASI model. Actual hyetographs were taken from the previous study (RCE 1993) and are based on both local data collection and the NOAA Atlas (Miller et al. 1973).

1.4.2 Computation of Average Runoff and Sediment Yield

The EASI model was used to evaluate runoff and sediment yield from a series of storm events having recurrence intervals of 2-, 5-, 10-, 25-, 50-, and 100 years. To define average annual conditions, the average annual runoff and sediment yield generated from storm events were computed using the commonly used equation of Lagasse et al. (1985).

1.5 Results

Figures 1.3 and 1.4 show the post- and premine basin delineations. Since the individual subareas differ in number, acreage and outlet locations, a direct comparison is not possible on a subarea basis. Therefore, the best way to compare the results is on an average basis for the CRA. **Table 1.4** shows pre- and postmine drainage area, runoff, and sediment yield for the J1/N6 and N6 East Central CRA. Runoff is defined as the total volume of water leaving the CRA on an average annual basis and, therefore, does not include water stored in depression areas and ponds. For the premine condition, this is equal to the amount of water that drains off the hillslopes and subwatersheds because there are no ponds or significant depressions. For the postmine condition, this is equal to the amount of hillslope runoff less the amount stored in ponds. Similarly, the sediment yield is the amount of eroded material that leaves the CRA on an average annual basis computed using the equation of Lagasse et al. (1985). The sediment yield is the production from the hillslope areas and erosion from the channels. The amount of erosion is the sediment yield from the hillslopes and subwatersheds only and does not include channel erosion, channel deposition or sediment trapped in ponds. Sediment yield can be greater or less than erosion, depending on the amount of channel erosion and the capacity of the channel network to convey sediment off the leasehold.

For the postmine condition, sediment yield is substantially less than the premine condition. Sediment yield is approximately one-third of the premine amount. Runoff is the same as the premine amount for the N6 East Central CRA, while runoff for postmine is much smaller than the premine amount for the J1/N6 CRA. The amount of hillslope runoff is virtually the same between pre- and postmine conditions and the difference between the runoff leaving the CRA is due to ponds and depressions storing water in the postmine condition. Hillslope and subwatershed erosion rates are lower for reclaimed (postmine) conditions due to more effective hydrologic cover and channel erosion control measures.

1.6 Discussion

Table 1.5 gives an overview of the geometric properties of the pre- and postmine topographies for the J1/N6 and N6 East Central CRA. The geometric properties for the postmine condition are similar to the premine condition.

Table 1.4. Average Runoff and Sediment Yield Results.					
Area	Condition	Drainage Area (ac)	Runoff (in)	Sediment Yield (t/ac/yr)	Erosion (t/ac/yr)
J1/N6	Premine	1024.8	0.42	3.79	1.74
J1/N6	Postmine	1039.7	0.22	1.32	1.22
N6 East Central	Premine	474.9	0.42	3.68	0.80
N6 East Central	Postmine	493.6	0.42	1.61	0.65
Combined	Premine	1499.7	0.42	3.76	1.44
Combined	Postmine	1533.3	0.28	1.41	1.03

Table 1.5. Average Physical Properties of the J1/N6 and N6 East Central CRA.		
	Premine	Postmine
Total Area (ac)	1499.7	1533.3
Total Channel Length (ft)	112,844	116,293
Mean Channel Slope	0.0563	0.0576
Drainage Density (mi/mi ²)	9.1	9.2
Mean Hillslope Length (ft)	269	320
Mean Hillslope Gradient	0.1171	0.1149

2. COMPARISONS WITH MEASURED SEDIMENT TRANSPORT

As discussed in Section 1, PWCC has monitored flow and sediment on the main channels, principal tributaries and small watersheds within the leasehold. These data, along with the runoff plots, were used to calibrate the EASI model soil erodibility and infiltration input variables. **Figures 2.1** and **2.2** show sediment transport and sediment concentration versus discharge for measured unmined (background), measured reclaimed, J1/N6 and N6 East Central's modeled unmined (premine) and modeled reclaimed (postmine) data. Although there is significant scatter shown in the data (as is expected with any sediment transport conditions), there are several conclusions that can be drawn from this data.

The open symbols in both figures depict measured data and whether the data were collected from reclaimed areas (the small watershed study) or from unmined or background surface water monitoring stations. The range of flows is generally greater for the background data but there is significant overlap between the two data sets between 0.1 cfs and 100 cfs. This is because the reclaimed data are from small watersheds and the unmined data are from channels draining larger basins. These data show the same trend for sediment transport and sediment concentration over the entire range of flows and very close agreement in the area of discharge overlap. This, in itself, is strong evidence that (1) the sediment yields are channel transport capacity limited, (2) overlap of model predictions for both pre- and postmine conditions with measured data strongly indicate that EASI model predictions are representative and reasonable, and (3) sediment yields from reclaimed areas will not be additive to yields on the receiving streams.

The closed symbols depict data from J1/N6 and N6 East Central's pre- and postmine EASI model runs. They represent data generated by EASI for both subwatersheds and channels for peak discharges resulting from 2-, 5-, 10-, 25-, 50- and 100-year storms. Using the peak flows from extreme events results in discharges that generally exceed 10 cfs. The trend of the model-derived data is similar and the ranges of concentration and sediment transport are similar to the measured data and between pre- and postmine conditions.

The sediment discharge plot (Figure 2.1) shows a stronger trend because it is plotting discharge (sediment) against discharge (flow). This is expected because the sediment discharge does depend on flow discharge. The concentration plot (Figure 2.2) shows the two separate variables and, therefore, a less significant trend. PWCC believes that data measurement may have some influence on the scatter (outliers were removed), but the process variability is probably the major influence. The majority of the data, however, fall in a group centered on 100 cfs and 100,000 mg/l, both in the observed data and in the model results. These plots support the use of the EASI model, the results of the modeling, the conclusion that sediment yields from reclaimed areas are not additive to receiving stream sediment loads, and that sediment impacts to the prevailing hydrologic balance have been minimized.

From Figures 2.1 and 2.2 it is apparent that sediment loads and concentrations are dependent on the channel sediment transport capacity for both pre- and postmine conditions. Channel sources of sediment in this arid environment are virtually unlimited. Therefore, channel transport capacity and channel derived sediment limits and governs sediment yields from the small tributaries, large channels and the CRA as a whole. The similarity of sediment discharge (or concentration) between pre- and postmine conditions appears to be inconsistent with the lower rates of sediment yield shown in Table 1.4.

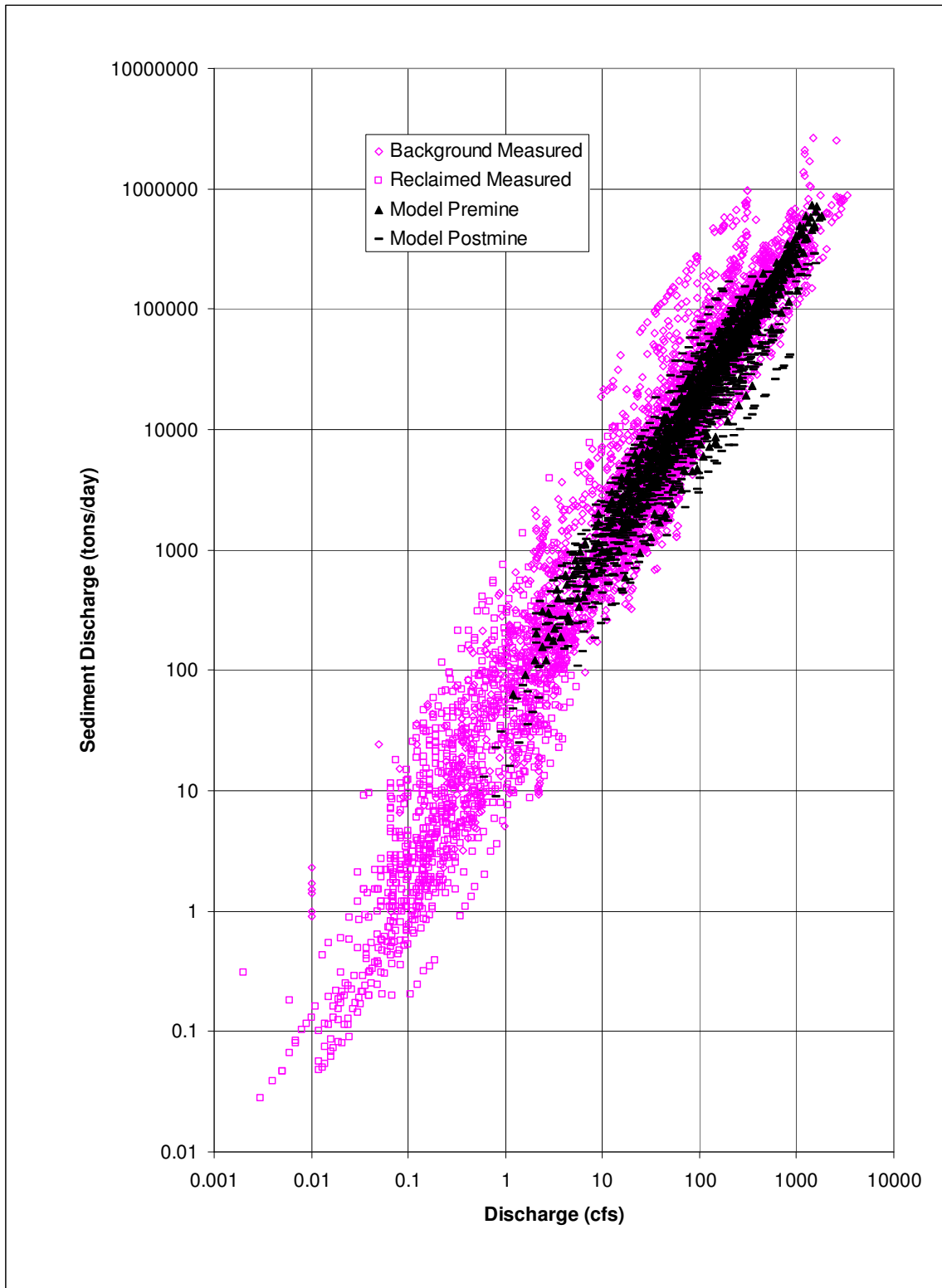


Figure 2.1. Observed and modeled sediment discharge and water discharge.

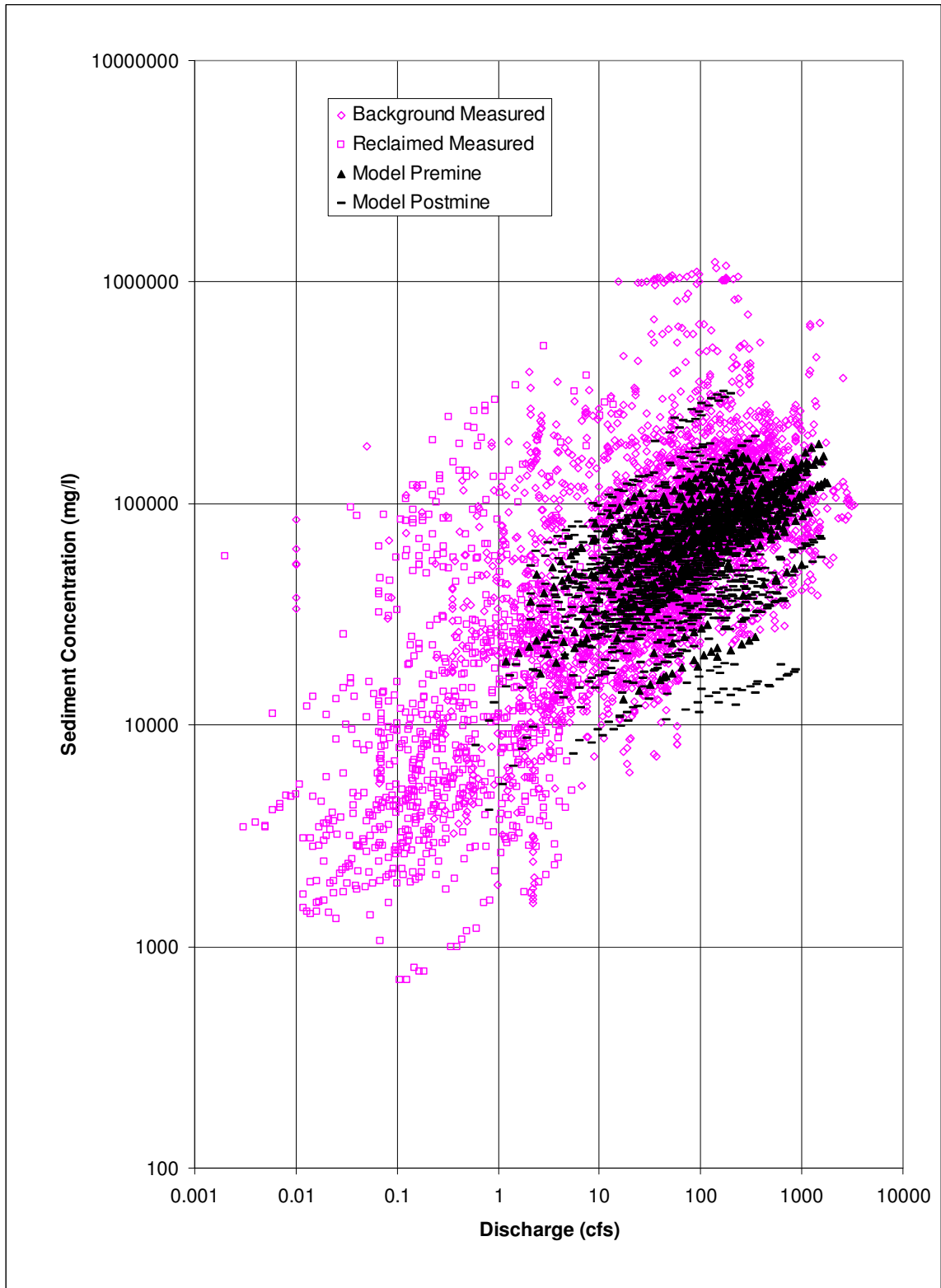


Figure 2.2. Observed versus modeled sediment concentration and discharge.

