Dewey-Burdock Project
Fall River and Custer Counties,
South Dakota
Large Scale Mine
Permit Application

Prepared for:

South Dakota Department of Environment and Natural Resources
Minerals and Mining Program
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1.0 APPLICATION

Powertech (USA) Inc. (Powertech (USA)) proposes to produce uranium (U_3O_8 or yellowcake) at the Dewey-Burdock Project using *in situ* recovery (ISR). This report has been developed to address the permitting requirements for a Large Scale Mine (LSM) established under the Administrative Rules of South Dakota (ARSD) Title 74, Article 29, which are governed by South Dakota Codified Law (SDCL) Chapter 45-6B. As outlined in ARSD 74:29:01:04, three copies of this document have been submitted to the South Dakota Department of Environment and Natural Resources (DENR). In addition, electronic copies have been provided to the South Dakota Department of Game, Fish and Parks (SDGF&P), the Department of Agriculture, the Department of Education and Cultural Affairs, the Custer and Fall River conservation districts, the Department of Health, the Bureau of Land Management (BLM), the U.S. Nuclear Regulatory Commission (NRC), and the U.S. Environmental Protection Agency (EPA). A proof of submission to the register of deeds in Custer and Fall River counties will be submitted separately from this application. The permit application is provided as Appendix 1.0-A. A proposed list of technical revisions prepared in accordance with ARSD 74:29:03:16 is provided as Appendix 1.0-B.

1.1 Statement of Procedural Completeness

The Dewey-Burdock Project LSM permit application and this accompanying report meet the requirements set forth in ARSD 74:29:02:01 for procedural completeness. References to SDCL requirements have been made in the application to indicate which sections of this report fulfill the statutory application requirements. Table 1.1-1 contains cross-references for each applicable SDCL. Table 1.1-2 contains cross-references for report sections pertinent to each applicable ARSD.

1.2 Project Overview

The proposed permit area is located approximately 13 miles north-northwest of Edgemont, South Dakota, in an area encompassing portions of Fall River and Custer counties. The permit boundary encompasses approximately 10,580 acres of mostly private land on both sides of S. Dewey Road (County Road 6463) and includes portions of Sections 1-5, 10-12, and 14-15, Township 7 South, Range 1 East and Sections 20-21 and 27-35, Township 6 South, Range 1 East, Black Hills Meridian. Approximately 240 acres are under control of the BLM in portions of Sections 3 and 10-12. Figure 1.2-1 shows the project location and proposed permit boundary.

The Dewey-Burdock Project is a proposed uranium ISR project. The uranium will be recovered by injecting groundwater fortified with oxidizing and complexing agents (oxygen and carbon

Table 1.1-1: South Dakota Codified Law

Statute	Information Required	Permit Application Reference
SDCL 45-6B-1	Citation of Chapter	Noted
SDCL 45-6B-2	Legislative findings and policy	Noted
SDCL 45-6B-3	Definition of terms	Reviewed
SDCL 45-6B-4	Local government permits	Sections 1.4 and 2.1; Appendix 2.1-A
SDCL 45-6B-5 (1)	Application for permit - form/copy	Appendix 1.0-A
SDCL 45-6B-5 (2)	Reclamation Plan	Section 6
SDCL 45-6B-5 (3)	Map of affected land	Plates 5.3-1 and 5.3-2
SDCL 45-6B-5 (4)	Application fee	Application fee of $50,000 is provided under separate cover
SDCL 45-6B-5 (5)	Postclosure Plan	Section 6.8
SDCL 45-6B-6 (1)	Legal description and area of affected land	Section 2.0
SDCL 45-6B-6 (2)	Owner of the surface area of affected land	Section 2.2, Plate 2.2-2 and Appendix 2.2-A
SDCL 45-6B-6 (3)	Owner of the substance mined	Section 2.2, Plate 2.2-1 and Appendix 2.2-A
SDCL 45-6B-6 (4)	Applicant's legal right to enter and mine	Section 2.2
SDCL 45-6B-6 (5)	Applicant's legal right to dispose of tailings	Not applicable since no tailings disposal will occur in the permit area
SDCL 45-6B-6 (6)	Address and telephone number of the general office and local address and telephone number of applicant	Section 1.5
SDCL 45-6B-6 (7)	Minerals extracted and milled	Sections 1.2 and 5.1.1
SDCL 45-6B-6 (8)	Description of method of mining and milling	Section 5
SDCL 45-6B-6 (8)(a)	Contour basis of mining operation	Section 5.3; Plates 5.3-1 and 5.3-2
SDCL 45-6B-6 (8)(b)	Depth and direction of mining	Sections 5.3.3.1.1 and 5.3.3.2.2
SDCL 45-6B-6 (8)(c)	Disposition of mine spoil and tailings	No tailings will be associated with uranium ISR; spoil is addressed in Section 5.3.7
SDCL 45-6B-6 (8)(d)	Method of blasting and control thereof	Not applicable since no blasting will occur
SDCL 45-6B-6 (9)	Size of the area worked at one time	Section 5.3.7
SDCL 45-6B-6 (10)	Timetable of proposed duration of mining operation	Sections 5.2 and 6.5
SDCL 45-6B-6 (11)	Written consent to grant access to the Board of Minerals and Environment	Noted
SDCL 45-6B-7	Reclamation Plan	Section 6
SDCL 45-6B-7 (1)	Description of reclamation types	Section 6.4
SDCL 45-6B-7 (2)	Standard soil survey	Section 3.3, Appendix 3.3-A and Plate 3.3-1
SDCL 45-6B-7 (3)	Vegetative survey	Section 3.7, Appendix 3.7-A and Plate 3.7-1

Table 1.1-1: South Dakota Codified Law (Continued)

Statute	Information Required	Permit Application Reference
SDCL 45-6B-7 (4)	Preliminary wildlife study	Section 3.9 and Appendix 3.9-A
SDCL 45-6B-7 (5)	Characteristics of affected land of historic, archaeological, geologic, scientific, or recreation significance	Sections 2.3 and 3.11
SDCL 45-6B-7 (6)	Description of implementation plan of Reclamation Plan to meet requirement of SDCL 45-6B-37 to SDCL 45-6B-46	Section 6
SDCL 45-6B-7 (7)	Description of how the Reclamation Plan will rehabilitate the affected land	Section 6.4
SDCL 45-6B-7 (8)(a) and (b)	Map of all the proposed affected land	Plates 5.3-1 and 5.3-2
SDCL 45-6B-7 (9)(a) through (mm)	Baseline water quality and level of aquifers	Section 3.4
SDCL 45-6B-7 (10)	Location of proposed reservoirs, tailings ponds, tailings disposal sites, dams, dikes, and diversion canals	Figure 5.3-1 and 5.3-2; Plates 5.3-1 and 5.3-2
SDCL 45-6B-7 (11)	Provisions for stripping, storage and replacement of overburden and topsoil	Sections 5.3.7 and 6.4.3
SDCL 45-6B-7 (12)	Estimated cost of implementing and completing the proposed reclamation	Section 6.7 and Appendix 6.7-A
SDCL 45-6B-8	Identification of previously mined land	Section 3.2.5.2 and Figure 3.2-8
SDCL 45-6B-9	Previously mined land reclamation for underground mining	Section 3.2.5.2 and Figure 3.2-8
SDCL 45-6B-10 (1)	Identify the area corresponding with application	Figure 2.0-1
SDCL 45-6B-10 (2)	Show adjoining surface owners of record	Plate 2.2-2
SDCL 45-6B-10 (3)	Map scale not more than 1:25,000	Noted
SDCL 45-6B-10 (4)	Show water wells, creeks, roads, buildings, pipelines, power and communication lines on and within 200 feet of all boundaries of affected land	Figures 3.1-1 and 3.2-6; Plates 3.4-1, 3.5-1, 5.3-1 and 5.3-2; Appendix 3.5-A
SDCL 45-6B-10 (5)	Show total area involved in operation	Plates 5.3-1 and 5.3-2
SDCL 45-6B-10 (6)	Indicate on map or by statement the general type, thickness, and distribution of soil	Section 3.3, Appendix 3.3-A and Plate 3.3-1
SDCL 45-6B-11	Approval of Reclamation Plan by other agencies.	Noted
SDCL 45-6B-12	Consultation with surface owner.	Appendix 6.4-A
SDCL 45-6B-13	Hearing and order for instrument of consultation not obtained.	Noted
SDCL 45-6B-14	Application fee	Application fee of $50,000 is provided under separate cover

Table 1.1-1: South Dakota Codified Law (Continued)

Statute	Information Required	Permit Application Reference
SDCL 45-6B-15	Copy of application filed with DENR and Fall River and Custer County Register of Deeds.	Appendix 1.0-A (DENR copy); application to be filed concurrently with Fall River and Custer County Register of Deeds
SDCL 45-6B-16	Publication of notice of application.	Notice will be published
SDCL 45-6B-17	Mailing of notice of application to owners.	Mailings will be conducted
SDCL 45-6B-18	Fees for permit amendments.	Noted
SDCL 45-6B-19	Protection of confidential information.	Noted
SDCL 45-6B-20	Site inspection prior to permit issuance.	Noted
SDCL 45-6B-20.1	Additional proof of financial assurance.	Powertech (USA) understands that the financial assurance will be set after a site inspection.
SDCL 45-6B-20.2	Time for filing under 45-6B-20.1.	Powertech (USA) understands that additional financial assurance may be required due to the use of chemicals in the extraction process.
SDCL 45-6B-21	Surety amount and duration determination criteria.	Noted
SDCL 45-6B-22	Surety bond	Noted
SDCL 45-6B-23	Cash or securities in lieu of surety.	Noted
SDCL 45-6B-24	Surety payable to state.	Noted
SDCL 45-6B-25	Surety liability.	Noted
SDCL 45-6B-26	Amount of surety penalty.	Noted
SDCL 45-6B-27	Increase or reduction in surety penalty.	Noted
SDCL 45-6B-28	Objections or support of application.	Noted
SDCL 45-6B-29	County request for hearing.	Noted
SDCL 45-6B-30	Hearing on application.	Noted
SDCL 45-6B-31	Modification of application prior to hearing.	Noted
SDCL 45-6B-32 (1)	Application incomplete or surety not posted.	Noted
SDCL 45-6B-32 (2)	Applicant has not paid required fee.	Application fee of $50,000 is provided under separate cover.
SDCL 45-6B-32 (3)	Any part of the proposed mining operation, reclamation program or proposed future use is contrary to the laws or regulations of this state or the United States.	The proposed ISR operations will be carried out under all applicable state and federal laws.
SDCL 45-6B-32 (4)	The mining operation will not adversely affect the stability of any significant, valuable, and permanent man-made structures located within 200 feet of the affected land, except where there is an agreement between the operator and the persons having an interest in the structure that damage to the structure is to be compensated by the operator.	Section 5.6.15

Table 1.1-1: South Dakota Codified Law (Continued)

Statute	Information Required	Permit Application Reference
SDCL 45-6B-32 (5)	The mining operation would be in violation of any county zoning or subdivision regulations.	Section 2.1; Appendix 2.1-A
SDCL 45-6B-32 (6)	The proposed mining operation and reclamation plan cannot be carried out in conformance with § 45-6B-35.	See permit application references for SDCL 45-6B-35
SDCL 45-6B-32 (7)	The operator is currently found to be in violation of the provisions of this chapter with respect to any mining operation in this state.	Powertech (USA) has submitted an affidavit certifying that Powertech (USA) is not in violation of the provisions of 45-6B.
SDCL 45-6B-32 (8)	The land is unsuitable for a mining operation, as determined pursuant to § 45-6B-33.	See permit application references for SDCL 45-6B-33
SDCL 45-6B-33 (1)	Unsuitable land – No permit issued if reclamation is not physically or economically feasible.	Section 6; Appendix 4.0-A
SDCL 45-6B-33 (2)	Unsuitable land – No permit issued if sediment deposition cannot be prevented.	Section 5.3.9
SDCL 45-6B-33 (3)	Unsuitable land – No permit issued if includes special, exceptional, critical, or unique lands.	Section 2.3; Appendix 2.3-A
SDCL 45-6B-33 (4)	Unsuitable land – No permit issued if loss or reduction of aquifer production, public or domestic water wells, watershed, aquifer recharge areas or significant agricultural areas.	Sections 5.6 and 3.3.3
SDCL 45-6B-33 (5)	Unsuitable land – No permit issued if jeopardize threatened or endangered species.	Sections 3.7.3 3.9.3, 3.10.3, 5.6.11.1.11 and 5.6.11.2
SDCL 45-6B-33 (6)	Unsuitable land – No permit issued if adverse socioeconomic impacts.	Appendix 4.0-A
SDCL 45-6B-33.1 (1) through (6)	Socioeconomic impact study.	Appendix 4.0-A
SDCL 45-6B-33.2	Permit application for small-scale mining.	Not applicable
SDCL 45-6B-33.3	Special, exceptional, critical, or unique land.	Section 2.3 and Appendix 2.3-A
SDCL 45-6B-33.4	List of special, exception, critical or unique lands.	Section 2.3 and Appendix 2.3-A
SDCL 45-6B-33.5(1) through (3)	Alternative restrictions on special, exceptional, critical, or unique land.	The board determined the lands described do not constitute special, exceptional, critical, or unique lands (Section 2.3).
SDCL 45-6B-33.6	Determination of classification for special, exceptional, critical, or unique lands.	The board determined the lands described do not constitute special, exceptional, critical, or unique lands (Section 2.3).
SDCL 45-6B-33.7	Appeal of special, exceptional, critical, or unique lands determination.	Noted
SDCL 45-6B-33.8	Underground mining beneath special, exceptional, critical, or unique lands.	Noted
SDCL 45-6B-34	Notice to county commissioners.	Noted

Table 1.1-1: South Dakota Codified Law (Continued)

Statute	Information Required	Permit Application Reference
SDCL 45-6B-35	Applicable laws for mining operations.	See permit application references for SDCL 45-6B-36 through 46
SDCL 45-6B-36	Annual filing of map and fee.	Powertech (USA) understands that an annual filing map and $50,000 fee will be due within 60 days prior to the anniversary date of the permit.
SDCL 45-6B-37	Grading final topography appropriate to final land use.	Sections 6.4.1 and 6.4.3.1; Plate 6.4-1
SDCL 45-6B-38	Disposal of refuse.	Section 5.4
SDCL 45-6B-39	Revegetation	Sections 6.4.2 and 6.4.3; Appendices 6.4-A, 6.4-B and 6.4-D
SDCL 45-6B-40	Overburden removal and topsoil storage and protection.	Section 5.3.7
SDCL 45-6B-41	Minimize disturbance to prevailing hydrologic balance.	Sections 5.3.9, 5.6.3, 5.6.3.1.4 and 5.6.4
SDCL 45-6B-42	Protection of areas outside of affected land.	Provisions specific to highwalls are not applicable since the ISR operation will not have high walls. Subsidence is addressed in Section 5.6.3.1.5.
SDCL 45-6B-43	Stabilization of affected land, control erosion, noxious weeds, air pollution, and water pollution.	Sections 5.3.7, 5.3.9 and 6.4.3; Appendix 6.4-C
SDCL 45-6B-44	Reclamation Plan developed by the operator, department, and landowner.	Section 6.4.1; Appendix 6.4-A; a copy of the reclamation plan has been provided to all adjacent surface owners
SDCL 45-6B-45	Choices of reclamation.	Sections 6.4.1 and 6.4.3.4; Appendix 6.4-A; pre-submission meeting held on May 10, 2012
SDCL 45-6B-46	Time for completion of reclamation and plantings not required under certain conditions.	Sections 6.4 and 6.5
SDCL 45-6B-47	Transfer of permit.	Noted
SDCL 45-6B-48	Notice to operator of violation.	Noted
SDCL 45-6B-49	Cease and desist order for violation.	Noted
SDCL 45-6B-50	Violation hearing.	Noted
SDCL 45-6B-51	Modification, suspension, or revocation of permit due to violation.	Noted
SDCL 45-6B-52	Action for temporary restraining order or injunction due to violation.	Noted
SDCL 45-6B-53	Special permit laws applicable for small-scale operations.	Not applicable
SDCL 45-6B-54	Application for permit for small-scale operations.	Not applicable
SDCL 45-6B-55	Surety for small-scale operation.	Not applicable
SDCL 45-6B-56	Annual notice of intent to continue for small-scale operation.	Not applicable
SDCL 45-6B-57	Notice of completion of reclamation for small-scale operation.	Not applicable
SDCL 45-6B-58	Permit application for new small-scale operation.	Not applicable
SDCL 45-6B-59	Laws applicable to procession and action on applications.	Not applicable

Table 1.1-1: South Dakota Codified Law (Continued)

Statute	Information Required	Permit Application Reference
SDCL 45-6B-60	Conversion of small-scale operation permit to larger operation.	Not applicable
SDCL 45-6B-61	Time for action on application on small-scale mine permit conversion.	Not applicable
SDCL 45-6B-62	Laws applicable to conversion of small-scale mine permit conversion.	Not applicable
SDCL 45-6B-63	Grounds for denial of small-scale mine permit conversion.	Not applicable
SDCL 45-6B-66	Proceedings by attorney general for forfeiture of surety due to violation.	Noted
SDCL 45-6B-67	Foreclosure of real estate by attorney general due to violation.	Noted
SDCL 45-6B-68	Reclamation of lands using surety following violation.	Noted
SDCL 45-6B-69	Fees deposited in environment and natural resources fee fund.	Noted
SDCL 45-6B-70	Liability for damages to environment.	Noted
SDCL 45-6B-71	Civil penalty for an operation without a permit.	Noted
SDCL 45-6B-71.1	Misdemeanor for operation without a permit near a lake or stream.	Noted
SDCL 45-6B-72	Violation for refusal of access or interference with inspection.	Noted
SDCL 45-6B-73	Jurisdiction and authority of board.	Noted
SDCL 45-6B-74	Studies and programs initiated and encourage by board.	Noted
SDCL 45-6B-75	Assistance provided by other departments and agencies.	Noted
SDCL 45-6B-76(1) through (3)	General powers of board.	Noted
SDCL 45-6B-77	Master list of permits, notices, and certificates kept by department.	Noted
SDCL 45-6B-79	Use of reclamation fund.	Noted
SDCL 45-6B-80	Exemption of educational and recreational activities.	Noted
SDCL 45-6B-81	Promulgation of rules by board regarding surface mining and reclamation.	Noted
SDCL 45-6B-86	Annual publication of amount of disturbed land.	Noted
SDCL 45-6B-87	Large-scale gold or silver surface mining operations not exempt from federal laws.	Not applicable
SDCL 45-6B-88	Procedures for issuance, suspension, revocation, and renewal of permits.	Noted
SDCL 45-6B-89	Legislative findings for large-scale surface gold or silver mines in Black Hills.	Not applicable

Table 1.1-1: South Dakota Codified Law (Continued)

Statute	Information Required	Permit Application Reference
SDCL 45-6B-91	Postclosure Plan	Section 6.8
SDCL 45-6B-92 (1)	Description of critical resources affected by reclamation plan - wildlife.	Section 5.6.11
SDCL 45-6B-92 (2)	Description of critical resources affected by reclamation plan - aquatic resources.	Section 5.6.11.1.10
SDCL 45-6B-92 (3)	Description of critical resources affected by reclamation plan - vegetation.	Section 5.6.11.1.1
SDCL 45-6B-92 (4)	Description of critical resources affected by reclamation plan - water.	Sections 5.6.3 and 5.6.4
SDCL 45-6B-92 (5)	Description of critical resources affected by reclamation plan - visual resources.	Section 5.6.14
SDCL 45-6B-92 (6)	Description of critical resources affected by reclamation plan - soils.	Section 5.6.2
SDCL 45-6B-92 (7)	Description of critical resources affected by reclamation plan - cultural resources.	Section 5.6.12
SDCL 45-6B-92 (8)	Description of critical resources affected by reclamation plan - air quality.	Section 5.6.10
SDCL 45-6B-92 (9)	Description of critical resources affected by reclamation plan - noise.	Section 5.6.13
SDCL 45-6B-92 (10)	Description of critical resources affected by reclamation plan - special, exceptional, critical or unique lands.	Section 2.3
SDCL 45-6B-93	Information to be included in annual report for large-scale gold or silver surface mining operation.	Not applicable
SDCL 45-6B-94	Legislative findings for gold or silver surface mining.	Not applicable
SDCL 45-6B-95	Permit limitations for new large-scale operations.	Not applicable
SDCL 45-6B-96	Permits for presently operating large-scale gold or silver surface mines.	Not applicable
SDCL 45-6B-97	Qualifications for credit on reclamation.	Not applicable
SDCL 45-6B-98	Submission of reclamation plan.	Not applicable
SDCL 45-6B-99	Exclusion of underground mining operators.	Not applicable
SDCL 45-6B-101	Mining inventory fund.	Noted
SDCL 45-6B-102	Abandon Mine Lands advisory committee.	Noted
SDCL 45-6B-103	Duties of abandoned Mine Land advisory committee.	Noted
SDCL 45-6B-104	New surface mining permits prohibited for private land in Spearfish Canyon.	This mine will not be located in Spearfish Canyon.
SDCL 45-6B-105	Location of Spearfish Canyon.	This mine will not be located in Spearfish Canyon.
SDCL 45-6B-106	Lake dredging activities license.	Not applicable since lake dredging will not be used.