However, the sediment yield shown in Table 1.4 is the amount of sediment leaving the CRA whereas the sediment discharge shown in Figure 2.1 is the peak rate of sediment in transport occurring in any channel on the CRA, whether the channel is located upstream or downstream of a pond. Therefore, with or without the ponds trapping sediment or storing water, the mine reclamation is not contributing additional sediment to the receiving streams and sediment impacts to the prevailing hydrologic balance have been minimized.

Smith and Best (2000) analyzed the measured data (background and reclaimed) shown in Figure 2.1 to develop an approach that can be used to determine if channels in reclaimed areas have similar sediment transport characteristics as background channels. The method that they used was to develop Sen lines (Sen 1968) and confidence intervals around the data. The slope of the Sen line is a non-parametric statistic computed as the median slope of all possible slopes determined from pairing all the data points. The Sen line is drawn through the median coordinate of the data. Smith and Best first showed that the large channel flume data (background) and the small watershed background data could be combined. They concluded that since the data from one data set fall within the Sen line bounds of the other data set then the two data sets are merely extensions of each other and could be combined. Also, because the main channel and background small watershed site data could be combined, it indicated there is an unlimited supply of sediment and the channels are conveying sediment at (or near) capacity. The Sen line and bounds are shown with the background measured data in **Figure 2.3**.

They then plotted the reclaimed measured data (**Figure 2.4**) with the Sen line and bounds from the background data to show that the reclaimed data have the same characteristics even though the flow range of the measurements is lower. The data indicate that channel flows in this environment achieve the sediment transport capacity of the channel, whether in reclaimed or background conditions.

Using the same approach with the modeled data generated for the CRA, **Figures 2.5 and 2.6** show the pre- and postmine computed sediment transport rates with the Sen lines and bounds. One difference between the plots is that the measured data occur throughout the flow hydrograph whereas the modeled data are tabulated at the peak of the simulation flow hydrograph. The premine data plot (Figure 2.5) shows the data grouped densely around the Sen line and well within the bounds. The postmine data (Figure 2.6) also plot closely around the Sen line and well within bounds. On these graphs data plotting below the Sen line indicate that there is less sediment in transport for a given discharge.

Several conclusions can be drawn from these data plots: (1) EASI model well replicates erosion and sediment transport processes at the mine site for background and reclaimed conditions, (2) all data show similar trends and are within the same bounds, (3) data trends indicate that channels are transporting sediment at or near capacity, and (4) amounts of sediment leaving the CRA for postmine conditions are similar to premine conditions and within the range expected for the background conditions. Therefore, the overall conclusion is that the postmine reclaimed condition in the J1/N6 and N6 East Central CRA is not contributing additional suspended solids to receiving streams, and related impacts to the hydrologic balance have been minimized.

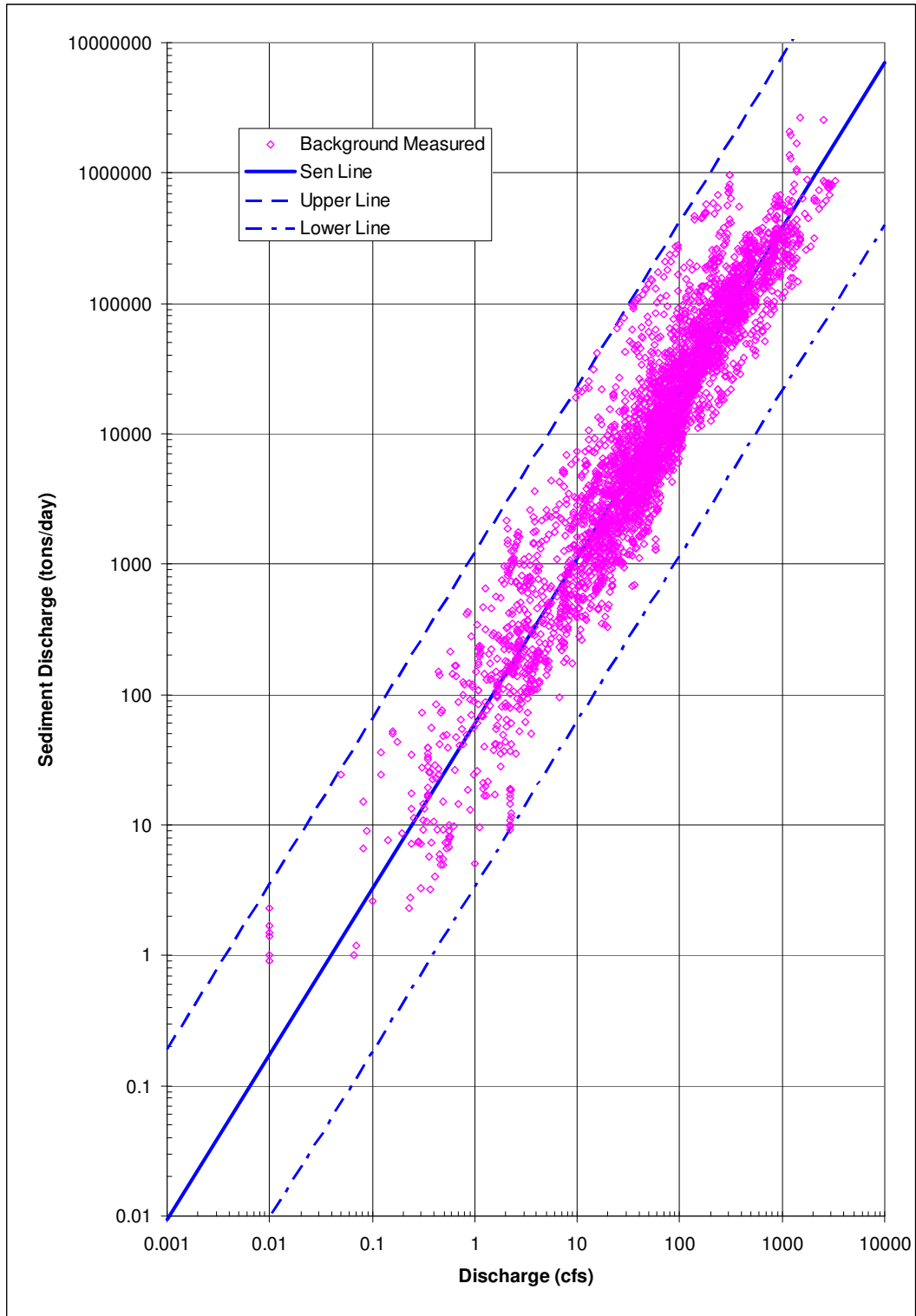


Figure 2.3. Background measured sediment and water discharge.

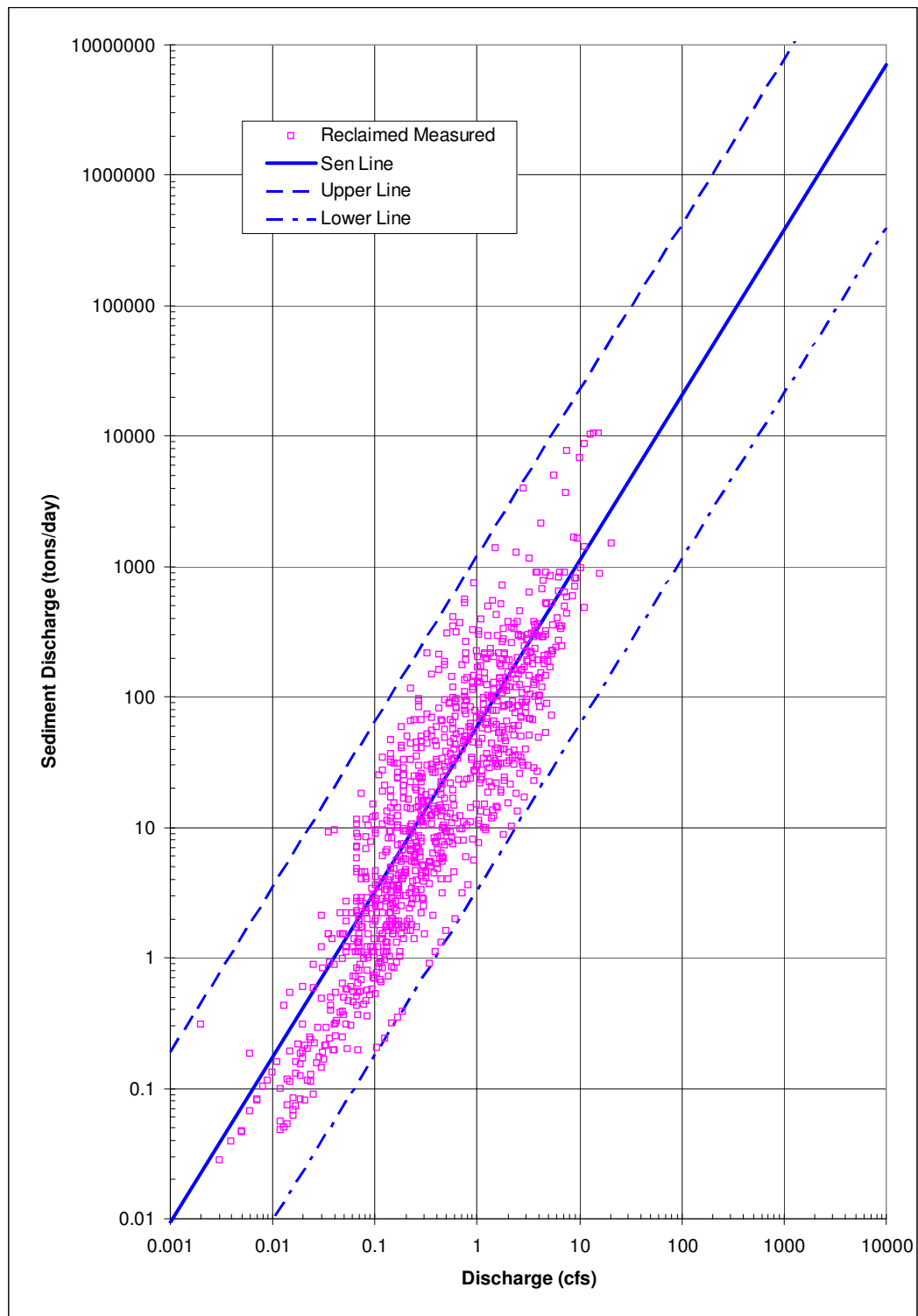


Figure 2.4. Reclaimed measured sediment and water discharge.