Table 1.1-2: Administrative Rules of South Dakota

Regulation	Information Required	Permit Application Reference
ARSD 74:29:01:01	Definitions	Reviewed
ARSD 74:29:01:02	Computation of time	Noted
ARSD 74:29:01:03	Presubmission meetings	Noted
ARSD 74:29:01:04	Proof of submission of application to Register of Deeds, DENR, SDGF&P, Department of Agriculture, Department of Education and Cultural Affairs, BLM, and Department of Health.	To be provided separately
ARSD 74:29:01:05	Interested persons mailing list.	Noted
ARSD 74:29:01:06	Request for a copy of mining permit application.	Noted
ARSD 74:29:01:07	Determination of procedural completeness.	Noted
ARSD 74:29:01:08	Notice of filing	Noted
ARSD 74:29:01:09	Intervention in application proceeding.	Noted
ARSD 74:29:01:10	Summary document	Noted
ARSD 74:29:01:11	Information added after filing.	Noted
ARSD 74:29:01:12	Notice to agencies of filing.	Noted
ARSD 74:29:01:13	Hearing date	Noted
ARSD 74:29:01:14	Notice of hearing	Noted
ARSD 74:29:01:15	Department recommendation	Noted
ARSD 74:29:01:16	Permit changes	Noted
ARSD 74:29:01:17	Permit area boundaries.	Figure 2.0-1
ARSD 74:29:01:17 (1)	County Conditional Use Permit (CUP) area boundary.	Section 2.1; Appendix 2.1-A
ARSD 74:29:01:17 (2)	Legal right to mine.	Section 2.2
ARSD 74:29:01:17 (3)	Location of permit boundary in relation to scenic and unique land.	Section 2.3
ARSD 74:29:01:17 (4)	Ratio of proposed permit area to affected land.	Based on an affected area of 2,528 to 3,792 acres (without or with land application) and a permit area of 10,580 acres, the ratio is 0.24 to 0.36.
ARSD 74:29:01:18	Contested and uncontested recommendations and notice of decision.	Noted
ARSD 74:29:01:19	Report following issuance of uncontested permit.	Noted
ARSD 74:29:02:01	Procedural completeness requirements.	Section 1.1
ARSD 74:29:02:02	Local zoning requirements.	Section 2.1; Appendix 2.1-A
ARSD 74:29:02:03	Surface and mineral owners.	Section 2.2; Plates 2.2-1 and 2.2-2; Appendix 2.2-A
ARSD 74:29:02:04 (1)	Mining and milling methods.	Section 5 (Mine Plan)

Table 1.1-2: Administrative Rules of South Dakota (Continued)

Regulation	Information Required	Permit Application Reference
ARSD 74:29:02:04 (2)	Description and maps of premining and postmining contours.	Sections 3.5.2.1, 5.3, 6.4.1 and 6.4.3.1; Plate 6.4-1
ARSD 74:29:02:04 (3)	Description of proposed depth and direction of mining and representative cross sections.	Sections 5.3.3.1.1 and 5.3.3.2.2; Plates 5.3-15 and 5.3-16
ARSD 74:29:02:04 (4)	Map of proposed waste facilities.	Figures 5.3-1 and 5.3-2; Plates 5.3-1 and 5.3-2
ARSD 74:29:02:04 (5)	Stability analysis for all critical earth structures.	Appendix 5.3-A
ARSD 74:29:02:04 (6)	A description of proposed blast procedures.	Not applicable since blasting will not be conducted.
ARSD 74:29:02:05	Timetable with narrative description of existing plans for future exploration and mining in the area of the proposed operation.	Sections 5.1, 5.2 and 6.5; Figure 6.5-1
ARSD 74:29:02:06	Historic or archaeological significance.	Section 3.11; Appendices 3.11-A and 3.11-B
ARSD 74:29:02:07	Water quality and water level data.	Sections 3.4 and 3.5; Figures 3.4-18 through 3.4-21
ARSD 74:29:02:08	Reclamation costs	Section 6.7; Appendix 6.7-A
ARSD 74:29:02:09	Permit area boundary - map requirements.	Figure 2.0-1
ARSD 74:29:02:10	Revegetation	Sections 6.4.2 and 6.4.3; Appendices 6.4-A, 6.4-B and 6.4-D
ARSD 74:29:02:11	Effect of hydrologic balance on surface and groundwater.	Section 5.3.9 and 5.6.3.1.4
ARSD 74:29:02:11 (1)	Baseline geology, surface, and groundwater reports.	Sections 3.2, 3.4 and 3.5
ARSD 74:29:02:11 (2)	Representative geologic cross sections.	Plates 3.2-12 through 3.2-22
ARSD 74:29:02:11 (3)	Surface water inventory map.	Plate 5.5-1; Figures 3.5-1 and 3.5-8 through 3.5-12; Appendix 3.5-A
ARSD 74:29:02:11 (4)	Well location inventory map.	Figures 3.2-7 and 3.4-17; Plate 3.4-1
ARSD 74:29:02:11 (5)	Potentiometric surface map.	Figures 3.4-2 through 3.4-5
ARSD 74:29:02:11 (6)	Geochemical characterization of ore and waste rock.	Section 3.2.4
ARSD 74:29:02:11 (7)	Surface and groundwater monitoring plan for life of mine.	Sections 5.5.2 and 5.5.3
ARSD 74:29:02:11 (8)	Meteorological monitoring plan.	Section 5.5.10
ARSD 74:29:02:11 (9)	Drainage, erosion, and sedimentation control plan.	Section 5.3.9; Plates 5.3-6 through 5.3-12
ARSD 74:29:02:11 (10)	Chemicals in the milling process, leak mitigation, and a spill contingency plan.	Sections 5.3.1, 5.3.5 and 5.6.5
ARSD 74:29:02:11 (11)	Estimate of project water requirements.	Section 5.3.3.5.3 and 5.6.3.1.1

Table 1.1-2: Administrative Rules of South Dakota (Continued)

Regulation	Information Required	Permit Application Reference
ARSD 74:29:02:11 (12)	Chemical characteristics of process solutions.	Sections 5.1 and 5.3
ARSD 74:29:02:11 (13)	Pollution control facilities.	Appendix 5.3-B
ARSD 74:29:02:12 (1)	Maps must show the name of the applicant.	The figures and plates indicate that Powertech (USA) Inc. is the applicant.
ARSD 74:29:02:12 (2)	Maps must be prepared and signed by a person qualified in the preparation of maps.	The figures and plate include a signature of the preparer.
ARSD 74:29:02:12 (3)	Maps must give the date prepared.	The figures and plates list the date the map was prepared.
ARSD 74:29:02:12 (4)	Maps must identify the requirement the map is intended to fulfill.	The figures and plates include ARSD or SDCL references.
ARSD 74:29:02:12 (5)	Maps must include a legend indicating the items shown on the particular map.	The figures and plates include legends.
ARSD 74:29:02:12 (6)	Maps must clearly indicate township, range, and section boundaries.	The figures and plates indicate township, range and section boundaries where applicable.
ARSD 74:29:02:12 (7)	Maps must identify scale.	The figures and plates include scale bars or labeled scales except for schematic drawings.
ARSD 74:29:03	Permit amendments	Section 1.0; Appendix 1.0-B
ARSD 74:29:04	Permit transfers	Noted
ARSD 74:29:05:01	Reclamation of millsites.	Section 6.3
ARSD 74:29:05:02	Choice of reclamation.	Section 6.4; Appendix 6.4-A
ARSD 74:29:05:03	Process pond reclamation.	Section 6.3.1.4
ARSD 74:29:05:04	Removal of equipment and buildings.	Section 6.3.1.3
ARSD 74:29:05:05	Reclamation of tailings impoundments.	Not applicable since the ISR facility will not have tailings.
ARSD 74:29:05:06	Treatment of tailings -- Initial sampling and chemical characterization.	Not applicable since the ISR facility will not have tailings.
ARSD 74:29:05:07	Treatment of tailings -- Monitoring during treatment process.	Not applicable since the ISR facility will not have tailings.
ARSD 74:29:05:08	Treatment of tailings.	Not applicable since the ISR facility will not have tailings.
ARSD 74:29:05:09	Retreatment of tailings.	Not applicable since the ISR facility will not have tailings.
ARSD 74:29:05:10	Treatment of tailings -- Final sampling program.	Not applicable since the ISR facility will not have tailings.
ARSD 74:29:05:11	Treatment and disposal of tailings from on/off load pads.	Not applicable since the ISR facility will not have tailings.
ARSD 74:29:05:12	Reclamation of tailings which cannot meet treatment standards.	Not applicable since the ISR facility will not have tailings.

Table 1.1-2: Administrative Rules of South Dakota (Continued)

Regulation	Information Required	Permit Application Reference
ARSD 74:29:05:13	Uranium tailings	Not applicable since the ISR facility will not have tailings.
ARSD 74:29:05:14 (1)	Land application of solution – plans and specifications prior to installation or construction.	The GDP application contains preliminary plans. As-constructed plans and specifications will be provided prior to operation (GDP Section 5.0)
ARSD 74:29:05:14 (2)	Land application of solution – chemical characterization of the solution.	Sections 5.4.1.1.4.1 and 5.7.2.6
ARSD 74:29:05:14 (3)	Land application of solution – compliance with § 74:29:05:08	Powertech (USA) anticipates that the GDP will include effluent limits that incorporate South Dakota groundwater standards and consider ambient water quality.
ARSD 74:29:05:14 (4)	Land application of solution – hydraulic loading rates	GDP Section 8.2
ARSD 74:29:05:14 (5)	Land application of solution – minimize erosion and disturbance of vegetation	GDP Sections 8.2 and 8.4
ARSD 74:29:05:15	Land application of solution – Sampling requirements.	Section 5.5.4; 5.5.6.1; 5.5.7.1
ARSD 74:29:05:16 (1)	Land application site evaluation – vegetation and wildlife.	Sections 5.4.1.1.2 and 5.5.6.2; GDP Section 6.5
ARSD 74:29:05:16 (2)	Land application site evaluation – geology.	Section 5.6.4.1.1,2; GDP Sections 3.6 and 8.1
ARSD 74:29:05:16 (3)	Land application site evaluation – groundwater and surface water.	Sections 5.6.4.1.1.2, 5.6.3 and 5.6.4
ARSD 74:29:05:16 (4)	Land application site evaluation – soils and depth to bedrock.	Section 5.4.1.1.2; GDP Sections 3.2 and 3.6
ARSD 74:29:05:16 (5)	Land application site evaluation – slopes.	Section 5.4.1.1.2
ARSD 74:29:05:16 (6)	Land application site evaluation – erodibility.	Section 5.4.1.1.2
ARSD 74:29:05:16 (7)	Land application site evaluation – distance to flowing streams.	Section 5.4.1.1.2
ARSD 74:29:05:16 (8)	Land application site evaluation – adjacent land use.	Section 5.4.1.1.2
ARSD 74:29:05:16 (9)	Land application site evaluation – weather monitoring.	Sections 5.4.1.1.2 and 5.5.10
ARSD 74:29:05:17 (1)	Land application of solution – Plan for operational monitoring – Methods for soil and soil water monitoring and sampling.	Section 5.5.6.1; GDP Sections 6.1.3 and 6.4
ARSD 74:29:05:17 (2)	Land application of solution – Plan for operational monitoring – Vegetation.	Section 5.5.7.1; GDP Section 6.5
ARSD 74:29:05:17 (3)	Land application of solution – Plan for operational monitoring – Soil characteristics and parameters.	Section 5.5.6.1; GDP Sections 6.4 and 8.3
ARSD 74:29:05:17 (4)	Land application of solution – Plan for operational monitoring – Analytical techniques.	Section 5.5.4.1; GDP Section 6
ARSD 74:29:05:17 (5)	Land application of solution – Plan for operational monitoring – Sampling frequency.	Section 5.5.4.1; GDP Section 6

Table 1.1-2: Administrative Rules of South Dakota (Continued)

Regulation	Information Required	Permit Application Reference
ARSD 74:29:05:17 (6)	Land application of solution – Plan for operational monitoring – Criteria for determining if and when land application should be initiated or discontinued.	GDP Sections 8.1.1 (based on alluvial monitoring results), 8.4 (based on soil sampling results), and 8.5 (based on vegetation sampling results)
ARSD 74:29:05:17 (7)	Land application of solution – Plan for operational monitoring – Surface and groundwater.	GDP Sections 6.1 and 6.2
ARSD 74:29:05:17 (8)	Land application of solution – Plan for operational monitoring – Maximum allowable metals accumulation values.	GDP Sections 8.3 and 8.4
ARSD 74:29:05:17 (9)	Land application of solution – Plan for operational monitoring – Sampling and analytical quality assurance and quality control plan.	Section 6.3.4.4
ARSD 74:29:05:18	Land application of solution –Notice of intent to implement.	Section 5.7.2.6
ARSD 74:29:05:19	Land application of solution –Revegetation of site -- Inspection.	Section 6.4.4
ARSD 74:29:05:20	Land application of solution – Written report.	Section 5.7.2.6
ARSD 74:29:06:01	Presubmission conference for postmine land use.	Section 6.4.1; Appendix 6.4-A; presubmission conference was held May 10, 2012
ARSD 74:29:06:02 (1)	Demonstrate that the affected land has the capability of meeting reclamation criteria.	Section 6.4.1; Appendix 6.4-A
ARSD 74:29:06:02 (2)	Demonstrate that the postmining land use is compatible with surrounding land uses.	Section 6.4.1
ARSD 74:29:06:02 (3)	Support and maintenance activities required for successful implementation.	Sections 6.4.2, 6.4.3 and 6.6
ARSD 74:29:06:02 (4)	Assurance that the proposed postmining land use meets the following requirements: (a) Is obtainable according to data on expected market and need. (b) Is supported by commitments from public agencies where appropriate. (c) Is practicable on the basis of private financial capability for completion of the proposed operations. (d) Is planned pursuant to a schedule attached to the reclamation plan that integrates the mining operations and reclamation with the postmining land use. (e) Is consistent with existing state and local land use plans and programs. Is of a beneficial use.	Section 6.4.1
ARSD 74:29:06:03	Economic study for future mineral exploration.	Noted

Table 1.1-2: Administrative Rules of South Dakota (Continued)

Regulation	Information Required	Permit Application Reference
ARSD 74:29:06:04	Alternative postmining land use.	Noted
ARSD 74:29:06:05	Approval for future mineral exploration.	Noted
ARSD 74:29:06:06	Confidential information.	Noted
ARSD 74:29:07:01	General requirements for all reclamation types.	Section 6.4
ARSD 74:29:07:02	Minimizing of adverse impacts.	Section 5.6
ARSD 74:29:07:02 (1)	Design of facilities to minimize surface disturbance.	Sections 5.3, 5.6.2.2 and 5.6.14.2
ARSD 74:29:07:02 (2)	Clearing of land in small sections.	Sections 5.3.3 and 5.3.7
ARSD 74:29:07:02 (3)	Visual screening	Section 5.6.14
ARSD 74:29:07:02 (4)	Minimize impacts to surface and groundwater.	Sections 5.3.3, 5.3.9, 5.6.3, 5.6.4 and 6.2
ARSD 74:29:07:02 (5)	Control of access.	Section 5.7.6
ARSD 74:29:07:02 (6)	Preventative measures to minimize harmful impacts to wildlife.	Sections 5.6.11.1.2 and 5.6.11.2
ARSD 74:29:07:02 (7)	Location of waste facilities, spoil piles, and topsoil stockpiles to facilitate implementation of reclamation and to minimize environmental impacts.	Section 5.3
ARSD 74:29:07:02 (8)	Minimizing the production of mine waste and spoil.	Section 5.4.3
ARSD 74:29:07:02 (9)	Design and location of facilities so they are compatible with surrounding land uses (i.e. waste facility and haul road).	Section 5.3
ARSD 74:29:07:02 (10)	Integration of mine operations planning with the Reclamation Plan.	Sections 5.3 and 6.4
ARSD 74:29:07:03	Grading and Backfilling - Necessity	Section 6.4.3.1
ARSD 74:29:07:04 (1)	Reclaimed slopes must be visually and functionally compatible with surrounding area, suitable for the postmining land use, structurally stable, and not exceed the angle of repose for fill slopes or other slopes composed of unconsolidated material.	Section 6.4.3.1; Plate 6.4-1
ARSD 74:29:07:04 (2)	Erosion and sedimentation control during final grading.	Section 5.3.9
ARSD 74:29:07:04 (3)	Grading and backfilling timetable.	Sections 6.4.3.1 and 6.5; Figures 5.2-1 and 6.5-1
ARSD 74:29:07:04 (4)	Depressions not allowed.	Section 6.4.3.1
ARSD 74:29:07:04 (5)	Drainages preserved.	Section 6.4.3.1
ARSD 74:29:07:04 (6)	Highwall reduction.	Not applicable, since highwalls will not be used.
ARSD 74:29:07:04 (7)	Landforms must blend in with and complement the visual continuity of the surrounding area.	Section 6.4.3.1
ARSD 74:29:07:05	Disposal of refuse.	Section 5.4
ARSD 74:29:07:06 (1)	Vegetative species and composition postmining land use.	Section 6.4.3.4

Table 1.1-2: Administrative Rules of South Dakota (Continued)

Regulation	Information Required	Permit Application Reference
ARSD 74:29:07:06 (2)	Vegetative success - reference areas.	Section 6.4.3.4; Appendix 6.4-D
ARSD 74:29:07:06 (3)	Reference areas.	Appendix 6.4-D; Plate 6.4-2
ARSD 74:29:07:06 (4)	Seeding and planting.	Section 6.4.3.4; Appendix 6.4-B
ARSD 74:29:07:07 (1)	Salvageable topsoil.	Section 5.3.7
ARSD 74:29:07:07 (2)	Interim reclamation.	Section 6.4.2
ARSD 74:29:07:06 (3)	Topsoil analyzed to determine if fertilizer .is required.	Section 6.4.3.2
ARSD 74:29:07:07 (4)	Signing of topsoil stockpiles.	Section 5.3.7
ARSD 74:29:07:07 (5)	Estimate of topsoil to complete reclamation.	Sections 5.3.7 and 6.4
ARSD 74:29:07:07 (6)	Use of excess topsoil for reclamation purposes elsewhere.	Section 6.4.3.2
ARSD 74:29:07:07 (7)	Separation of rocks and trees from topsoil.	Section 5.3.7
ARSD 74:29:07:07 (8)	Segregation of topsoil and subsoil stockpiles.	Section 5.3.7
ARSD 74:29:07:08 (1)	Compliance with South Dakota water rights laws and regulations.	Section 5.6.3.1.2
ARSD 74:29:07:08 (2)	Compliance with South Dakota water quality laws and regulations.	Sections 5.6.3.2 and 5.6.4.2
ARSD 74:29:07:08 (3)	Compliance with dredge and fill laws in Sections 401 and 404 of the Clean Water Act.	Sections 5.6.4.1.3 and 5.6.4.2
ARSD 74:29:07:08 (4)	Removal of temporary or large sedimentation, erosion, or drainage control structures.	Section 5.3.9
ARSD 74:29:07:08 (5)	Permanent diversion structure design.	Section 5.3.9.1
ARSD 74:29:07:08 (6)	Diversion of unchannelized surface water.	Section 5.3.9
ARSD 74:29:07:09 (1)	Surface runoff diversions - side slopes and erosion protection.	Section 5.3.9
ARSD 74:29:07:09 (2)	Surface runoff diversions - stable sides in rock.	Section 5.3.9
ARSD 74:29:07:09 (3)	Surface runoff diversions - erosion protection.	Section 5.3.9
ARSD 74:29:07:09 (4)	Surface runoff diversions - culverts or bridges where necessary.	Section 5.3.9
ARSD 74:29:07:09 (5)	Surface runoff diversions - minimize hazards to humans, wildlife or livestock.	Section 5.3.9
ARSD 74:29:07:09 (6)	Surface runoff diversions - diversions around milling or processing facilities must be capable of carrying the flow from the 6-hour PMP event.	Section 5.3.9
ARSD 74:29:07:09 (7)	Surface runoff diversions - all other diversions must be capable of carrying a minimum of the 2-year, 6-hour event.	Section 5.3.9
ARSD 74:29:07:09 (8)	Surface runoff diversions - may not discharge on topsoil storage areas, spoil, or other unconsolidated material.	Section 5.3.9

Table 1.1-2: Administrative Rules of South Dakota (Continued)

Regulation	Information Required	Permit Application Reference
ARSD 74:29:07:10	Diversion of intermittent and perennial streams.	Not applicable; no diversions of intermittent or perennial streams are planned.
ARSD 74:29:07:11	Permanent impoundments	Powertech (USA) does not plan to leave any impoundments constructed for the ISR facility as a permanent feature.
ARSD 74:29:07:12 (1)	Roads and railroad spurs - avoid construction within riparian zones.	Section 5.3.8
ARSD 74:29:07:12 (2)	Roads within riparian zones - minimize negative impacts on streams.	Section 5.6.4.1.2
ARSD 74:29:07:12 (3)	Roads or railroad spurs within riparian zone of a coldwater permanent fishery.	Not applicable; there are no coldwater permanent fisheries within the permit area.
ARSD 74:29:07:12 (4)	Stream crossings.	Section 5.6.4.1.2
ARSD 74:29:07:12 (5)	Drainage control structures.	Section 5.6.4.1.2
ARSD 74:29:07:12 (6)	Culverts.	Section 5.6.4.1.2
ARSD 74:29:07:12 (7)	Minimize clearing width of trees and vegetation.	Section 5.6.4.1.2
ARSD 74:29:07:12 (8)	Access and haul road drainage structure maintenance.	Sections 5.3.8 and 5.6.4.1.2
ARSD 74:29:07:12 (9)	Transport facilities and utilities.	Section 5.6.4.1.2
ARSD 74:29:07:12 (10)	Unreclaimed roads subject to surface landowner request.	Section 6.4.3.3
ARSD 74:29:07:13	Buildings and structures.	Section 6.3.1
ARSD 74:29:07:14 (1)	Spoil piles located to avoid blocking intermittent or perennial drainages.	Section 5.3.7
ARSD 74:29:07:14 (2)	Permanent spoil dumps.	Not applicable; no permanent spoil dumps are planned.
ARSD 74:29:07:14 (3)	Analysis of spoil material to determine if it will be a source of water pollution.	Section 5.3.7
ARSD 74:29:07:14 (4)	Disposal of spoil material that is determined to be toxic or acid-forming.	Section 5.3.7
ARSD 74:29:07:15	Noxious weed control plan.	Section 6.4.3.5; Appendix 6.4-C
ARSD 74:29:07:16	Subsidence from mining activities - prevent or minimize.	Section 5.6.3.1.5
ARSD 74:29:07:17	Underground mines - sealed during reclamation.	Sections 3.2.5.2 and 5.3.3.7
ARSD 74:29:07:18	Requirements for specific types of reclamation.	Sections 6.1 and 6.4; Appendix 6.4-D
ARSD 74:29:07:19	Forest planting	Noted
ARSD 74:29:07:20	Rangeland	Section 6.4.1.1; Appendix 6.4-D
ARSD 74:29:07:21	Agriculture crops	Sections 6.4.1.2 and 6.4.3.4; Appendix 6.4-D
ARSD 74:29:07:22	Wildlife habitat	Noted
ARSD 74:29:07:23	Recreation	Noted

Table 1.1-2: Administrative Rules of South Dakota (Continued)

Regulation	Information Required	Permit Application Reference
ARSD 74:29:07:24	Industrial Use	Noted
ARSD 74:29:07:25	Homesites	Noted
ARSD 74:29:07:26	Future mineral exploration or development.	Noted
ARSD 74:29:07:27	Permanent surface impoundment.	Noted
ARSD 74:29:07:28	Changes in approved reference area.	Noted
ARSD 74:29:08:01	Requirements for concurrent reclamation.	Section 6.4
ARSD 74:29:08:02	Requirements for interim reclamation.	Section 6.4.2
ARSD 74:29:08:03	Requirements for final reclamation.	Section 6.4
ARSD 74:29:08:04	Disturbance to avoid requirements.	Noted
ARSD 74:29:09	Temporary cessation	Noted
ARSD 74:29:10	Special, exceptional, critical, or unique lands.	Section 2.3 and Appendix 2.3-A

drill holes have been used to generate the geologic model and delineate the extent of the mineralized sands.