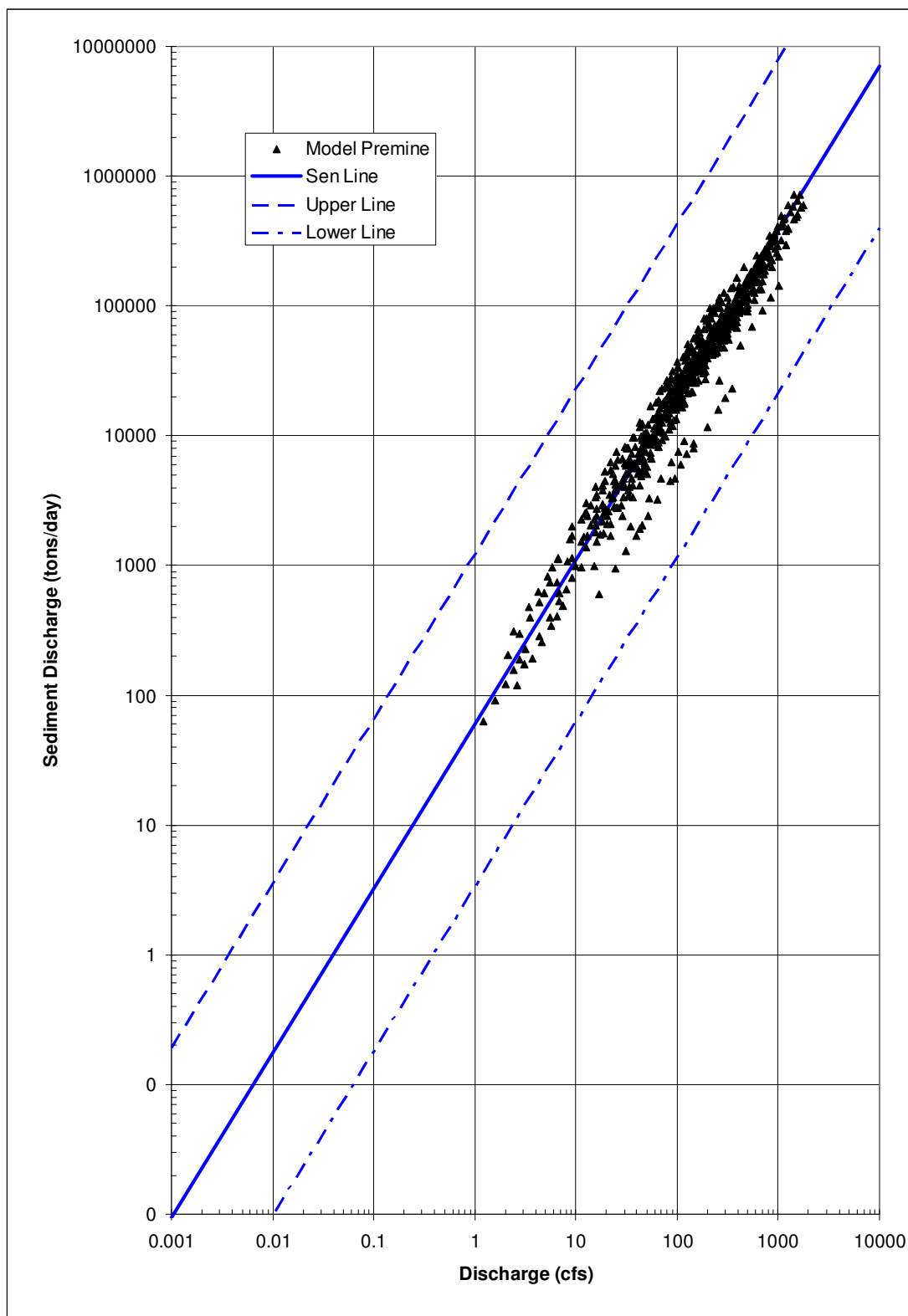


Figure 2.5. Modeled premine sediment and water discharge for J1/N6 and N6 East Central.

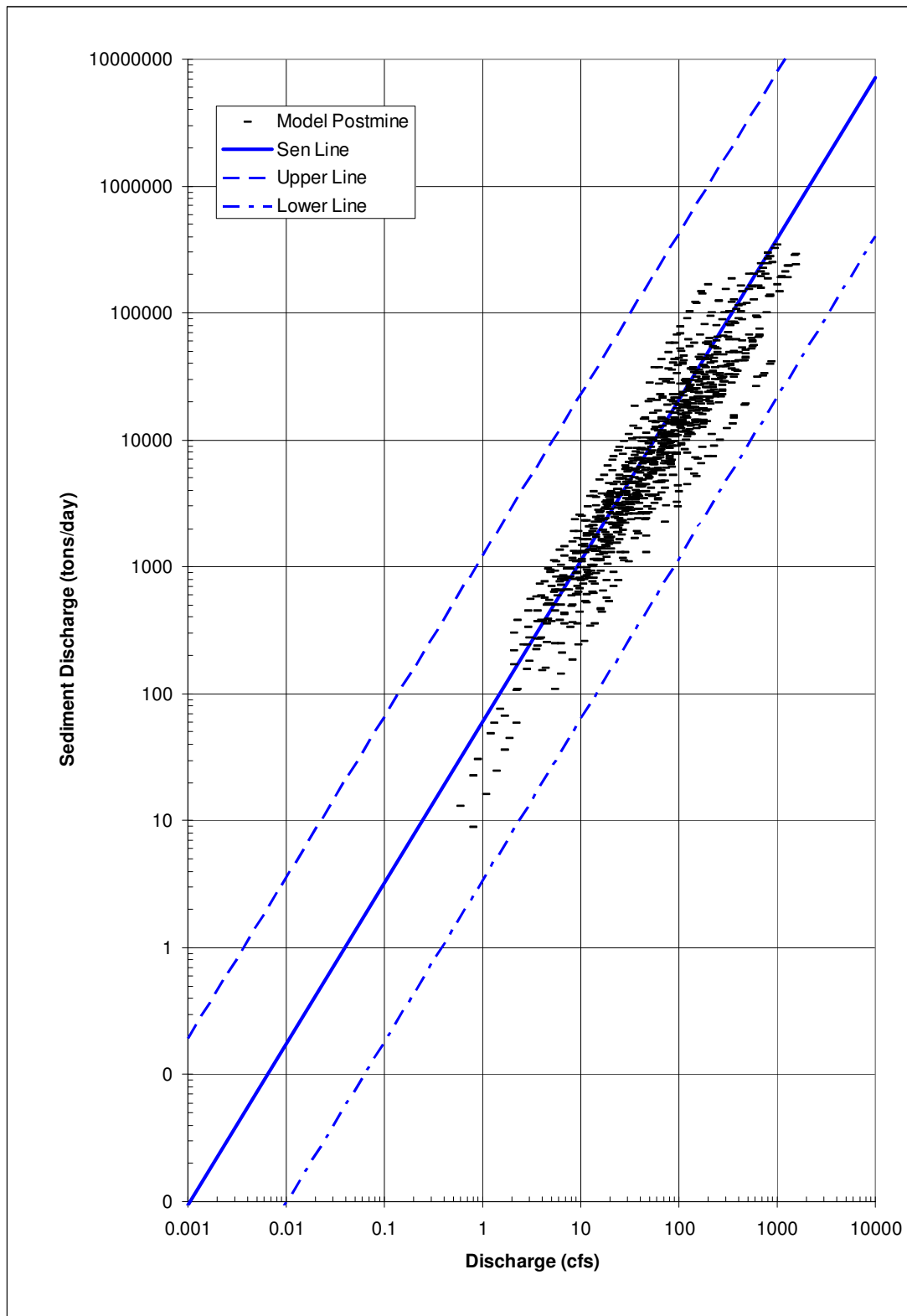


Figure 2.6. Modeled postmine sediment and water discharge for J1/N6 and N6 East Central.

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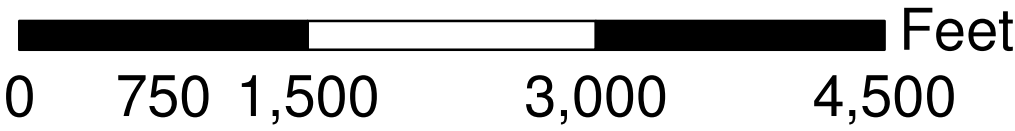
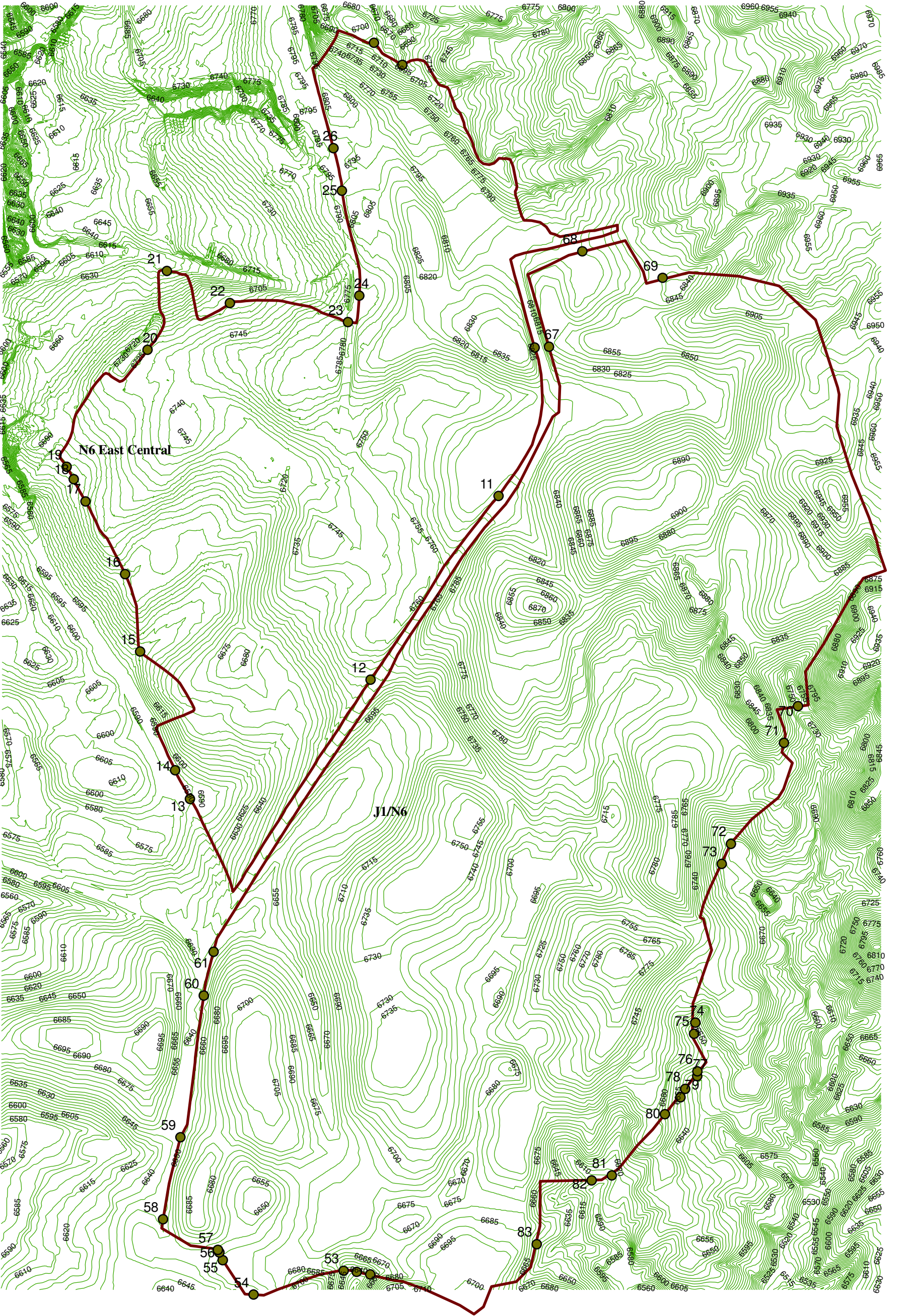
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EXHIBIT 1
Postmine Topography



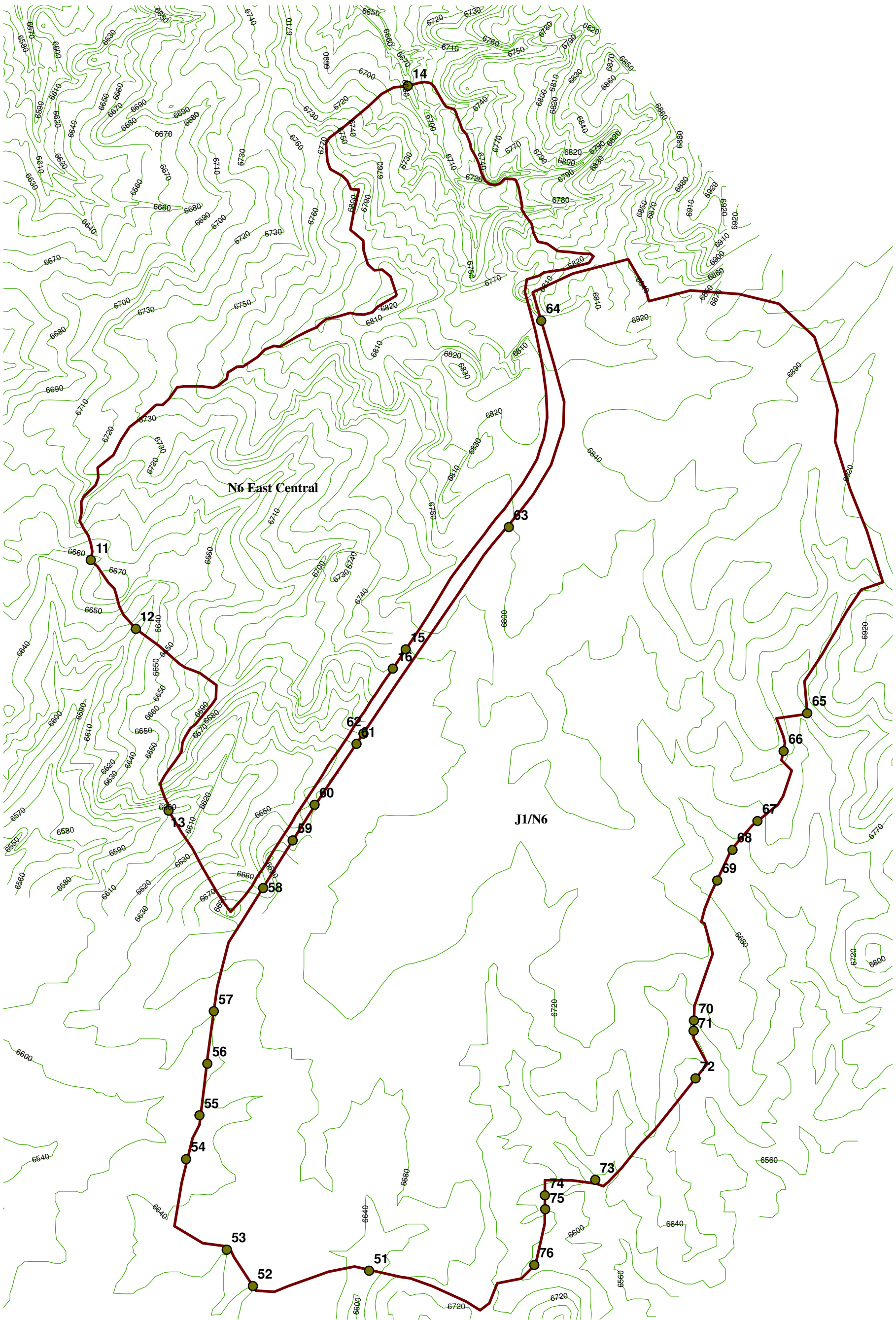
Legend

- End Points
- Modeling Area Post



Exhibit 1. Postmine Topography
(5 foot contour)

EXHIBIT 2
Premine Topography



Legend

- End Points
- ▭ Modeling Area Pre

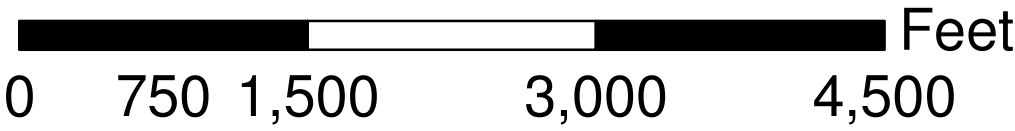


Exhibit 2. Premine Topography
(10 & 40 foot contour)

**SURFACE WATER MODELING OF RECLAIMED PARCELS AT THE
J19 COAL RESOURCE AREA, KAYENTA COMPLEX**

**Peabody Western Coal Company
Highway 160, Navajo Route 41
Kayenta, Arizona 86033**



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September 2011

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1. RECLAIMED PARCEL MODELING

1.1 Introduction

The purpose of this project is to use a previously calibrated and validated runoff and erosion model EASI - Erosion And Sediment Impacts (Zevenbergen et al. 1990; WET 1990) for the Kayenta Complex (previously identified as the Black Mesa and Kayenta Mines) to predict mean annual runoff and sediment yields from the reclaimed parcel J19. The objective of this project included computation of runoff and sediment yields under premine conditions for the same area. The response of the reclaimed parcels was evaluated relative to undisturbed (premine) conditions in the corresponding undisturbed watersheds. All soils and rainfall input to the model were taken from models calibrated in the previous study (RCE 1993). The input variables that were calibrated to the mine areas and used in this study include soil infiltration parameters, erodibility parameters, and the grain size distribution. Parameters that are specific to this study are vegetative canopy and ground cover percentages from data collected on site. The model serves as a tool for assessing the success of reclamation efforts to protect the hydrologic balance (30 CFR 715.17 and 30 CFR 816.41).

The model calibration was conducted in a previous study (RCE 1993) using data obtained from instrumented watersheds and small hillslope plots collected under natural rainfall conditions. For a detailed discussion of data collection and model calibration, please refer to the previous study (RCE 1993).

1.2 Background

The J19 Coal Resource Area (CRA) at the Kayenta Complex that is the focus of this project was reclaimed between 1989 and 2010. This reclaimed area is now eligible for Phase II Bond Release from the Office of Surface Mining Reclamation and Enforcement (OSM). The fundamental purpose of this study was to quantify the expected behavior and hydrologic response of the current conditions of reclaimed areas relative to the conditions that existed prior to the occurrence of mining activities.

Runoff and sediment yield response from the reclaimed lands should be managed by implementing Best Management Practices (BMP's) in conjunction with an OSM approved reclamation plan in order to not adversely impact the prevailing hydrologic balance and to limit additional contributions of suspended sediment to streamflow or runoff outside the mine permit areas. BMP's include regrading, replacing salvaged topsoil, revegetation, and other controls such as riprapped channel bottoms, check dams, rock down drains, and where practicable, contour terraces. The natural watersheds on Black Mesa contribute significant quantities of sediment to the channel system. It is expected that the postmine condition will also produce comparable amounts of sediment without adversely impacting the hydrologic balance.

The next sections describe the data and procedures used to evaluate the J19 CRA. This area was modeled to determine the average annual hydrologic response following the completion of reclamation activities and maturation of the reclaimed area vegetation taking into account BMP's implemented as part of the reclamation process. Infiltration, runoff, and erosion processes from both hillslopes and channels within the CRA were modeled using EASI. Results were determined for concentration points at the outlets of the reclaimed watersheds. The locations of these points are shown in **Exhibit 1**. Modeling was also conducted to determine hydrologic response under premine conditions based on the topography, soils, cover, and other conditions that typified the undisturbed watersheds draining to each concentration point. **Exhibit 2** shows the modeling endpoints for the J19 premining watersheds.

1.3 Data

1.3.1 Soils

Soils data used for the current study (CRA J19) were based on data developed from the calibration of models used in the previous study for Coal Resource Areas (CRAs) N1/N2 and J27 (RCE 1993). The composition of postmine soil in the current study is depicted along with the composition of postmine soils from the previous study in **Figure 1.1**. This figure shows that the soil composition of CRA J19 is very similar to soils evaluated during model calibration. Therefore, the soil properties developed in the previous study are valid for this modeling project. These properties include calibrated parameters, such as infiltration and erodibility coefficients, and measured soil size distributions. **Table 1.1** lists the premine and postmine soils data used during EASI modeling of CRA J19.

1.3.2 Vegetation

Vegetative cover data representative of both pre- and postmine conditions in CRA J19 were supplied by PWCC. For the premine condition, land was characterized as being covered by sagebrush or pinon juniper. The spatial distribution of vegetative cover for the J19 CRA premine condition appears in **Figure 1.2**. Average cover properties for CRAs N1/N2 and J27 of the previous study and CRA J19 of the current study appear in **Table 1.2**. For the postmine condition, the reclaimed area was assigned the postmine cover type and any unmined area was assigned the same cover type as the premine condition. **Table 1.3** lists the pre- and postmine vegetative cover data used in the EASI model runs generated for the J19 CRA. Note that if a unit contained significant portions of both sagebrush and pinon juniper cover types, it was classified as half pinon juniper and half sagebrush.

1.3.3 Topography

Pre- and postmine topography was supplied by PWCC in the form of ArcGIS geodatabase. Basin delineations, hillslope delineations, subwatershed delineations, as well as areas, slopes, and lengths of all units of the study area were defined and calculated using ArcGIS software. **Figures 1.3 and 1.4** show the watershed delineation and numbers assigned to the basins used in the EASI model for the post- and premine conditions, respectively. Channel dimensions input to EASI were based on the topography supplied and limited field observations.

1.4 Methodology

Runoff and sediment yield in the semiarid western United States is largely governed by the occurrence of high-intensity, short-duration rainstorms of limited areal extent (Renard and Simanton 1975). Research has indicated that relatively few events may produce the greatest erosion (e.g., Hjelmfelt et al. 1986 reported that only 3 to 4% of rainfall events accounted for 50% of long-term sediment yields). Although there is a relatively limited physical basis for definition of an "average annual" runoff or sediment yield in a semiarid environment due to the extreme variability in response and importance of single infrequent events, such a term does provide a useful basis for long-term comparison between reclaimed and undisturbed conditions.

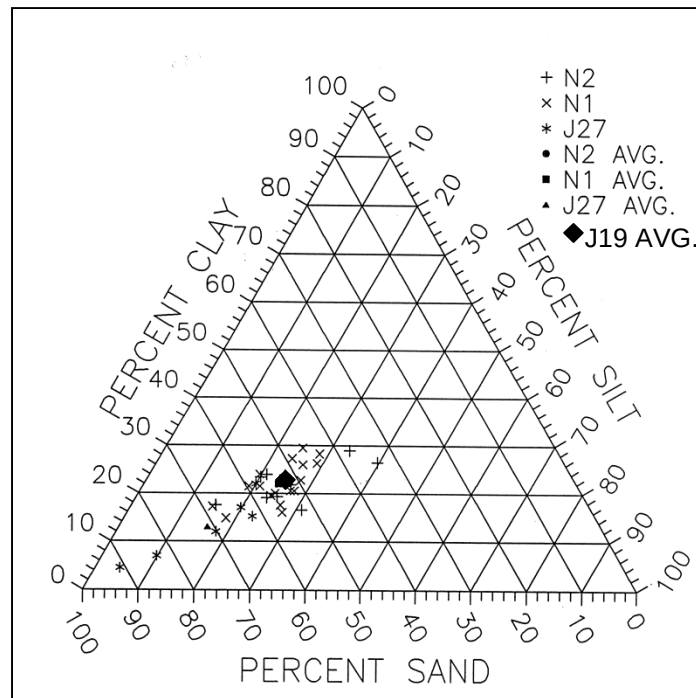


Figure 1.1. Reclaimed Area Soils Trilinear Graph.