1.4 Permitting History

Powertech (USA) is currently working on obtaining all the necessary permits and licenses for the Dewey-Burdock Project. Table 1.4-1 presents the permits and licenses being obtained. In addition to the Dewey-Burdock Project, Powertech (USA) has one exploration permit in Colorado (Centennial Project) and two exploration permits in Wyoming (Dewey Terrace and Aladdin projects).

1.5 Owner/Operator Information

The LSM permit application and accompanying report are submitted by Powertech (USA), which is the U.S.-based wholly owned subsidiary of Powertech Uranium Corporation, a corporation registered in British Columbia. Powertech Uranium Corporation shares are publicly traded on the Toronto Stock Exchange as PWE and the Frankfurt Stock Exchange as P8A. Powertech Uranium Corporation owns 100 percent of the shares of Powertech (USA). The corporate office of Powertech Uranium Corporation is located in Vancouver, British Columbia. Powertech (USA) is a U.S.-based corporation incorporated in the State of South Dakota.

The addresses and telephone numbers for the general office (Colorado) and the local office (South Dakota) of the applicant are listed as follows:

Name and address of applicant:

Company:	Powertech (USA) Inc.
Signatory:	Richard Blubaugh
Title:	Vice President, Environmental Health & Safety Resources
Address:	5575 DTC Parkway, Suite #140 Greenwood Village, CO 80111
Telephone:	(303) 790-7528

Local representative or contact person:

Name:	Mark Hollenbeck, P.E.
Title:	Project Manager
Address:	Powertech (USA) Inc. 310 2nd Avenue P.O. Box 812 Edgemont, SD 57735
Telephone:	(605) 662-8308

Table 1.4-1: Permits and Licenses for the Dewey-Burdock Project

Issuing Agency	Permit or License	Status
South Dakota Department of Environment and Natural Resources Joe Foss Building 523 E. Capitol Pierre, SD 57501	Large Scale Mine Permit	This application
	Uranium Exploration Permit	Approved, Permit EXNI-404
	Special, Exceptional, Critical, or Unique Land Determination	Based on a February 19, 2009 hearing, the Board of Minerals and Environment determined that the lands in the nominating petitions do not constitute special, exceptional, critical, or unique lands.
	Groundwater Discharge Plan (Land Application)	Submitted March 9, 2012
	Water Right (Madison Limestone)	Submitted June 11, 2012
	Water Right (Inyan Kara Group)	Submitted June 11, 2012
	Temporary Water Right for Testing	Approved January 2, 2008
	Temporary NPDES Permit for Testing	Approved December 5, 2007, Permit SDG 070626
	Air Quality Permit	In preparation
	NPDES Construction Stormwater Permit	Pending
	NPDES Industrial Stormwater Permit	Pending
	Public Water Supply System Construction Permit	Pending
	Class V Underground Injection Control Permit for Septic Wastes	Pending
US Nuclear Regulatory Commission TWFN, Mail stop: 8 F5 Washington, DC 20555-0001	Source and Byproduct Material License	Submitted August 10, 2009, Docket No. 40-9075 Draft license SUA-1600 issued July 31, 2012
US EPA Region 8 8P-W-GW, UIC 1595 Wynkoop St Denver, CO 80202-1129	Class III Underground Injection Control Permit	Submitted January 2009, revised July 2012
	Aquifer Exemption (Class III Wells)	Submitted January 2009, revised July 2012
	Class V Underground Injection Control Permit	Submitted March 2010
BLM Eastern Montana/Dakotas District 310 Roundup Street Belle Fourche, SD 57717	Plan of Operations	Submitted October 2009
Custer County 420 Mount Rushmore Road Custer, SD 57730-1934	Building Permit, Grading Permit, Floodplain Construction Permit (if applicable), Sign Permit and Septic System Permit	Pending
	Conditional Use Permit	Not required
Fall River County 906 N. River Street Hot Springs, SD 57747	Building Permit, Grading Permit, Floodplain Construction Permit (if applicable), Sign Permit and Septic System Permit	Not required
	Conditional Use Permit	Not required

2.0 PROPERTY DESCRIPTION

The proposed permit area is located approximately 13 miles north-northwest of Edgemont, South Dakota and includes portions of Fall River and Custer counties. The permit area encompasses approximately 10,580 acres of mostly private land on either side of County Road 6463 (S. Dewey Road). Figure 2.0-1 presents the proposed permit boundary.

The permit area is described as follows:

Custer County, South Dakota

Township 6 South, Range 1 East, Black Hills Meridian:

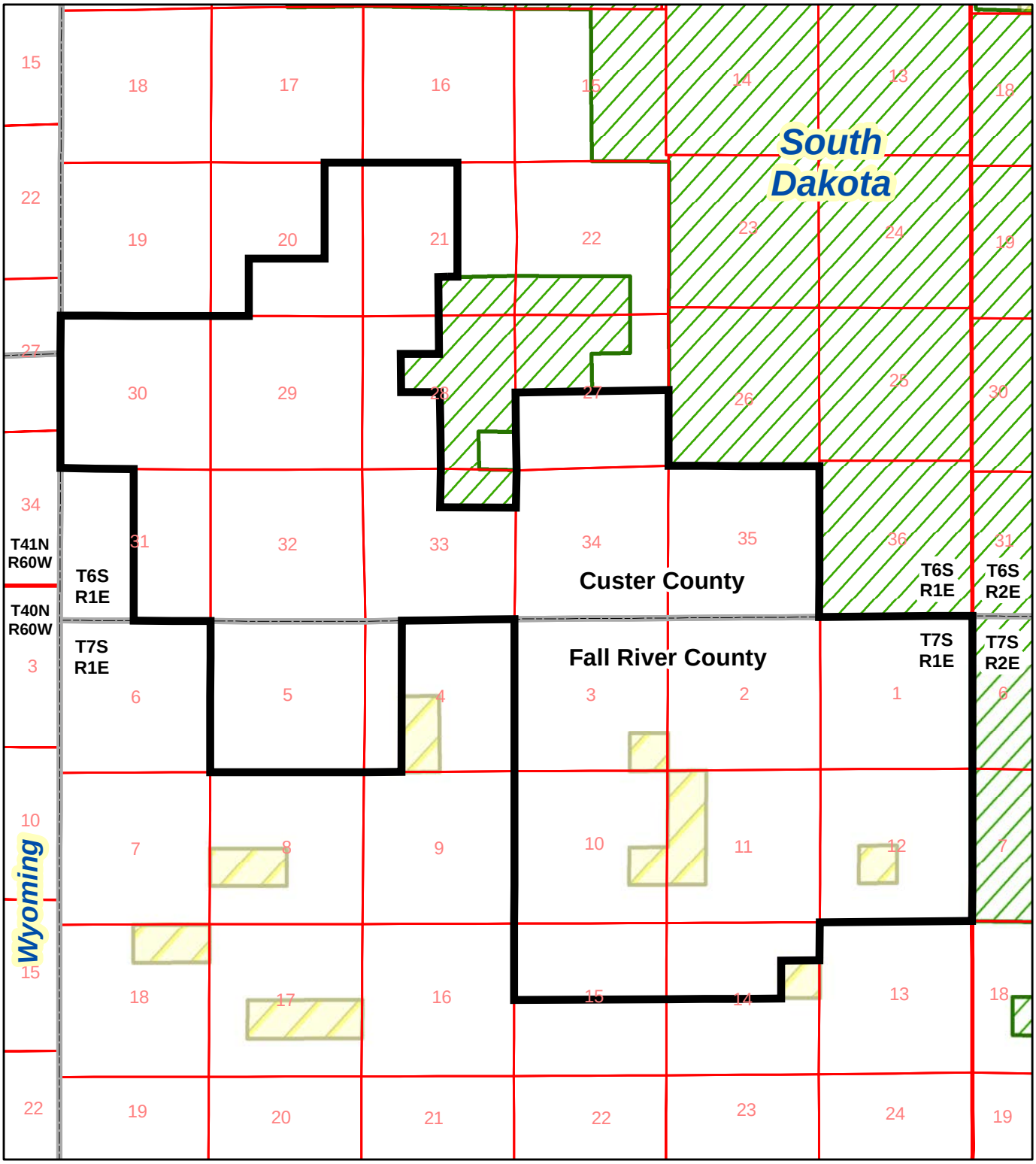
Section 20: E½NE¼; E½SE¼; SW¼SE¼; S½NW¼SE¼; SE¼SW¼; and S½NE¼SW¼
Section 21: W½; W½W½NE¼; W½NW¼SE¼
Section 27: S½
Section 28: N½NW¼; SW¼NW¼; SW¼
Section 29
Section 30
Section 31: E½
Section 32
Section 33: NW¼; SW¼; SE¼; S½NE¼
Section 34
Section 35

Fall River County, South Dakota

Township 7 South, Range 1 East, Black Hills Meridian:

Section 1
Section 2
Section 3
Section 4: W½W½
Section 5
Section 10
Section 11
Section 12
Section 14: NW¼; W½NE¼; NE¼NE¼
Section 15: N½

The site can be accessed from the northeast and the west via U.S. Highway 18 to County Road 6463. From the south, the site can be access from State Highway 471 to U.S. Highway 18 to County Road 6463. The main access road to the CPP and Burdock well fields is located off County Road 6463 in Section 15, T7S, R1E. This access road joins with several pre-existing roads that traverse through the Burdock portion of the proposed permit area. Further to the north in Section 20, T6S, R1E is the access road for the satellite facility and Dewey well fields. This road joins with several other pre-existing roads. These pre-existing roads within the Burdock



This figure is provided to fulfill the requirements of ARSD 74:29:01:17, 74:29:02:09 and SDCL 45-6B-10(1).

Legend

- Permit Boundary
- Black Hills National Forest
- BLM Land

Feet
0 2,500 5,000
0 1,000 2,000
Meters

N

Figure 2.0-1

Permit Boundary

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	10-Sep-2012
FILE	PermitBoundary.mxd

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and Dewey portions of the permit area will be used to the extent possible to access facility structures and well fields. Secondary roads will be built from the existing roads to provide access to other facilities and well fields that are not currently reached from the pre-existing roads. Refer to Section 5.3.8 for road design information.

Table 1.4-1 shows that county permits will be required for the Dewey-Burdock Project. These are anticipated to include a Custer County building permit, grading permit, floodplain construction permit (if applicable), and septic system permit. Powertech (USA) has been informed by Fall River County that these permits will not be required for Fall River County. Appendix 2.1-A contains or will contain documents from Custer and Fall River counties indicating that county permits are not required or that Powertech (USA) is in substantial compliance with the procedures for obtaining county permits.

2.1 County Conditional Use Permit/Zoning

The permit area is located within Fall River and Custer counties. Conditional use permits are not required from either of these counties. Documents presented in Appendix 2.1-A confirm that county conditional use permits will not be required.

2.2 Legal Right to Enter and Mine

Powertech (USA) has the legal right to conduct mining within the proposed permit area (ARSD 74:29:01:17). Powertech (USA) owns or controls all mineral rights within the permit area and has executed surface lease agreements covering the entire permit area except for the BNSF railroad right of way. Prior to commencing construction activities on federal surface Powertech (USA) will obtain BLM approval of the plan of operations previously submitted (refer to Table 1.4-1). Appendix 2.2-A provides details on mineral ownership within the permit area and surface ownership within and adjacent to the permit area. Plate 2.2-1 depicts the mineral ownership within the permit area, and Plate 2.2-2 depicts the surface ownership within and adjacent to the permit area.

2.3 Determination of Special, Exceptional, Critical, or Unique Lands

ARSD 74:29:10:02 requires, “Any prospective operator contemplating the establishment of a mining operation must request the department to determine whether or not the lands included in the proposed mining operation constitute special, exceptional, critical, or unique lands by submitting a notice of intent to operate to the department.” To fulfill the requirement, SDCL 45-6B-33.3 and ARSD 74:29:10:02 require the operator to submit a request for determination of special, exceptional, critical, or unique lands. Powertech (USA) submitted the request along with

a notice of intent to operate on August 21, 2008. Supplemental information was submitted on October 6, 8, and 17, 2008. DENR conducted on-site inspections of the proposed permit area on August 26 and October 8, 2008. Notices were published in the Hot Springs Star on November 4, 2008 and in the Custer County Chronicle on November 13, 2008. On December 31, 2008 DENR submitted its determination on the proposed permit area stating that, "the nominated lands do not constitute special, exceptional, critical, or unique lands." A hearing was held before the Board of Minerals and Environment on February 19, 2009. The board determined that the lands described do not constitute special, exceptional, critical or unique lands. The board findings are included as Appendix 2.3-A.

SDCL 45-6B-7 requires a statement of any characteristics of the affected land of historic, archeological, geologic, scientific, or recreational significance which are known to the applicant. Section 3.11 and Appendix 3.11-A describe the cultural resources evaluation that was conducted in the permit area. Aside from the findings of the cultural resources inventory, Powertech (USA) is unaware of any areas of historic or archeological significance. Section 3.11.3 describes how Powertech (USA) has entered into a memorandum of agreement with the South Dakota State Archeologist that establishes procedures to avoid or mitigate potential effects on archeological and historic sites. Powertech (USA) is unaware of any areas of geologic significance within the permit area. Section 3.2.2 describes how the Fall River Formation and Graneros Group crop out within the permit area. The geology is similar to surrounding areas near the Black Hills Uplift. Powertech (USA) is unaware of any areas of scientific significance in the permit area. Powertech (USA) also is unaware of any areas of recreational significance in the permit area. Section 3.1 describes how recreational use is limited primarily to large game hunting in designated areas or with landowner permission.

3.0 BASELINE

3.1 Land Use

3.1.1 General Setting

The permit area occupies portions of Custer and Fall River counties, South Dakota. Land within the permit boundary is predominantly privately owned (97.7 percent), with the remaining 2.3 percent managed by BLM.

3.1.2 Baseline Land Use

The predominant land use within the permit area is agricultural production related to grazing (rangeland). Most of the land serves as grazing land for cattle and a few horses. Approximately 390 acres of land are irrigated for hay production along Beaver Creek. Historically, some of the land within the permit area was used for mining.

According to the U.S. Department of Agriculture (USDA) 2007 census, Custer County generated $13,800,000 and Fall River County generated $95,534,000 from the selling of livestock, poultry and their products (USDA, 2012). Table 3.1-1 shows the 2007 livestock inventory for Custer and Fall River counties.

Recreation lands are present in Custer, Fall River and Pennington counties within a 50-mile radius of the permit area (Table 3.1-2). Major attractions include Mount Rushmore National Memorial and Wind Cave National Park, which are set in the backdrop of the Black Hills National Forest. There are no designated recreation lands within the permit area or within the surrounding 2 km area. Most of the land is privately owned with a small portion, approximately 240 acres, managed by BLM.

Recreational use in and around the permit area is limited primarily to large game hunting. Within the permit area, hunting currently is open to the public on approximately 5,700 acres. SDGF&P leases around 3,000 acres annually of privately owned land that is designated as walk-in hunting areas (WIA).The number of acres designated as WIA can change from year to year, since participants enroll their lands annually.

The WIAs are on privately owned lands. The WIA program compensates private landowners annually for use of the lands enrolled in the program. Landowners must renew their agreement with the State each year by May 1. Rules related to the program prohibit the firing of a firearm within 100 yards of a person or a structure. The landowner can terminate the program

Table 3.1-1: 2007 Livestock Inventory for Custer and Fall River Counties

Type of Livestock	Number Custer County	State Rank	Number Fall River County	State Rank
Cattle and calves	22,055	64	53,197	31
Bison	2,754	5	NR	NR
Horses and ponies	1,798	11	1,503	14
Sheep and lambs	NR	63	2,480	38

NR – not reported
Source: USDA, 2012

Table 3.1-2: Recreational Areas within 50 Miles of the Proposed Project

Name of Recreational Facility	Managing Agency	Distance From Permit Area (miles)
Mount Rushmore National Memorial	U.S. Department of the Interior	44.0
Jewel Cave National Monument	U.S. Department of the Interior	23.0
Buffalo Gap National Grassland	U.S. Forest Service	3.0
Custer State Park	South Dakota Department of Game, Fish and Parks	35.0
Wind Cave National Park	U.S. Department of the Interior	29.0
Black Hills National Forest	U.S. Forest Service	0.0
Angostura State Recreation Area	South Dakota Department of Game, Fish and Parks	29.0
George S. Mickelson Trail	South Dakota Department of Game, Fish and Parks	17.0

Source: Google Earth (20 June, 2008)

at any time with a written notice 30 days prior to termination and reimbursement of the annual compensation.

Prior to commencement of operations, Powertech (USA) will work with BLM, SDGF&P and private landowners to limit hunting within the permit area to the extent practicable. Temporary fencing, signage, gates and other means of restricting public access will be installed in areas of active ISR operations such as well fields, processing plants and other facility areas in order to protect the public, protect workers, prevent damage to facilities, and provide security.

Table 3.1-3 lists the distances from nearby residences to the proposed affected area boundary. Residences are depicted on Figure 3.1-1. There are five residences within the permit area, including seasonal residences.

Aesthetics

The permit area is located within the Great Plains physiographic province on the edge of the Black Hills Uplift. The vegetation is a mix of short grasses and shrubs typical of semi-arid steppe land along with Ponderosa Pine forest toward the Black Hills. The color of the landscape varies from light brown and green to dark green with wildflowers in the springtime to light brown to golden during the later, drier months. With the exception of historical open mine pits in the eastern portion of the permit area, the visual aspects of human influence on the area are minor with most of the area used for grazing activities and associated facilities (e.g., fences and stock wells). The area's infrastructure includes the BNSF railroad that runs north through Edgemont to Newcastle, Wyoming, Country Road 6463 that parallels the railroad between Edgemont and the town of Dewey, overhead power lines and several gravel access roads.

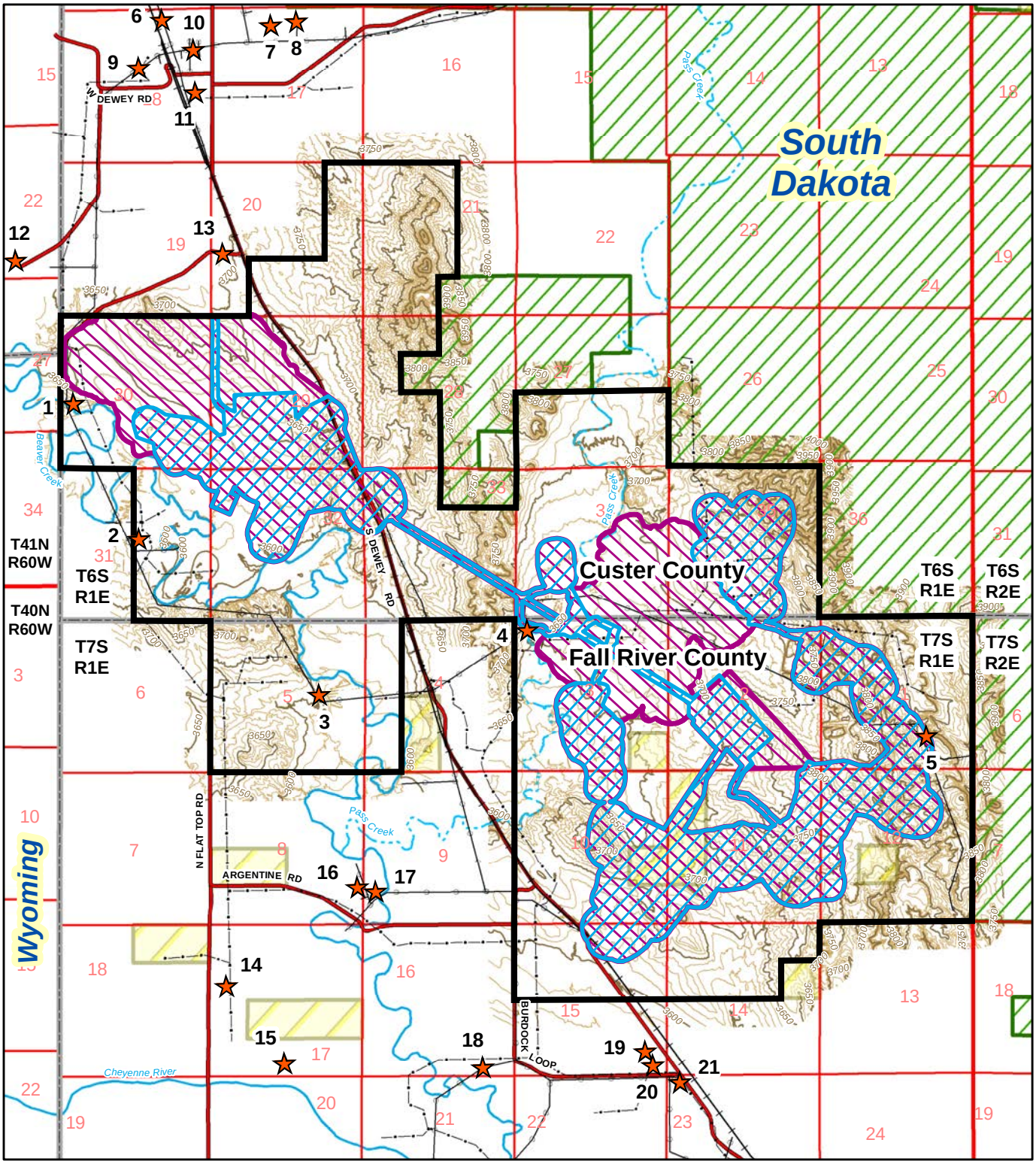
Transportation and Utilities

The permit area generally will be accessed north from Edgemont along County Road 6463. To the east, U.S. Highway 18 connects Edgemont with Hot Springs and to the north, State Highway 89 and U.S. Highway 385 connect Edgemont with Pringle and Custer City. The 2011 annual average daily traffic (AADT) on U.S. Highway 18 between Edgemont and the junction with State Highway 89 was 1,782 vehicles (SDDOT, 2012). The 2011 AADT on State Highway 89 between Pringle and the junction with U.S. Highway 18 was 659 vehicles (SDDOT, 2012).