Table 1.1. Soils Data.			
Condition	Premine	Postmine	Rock Chutes
Rainfall detachment	0.005	0.005	0
Overland flow detachment	0.44	0.44	0
Channel flow detachment	0.5	0.5	0
Initial soil moisture, %	70	70	70
Final soil moisture, %	90	90	90
Soil porosity, %	45	45	46
Temperature, *F	70	70	70
Hydraulic conductivity, in/hr	0.23	0.29	0.3
Capillary suction, in	3.7	2.6	2.6
Particle Size Distribution (all conditions)			
	Size, mm	% Finer	
	0.001	0	
	0.004	18.0	
	0.016	27.4	
	0.062	36.6	
	0.125	56.2	
	0.250	64.3	
	0.500	72.4	
	1.000	80.5	
	2.000	88.6	
	4.000	92.4	
	16.000	100	

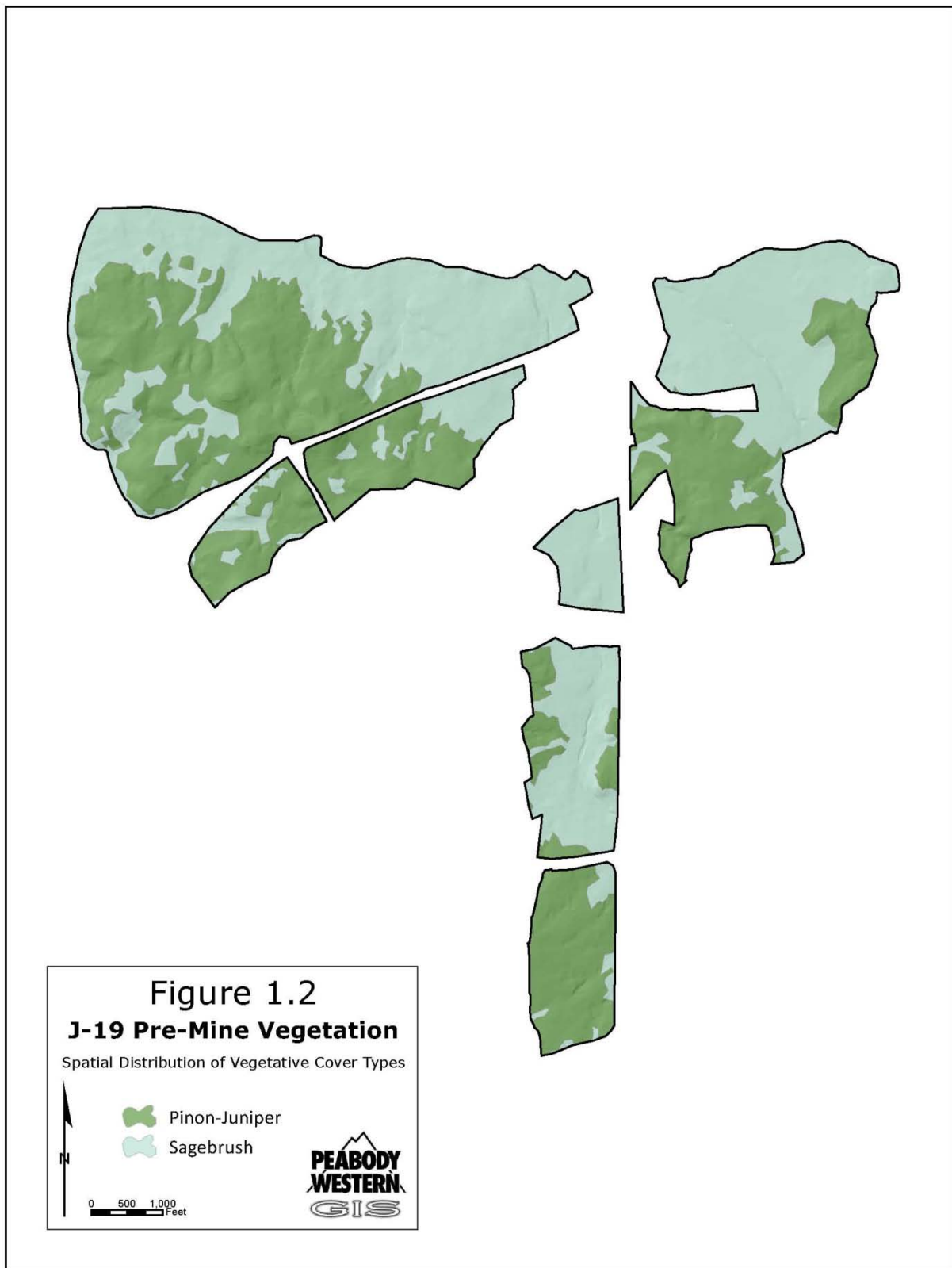


Figure 1.2. Spatial Distribution of Vegetative Cover Types for J19 Pre-Mine Condition.

Table 1.2. Cover Sampling Data.								
Area	Condition	Cover Type	Nonstratified Vegetation Cover (%)	Vegetation Canopy Cover (%)	Vegetation Ground Cover (%)	Litter* (%)	Rock (%)	Total Ground Cover (%)
N1/N2	Postmine	Postmine	25.6	1.4	24.2	13.6	4.2	42.0
J19	Postmine	Postmine	28.8	0.2	31.3	17.9	6.6	55.8
N1/N2/J27	Premine	Pinon Juniper	32.7	31.1	3.0	44.0	19.7	66.7
J19	Premine	Pinon Juniper	19.1	17.0	2.5	28.8	16.7	48.0
N1/N2	Premine	Sagebrush	25.1	16.0	10.3	25.3	18.1	53.7
J27	Premine	Sagebrush	30.6	9.7	22.0	24.0	1.6	47.6
J19	Premine	Sagebrush	16.7	3.8	13.4	30.6	1.7	45.7
*Including standing dead litter								

Table 1.3. Cover Data for J19.				
Condition	Pinon Juniper	Sagebrush	Half Pinon Juniper-Half Sagebrush	Postmine
Canopy cover, %	17.0	3.8	10.4	0.2
Ground cover, %	48.0	45.7	46.9	55.8
Canopy storage, in	0.05	0.05	0.05	0.05
Ground storage, in	0.05	0.05	0.05	0.05
Depression storage, in	0.03	0.03	0.03	0.03
Impervious area, %	0	0	0	0
Manning n	0.07	0.07	0.07	0.05

To make comparisons between reclaimed lands and associated undisturbed lands at the Kayenta Complex on the basis of average annual sediment yield, a procedure was used that considers the importance of infrequent storm events in defining sediment yield in the semiarid west. First, however, the site-specific rainfall data available for the Kayenta Complex were used to evaluate the frequency and magnitude of the measured events relative to existing predictions for rainfall depth-duration (Miller et al. 1973). The analysis of the rainfall data was performed as part of a previous study of the N1/N2 and J27 CRAs (RCE 1993).

Comparisons between runoff and sediment yield from undisturbed and reclaimed areas in CRA J19 were developed for specific modeling endpoints shown in Exhibits 1 and 2. Mining and reclamation activities did not exactly replicate the topography, drainage network, or drainage areas that existed prior to mining. Consequently, direct comparisons of total runoff and sediment yield cannot be made between undisturbed and reclaimed response at a given point in a watershed. Comparisons were made on the basis of unit rates of runoff (inches) and sediment yield (tons/acre) at the various modeling computation endpoints. Although the same disturbance boundary was used to define the extent of both pre- and postmine conditions, the topographic differences that resulted after mining and reclamation occurred in the J19 CRA dictated that some areas would be included or excluded from the modeling. The total area modeled for premine conditions is 943.4 acres (Exhibit 2) and for postmine conditions is 943.4 acres (Exhibit 1).

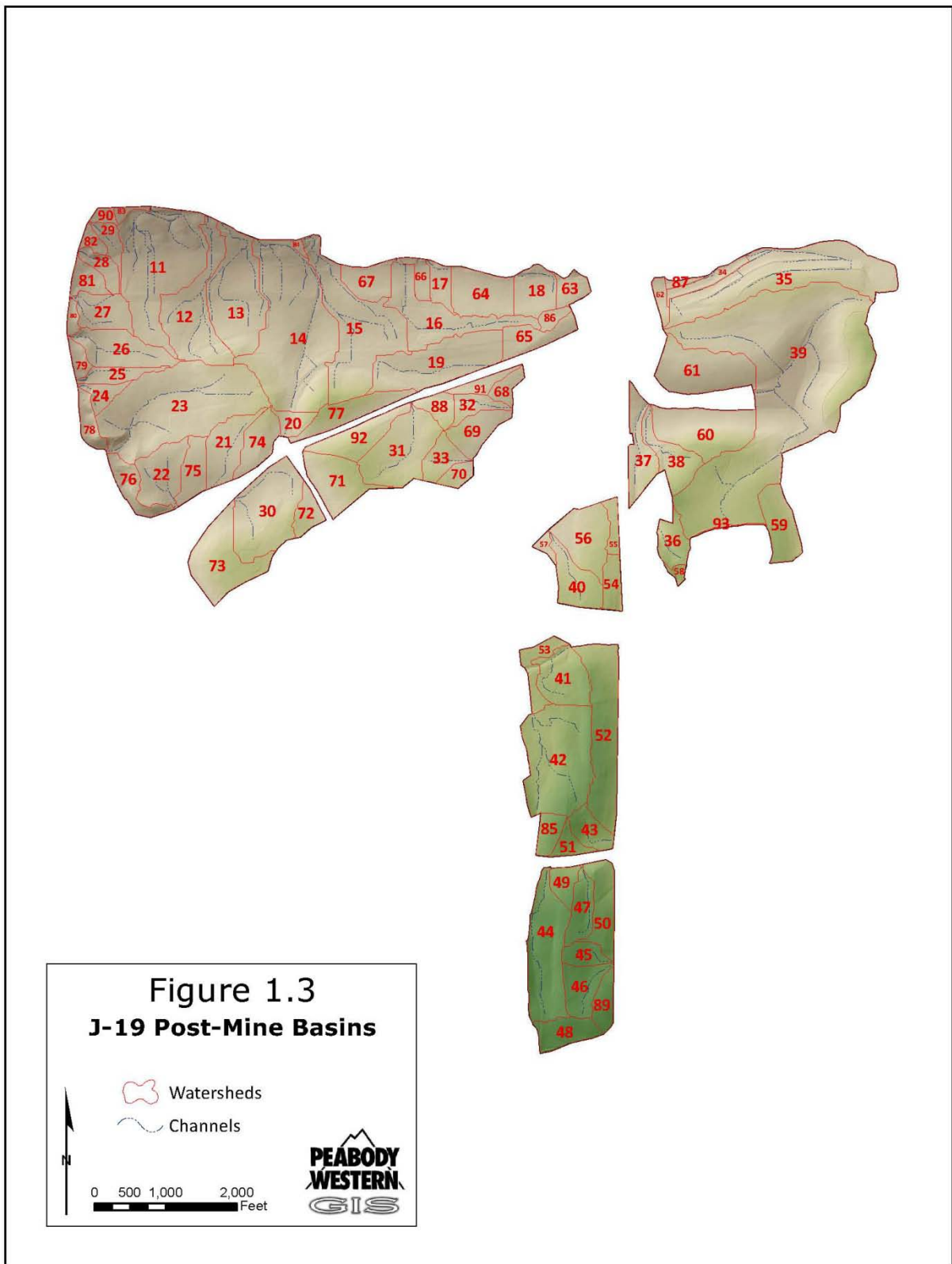


Figure 1.3. J19 Post-Mine Basins.

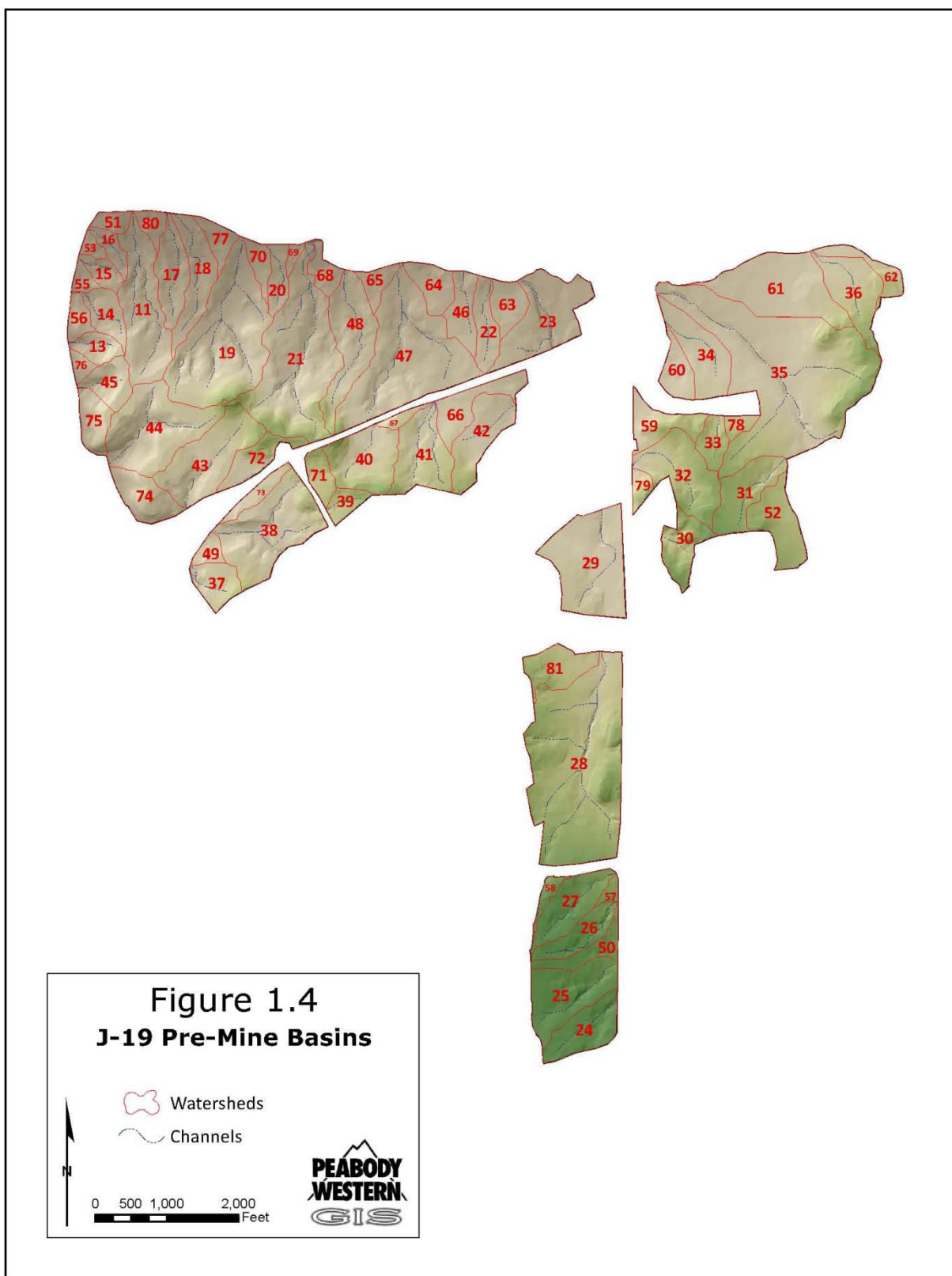


Figure 1.4. J19 Pre-Mine Basins.

1.4.1 Synthetic Rainfall

Synthetic storms of 2-, 5-, 10-, 25-, 50-, and 100-year return periods were used as input to the EASI model. Actual hyetographs were taken from the previous study (RCE 1993) and are based on both local data collection and the NOAA Atlas (Miller et al. 1973).

1.4.2 Computation of Average Runoff and Sediment Yield

The EASI model was used to evaluate runoff and sediment yield from a series of storm events having recurrence intervals of 2-, 5-, 10-, 25-, 50-, and 100 years. To define average annual conditions, the average annual runoff and sediment yield generated from storm events were computed using the commonly used equation of Lagasse et al. (1985).

1.5 Results

Figures 1.3 and 1.4 show the post- and premine basin delineations. Since the individual subareas differ in number, acreage and outlet locations, a direct comparison is not possible on a subarea basis. Therefore, the best way to compare the results is on an average annual basis for the CRA. **Table 1.4** shows pre- and postmine drainage area, runoff, sediment yield, and erosion for the J19 CRA. Runoff is defined as the total volume of water leaving the CRA on an average annual basis and, therefore, does not include water stored in depression areas and ponds. For the premine condition, this is equal to the amount of water that drains off the hillslopes and subwatersheds because there were no ponds or significant depressions. For the postmine condition, this is equal to the amount of hillslope runoff less the amount stored in ponds. Similarly, the sediment yield is the amount of eroded material that leaves the CRA on an average annual basis computed using the equation of Lagasse et al. (1985). The sediment yield is the production from the hillslope and subwatershed areas and erosion from the channels. The amount of erosion is the sediment yield from the hillslopes and subwatersheds only and does not include channel erosion, channel deposition or sediment trapped in ponds. Sediment yield can be greater or less than erosion, depending on the amount of channel erosion and the capacity of the channel network to convey sediment off the leasehold.

For the postmine condition, sediment yield is substantially less than the premine condition. Postmining sediment yield is approximately 71% of the premine amount. Runoff is the same as the premine amount for the J19 CRA. Hillslope and subwatershed erosion rates are about 9% higher for the reclaimed (postmine) condition than the premine condition. However, the erosion rates are comparable between both conditions, and remain below 1.0 tons/acre/year. The reduction of sediment yield is due to effective hydrologic cover combined with effective channel erosion control measures in the postmining landscape.

1.6 Discussion

Table 1.5 gives an overview of the geometric properties of the pre- and postmine topographies for the J19 CRA. Postmine hillslopes are generally about 15% shorter and 7% steeper than premine hillslopes, postmine channels are slightly less steep than premine channels, and the drainage density of the postmine condition is about 13% greater than that of the premine condition. These properties agree with the postmine versus premine topography: the premine topography is fully dissected.

Table 1.4. Average Runoff and Sediment Yield Results.					
Area	Condition	Drainage Area (ac)	Runoff (in)	Sediment Yield (t/ac/yr)	Erosion (t/ac/yr)
J19	Premine	943.4	0.42	3.13	0.75
J19	Postmine	943.4	0.42	2.22	0.82

Table 1.5. Average Physical Properties of the J19 CRA.		
	Premine	Postmine
Total Area (ac)	943.4	943.4
Total Channel Length (ft)	70,077	79,298
Mean Channel Slope	0.0662	0.0653
Drainage Density (mi/mi ²)	9.0	10.2
Mean Hillslope Length (ft)	243	206
Mean Hillslope Gradient	0.1115	0.1197

2. COMPARISONS WITH MEASURED SEDIMENT TRANSPORT

2.1 Sediment Discharge and Concentration

As discussed in Section 1, PWCC has monitored flow and sediment on the main channels, principal tributaries and small watersheds within the leasehold. These data, along with the runoff plots, were used to calibrate the EASI model soil erodibility and infiltration input variables. **Figures 2.1** and **2.2** show sediment transport and sediment concentration versus discharge for measured unmined (background), measured reclaimed, modeled unmined (J19 premine) and modeled reclaimed (J19 postmine) data. Although there is significant scatter shown in the data (as is expected with sediment transport), there are several conclusions that can be drawn from this data.

The open symbols in both figures depict measured data and whether the data were collected from reclaimed areas (the small watershed study) or from unmined or background surface water monitoring stations. The range of flows is generally greater for the background data but there is significant overlap between the two data sets between 0.1 cfs and 100 cfs. This is because the reclaimed data are from small watersheds and the unmined data are from channels draining larger basins. These data show the same trend for sediment transport and sediment concentration over the entire range of flows and very close agreement in the area of discharge overlap. This, in itself, is strong evidence that (1) the sediment yields are channel transport capacity limited, (2) overlap of model predictions for both pre- and postmine conditions with measured data strongly indicate that EASI model predictions are representative and reasonable, and (3) sediment yields from reclaimed areas will not be additive to yields on the receiving streams.

The closed symbols depict data from the J19 CRA pre- and postmine EASI model runs. They represent data generated by EASI for both subwatersheds and channels for peak discharges resulting from 2-, 5-, 10-, 25-, 50- and 100-year storms. Using the peak flows from extreme events results in discharges that generally exceed 10 cfs. The trend of the model-derived data is similar and the ranges of concentration and sediment transport are similar to the measured data and between pre- and postmine conditions.

The sediment discharge plot (**Figure 2.1**) shows a stronger trend because it is plotting discharge (sediment) against discharge (flow). This is expected because the sediment discharge does depend on flow discharge. The concentration plot (**Figure 2.2**) shows the two separate variables and, therefore, a less significant trend. PWCC believes that data measurement may have some influence on the scatter (outliers were removed), but the process variability is probably the major influence. The majority of the data, however, fall in a group centered between 10 and 100 cfs and between 10,000 and 100,000 mg/l, both in the observed data and in the model results. These plots support the use of the EASI model, the results of the modeling, the conclusion that sediment yields from reclaimed areas are not additive to receiving stream sediment loads, and that sediment impacts to the prevailing hydrologic balance have been minimized.

From **Figures 2.1** and **2.2** it is apparent that sediment loads and concentrations are dependent on the channel sediment transport capacity for both pre- and postmine conditions. Channel sources of sediment in this arid environment are virtually unlimited. Therefore, channel transport capacity and channel derived sediment limits and governs sediment yields from the small tributaries, large channels and the CRA as a whole. The similarity of sediment discharge (or concentration) between pre- and postmine conditions appears to be inconsistent with the lower rates of sediment yield shown in **Table 1.4**.

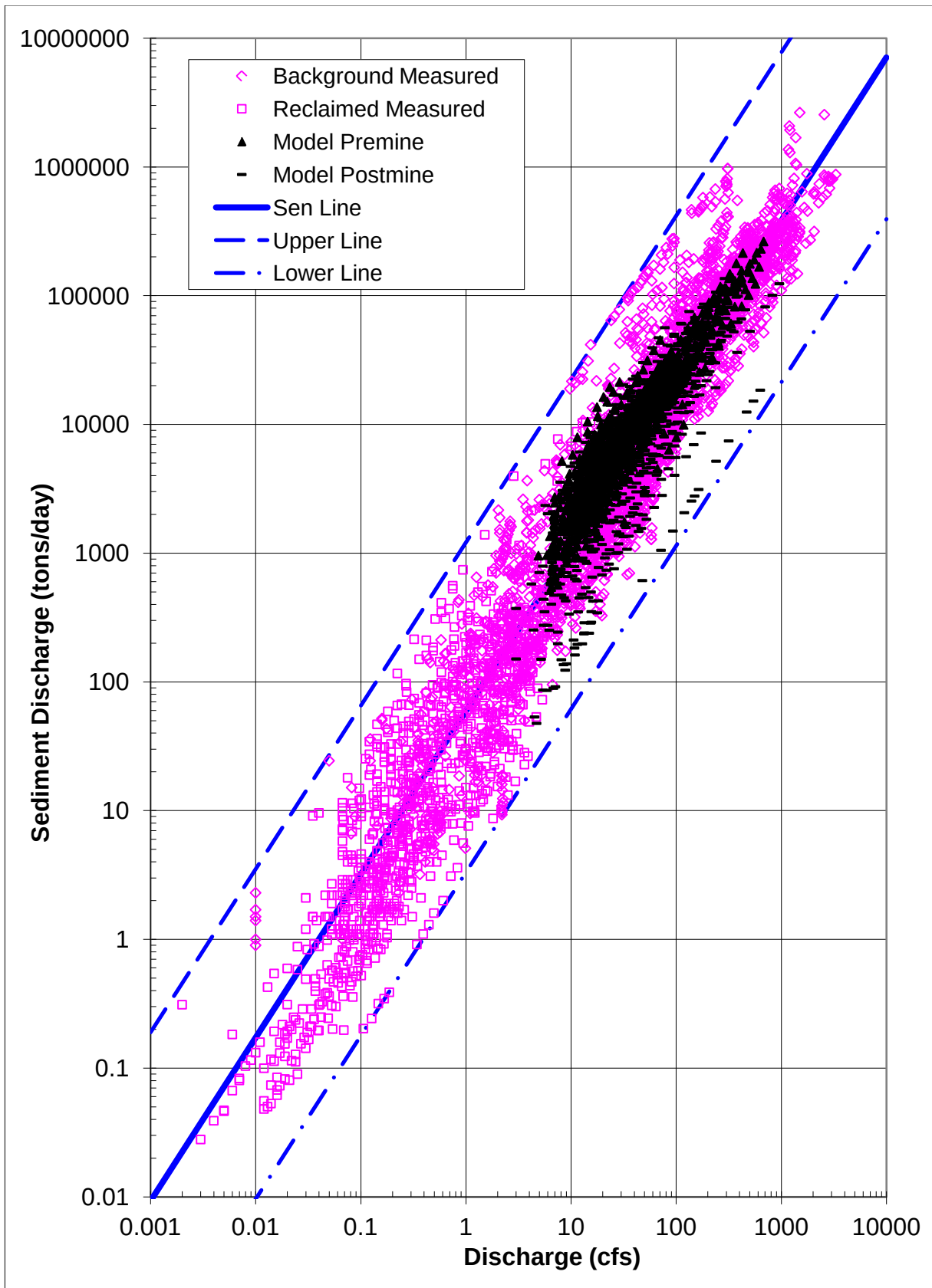


Figure 2.1. Observed and Modeled Sediment Discharge and Water Discharge.