Table 3.1-3: Distance from Nearby Residences to Proposed Affected Area Boundary

Residence[1]	Distance from Proposed Affected Area Boundary (miles)	
	Deep Disposal Well Option	Land Application Option
1	0.4	0.1
2	0.5	0.5
3	0.9	0.9
4	0.0	0.0
5	0.0	0.0
6	2.0	1.9
7	1.9	1.9
8	2.0	2.0
9	1.7	1.6
10	1.8	1.7
11	1.5	1.5
12	1.3	0.6
13	0.4	0.4
14	2.4	2.4
15	2.1	2.1
16	1.5	1.5
17	1.4	1.4
18	1.0	1.0
19	0.6	0.6
20	0.7	0.7
21	0.9	0.9

[1] Refer to Figure 3.1-3 for the residence designations.



This figure is provided to fulfill the requirements of ARSD 74:29:02:12 and SDCL 45-6B-10(4).

Legend

- Permit Boundary
- Black Hills National Forest
- BLM Land
- Ephemeral Streams
- Perennial Streams
- BNSF Railroad
- County Roads
- Residences
- BHEC Powerlines
- Golden West Telephone Lines
- Proposed Affected Area Boundary, Deep Disposal Well Option
- Proposed Affected Area Boundary, Land Application Option

Feet: 0 2,500 5,000
Meters: 0 1,000 2,000

N

Figure 3.1-1

Residences in the Vicinity of the Permit Area

Dewey-Burdock Project

SIGNATURE OF PREPARER	Mark J Hollenbeck
PREPARER	Mark J. Hollenbeck
DATE	02-Nov-2012
FILE	PermitResVicinity.mxd

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3.2 Geology and Depositional Environment

3.2.1 Regional Geology

The permit area is located in the Great Plains Physiographic province on the southwestern flank of the Black Hills Uplift in southwestern South Dakota. To the west of the permit area is the Powder River Basin of Wyoming. The regional geologic map of this region is shown on Figure 3.2-1.

3.2.1.1 Regional Structure

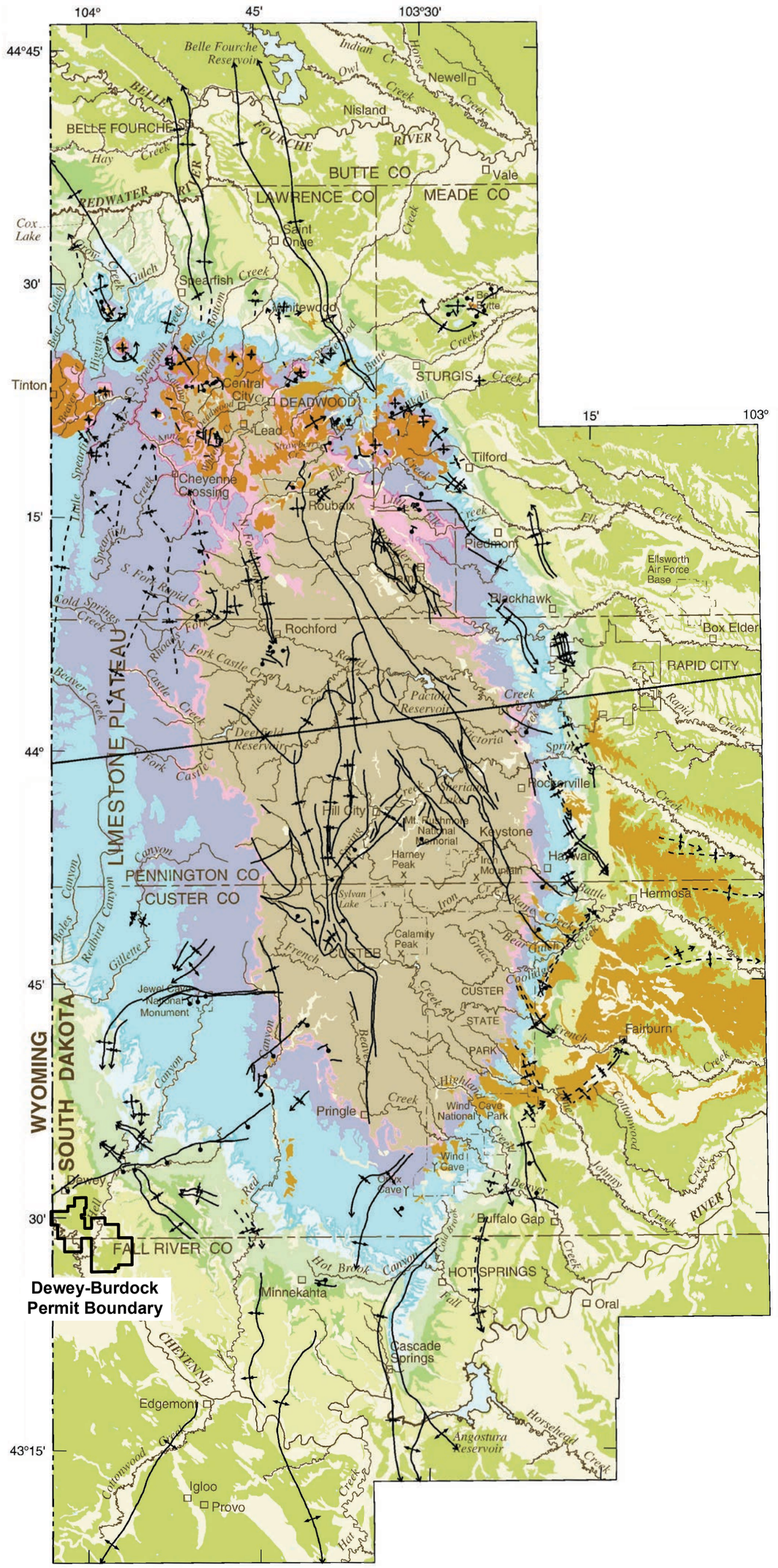
The dominant structural feature in this region is the Black Hills Uplift. This uplift is of Laramide age (65 million years ago) and is an elongate northwest trending dome about 125 miles long and 60 miles wide. Igneous and metamorphic Precambrian-age rocks are exposed in the core of the uplift and are surrounded by outward-dipping Paleozoic and Mesozoic rocks that form cuestas and hogbacks around the core of the uplift. Folds constitute the major structural features in the Black Hills. During the early Cretaceous period, minor deformation along concealed northeast-trending remnant structures of Precambrian age affected the courses of the northwest-flowing streams and their tributaries, thereby influencing the location of the fluvial sandstone deposits of the Inyan Kara Group.

3.2.1.2 Regional Stratigraphy

The oldest rocks in the region are Precambrian metamorphic rocks and granites. These form the core of the Black Hills Uplift and are exposed at the surface of this structural feature. Overlying these crystalline rocks as one moves radially outward from the core of the uplift are 2,000-3,000 feet of Paleozoic sediments. This sedimentary sequence contains several regional aquifers, including the Deadwood Formation of Cambrian age, the Mississippian Madison Limestone and the Pennsylvanian/Permian-age Minnelusa Formation.

Mesozoic sediments include the Triassic-age Spearfish Formation and the Sundance Formation, Unkpapa Sandstone, and Morrison Formation of Jurassic age. A thick sequence of Cretaceous-age sediments completes the Mesozoic section.

The Early Cretaceous sediments of the Inyan Kara Group consist of the Lakota and the Fall River formations. The Inyan Kara Group is a transitional unit, exhibiting a change from terrestrial to marine deposition. The basal Lakota Formation (Chilson Member) is a fluvial sequence, which grades upward into marginal marine sediments where the Cretaceous Seaway inundated a stable land surface. Basal units of the Lakota Formation scour into clays of the



EXPLANATION

HYDRO-GEOLOGIC UNITS	STRATI-GRAPHIC UNITS	MAP UNITS
Unconsolidated units	QTac	Alluvium, terraces, and colluvium, undifferentiated
White River aquifer	Tw	White River Group
Tertiary intrusive units	Tui	Undifferentiated intrusive igneous rocks
Cretaceous-sequence confining unit	Kps	Pierre Shale to Skull Creek Shale, undifferentiated
Inyan Kara aquifer	Kik	Inyan Kara Group
Jurassic-sequence semiconfining unit	Ju	Morrison Formation to Gypsum Spring Formation, undifferentiated
Spearfish confining unit	TRs	Spearfish Formation
Minnekahta aquifer	Pmk	Minnekahta Limestone
Opeche confining unit	Po	Opeche Shale
Minnelusa aquifer	PIPm	Minnelusa Formation
Madison aquifer	MDme	Madison (Pahasapa) Limestone and Englewood Formation
Ordovician-sequence semiconfining unit	Ou	Whitewood Formation and Winnipeg Formation
Deadwood aquifer	O€d	Deadwood Formation
Precambrian aquifer	p€u	Undifferentiated igneous and metamorphic rocks

FAULT—Dashed where approximated. Bar and ball on downthrown side

ANTICLINE—Showing trace of axial plane and direction of plunge. Dashed where approximated

SYNCLINE—Showing trace of axial plane and direction of plunge. Dashed where approximated

MONOCLINE—Showing trace of axial plane. Dashed where approximated

DOME—Symbol size approximately proportional to size of dome. Dome asymmetry indicated by arrow length

Miles: 0 5 10 20

Kilometers: 0 5 10 20 30

N

Base modified from U.S. Geological Survey digital data, 1:100,000, 1977, 1979, 1981, 1983, 1985
Rapid City, Office of City Engineer map, 1:18,000, 1996; Universal Transverse Mercator projection, zone 13

Figure 3.2-1

Geologic Map of the Black Hills

Dewey-Burdock Project

DRAWN BY	Bonner, Hetrick
DATE	10-Sep-2012
FILENAME	BlackHillsGeoMap.dwg

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Source: Carter et al. (2003)

underlying Morrison Formation and display the depositional nature of a large braided stream system, crossing a broad, flat coastal plain and flowing toward the northwest. Younger fluvial sand units of the Lakota become progressively thinner and less continuous and are separated by thin deposits of overbank and floodplain silts and clays. At the top of the Lakota is the Fuson Member. The Fuson consists of shale with minor beds of fine-grained sandstone and siltstone. The Fuson separates the underlying Lakota Formation from the overlying Fall River Formation. The Fall River consists of thick, widespread fluvial sands in the lower portion, grading to thinner, less continuous, marginal sands in the upper part. The Cretaceous Lakota and Fall River Formations are the hosts of the roll-front uranium mineralization in the Black Hills region.

Following deposition of the Fall River, this region was covered by the North American Cretaceous Seaway, which resulted in the accumulation of vast thicknesses of marine sediments (from 3,000-5,000 feet thick). These marine sediments are represented by the Skull Creek Shale, Newcastle Sandstone, Mowry Shale, Belle Fourche Shale, Greenhorn Formation, Carlile Shale, Niobrara Formation and Pierre Shale. In Late Cretaceous time, the modern Rocky Mountain Uplift began, forcing the retreat of the Cretaceous Seaway.

Unconformably overlying the Cretaceous sediments in the Black Hills region is the Tertiary-age (Oligocene) White River Group. This thick sequence is primarily composed of tuffaceous mudstones and siltstones, with minor amounts of fluvial, coarse sandstone, lacustrine limestone and gypsum, and tuff beds. The tuff beds were deposited from volcanic eruptions to the west (Larson and Evanoff, 1998). The majority of the White River sediments have been removed by erosion and the remainder can be found as erosional remnants. This unit is thought to be the source of the uranium deposits found in the Black Hills region and the Powder River Basin of Wyoming.

The most recent sediments in the region are Quaternary-age deposits consisting of local material derived as a result of post-Laramide-uplift erosion. Recent deposits include alluvium and floodplain terrace deposits.

Figure 3.2-2 provides a stratigraphic column of the Black Hills.

3.2.2 Site Geology

The site surface geology is shown on Figure 3.2-3. The Fall River Formation crops out across the eastern part of the permit area and the Skull Creek Shale, Mowry Shale, and Belle Fourche

ERATHEM	SYSTEM	ABBREVIATION FOR STRATIGRAPHIC INTERVAL	STRATIGRAPHIC UNIT	THICKNESS IN FEET	DESCRIPTION
CENOZOIC	QUATERNARY & TERTIARY (?)	QTac	UNDIFFERENTIATED ALLUVIUM AND COLLUVIUM	0 - 50	Sand, gravel. boulder and clay.
		Tw	WHITE RIVER GROUP	0 - 300	Light colored clays with sandstone channel fillings and local limestone lenses.
	TERTIARY	Tui	INTRUSIVE IGNEOUS ROCKS	--	Included rhyolite, latite, trachyte and phonolite.
MESOZOIC	CRETACEOUS	Kps	PIERRE SHALE	1,200 - 2,700	Principal horizon of limestone lenses giving teepee buttes. Dark-gray shale containing scattered concretions. Widely scattered limestone masses giving small teepee buttes. Black fissile shale with concretions.
			NIOBRARA FORMATION	80 - 300 §	Impure chalk and calcareous shale.
			CARLILE SHALE — Turner Sandy Member Wall Creek Member	350 - 750 §	Light-gray shale with numerous large concretions and sandy layers. Dark-gray shale.
			GREENHORN FORMATION	225 - 380	Impure slabby limestone. Weathers buff. Dark-gray calcareous shale with thin Oman Lake limestone at base.
			GRANEROS GROUP — BELLE FOURCHE SHALE	150 - 850	Gray shale with scattered limestone concretions. Clay spur bentonite at base.
			GRANEROS GROUP — MOWRY SHALE	125 - 230	Light-gray siliceous shale. Fish scales and thin layers of bentonite.
			GRANEROS GROUP — MUDDY SANDSTONE — NEWCASTLE SANDSTONE	0 - 150	Brown to light-yellow and white sandstone.
			GRANEROS GROUP — SKULL CREEK SHALE	150 - 270	Dark-gray to black siliceous shale.
		Kik	INYAN KARA GROUP — FALL RIVER FORMATION	10 - 200	Massive to thin-bedded, brown to reddish-brown sandstone.
			INYAN KARA GROUP — LAKOTA FORMATION — Fuson Shale Minnewaste Limestone Chilson Member	10 - 190 0 - 25 25 - 485	Yellow, brown and reddish brown massive to thinly bedded sandstone, pebble conglomerate, siltstone and claystone. Local fine-grained limestone and coal.
	JURASSIC	Ju	MORRISON FORMATION	0 - 220	Green to maroon shale. Thin sandstone.
			UNKPAPA SANDSTONE	0 - 225	Massive fine-grained sandstone.
			SUNDANCE FORMATION — Redwater Member Lak Member Hulett Member Stockade Beaver Member Canyon Spr Member	250 - 450	Greenish-gray shale, thin limestone lenses. Glauconitic sandstone, red sandstone near middle.
			GYPSUM SPRING FORMATION	0 - 45	Red siltstone, gypsum and limestone.
	TRIASSIC	ŦPs	SPEARFISH FORMATION — Goose Egg Equivalent	375 - 800	Red silty shale, soft red sandstone and siltstone with gypsum and thin limestone layers. Gypsum locally near the base.
PALEOZOIC	PERMIAN	Pmk	MINNEKAHTA LINESTONE	25 - 65 §	Thin to medium-bedded, fine-grained, purplish gray laminated limestone.
		Po	OPECHE SHALE	25 - 150 §	Red shale and sandstone.
		PIPm	MINNELUSA FORMATION	375 - 1,175 §	Yellow to red cross-bedded sandstone, limestone and anhydrite locally at top. Interbedded sandstone, limestone, dolomite, shale and anhydrite. Red shale with interbedded limestone and sandstone at base.
	PENNSYLVANIAN				
	MISSISSIPPIAN	MDme	MADISON (PAHASAPA) LIMESTONE	< 200 - 1,000 §	Massive light-colored limestone. Dolomite in part. Cavernous in upper part.
	DEVONIAN		ENGLEWOOD FORMATION	30 - 60	Pink to buff limestone. Shale locally at base.
	ORDOVIOAN	Ou	WHITEWOOD (RED RIVER) FORMATION	0 - 235 §	Buff dolomite and limestone.
			WINNIPEG FORMATION	0 - 150 §	Green shale with siltstone.
	CAMBRIAN	O€d	DEADWOOD FORMATION	0 - 500 §	Massive to thin-bedded buff to purple sandstone. Greenish glauconitic shale flaggy dolomite and flat-pebble limestone conglomerate. Sandstone with conglomerate locally at the base.
PRECAMBRIAN		p€u	UNDIFFERENTIATED IGNEOUS AND METAMORPHIC ROCKS		Schist, slate, quartzite and arkosic grit. Intruded by diorite, metamorphosed to amphibolite, and by granite and pegmatite.

Source:
Driscoll et al. (2002).

§ Modified based on drill-hole data

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(1).

Figure 3.2-2

Stratigraphic Column of the Black Hills Area

Dewey-Burdock Project

DRAWN BY	Mays, Hetrick
DATE	10-Sep-2012
FILENAME	StratColBlackHills.dwg

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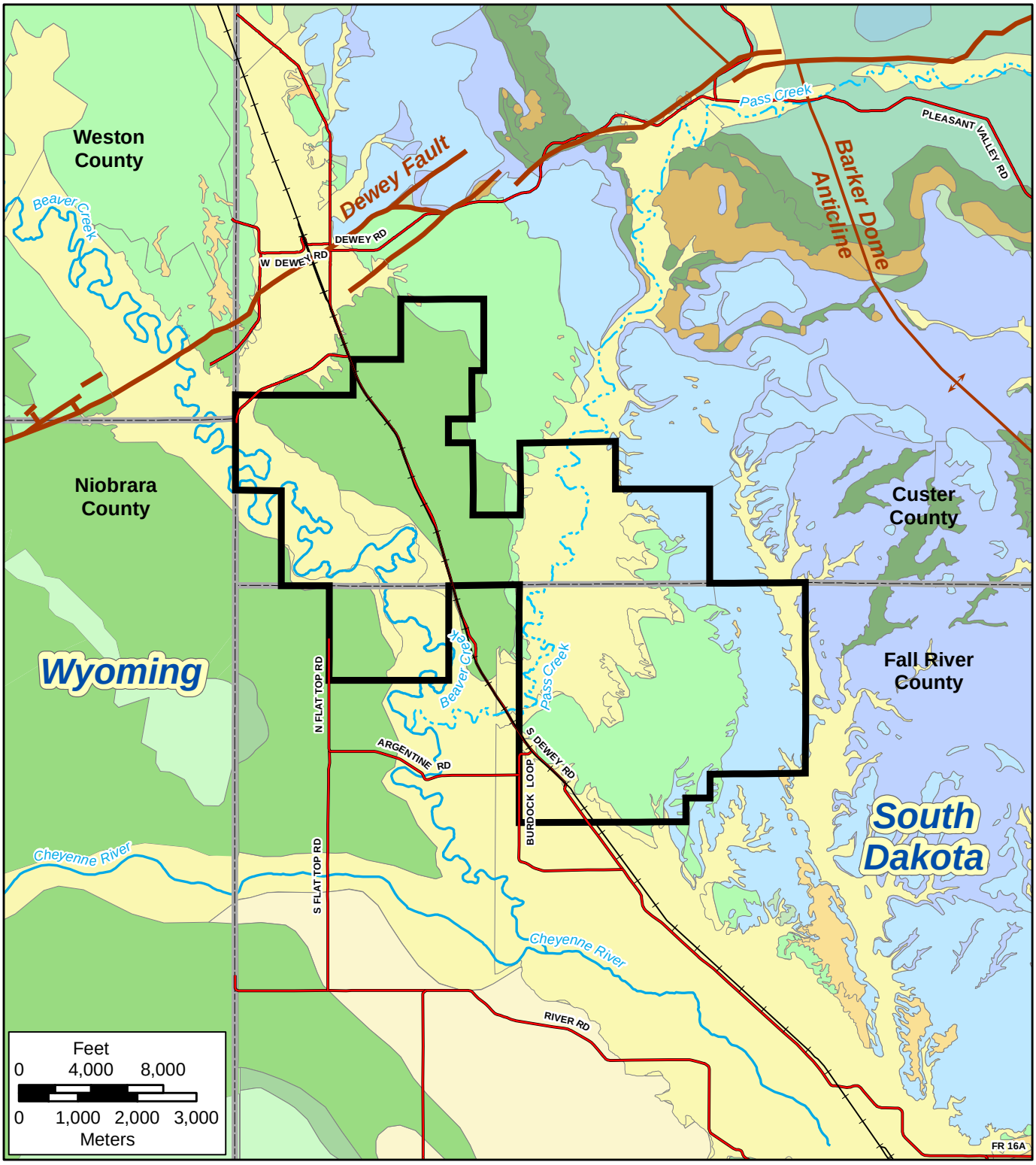

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(1).