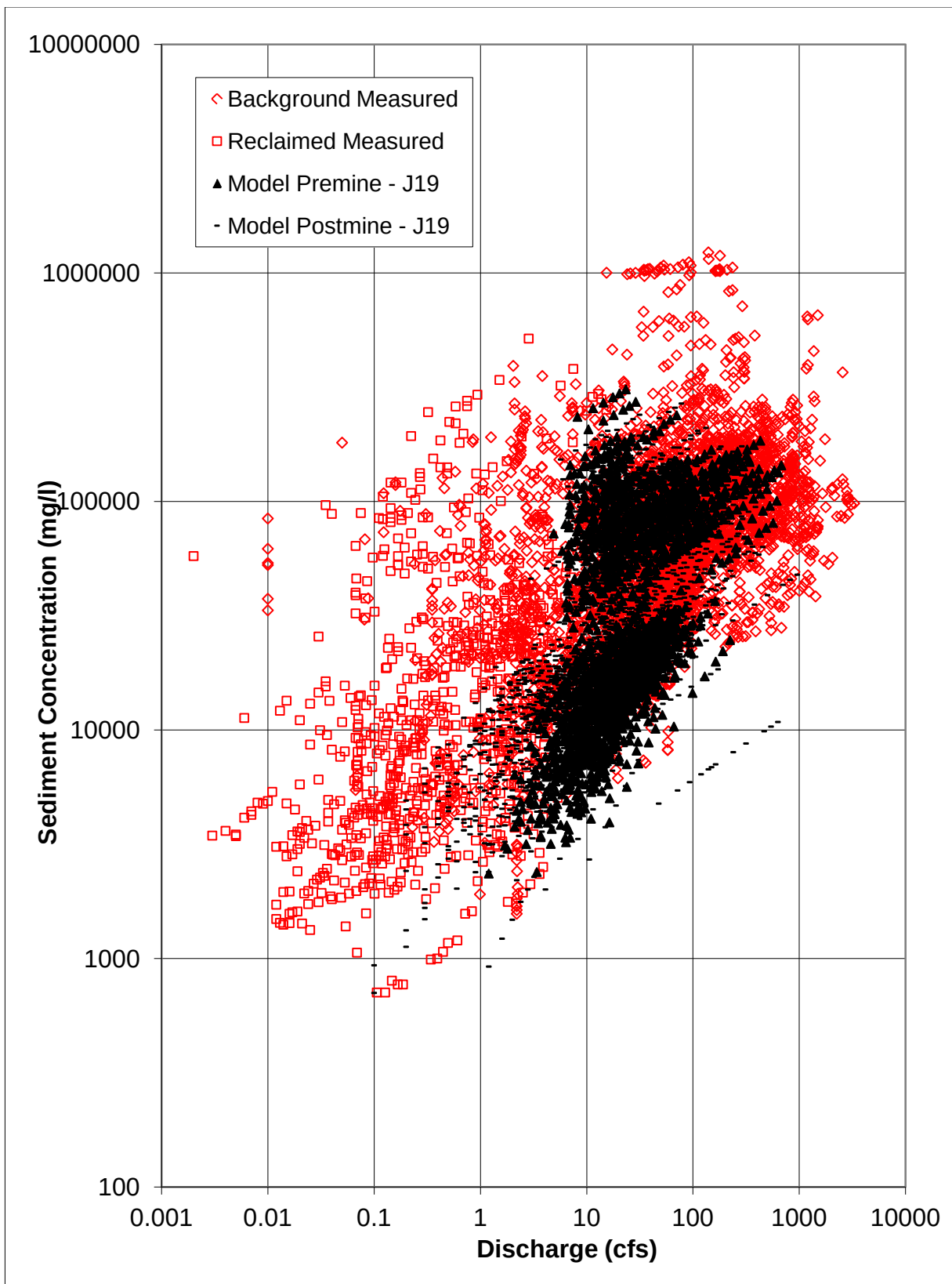


Figure 2.2. Observed versus Modeled Sediment Concentration and Discharge.

However, the sediment yield shown in **Table 1.4** is the amount of sediment leaving the CRA whereas the sediment discharge shown in **Figure 2.1** is the peak rate of sediment in transport occurring in any channel on the CRA, whether the channel is located upstream or downstream of a pond. Therefore, with or without the ponds trapping sediment or storing water, the mine reclamation is not contributing additional sediment to the receiving streams, and sediment impacts to the prevailing hydrologic balance have been minimized.

2.2 Statistical Analysis

Smith and Best (2000) analyzed the measured data (background and reclaimed) shown in **Figure 2.1** to develop an approach that can be used to determine if channels in reclaimed areas have similar sediment transport characteristics as background channels. The method that they used was to develop Sen lines (Sen 1968) and confidence intervals around the data. The slope of the Sen line is a non-parametric statistic computed as the median slope of all possible slopes determined from pairing all the data points. The Sen line is drawn through the median coordinate of the data. Smith and Best first showed that the large channel flume data (background) and the small watershed background data could be combined. They concluded that since the data from one data set fall within the Sen line bounds of the other data set then the two data sets are merely extensions of each other and could be combined. Also, because the main channel and background small watershed site data could be combined, it indicated there is an unlimited supply of sediment and the channels are conveying sediment at (or near) capacity. The Sen line and bounds are shown with the background measured data in **Figure 2.3**.

Smith and Best then plotted the reclaimed measured data (**Figure 2.4**) with the Sen line and bounds from the background data to show that the reclaimed data have the same characteristics even though the flow range of the measurements is lower. The data indicate that channel flows in this environment achieve the sediment transport capacity of the channel, whether in reclaimed or background conditions.

Using the same approach with the modeled data generated for the J19 CRA, **Figures 2.5 and 2.6** show the pre- and postmine computed sediment transport rates with the Sen lines and bounds, respectively. One difference between the plots is that the measured data occur throughout the flow hydrograph whereas the modeled data are tabulated at the peak of the simulation flow hydrograph. The premine data plot (**Figure 2.5**) shows the data grouped densely around the Sen line and well within the bounds. The postmine data (**Figure 2.6**) also plot closely around the Sen line and well within bounds.

2.3 Conclusions

Several conclusions can be drawn from these data plots: (1) the EASI model well replicates erosion and sediment transport processes at the mine site for background and reclaimed conditions, (2) all data show similar trends and are within the same bounds, (3) data trends indicate that channels are transporting sediment at or near capacity, and (4) amounts of sediment leaving the CRA for postmine conditions are similar to premine conditions and within the range expected for the background conditions. Therefore, the overall conclusion is that the postmine reclaimed condition in the J19 CRA is not contributing additional suspended solids to receiving streams, and related impacts to the hydrologic balance have been minimized.

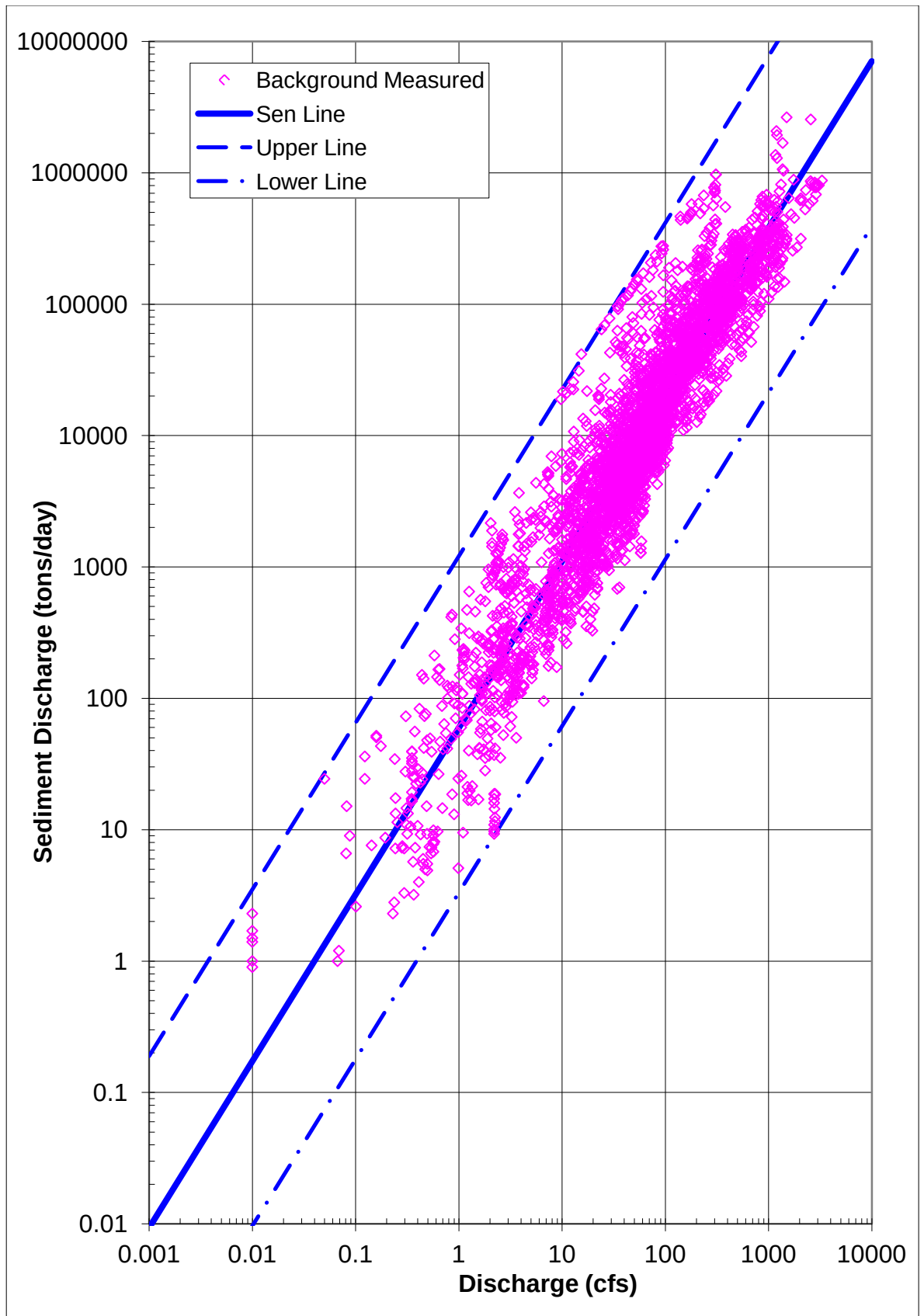


Figure 2.3. Background Measured Sediment and Water Discharge.

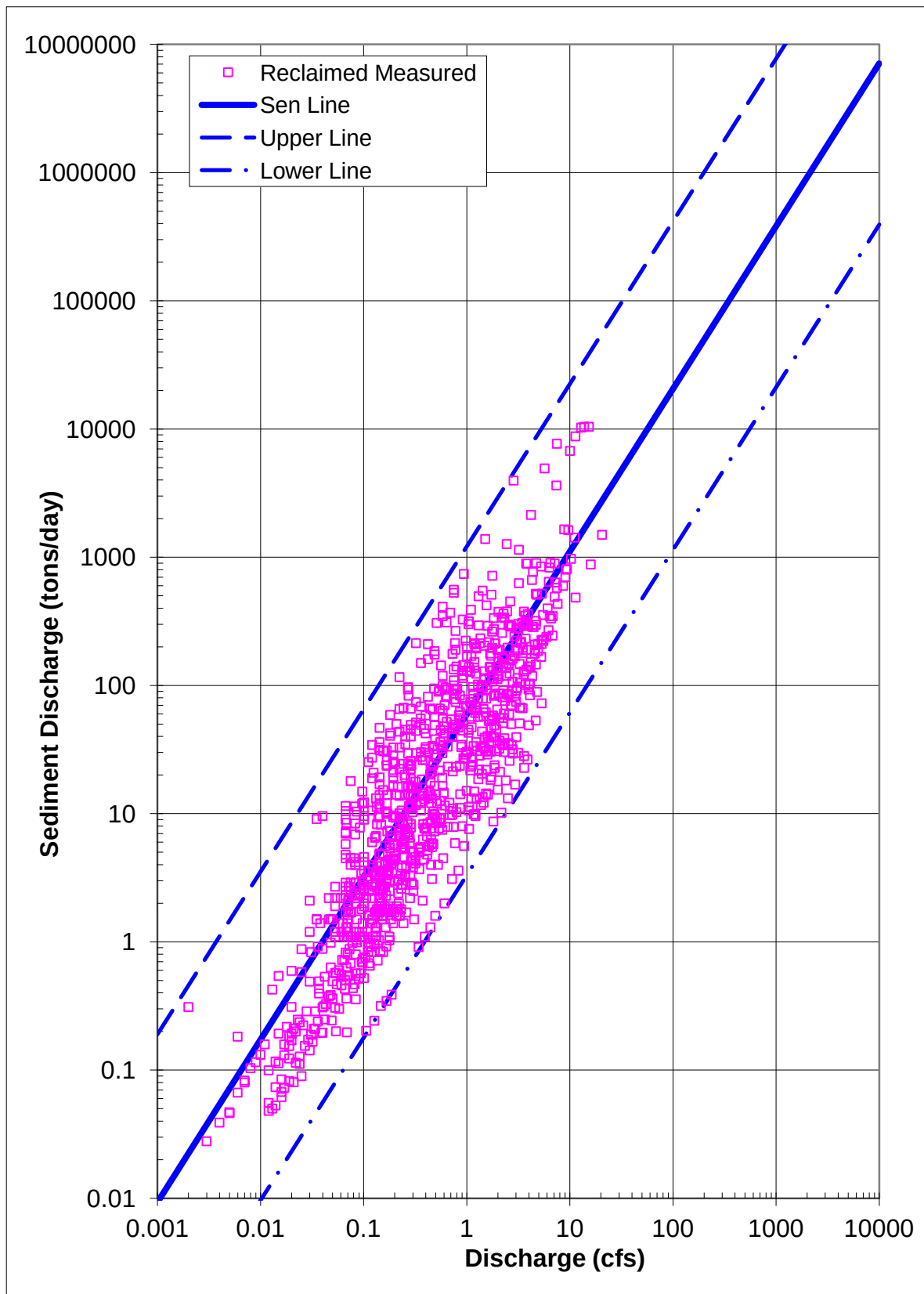


Figure 2.4. Reclaimed Measured Sediment and Water Discharge.