Legend

- Alluvium
- Wind Blown Sand
- Gravel Deposits
- Landslide Deposits
- Carlile Shale
- Greenhorn
- Belle Fourche Shale
- Mowry and Skull Creek Shale
- Fall River
- Lakota
- Morrison, Sundance
- Spearfish

- Permit Boundary
- County Roads
- BNSF Railroad
- Ephemeral Streams
- Perennial Streams
- Fault
- Anticline

N

Figure 3.2-3

Site Surface Geology

Dewey-Burdock Project

SIGNATURE OF PREPARER	
PREPARER	F. L. Lichnovsky
DATE	25-Sep-2012
FILE	SurfaceGeology.mxd

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Shale (collectively referred to as the Graneros Group) crop out across the western part of the permit area. The formations dip west and southwest at 2 to 6 degrees.

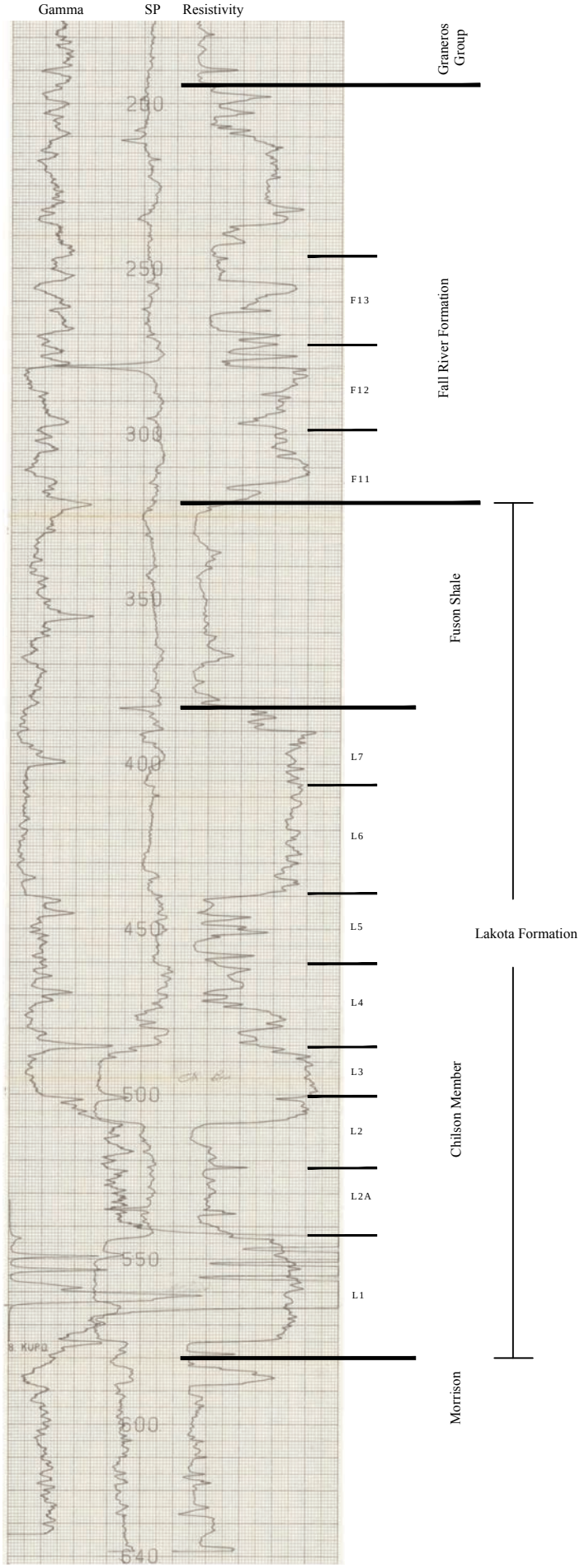
The geology of the permit area was developed through the interpretation of data gathered from thousands of exploration drill holes. For each drill hole there was a suite of down-hole geophysical logs run to characterize natural radioactivity and the lithology of the sediments in the subsurface. Resistivity and self potential define the rock types encountered in the subsurface (sandstone, siltstone, shale, etc.). This is further enhanced by a geologist's description of the drill cuttings. Figure 3.2-4 is an example of a "type log" from the permit area. Appendix 3.2-A provides a listing of the drill holes within 1 mile of the permit area.

3.2.2.1 Site Structure

The structure across the permit area is simple and shows sediments dipping gently 2 to 6 degrees to the southwest. This is illustrated by structure contour maps on the tops of the Unkpapa Sandstone (Plate 3.2-1), the Morrison Formation (Plate 3.2-2), the Chilson Member of the Lakota Formation (Plate 3.2-3), the Fuson Shale (Plate 3.2-4), and the Fall River Formation (Plate 3.2-5). Isopach maps also are provided for the Morrison Formation (Plate 3.2-6), Chilson Member (Plate 3.2-7), Fuson Shale (Plate 3.2-8), Fall River Formation (Plate 3.2-9), Graneros Group (Plate 3.2-10) and Alluvium (Plate 3.2-11).

The Dewey Fault, a northeast to southwest trending fault zone, is present approximately one mile north of the permit area. The Dewey Fault is a steeply dipping to vertical normal fault with the north side uplifted approximately 500 feet by a combination of displacement and drag. The U.S. Geological Survey (USGS) considers an area 7 miles southeast of the permit area as the Long Mountain Structural Zone. This northeast-southwest trend contains several small, shallow surface faults in the Inyan Kara Group. No faults were identified along this trend on subsurface structure maps of the underlying Madison Limestone, Minnelusa Formation or the Deadwood Formation.

Despite the presence of faulting north and south of the site, there are no identified faults within the permit area. There is some folding in the areas surrounding the permit area. East of the permit area is a northwest-southeast trending anticline that ends in a closed structure called the Barker Dome. To the west is the Fanny Peak Monocline. This monocline is the structural boundary between the Black Hills Uplift and the Powder River Basin.



PR-7

Elev. 3655

Vertical Scale

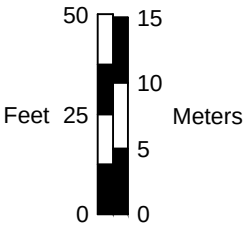


Figure 3.2-4

Type Log

Dewey-Burdock Project

SIGNATURE OF PREPARER	
PREPARER	F. L. Lichnovsky
DATE	24-Sep-2012
FILE	TypTypeLog.dwg

POWERTECH (USA) INC.

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(1).

3.2.2.2 Site Stratigraphy

The sedimentary rocks of primary interest that underlie the permit area range in age from Upper Jurassic to Early Cretaceous. The Upper Jurassic Morrison Formation is considered to be the lowermost confining unit for ISR operations (see discussion below). The uranium mineralization is contained within the Inyan Kara Group (specifically within the Fall River Formation and Chilson Member of the Lakota Formation). The depth of ore targeted for ISR ranges from 200 to 800 feet. The Graneros Group is the uppermost confining unit for ISR operations. Figure 3.2-4 is a type log for the permit area, illustrating the relationship between these sedimentary units. Figure 3.2-2 demonstrates the relationship between these sedimentary units and underlying rocks, ranging in age from Jurassic to Precambrian.

Plate 3.2-12 is a cross section index map for nine geologic cross sections (Plates 3.2-13 through 3.2-21) covering the permit area. In addition to showing the scaled vertical location of each ore body proposed for uranium recovery, the nine cross sections also illustrate the continuity of the Graneros Group, the Fuson Shale and the Morrison Formation, the major confining units, across the entire permit area:

1) The Graneros Group is the uppermost confining unit and overlies the Fall River Formation. This marine shale sequence has a maximum thickness of 550 feet in the permit area. The Graneros Group is composed of several geologic formations including the Skull Creek, Newcastle (not present in the permit area), Mowry and Belle Fourche.
2) The Fuson Member is the confining unit between the Fall River Formation and the Chilson Member of the Lakota Formation. The Fuson Shale is a low-permeability shale unit within the Fuson Member that ranges in thickness from 20 to 80 feet across the entire permit area and crops out east of the permit boundary.
3) The Morrison Formation is the lowermost confining unit and underlies the Chilson Member of the Lakota Formation. This low-permeability shale unit that ranges in thickness from 60 to 140 feet across the entire permit area crops out east of the permit boundary.

The nine cross sections presented in Plates 3.2-13 through 3.2-21 also provide detailed lithologic interpretations of the host sandstones within the Fall River Formation and the Chilson Member of the Lakota Formation. These interpretations show that interbedded clay beds are found locally within both the Fall River and Chilson sandstones and may be sufficiently continuous as to further subdivide the Fall River and Chilson into discrete, mappable fluvial sandstone packages (i.e., Upper Fall River, Lower Fall River, Upper Chilson, etc.). These interbedded clay beds may act as confining units within individual well fields. However, they cannot be considered as regional confining units because they are discontinuous. This will be confirmed

through delineation drilling and aquifer pump tests. Potential use of these interbedded clay beds, as they relate to operational fluid control and monitoring, will be addressed in hydrogeologic data packages prepared for each well field (refer to Section 5.3.3.4).

The three major confining units (Graneros Group, or uppermost confining unit, Fuson Shale, and Morrison Formation, or lowermost confining unit) are depicted on Figure 3.2-4 in their typical relationship to the host sands, which are in the Fall River and Lakota formations.

The following is a brief description of the formations of interest in the permit area:

Sundance Formation and Unkpapa Sandstone - The Sundance Formation is composed primarily of shale and sandstone with an average thickness of 280 feet thick near the permit area. Where present, the Unkpapa Sandstone is 50 to 80 feet thick and consists of well sorted, fine-grained, eolian sandstone.

Morrison Formation - The Upper Jurassic Morrison Formation was deposited as floodplain deposits. It is composed of waxy, unctuous, calcareous, noncarbonaceous massive shale with numerous limestone lenses and a few thin, fine-grained sandstones. Within the permit area, this formation has an average thickness of approximately 100 feet and is the lowermost confining unit for ISR operations. The confining properties of the Morrison Formation are well documented. An article entitled "Clay Mineralogy of the Morrison Formation – Black Hills Area," published in the Bulletin of the American Association of Petroleum Geologists, Vol. 40, No. 5, by Ronald Warren Tank (1956), provides an excellent description of Morrison clays in this area. The Morrison Formation is an extensive, low-permeability, terrestrial clay unit, with illite being the dominant clay mineral. Illite is a stable clay mineral that is usually deposited in fairly stagnant waters in an alkaline pH. The continuity, thickness, and lithology of the Morrison Formation ensure hydraulic isolation of the overlying Chilson sandstones from any potential aquifers below the Morrison.

Exploration holes drilled to evaluate the economic geology of the Lakota Formation were generally not continued the additional 100 feet required to penetrate the entire Morrison Formation. Powertech (USA) drilled eight holes that penetrated through the Morrison Formation, and records indicate that 16 historical TVA exploration holes penetrated the entire Morrison Formation. Two electric logs from plugged and abandoned oil test holes in the permit area also were used to assist with evaluation of the Morrison Formation. Table 3.2-1 provides a listing of these 26 identified Morrison Formation penetrations.

Table 3.2-1: Drill Holes Penetrating the Morrison Formation

	Hole No.	Easting (ft)	Northing (ft)	Elevation (ft amsl)
1.	CAT1	1028330	444666	3738
2.	DRJ90	1037602	438720	3762
3.	FBR31	1038131	433097	3800
4.	RONA81	1033459	429385	3688
5.	PM159	1032551	433100	3651
6.	DWT48	1025864	444053	3702
7.	DWT49	1025235	442634	3661
8.	ELT14	1017626	444849	3617
9.	DWT40	1022610	445875	3681
10.	DWW190	1032799	450521	3760
11.	DWW192	1033149	450479	3740
12.	DY12	1025946	450088	3820
13.	DY17	1027335	455821	3818
14.	DY308	1012901	445124	3616
15.	HDA1	1028537	448585	3780
16.	TRM38	1035605	441152	3749
17.	DB07-11-31	1038312	429998	3731
18.	DB07-11-16C	1035139	429992	3698
19.	DB08-11-18	1035133	429986	3700
20.	DB08-32-12	1022352	439368	3590
21.	DB08-32-11	1020339	443666	3627
22.	DB08-5-1	1017626	444849	3629
23.	DB08-1-7	1042271	434137	3913
24.	DB09-21-1	1028628	453319	3822
25.	API 40 047 05095	1038166	433840	3792
26.	API 40 047 05093	1032429	423452	3576

Note: Coordinate system is NAD 27 South Dakota State Plane South

Plate 3.2-2 is a structure contour map of the top of the Morrison Formation. This map shows the Morrison Formation generally dipping 2½ degrees to the southwest – away from the southwestern flank of the Black Hills Uplift. The irregular contour lines on Plate 3.2-2 in the Dewey and Burdock portions of the permit area may indicate some minor scouring into the top of the Morrison Formation and subsequent deposition of the Lower Chilson sands. This minor scouring has not cut deeply into the Morrison clays, and the overall 60- to 140-foot thickness of this formation has not been significantly affected.

A good understanding of the Morrison Formation is important to the Dewey-Burdock Project. For this reason, in addition to providing the structure contour map of the Morrison Formation, Plate 3.2-6 provides an isopach map of the Morrison Formation. This map was based on the 26 drill holes that fully penetrated the Morrison Formation and shows the thickness of the Morrison varying from approximately 60 to 140 feet beneath the permit area. Also shown on this isopach map is the location of cross section A-A'-A", which is shown on Plate 3.2-22.

Cross section A-A'-A" depicts the surface to the base of the Morrison Formation based on 10 of the drill holes used in the development of the isopach map. The electric logs shown on this cross section illustrate a consistently thick sequence of Morrison clays across the permit area. Copies of all electric logs from test holes that penetrate the Morrison Formation are provided in Appendix 3.2-B. The A-A' portion of the cross section traverses the permit area in an "updip" direction through the initial proposed well field in the Dewey area. Due to the 2½ degree dip, the Fall River Formation is shown to rise from a depth of 550 feet below ground surface in the Dewey area and crop out along the eastern edge of the permit area near A' (drill hole DB08-1-7). The A'-A" portion of the cross section proceeds in a "downdip" direction from the outcrop and continues through the initial proposed well field in the Burdock area.

Cross section A-A'-A" also illustrates the presence of the project's uppermost confining unit (the Graneros Group) and the Fuson Shale confining unit between the Fall River Formation and the Chilson Member of the Lakota Formation. The thickness of the Graneros Group ranges from 0 feet at its outcrop within the eastern portion of the permit area to over 550 feet in the southwestern portion of the permit area. The Fuson Shale ranges from 20 to 80 feet thick throughout the permit area.

Inyan Kara Group - This Group consists of the Lakota Formation and the Fall River Formation. Sandstones within these two formations are hosts to all the uranium mineralization for the project.

Lakota Formation - The Lakota Formation consists of three members: from lower to upper they are the Chilson Member, the Minnewaste Limestone Member and the Fuson Member.

The Chilson Member (commonly referred to as the Lakota Sandstone) is composed largely of fluvial deposits. These deposits consist of sandstone, shale, and siltstone. The member consists of a complex of channel sandstone deposits and their laterally fine-grained equivalents. The Chilson Member consists of two units: a basal carbonaceous black mudstone and an overlying unit of channel sandstones with laterally fine-grained equivalents and interbedded shales. The sandstones are very fine to medium grained and well sorted and were deposited by a northwest flowing river system. The massive sandstone is made up of numerous individual sand-filled channels, which contain the uranium deposits.

The isopach map of the Chilson Member of the Lakota Formation (Plate 3.2-7) shows the thickness of the channel sandstones and interbedded shales within the Chilson Member. Thicknesses vary from 100 to 240 feet. In some cases the thickness of the Chilson may be greater than shown on Plate 3.2-7; drilling was usually stopped in the lower carbonaceous shale unit of the Chilson Member and typically did not reach the Morrison Formation.

The Minnewaste Limestone Member, although present in the region, is not present in the permit area. Darton (1909) noted that the Minnewaste Limestone is some 20 feet thick at its type locality at the falls of the Cheyenne River (25 miles east of the permit area, now under Angostura Reservoir). In USGS Professional Paper 763 (Gott et al., 1974), the Minnewaste Limestone is described in the type locality as being a pure limestone, but grading out laterally to a sandy limestone and to a calcareous sandstone at its margins. Gott et al. also state that it is discontinuous west and northwest of the type locality (toward the permit area).

A review of all drill hole and geologic lithology logs confirms the Minnewaste Limestone does not occur within the permit area. Geologic cross section E-E' (Plate 3.2-17), along the northeastern portion of the permit area, illustrates the geologic section where, if present, the Minnewaste Limestone would occur. If present, this limestone unit would occur immediately beneath the Fuson Shale confining unit and above the Chilson Member of the Lakota Formation. A limestone would have a characteristically high (off-scale) response on the resistivity curve on the electric logs. This response is not present on geophysical logs within the permit area. As shown on cross section E-E' (Plate 3.2-17), no limestone is present.

The Fuson Member is the uppermost member of the Lakota Formation. The shale-siltstone portion of the Fuson (Fuson Shale) has been used to divide the Lakota Formation from the Fall River Formation.

For clarification, the Fuson Shale is differentiated from the Fuson Member of the Lakota Formation by Powertech (USA) for the purpose of characterizing the site geology. The Fuson Shale has been mapped by Powertech (USA) and consists of 20 to 80 feet of low-permeability shales and clays, which generally occur at or near the base of the unit. The Fuson Member of the Lakota, in comparison, has been mapped based on outcrop by the USGS and others to be from 40 to 80 feet thick and consisting of interbedded fluvial shales, clays, mudstones, and sands.

The Fuson Member is described as having a lower discontinuous sandstone unit at its base and an upper discontinuous sandstone at the top of the member. If present the lower sandstone unit was mapped as Lakota sandstone. Similarly if the upper sandstone was present it was mapped as Fall River sandstone. The isopach map of the Fuson Shale shows the thickness of the shale-siltstone unit ranging from 20 to 80 feet (Plate 3.2-8). It shows thinning of the shale under the overlying channel sandstones of the Fall River Formation.

The shales and mudstones within the Fuson Shale are highly stratified. Due to this stratification, the vertical permeability is estimated to be several orders of magnitude smaller than the horizontal permeability. Measurements of vertical permeability from core samples and estimates from pumping tests are provided in Section 3.4.2.1.2.

The Fuson Member, being of fluvial origin, locally contains sand deposits (Schnabel and Charlesworth, 1963). The presence of the sand facies within the Fuson Member does not diminish the confining capacity of the Fuson Shale within the Fuson Member as defined and mapped by Powertech (USA). The geologic map of the Burdock quadrangle (Schnabel and Charlesworth, 1963) indicates that the Fuson Shale may pinch out in some areas. In particular, the interpretive fence diagram presented by Schnabel and Charlesworth shows an area approximately 1½ miles east and northeast of the permit area, across Bennett Canyon, in the E/2 Section 30, T6S, R2E, where the Fuson Member pinches out. However, based on available borehole logs, the Fuson Shale is continuous and no less than 20 feet thick throughout the entire permit area. The pervasive occurrence and continuity of the Fuson Shale throughout the permit area is shown on the geologic cross sections (Plates 3.2-13 through 22).

Fall River Formation - The Fall River formation is composed of carbonaceous interbedded siltstone and sandstone, channel sandstones, and a sequence of interbedded sandstone and shale. The lower part of the Fall River consists of dark carbonaceous siltstone interbedded with thin laminations of fine-grained sandstone. Channels were cut into this interbedded sequence by northwest-flowing rivers and fluvial sandstones were deposited. These channel sandstones occur across various parts of the permit area and generally contain the uranium deposits. Overlying the channel sandstones is another sequence of alternating sandstones and shales. The sandstones are cross-bedded to massive, fine to medium grained, and well sorted.

The isopach map of the Fall River Formation (Plate 3.2-9) shows a range of thickness of 120 to 160 feet. The thickening of the formation indicates the presence channel sandstones. Along the northeastern portion of the permit area, this formation is exposed on the surface and erosion has taken place.

Graneros Group - The Cretaceous Graneros Group consists of several geologic units, including the Skull Creek Shale, Newcastle Sandstone (where present), Mowry Shale, and Belle Fourche Shale, which act as a single confining unit overlying the Inyan Kara. In the permit area, the thickness of the Graneros Group ranges from zero at the outcrop of the Fall River to more than 500 feet (Plate 3.2-10).

Skull Creek Shale - The Skull Creek Shale, which directly overlies the Fall River Formation, consists of dark gray to black shale, organic material, and some silt-sized quartz grains. The Skull Creek Shale has a thickness of approximately 200 feet. The Skull Creek Shale and overlying Mowry Shale have been removed by erosion from the eastern parts of the permit area.

Mowry Shale - At the permit area the Skull Creek Shale is directly overlain by the Mowry Shale. The Mowry Shale consists of light gray marine shale with minor amounts of siltstone, fine-grained sandstone, and a few thin beds of bentonite. Dark gray to purple and black iron and manganese concretionary zones are common within the shale.

The Newcastle Sandstone, which is normally present between the Skull Creek Shale and the Mowry Shale, is absent across the permit area. Extensive drilling in the permit area has encountered no Newcastle Sandstone.

Belle Fourche Shale - The uppermost unit of the Graneros Group is the Belle Fourche Shale. This 300-foot thick unit consists of thin-bedded gray to black soft shale, containing black to reddish-brown ironstone concretions, which are particularly abundant in the basal 20-30 feet.

There is bentonite production from the lower part of the Belle Fourche Shale, but not within the permit area.

Terrace Deposits - Along the sides of drainages are relatively thin and flat-lying terrace deposits representing floodplains and former levels of streams. The terraces are primarily overbank deposits of clay and silt with gravel beds. Gravel deposits consist of boulders and pebbles of chert, sandstone, and limestone.

Alluvium - The most recent sedimentary units deposited within the permit area are the Quaternary-age alluvium deposits. Alluvium is present in the major drainages and their tributaries. The alluvium consists of silt, clay, sand and gravel. An isopach of the alluvium is presented as Plate 3.2-11.