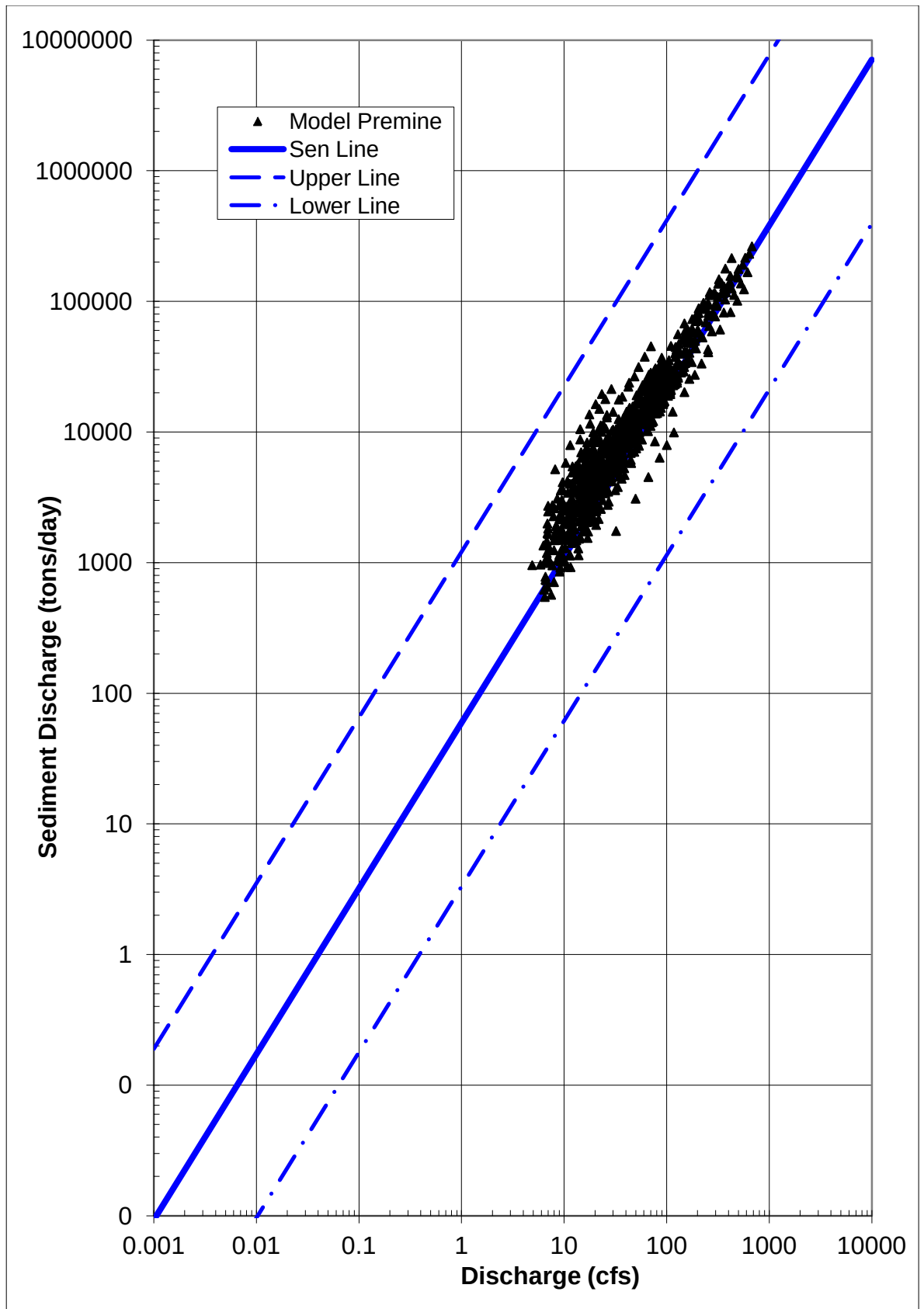


Figure 2.5. Modeled Pre-Mine Sediment and Water Discharge for J19.

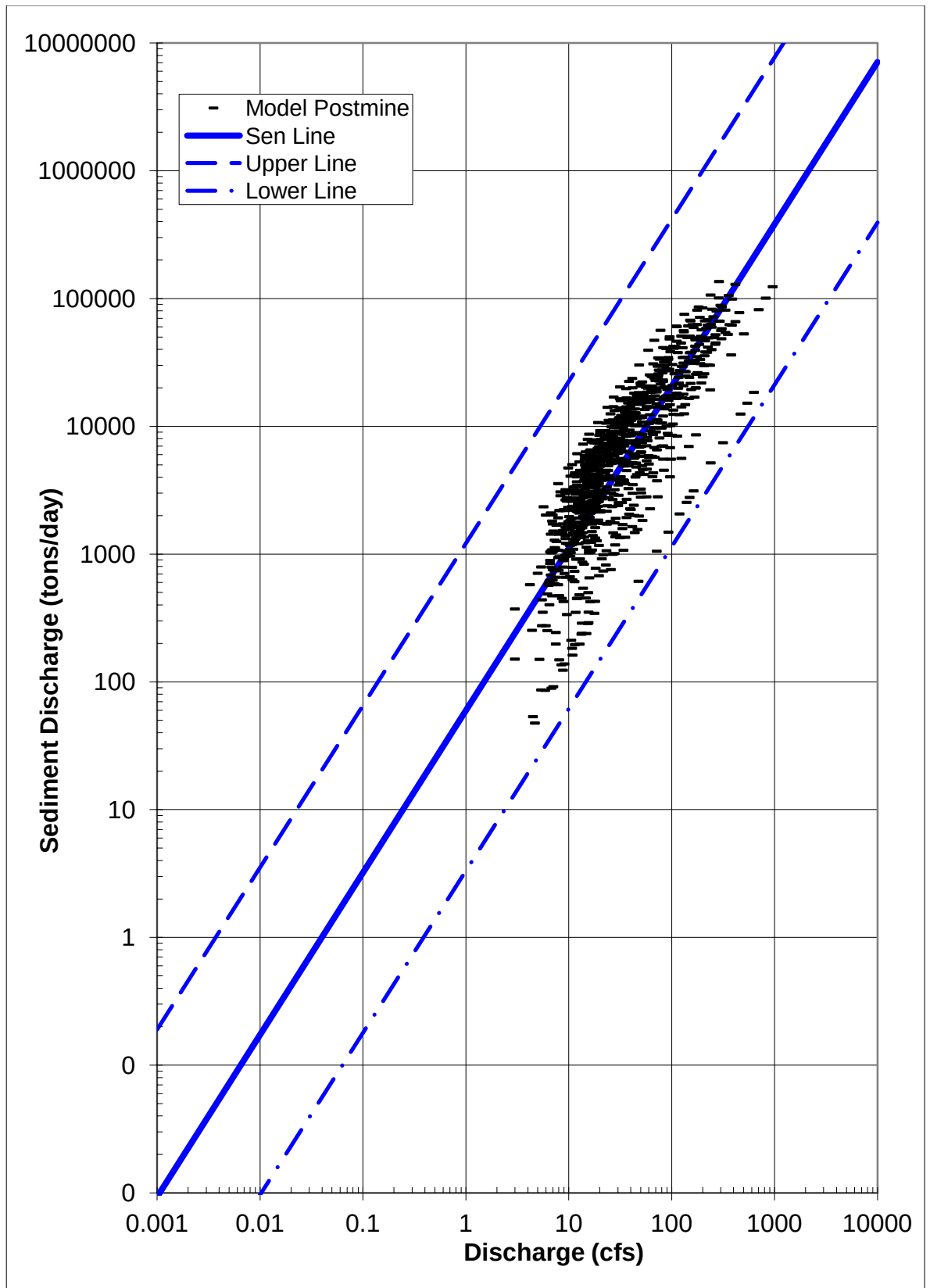


Figure 2.6. Modeled Post-Mine Sediment and Water Discharge for J19.

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Exhibit 1
J-19 Post-Mine Topography

10-Foot Contours
Indexes at 50 Feet

■ EndPoints

0 500 1,000 2,000 Feet

**PEABODY
WESTERN**
GIS

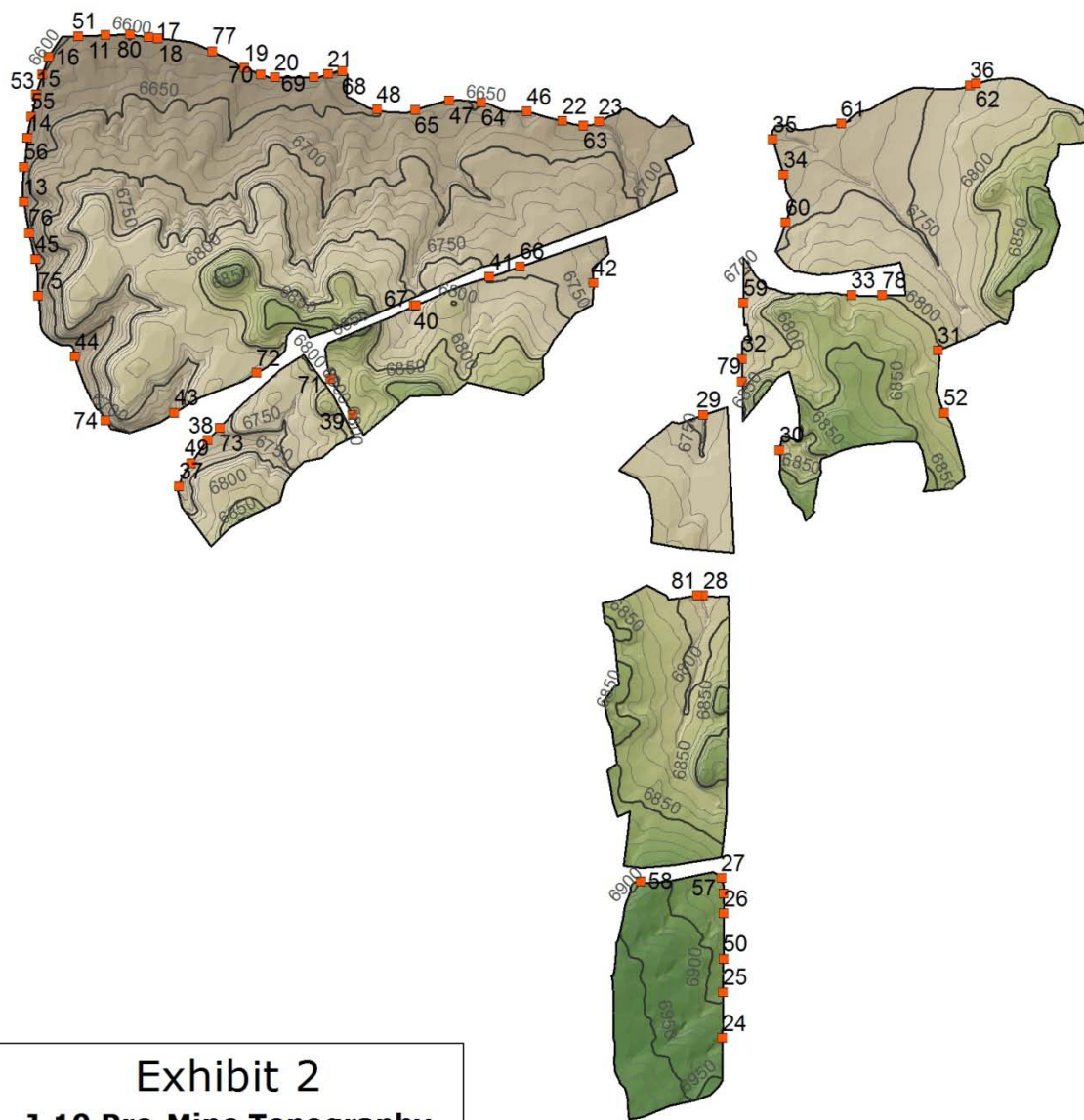


Exhibit 2
J-19 Pre-Mine Topography

10-Foot Contours
Indexes at 50 Feet

■ EndPoints

0 500 1,000 2,000 Feet

**PEABODY
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