3.2.3 Clarification of Breccia Pipes

Powertech (USA) evaluated the potential for breccia pipes in and around the permit area and concluded that there is no evidence of breccia pipes. The detailed evaluation is presented in Appendix 3.2-C and summarized below.

Breccia pipes have been studied and mapped in the southern Black Hills and are known to originate in anhydrite and gypsum sequences within the upper portion of the Minnelusa Formation. Dissolution of these evaporite sequences by underlying Minnelusa and/or Madison artesian water created solution cavities into which overlying Permian sediments collapsed. The aerial extent of dissolution is limited to a few miles downgradient from the Minnelusa outcrop. The probable maximum downgradient limit of dissolution, or dissolution front, has been mapped by the USGS and is more than 6 miles northeast of the permit area. There is no evidence of dissolution of the Minnelusa in the permit area based on evaluation of an electric log from an abandoned oil and gas test well within the permit area. In areas where there has been no dissolution, there is no geologic foundation for the creation of breccia pipes in overlying sediments.

Further evidence against the presence of breccia pipes is presented in Appendix 3.2-C and includes exploration drilling, field investigations for breccia pipes, an evaluation of Inyan Kara water temperatures, regional pumping tests, and evaluation of CIR imagery. Further, calibration of the groundwater model presented in Appendix 5.6-A does not support inflow to the Inyan Kara from deeper formations including through breccia pipes.

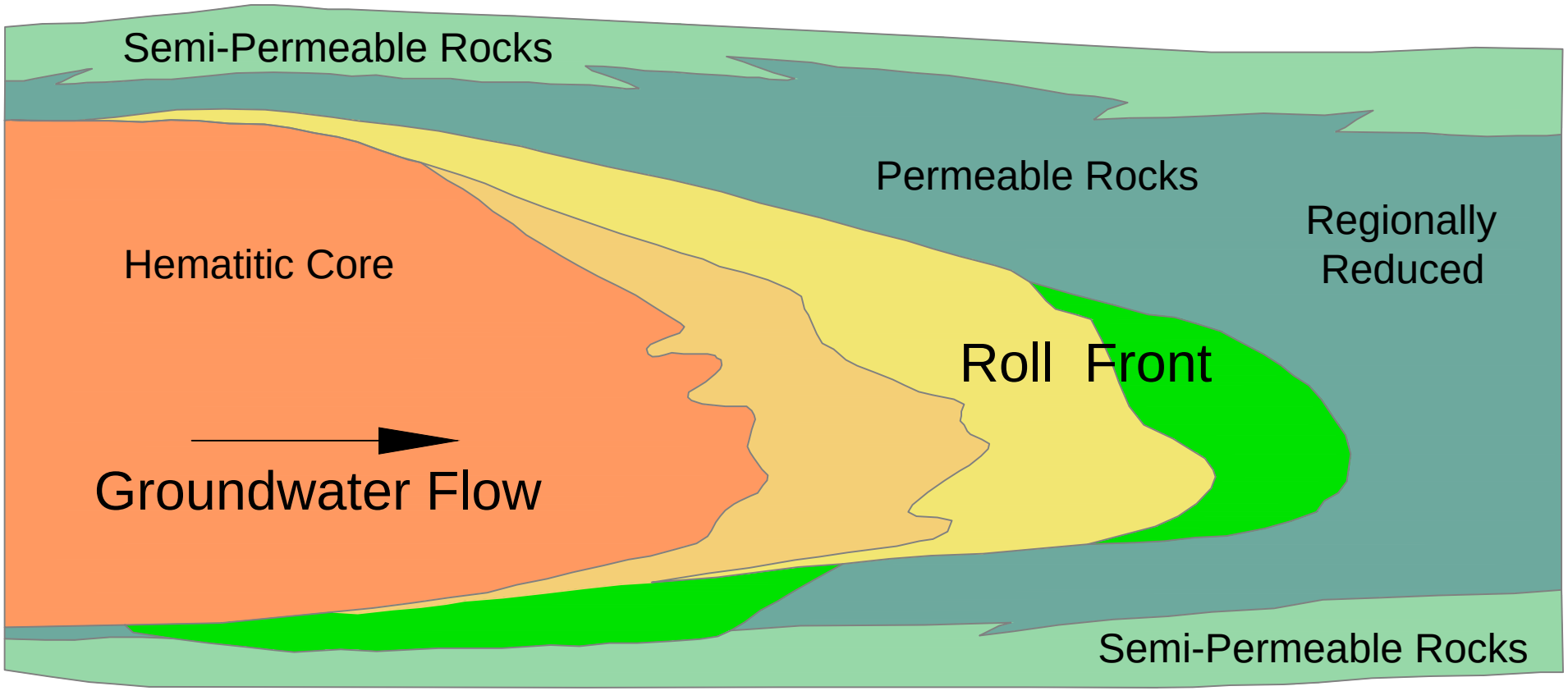
3.2.4 Ore Mineralogy and Geochemistry

Uranium deposits within the permit area are classic, sandstone, roll-front type deposits, located along oxidation-reduction boundaries, similar to those in Wyoming, Nebraska and Texas. These type deposits are usually C-shaped in cross section, with the concave side of the deposit facing updip, toward the outcrop. Roll-front deposits are a few tens of feet to 100 or more feet wide and often thousands of feet long. It is generally believed that these epigenetic uranium deposits are the result of uranium minerals leached from the surface environment, transported downgradient by oxygenated groundwater and precipitated in the subsurface upon encountering a reducing environment at depth. These roll-front deposits are centered at and follow the interface of naturally occurring chemical boundaries between oxidized and reduced sands (see Figure 3.2-5). Roll-front deposits similar to those in the permit area are described in NRC (2009).

Within the permit area, roll-front deposits occur at depths ranging from less than 100 feet in the outcrop area of the Fall River Formation up to 800 feet in sands of the Chilson Member of the Lakota Formation in the northwestern part of the permit area. The mineralized sandstones are typically fine to medium-grained quartz sands that are moderately to very well sorted and show sub-angular to sub-rounded grain angularity. Scattered pyrite concretions up to 1" in diameter are sometimes present as are very thin carbonaceous stringers and very well cemented calcite zones.

There is a geochemical “footprint” associated with these uranium roll-front systems, consisting of 1) a reduced zone, 2) an oxidized zone, and 3) an ore zone. The following is a geological and geochemical description of each of these zones for uranium deposits within the permit area. Information included in this description was obtained from a 1971 petrographic study of core from the Dewey portion of the permit area by Homestake-Wyoming Partners utilizing microscopic, thin section, polished section, X-ray powder diffraction and spectrographic analyses (Honea, 1971).

> **Reduced Zone** – This zone represents the original character of the Inyan Kara sediments, unaffected by any mineralizing events. Today, it is the unaltered portion of the system, ahead of or down-gradient of the roll front. Reduced sandstones are gray in color, pyritic and/or carbonaceous. Organic material consists of carbonized wood fragments and interstitial humates. Pyrite is abundant within the host sandstones and present as very small cubic crystals or as very fine-grained aggregates. Marcasite is also present as nodular masses in the sandstones. This disseminated pyrite resulted from replacement of original iron (magnetite or similar minerals) and organic material. This early-stage pyrite precipitation contains trace amounts of transition metals (Cu, Ni, Zn, Mo and Se) and resulted from either biogenic (bacterial) or inorganic reduction of groundwater sulfate.



Hematite	Alteration Envelope	Ore Stage Uranium	Ore-Stage Pyrite	Reduced Sandstone
Hematite Magnitite	Siderite Sulfur-S Ferroselite Goethite	Uraninite Pyrite FeS Selenium Ilsmannite	Molybdenite Pyrite Jordisite Calcite	Pyrite Jordisite Calcite

Source: DeVoto (1978).

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(1).

Figure 3.2-5

Conceptual Model of Uranium Roll Front Deposit

Dewey-Burdock Project

DRAWN BY	Lichnovsky, Bonner
DATE	10-Sep-2012
FILENAME	DeVotoRollFrontConcept.dwg

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Plagioclase and potassium feldspar clasts are fresh and, with the exception of localized areas of calcite cementing, calcite is sparse - averaging only 0.15%. A heavy mineral suite (ranging from trace to 3%) of tourmaline, ilmenite, apatite, zircon and garnet is typical of those found in mature, siliceous sandstones.

Oxidized Zone – This portion of the system, behind or upgradient of the roll front, is characterized by the presence of iron oxides resulting in a brown, pink, orange or red staining of host sandstones. The oxidized zone marks the progression of the down-gradient movement of mineralizing solutions through the host sandstones. In the vicinity of the oxidized zone, original iron has been altered and is present as hematite or goethite as grain coatings, clastic particles or as pseudomorphs after original pyrite. Goethite is considered to be metastable and is found near the oxidation/reduction boundary, while the more stable hematite is found greater distances upgradient from the roll front. The heavy mineral leucoxene – a white titanium oxide – is also present as a pseudomorph of ilmenite. All organic material has been destroyed in the oxidized zone, where quartz particles show solution or etching effects and feldspars have been replaced with clays.

In the oxidation process of the original pyrite, it is believed the transition metals (Cu, Ni, Zn, Mo and Se) were liberated and incorporated into the mineralizing solution. This solution was slightly alkaline, initially having a positive oxidation potential. Uranium was in solution as the anionic uranyl dicarbonate complex. Other metals associated with uranium were also carried in anionic complexes. In the vicinity of the permit area, the oxidized zone in Inyan Kara sands has been mapped over a lateral distance of 15 miles and found to extend up to 4-5 miles down-dip from the outcrop.

Ore Zone – This portion of the system is located at the oxidation/reduction boundary where metals were precipitated when mineralizing solutions encountered a steep Eh (oxidation/reduction potential) gradient and a strongly negative oxidation potential. Sandstones in this zone are greenish-black, black, or dark gray in color. The primary uranium minerals are uraninite and coffinite, which occur interstitial to and coating sand grains and as intergrowths with montroseite (VO(OH)) and pyrite. Other vanadium minerals (haggite and doloresite) are found adjacent to the uranium mineralization, extending up to 500 feet into the oxidized portion of the system. Overall, the V:U ratios can be as high as 1.5:1. The high concentrations of uranium and vanadium within the ore zone indicate the original source of these metals was external to the Inyan Kara sediments.

Transition metals were also precipitated at or adjacent to the oxidation/reduction boundary. Native arsenic and selenium are found adjacent to the uranium, in the oxidized portion of the front - filling pore spaces between quartz grains. Molybdenum is found as jordisite adjacent to the uranium on the reduced portion of the front. The relatively low concentrations of transition metals indicate their source could have been internal to the Inyan Kara sediments rather than having been introduced from overlying tuffaceous material which is believed to be the source of the uranium and vanadium.

Late-stage deposition of calcite and pyrite also appear to be part of the ore-forming process. Filling of pore spaces by nodular and concretionary calcite is found with the uranium mineralization and extending out into the reduced portion of the front. It is believed that uranium was transported as a uranyl dicarbonate complex and carbonate deposition took place along with the precipitation of uranium. Late-stage, coarse-grained, nodular or concretionary pyrite is also found associated with uranium ore and adjacent to the uranium in the reduced portion of the front.

3.2.5 Historical Exploration and Mine Workings

3.2.5.1 Historical Oil and Gas Activities

No formerly producing or actively producing oil and gas wells exist within the permit boundary or within 2 km of the boundary. Within this overall area, the locations of 13 plugged and abandoned oil test wells have been identified, 3 of which are within the permit area. The locations of these abandoned test wells are depicted on Figure 3.2-6.

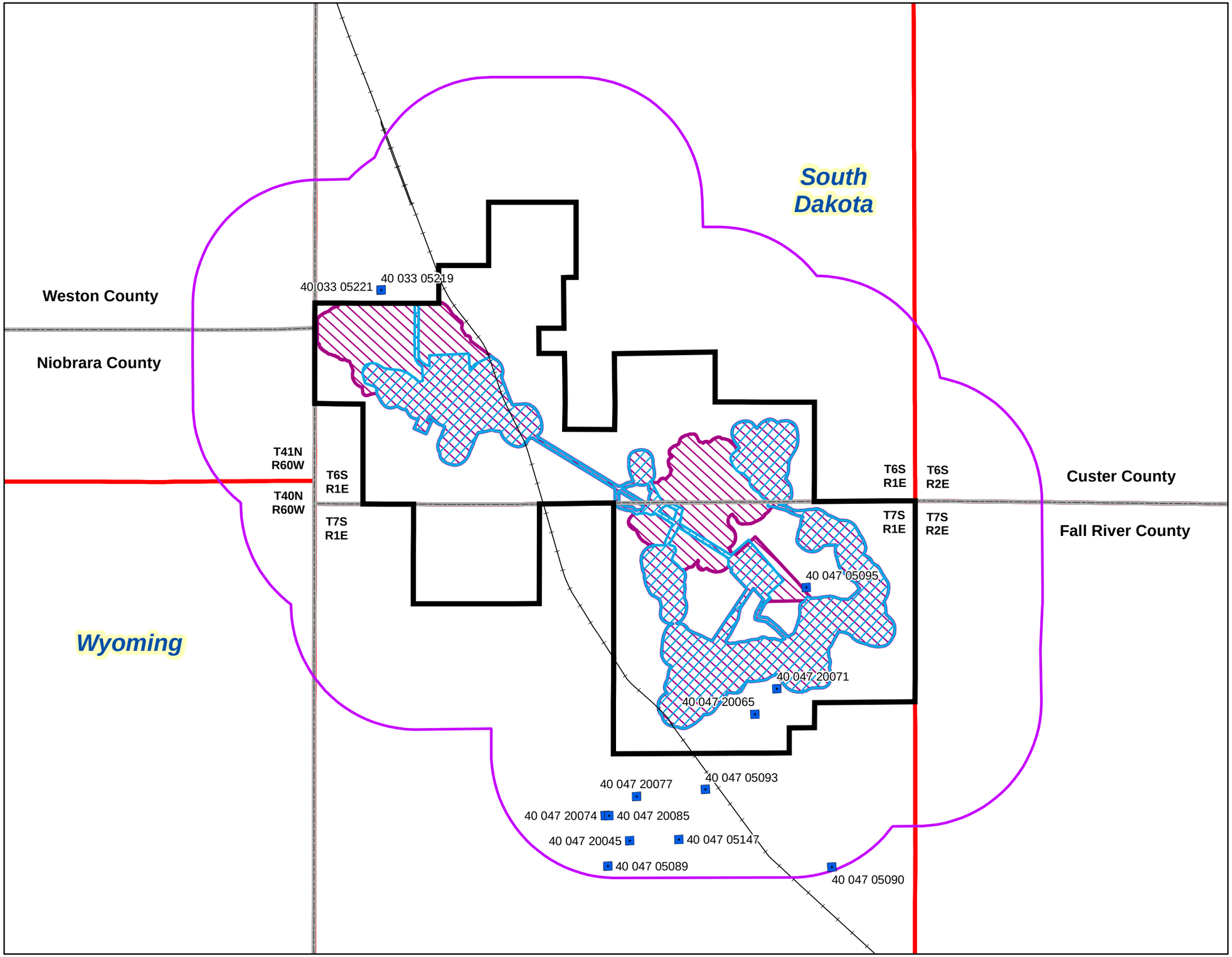
3.2.5.2 Historical Uranium Activities

The first uranium mines in the Edgemont District were developed in the 1950s by prospectors who followed mineralized Fall River outcrops into the subsurface by driving declines into the mineralized sandstones. Susquehanna Western Inc. consolidated all mining operations in the district in the 1950s and operated underground mines, surface mines, and the Edgemont Mill.

Refer to Section 1.3 for the history of uranium exploration in and around the permit area. In total, more than 4,000 exploration drill holes were completed on this project. Figure 3.2-7 is a map showing the location of all known drill holes. Appendix 3.2-A provides a listing of the drill holes within 1 mile of the permit area.

There are historical uranium mine workings, including surface and underground mines, along the eastern portion of the permit area. Underground workings are associated with four former, shallow underground uranium mines and two open-pit adits. The locations of historical surface and underground mining operations in the Triangle Mine area and the Darrow Mine area are depicted on Figure 3.2-8. Susquehanna Western Inc. often drove adits short distances into open-pit walls to recover additional uranium ore that was adjacent to the pit. These types of underground workings were common at historical surface mines and were considered to be extensions of the open-pit mining operations.

All of the underground workings within the permit area are associated with open-pit remnants that are clearly visible or, in the case of the Triangle Mine, have been backfilled and partially



Legend

- Permit Boundary
- 2 km Search Radius
- BNSF Railroad
- P&A Oil and Gas Well
- Proposed Affected Area Boundary, Deep Disposal Well Option
- Proposed Affected Area Boundary, Land Application Option

This figure is provided to fulfill the requirements of SDCL 45-6B-10(4).

Feet: 0, 2,500, 5,000, 10,000
Meters: 0, 1,000, 2,000, 3,000
N

Figure 3.2-6
Plugged and Abandoned Oil and Gas Wells within 2 km of the Permit Boundary
Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	06-Nov-2012
FILE	Wells-OilGas-PA2km.mxd

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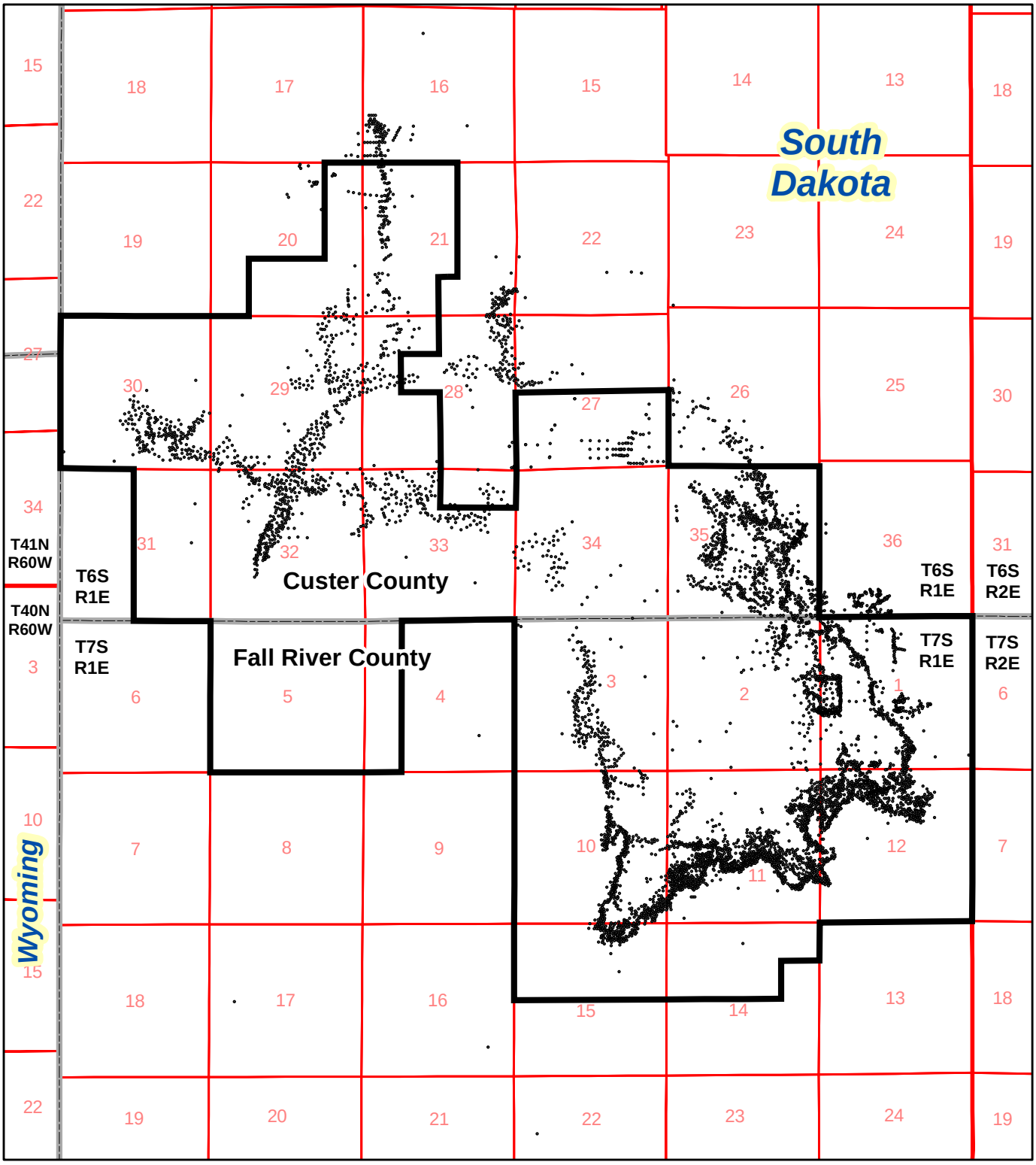

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(1).

Legend

- Permit Boundary
- Drill Hole Locations

Feet
0 2,500 5,000
0 1,000 2,000
Meters

N

Figure 3.2-7

Dewey-Burdock Drill Hole Map

Dewey-Burdock Project

SIGNATURE OF PREPARER	
PREPARER	F. L. Lichnovsky
DATE	24-Sep-2012
FILE	ExploreDrillHoles.mxd

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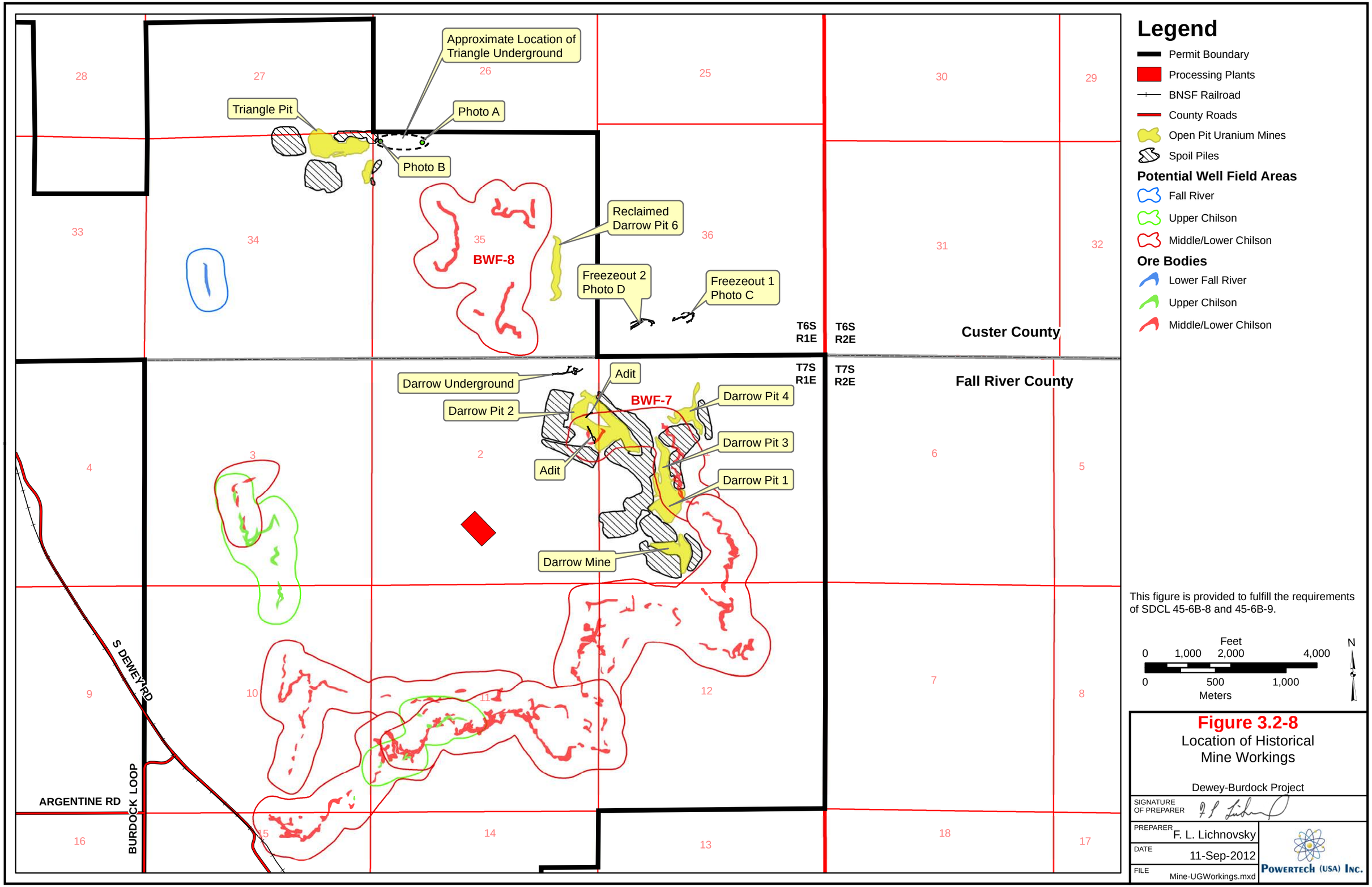
Approximate Location of Triangle Underground
Triangle Pit
Photo A
Photo B
Reclaimed Darrow Pit 6
BWF-8
Freezeout 2 Photo D
Freezeout 1 Photo C
T6S R1E
T6S R2E
Custer County
T7S R1E
T7S R2E
Fall River County
Darrow Underground
Adit
BWF-7
Darrow Pit 2
Darrow Pit 4
Darrow Pit 3
Darrow Pit 1
Darrow Mine
S DEWEY RD
ARGENTINE RD
BURDOCK LOOP
Legend
Permit Boundary
Processing Plants
BNSF Railroad
County Roads
Open Pit Uranium Mines
Spoil Piles
Potential Well Field Areas
Fall River
Upper Chilson
Middle/Lower Chilson
Ore Bodies
Lower Fall River
Upper Chilson
Middle/Lower Chilson
This figure is provided to fulfill the requirements of SDCL 45-6B-8 and 45-6B-9.
Feet
0 1,000 2,000 4,000
0 500 1,000
Meters
N
Figure 3.2-8
Location of Historical Mine Workings
Dewey-Burdock Project
SIGNATURE OF PREPARER
PREPARER F. L. Lichnovsky
DATE 11-Sep-2012
FILE Mine-UGWorkings.mxd
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reclaimed. There are no underground mines within the permit area that are not associated with, adjacent to, or extensions of the open pits, all of which are within the upper Fall River Formation. The underground mines consisted of declines (downward sloping ramps) ranging in depth from 0 to 80 feet below land surface. The adits (horizontal tunnels) were driven into the sidewalls of the historical open-pit mines. All underground workings were conducted within sandstones of the Fall River Formation at or above the water table and above the Fuson Shale confining unit such that these workings did not penetrate or otherwise compromise the integrity of this confining unit. Refer to Section 3.2.2.2 for a description of confining units relative to ISR. These workings will not be affected by Powertech (USA)'s proposed ISR operations, since Powertech (USA) will not develop well fields within Fall River Formation sandstones in this portion of the permit area (refer to Section 5.3.3.7) and the Fuson Shale confining unit is intact and undisturbed (refer to Section 3.2.2.2). The following discussion provides detailed information on the surface and underground workings.

Triangle Mine Area

As shown on Figure 3.2-8, the Triangle Mine was an open-pit mining operation along the northeastern border of the permit area in the NE¼ Section 34, T6S, R1E. Immediately east of this open pit was the Triangle underground mine. Although maps of the Triangle underground workings are not available, Powertech (USA) has obtained a description of this operation through personal communication with Donald Spencer (2011), a local rancher who worked in this underground mine.

Mr. Spencer advised that he worked in the Triangle underground mine in 1957-58. He showed Powertech (USA) personnel the location of the decline that was used to access the mine. The decline is located approximately 1,000 feet southeast and updip of the eastern boundary of the Triangle open pit in the NW¼ Section 35, T6S, R1E (see Photo A). Photo locations are depicted on Figure 3.2-8. As shown in the photo, the haulage road from the decline is still visible, but the entrance to the underground workings has been covered for safety reasons. There were about 1,000 feet of underground workings in the mine. The depth of these workings ranged from outcrop to 70 feet below ground surface. The mineralized sandstone of the Fall River Formation was unsaturated near the ground surface. Approximately 70 feet below the surface, the Fall River sands became saturated, resulting in 2-3 feet of water in the mine, requiring dewatering. Near the end of the underground workings, a vent shaft was installed approximately 400 feet from the eastern highwall of the Triangle open pit to provide air to the underground workings (see Photo B). Powertech (USA) measured the depth to the bottom of this vent shaft in April

Photo A: Former Triangle Underground Mine Decline

Photo B: Triangle Underground Mine Vent Shaft

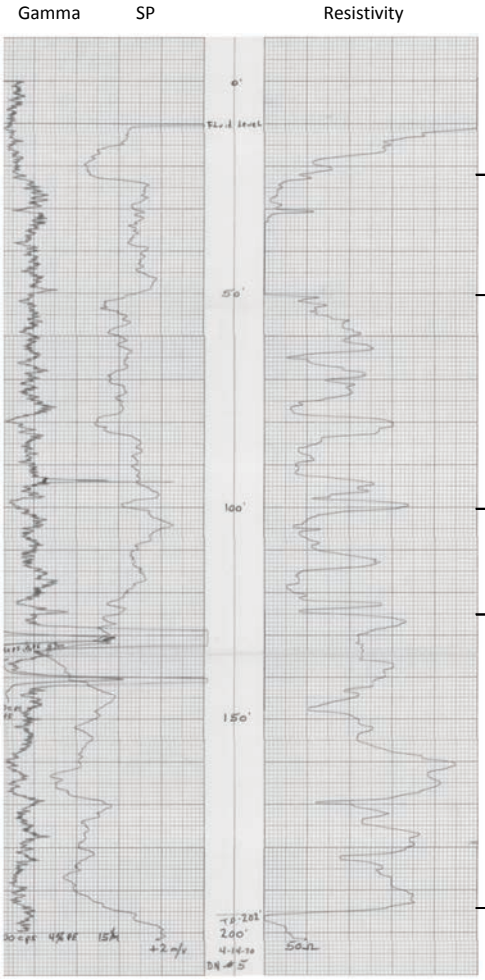
2011 and found it to be 68 feet below ground surface with approximately 3 feet of groundwater. Mr. Spencer stated that after the Triangle surface mine was completed, an adit was driven into the eastern wall of the pit to recover additional ore. This adit connected the open pit with the abandoned underground workings.

In 1960, Susquehanna Western Inc. began to develop the Triangle surface mine. A description of the mining zone was obtained through personal communication in 2011 with James F. Davis, the Susquehanna Western Inc. geologist who directed the delineation drilling for this mine (Davis, 2011). Mr. Davis stated a single mineralized front progressed from the underground mine area through the surface mine area in an east-west direction. In the western portion of the surface mine area, the trend abruptly turned to the north and the grade of the mineralization quickly diminished. The Triangle surface mine area is down-dip from the underground workings; therefore, the depth to the mining horizon increased steadily. Mr. Spencer recalls the depth of the Triangle open pit to have been approximately 120 feet below ground surface.

Figure 3.2-9 is an electric log from an historical exploration drill hole located approximately 200 feet north of the mined area. The gamma activity shown in the type log corroborates the portion of the Fall River sand that was mined in the Triangle Mine and its position relative to the Fuson Shale confining unit. The top of the mineralized sand unit in the type log is at a depth of 125 feet below ground surface. The single mineralized front present within this sand unit correlates to Powertech (USA)'s F13 interval, which is the upper mineralized zone within the Lower Fall River sand, the bottom of which is approximately 45 feet above the Fuson Shale. All mining took place well above the Fuson Shale, which averages 50 feet thick in this area. Accordingly, these historical mining operations did nothing to compromise the integrity of the Fuson Shale confining unit.

Darrow Mines Area

Figure 3.2-8 depicts the location of the Darrow Mine surface pits in the eastern portion of the permit area. These pits were developed within unsaturated sandstones of the Fall River Formation at depths ranging from 50 to 90 feet below ground surface. As illustrated on Figure 3.2-8, the Freezeout underground mines were located approximately ½ mile north of the Darrow surface mines. These historical underground mines are outside of the permit area in the SW¼ Section 36, T6S, R1E. Freezeout No. 1 and Freezeout No. 2 each have approximately 1,000 feet of underground workings. Plan view maps obtained from TVA show the underground workings at Freezeout No. 1 were accessed by two declines, and access to the workings of Freezeout No. 2 was provided by three declines. Photos C and D show the current condition of



Alluvium

Graneros Group

Upper Fall River Sand

Interbedded Fall River Clays

Lower Fall River Sand
(Surface and underground mines developed in the upper sand unit.)

Fuson Shale

Vertical Scale

Feet 50 25 0

Meters 15 10 5 0

Figure 3.2-9

Type Log
Triangle Mine Area

Dewey-Burdock Project

SIGNATURE OF PREPARER	
PREPARER	F. L. Lichnovsky
DATE	24-Sep-2012
FILE	Mine-TriangleTypeLog.dwg

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This figure is provided to fulfill the requirements of ARSD 74:29:02:11(1).

Photo C: Former Freezeout Mine Decline

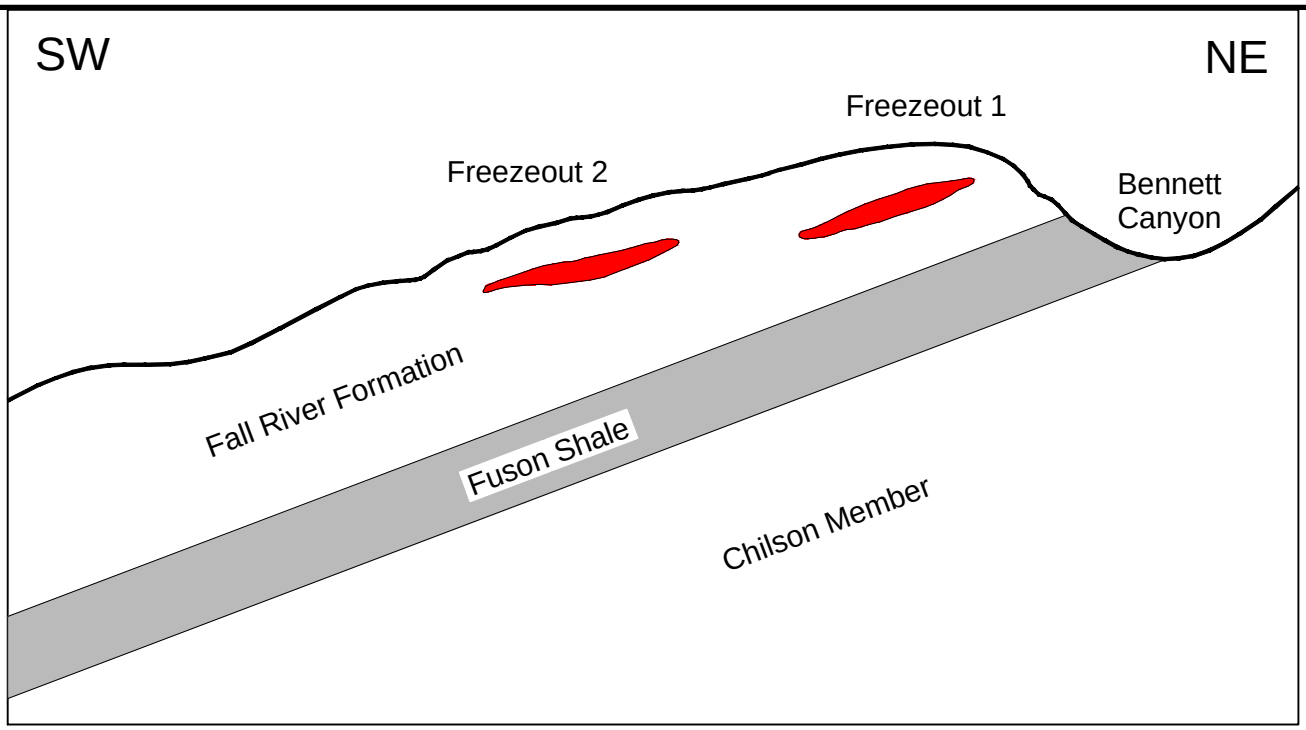
Photo D: Former Freezeout Mine Decline

the declines for the Freezeout mines. The haulage roads are still visible but the access ways or portals to the underground workings have collapsed or have been covered. Figure 3.2-10 illustrates how these shallow underground mining operations were used to recover ore in this rugged terrain. It is important to note that the workings were above the water table and followed the dip of the mineralized sandstones. Accordingly, these mining operations did not intersect or compromise the integrity of the underlying Fuson Shale confining unit.

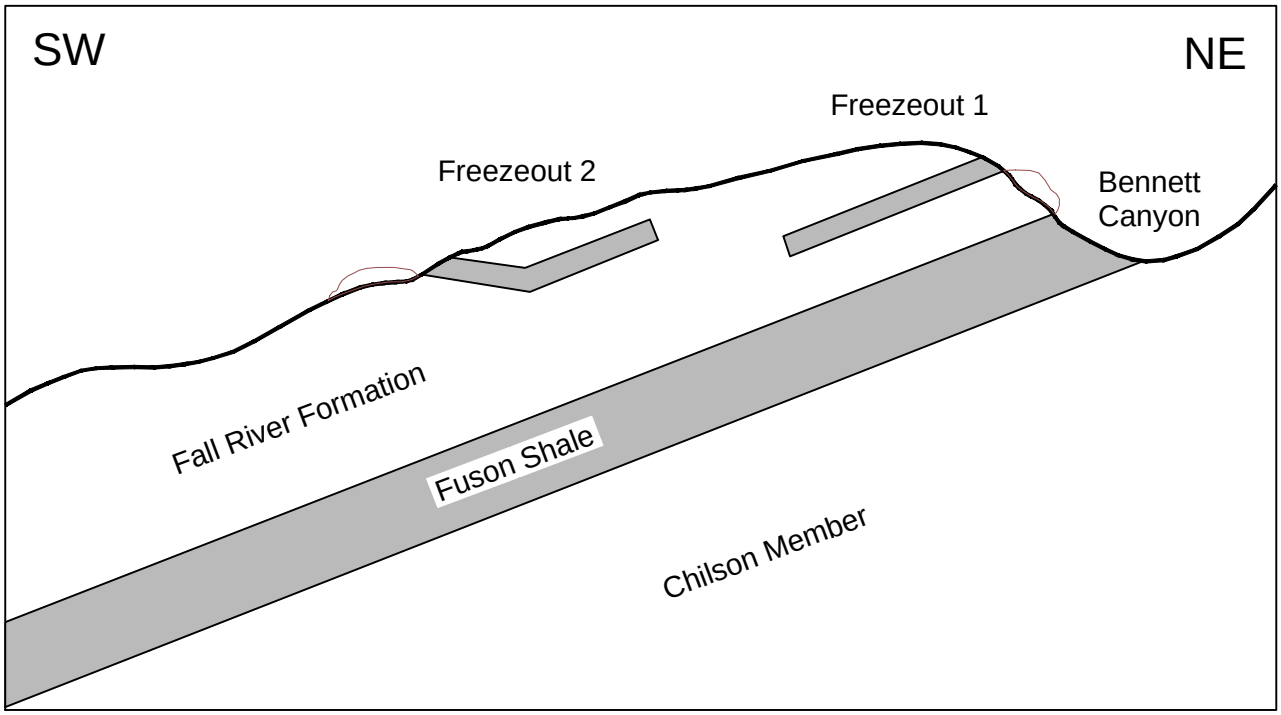
Figure 3.2-8 shows the location of the Darrow underground mine, approximately 500 feet northwest of Darrow Pit No. 2, in the NE¼ of Section 2, T7S, R1E. According to personal communication with Donald Spencer (2011), this underground mine consisted of approximately 1,200 feet of workings within a 250-foot x 700-foot area, which also was accessed by declines. The surface in this area has been reclaimed and all evidence of mining operations has been removed.

Figure 3.2-11 is a plan view map of the Darrow underground workings taken from a TVA drill hole map. This map shows the locations of many Susquehanna Western Inc. drill holes and air vents for the underground workings. Also shown on this map are five TVA drill holes, one of which is located less than 20 feet from one of the underground drifts. The electric log from this drill hole (DRA-36) is an excellent representation of the mining horizon in these underground workings and is shown in Figure 3.2-12. The gamma trace on this type log again corroborates that the top of the mining zone for this underground mine was at a depth of 73 feet below ground surface. The base of the mineralized sand lies 23 feet above the top of the Fuson Shale, which is more than 50 feet thick in this area. The Darrow underground mine workings were restricted to the mineralized sand interval, and these mining operations did not intersect or compromise the integrity of the underlying Fuson Shale confining unit.

Maps obtained from TVA show the locations of two adits within Darrow Pit No. 2 in the NE¼ Section 2, T7S, R1E (Figure 3.2-8). Although not classified as underground mines, these adits consisted of two separate horizontal tunnels that were driven into the pit walls in order to access additional uranium ore that was not recovered in the surface mining operations. These two adits total approximately 650 feet of workings. Because of the horizontal nature of the adits, these workings were conducted at elevations equal to or above the elevation of the bottom of the pit and were considered to be an extension of the surface mining operations. These small operations did not intersect or compromise the integrity of the underlying Fuson Shale confining unit.



A. Shallow ore bodies in Fall River



B. Declines developed to access Fall River ore bodies.

Figure 3.2-10

Schematic - Underground Workings - Freezeout Mines

Dewey-Burdock Project

SIGNATURE OF PREPARER	
PREPARER	F. L. Lichnovsky
DATE	11-Sep-2012
FILE	Mine-FreezeoutUGWork.dwg

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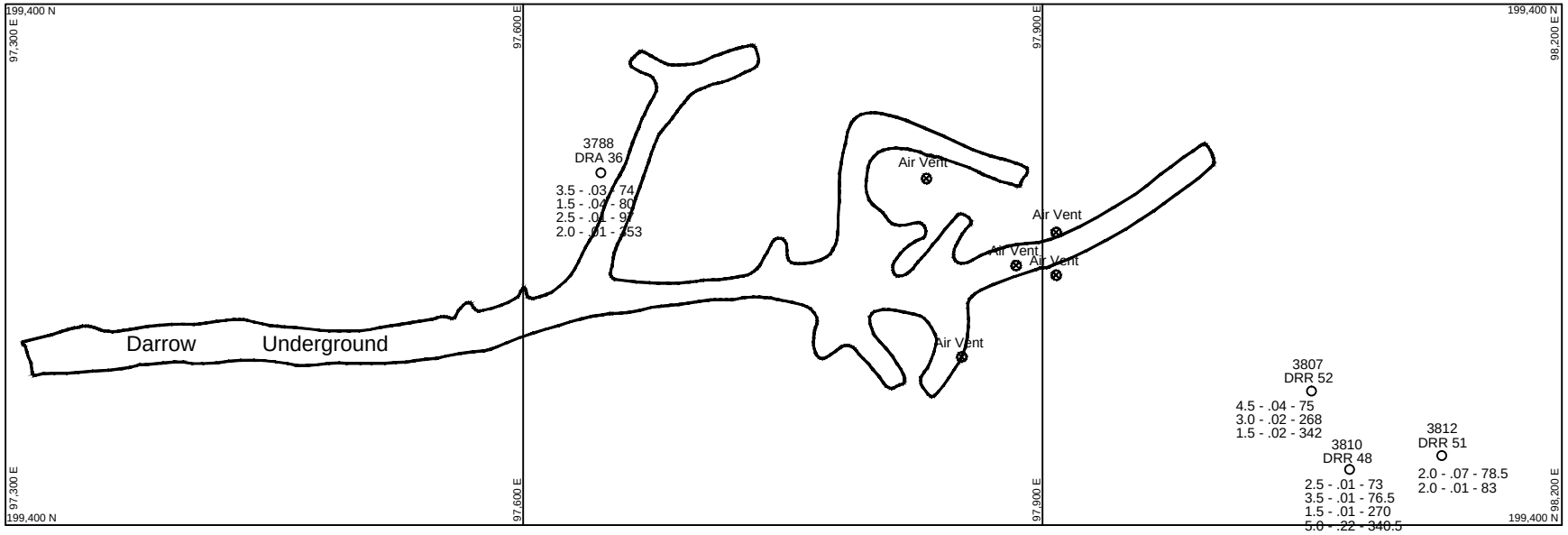

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(1).

Legend

DRR 52 Boreholes

Source: TVA drill hole map

N

Feet
0 50 100 200
0 10 20 40 60
Meters

Figure 3.2-11

Plan View - Darrow Underground Mine

Dewey-Burdock Project

SIGNATURE OF PREPARER	
PREPARER	F. L. Lichnovsky
DATE	11-Sep-2012
FILE	Mine-DarrowPlanView.dwg

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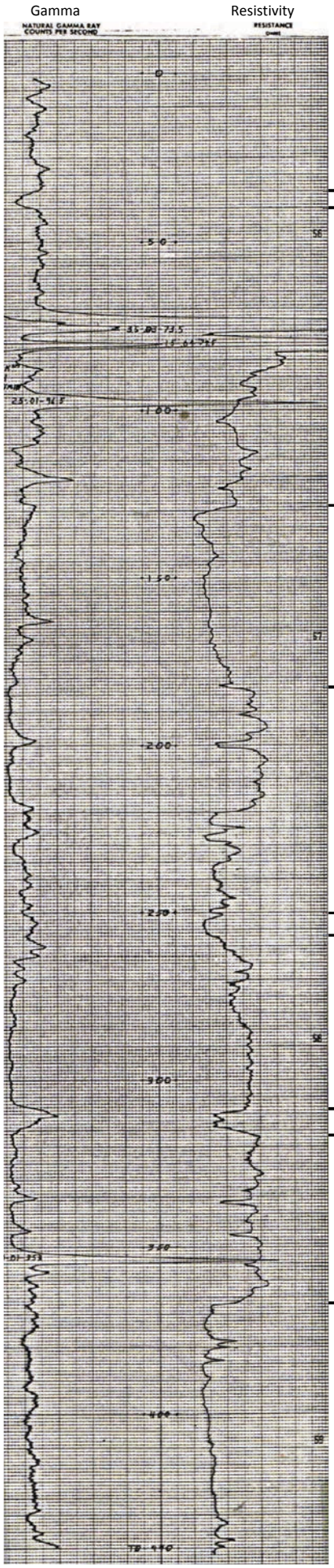

Upper Fall River Sand

Shale

Lower Fall River Sand

Fuson Shale

Upper Chilson Sand

Shale

Middle Chilson Sand

Shale

Lower Chilson Sand
(Resources in the Burdock Well Field 7 are located in this sand unit.)

Morrison Formation

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(1).

Vertical Scale

Feet: 50, 25, 0
Meters: 15, 10, 5, 0

Figure 3.2-12

Type Log,
Darrow Underground

Dewey-Burdock Project

SIGNATURE OF PREPARER	
PREPARER	F. L. Lichnovsky
DATE	24-Sep-2012
FILE	Mine-DarrowUGTypeLog.dwg

POWERTECH (USA) INC.

As demonstrated above, neither the surface mining activity nor the shallow underground workings intersected or compromised the integrity of the underlying Fuson Shale confining unit. Cross section F-F' (Plate 3.2-18) illustrates the continuous Fuson Shale confining unit throughout this area. In addition, outcrop examinations of the Fuson Shale in Bennett Canyon, ½-mile updip from the Darrow Mine area, reveal the presence of continuous, low-permeability mudstones and shales.

3.3 Soils

Powertech (USA) conducted baseline soil sampling and mapping covering the permit area. Soils within the permit area are typical for semi-arid grasslands and shrublands in the Western United States. Parent material included colluvium, residuum, and alluvium. Most soils are classified taxonomically as Aridic Argiustolls, Aridic Ustorthents, and Aridic Haplusterts.

A detailed soils investigation report is included in Appendix 3.3-A. The following information is provided as a summary of the information in the full report. A soil map for the permit area (Plate 3.3-1) was developed using the information presented in Appendix 3.3-A.

3.3.1 Methodology

BKS Environmental Associates, Inc. (BKS) of Gillette, WY performed the 2007 soil survey field work and compiled the resulting report. All soil analysis was handled by Energy Labs in Gillette, Wyoming. Construction of the soil map was completed according to techniques and procedures of the National Cooperative Soil Survey. A total of 10,557 acres were included in the final soil mapping of the permit area. Series were sampled and described by coring with a mechanical auger, i.e., truck-mounted Giddings. The physical and chemical nature of each horizon within the sampled profile was described and recorded in the field. Each hole augured for series and map unit verification was plotted on the soils map included with this report. Sampled soil material was placed in clean, labeled, polyethylene plastic bags and kept cool to limit chemical changes. Samples were kept out of direct sunlight and transported to Energy Labs for analysis.

Stripping depths for the Dewey-Burdock Project were evaluated during mapping and sampling. Soil depths within a given mapping unit will vary based on any combination of the five primary soil forming factors, i.e., climate including effective precipitation, organisms, relief or topography, parent material, and time. Subtle differences in any one of the previously mentioned factors will impact development between series and within series designation but may not be as noticeable as when topography is a major factor. The proposed topsoil salvage depths for the

permit area are based on laboratory data of the samples found within the permit area, as well as field observations and knowledge of the soils in Custer and Fall River counties, South Dakota.

3.3.2 Soil Survey Results and Discussion

The general topography of the area ranged from nearly level uplands to very steep hills, ridges and breaks of dissected shale plains. The soils within the permit area were generally a clayey or very fine texture throughout with patches of sandy loam on upland areas and fine, clay textured soils occurring in or near drainages. The permit area contained deep soils on level upland areas with shallow and very shallow soils located on hills, ridges and breaks.

Table D-7.1.1 in Appendix 3.3-A summarizes the soil mapping unit acreages within the permit area. Note that this table includes a "Disturbance Areas" column, which was based on an initial estimate of the ore body and perimeter monitor ring extents and does not reflect the actual area proposed for disturbance by Powertech (USA). When the soil mapping was completed, Powertech (USA) had not yet designed the proposed facilities and potential well field areas to the level of detail presented in this application. Refer to Section 5.3.7 for a discussion of the anticipated disturbance acreage within the permit area.

Laboratory soil texture analysis did not include percent fine sands. Field observations of fine sands within individual pedestals as well as sample site topographic position were used in conjunction with laboratory analytical results to determine series designation. In several of the pedestal sampling locations, laboratory analysis yielded finer than expected textures (based upon field observations).

Within the permit area, suitability of soil as a plant growth medium is generally affected by physical factors such as texture (clay percentage) and saturation percentage. Chemical limiting factors included selenium (Se), calcium carbonate content (based upon field observations of strong or violent effervescence), SAR, EC, pH, and boron (B). Marginal material, according to Wyoming Department of Environmental Quality (WDEQ) Guideline 1, was found in 26 of the 33 profiles. Unsuitable material, according to WDEQ Guideline 1, was found in 14 of the 33 profiles. Based on laboratory analysis and field observations, marginal material parameters primarily consisted of texture (clay percentage), calcium carbonates, EC, and SAR.

Based on the 2007 fieldwork with associated field observations and subsequent chemical analysis, the recommended topsoil average salvage depth over the permit area was determined to

be 1.63 feet (refer to Table D-7.1.6 in Appendix 3.3-A). Approximate salvage depths of each map unit series ranged from 0.0 to 5.0 feet.

Based on the soil mapping unit descriptions, the hazard for wind and water erosion within the permit area varies from negligible to severe. The potential for wind and water erosion is mainly a factor of surface characteristics of the soil, including texture and organic matter content. Given the very fine and clayey texture of the surface horizons throughout the majority of the permit area, the soils are more susceptible to erosion from water than wind.

3.3.3 Prime Farmland

Prime farmland was assessed by Dan Shurtliff, the Acting State Soil Scientist out of Huron, South Dakota. Prime farmland designations are located in Addendum D-7-E of Appendix 3.3-A. Soil series Alice, Ascolon, Barnum, Boneek, Haverson, Norka, Nunn, Satanta, and Tilford have been listed as Prime Farmland if irrigated. The following sections contain prime farmland if irrigated:

- Township 6 South, Range 1 East, Sections 27, 30, 31, 32, 34, and 35
- Township 7 South, Range 1 East, Sections 1, 3, 4, 5, 10, 12, 14, and 15.

The soil series Kyle, Lohmiller, Nunn, Pierre, Satanta, and Stetter have been listed as Farmland of statewide importance. These soils were located in Sections 2, 3, 4, 5, 10, 11, 12, 14, and 15 in Township 7 South, Range 1 East.

3.4 Groundwater

3.4.1 Regional Hydrogeology

In this section, groundwater occurrence and flow are described specifically as they relate to the Dewey-Burdock Project. While the permit area is generally similar to the Black Hills regional setting, the site hydrogeology has several unique characteristics as described below.

3.4.1.1 Regional Hydrostratigraphic Units

The Black Hills Uplift is the principal recharge area for the regional bedrock aquifer systems in southwestern South Dakota and northeastern Wyoming. The stratigraphy of the Black Hills area is summarized on Figure 3.2-2. Figure 3.4-1 provides an overview of the hydrogeologic setting and general hydrogeologic flow within the Black Hills. Regionally, four aquifers are utilized as major sources of water supply. These are the Inyan Kara Group, Minnelusa Formation, Madison Limestone, and Deadwood Formation. Table 3.4-1 summarizes hydraulic properties of major

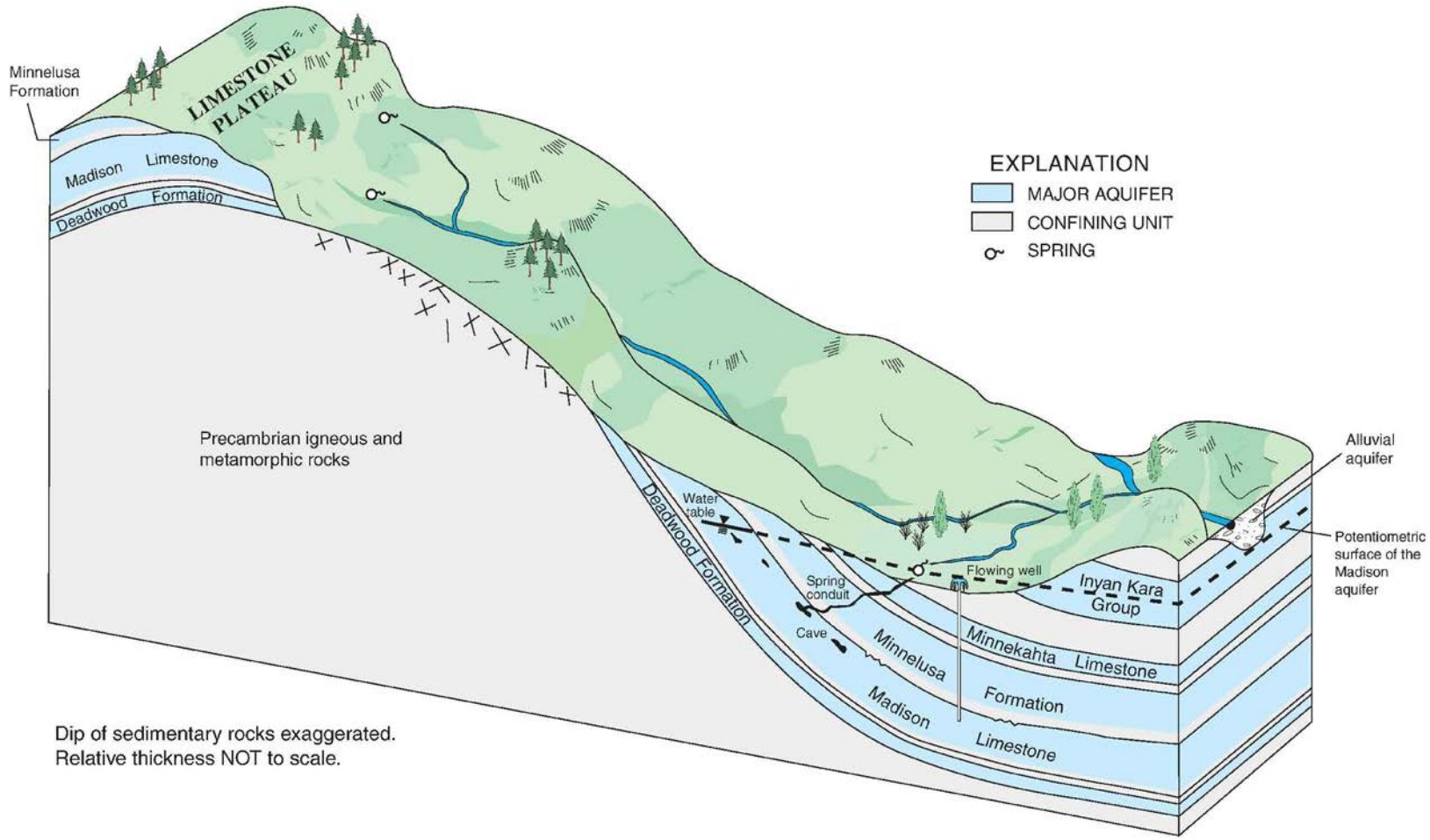

Figure 3.4-1
Diagram Showing a Simplified View of the Hydrogeologic Setting of the Black Hills Area

Dewey-Burdock Project

DRAWN BY	Mays, Hetrick
DATE	11-Sep-2012
FILENAME	Driscoll_L.dwg

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Source: Carter et al. (2003)

Table 3.4-1: Estimates of Hydraulic Properties of Major Aquifers from Previous Investigations

Source	Hydraulic conductivity (ft/d)	Transmissivity (ft^2/d)	Storage coefficient	Total porosity/ effective porosity	Area represented
Precambrian aquifer					
Rahn, 1985	--	--	--	0.03/0.01	Western South Dakota
Galloway and Strobel, 2000		450 - 1,435		0.10/--	Black Hills area
Deadwood aquifer					
Downey, 1984	--	250 - 1,000	--	--	Montana, North Dakota, South Dakota, Wyoming
Rahn, 1985	--	--	--	0.10/0.05	Western South Dakota
Madison aquifer					
Konikow, 1976	--	860 - 2,200	--	--	Montana, North Dakota, South Dakota, Wyoming
Miller, 1976	--	0.01 - 5,400	--	--	Southeastern Montana
Blankennagel and others, 1977	$2.4x10^{-5}$ - 1.9	--	--	--	Crook County, Wyoming
Woodward-Clyde Consultants, 1980	--	3,000	$2x10^{-4}$ - $3x10^{-4}$	--	Eastern Wyoming, western South Dakota
Blankennagel and others, 1981	--	5,090	$2x10^{-5}$	--	Yellowstone County, Montana
Downey, 1984	--	250 - 3,500	--	--	Montana, North Dakota, South Dakota, Wyoming
Plummer and others, 1990	--	--	$1.12x10^{-6}$ - $3x10^{-5}$	--	Montana, South Dakota, Wyoming
Rahn, 1985	--	--	--	0.10/0.05	Western South Dakota
Cooley and others, 1986	1.04	--	--	--	Montana, North Dakota, South Dakota, Wyoming, Nebr.
Kyllonen and Peter, 1987	--	4.3 - 8,600	--	--	Northern Black Hills
Imam, 1991	$9.0x10^{-6}$	--	--	--	Black Hills area
Greene, 1993	--	1,300 - 56,000	0.002	0.35/--	Rapid City area
Tan, 1994	5 - 1,300	--	--	0.05	Rapid City area
Greene and others, 1999	--	2,900 - 41,700	$3x10^{-4}$ - $1x10^{-3}$	--	Spearfish area
Carter, Driscoll, Hamade, and Jarrell, 2001	--	100 - 7,400	--	--	Black Hills area
Minnelusa aquifer					
Blankennagel and others, 1977	$<2.4x10^{-5}$ - 1.4	--	--	--	Crook County, Wyoming
Pakkong, 1979	--	880	--	--	Boulder Park area, South Dakota
Woodward-Clyde Consultants, 1980	--	30 - 300	$6.6x10^{-5}$ - $2.0x10^{-4}$	--	Eastern Wyoming, western South Dakota

Table 3.4-1: Estimates of Hydraulic Properties of Major Aquifers from Previous Investigations (Continued)

Source	Hydraulic conductivity (ft/d)	Transmissivity (ft^2/d)	Storage coefficient	Total porosity/ effective porosity	Area represented
Minnelusa aquifer—Continued					
Rahn, 1985	--	--	--	0.10/0.05	Western South Dakota
Kyllonen and Peter, 1987	--	0.86 - 8,600	--	--	Northern Black Hills
Greene, 1993	--	12,000	0.003	0.1/--	Rapid City area
Tan, 1994	32	--	--	--	Rapid City area
Greene and others, 1999	--	267 - 9,600	$5.0x10^{-9}$ - $7.4x10^{-5}$	--	Spearfish area
Carter, Driscoll, Hamade, and Jarrell, 2001	--	100 - 7,400	--	--	Black Hills area
Minnekahta aquifer					
Rahn, 1985	--	--	--	0.08/0.05	Western South Dakota
Inyan Kara aquifer					
Niven, 1967	0 - 100	--	--	--	Eastern Wyoming, western South Dakota
Miller and Rahn, 1974	0.944	178	--	--	Black Hills area
Gries and others, 1976	1.26	250 - 580	$2.1x10^{-5}$ - $2.5x10^{-5}$	--	Wall area, South Dakota
Boggs and Jenkins, 1980	--	50 - 190	$1.4x10^{-5}$ - $1.0x10^{-4}$	--	Northwestern Fall River County
Bredehoeft and others, 1983	8.3	--	$1.0x10^{-5}$	--	South Dakota
Rahn, 1985	--	--	--	0.26/0.17	Western South Dakota
Kyllonen and Peter, 1987	--	0.86 - 6,000	--	--	Northern Black Hills

Source: Driscoll et al. (2002)

aquifers determined in previous investigations. In addition to these four major aquifers, other units including the Precambrian, Minnekahta Limestone, Sundance Formation, and Unkpapa Sandstone are utilized locally as sources of water supply at or near the outcrop areas in the central portion of the Black Hills. Within the permit area, none of the deeper regional aquifers below the Sundance Formation is used as a water supply, mainly because of the availability of shallower sources and/or the poor water quality in the deeper aquifers. There are no water supply wells within 2 km of the permit area completed in aquifers below the Sundance Formation. The closest municipal wells are the Edgemont Madison wells, which are approximately 15 miles to the south-southeast of the center of the permit area.

In the 1990s, the USGS undertook an extensive study focusing on the evaluation of the hydrologic significance of selected bedrock aquifers in the Black Hills area – specifically the Deadwood, Madison, Minnelusa, Minnekahta, and Inyan Kara aquifers. In these evaluations, the USGS placed priority on the Madison and Minnelusa aquifers, both of which are used extensively elsewhere in the region for water supplies.

While the review of regional hydrology is prudent and necessary for this application, it should be noted that the site hydrology within the permit area is unique compared to the regional Black Hills hydrology. In this regard, intermediate groundwater flow systems in the Fall River Formation and the Chilson Member of the Lakota Formation are independent of the regional flow system. These intermediate flow systems have their origin in the areas within the eastern portion of the permit area (Fall River) and immediately to the east and north of the permit area (Fall River and Chilson) where the Fall River and Chilson crop out at the land surface. Both of these flow systems are recharged directly by precipitation and infiltration of surface runoff along the outcrops in and near the eastern portion of the permit area.

3.4.1.2 Inyan Kara Aquifer

At distance from the central core of the Black Hills Uplift, the Inyan Kara Group typically contains the first significant aquifer encountered. The Inyan Kara includes two sub-aquifers, the Chilson Member of the Lakota Formation and the Fall River Formation, which are separated by the Fuson Shale confining unit. Refer to Section 3.2.2.2 for a description of confining units relevant to ISR. The Inyan Kara aquifer is heterogeneous, which results in the two sub-aquifers exhibiting large variations in their hydraulic characteristics at some locations. Regionally, the Inyan Kara ranges from 250 to 500 feet thick, exhibits a large effective porosity (17 percent), and can yield considerable quantities of water from storage (Driscoll et al., 2002). Within the Black Hills, the transmissivity of the Inyan Kara ranges from 1 to 6,000 ft^2/day (Table 3.4-1). The

Inyan Kara is confined below by the Jurassic Morrison Formation and above by the Cretaceous Graneros Group.

3.4.1.3 Minnelusa Aquifer

The Minnelusa Formation consists of interbedded siltstone, sandstone, anhydrite, and limestone. The Minnelusa aquifer occurs primarily in saturated sandstone and anhydrite beds within the upper part of the formation (Williamson and Carter, 2001). Within the Black Hills, the Minnelusa ranges in thickness from 375 to 1,175 feet (Driscoll et al., 2002). The porosity is dominantly primary porosity within the sandstone beds, although secondary porosity is present in association with fractures and dissolution features (Williamson and Carter, 2001). Various studies have found the transmissivity of the Minnelusa to range from 1 to 12,000 ft^2/day (Table 3.4-1). The Minnelusa aquifer is confined above by the Opeche Shale and below by the lower permeability layers at the base of the Minnelusa.

Locally, the Minnelusa produces oil and gas in the Barker Dome to the east of the permit area.

3.4.1.4 Madison Aquifer

The Madison Limestone, also known as the Pahasapa Limestone, is the source of municipal water supplies in numerous communities within the Black Hills including Rapid City and Edgemont.

The hydraulic characteristics of the Madison aquifer have been extensively studied; aquifer characteristics of the Madison based on the numerous regional investigations are summarized in Table 3.4-1. The Madison aquifer is mainly a dolomite unit and is characterized by extensive secondary porosity resulting from fractures and associated karstic features (Williamson and Carter, 2001). The thickness of the Madison ranges from 200 feet in the southern Black Hills to 1,000 feet regionally. In the Rapid City area, Greene (1993) found the transmissivity to vary between 1,300 and 56,000 ft^2/day. The aquifer varies from unconfined at its outcrop areas to confined, where reported storativity values range from 10^{-3} to 10^{-6} (Table 3.4-1). Regionally, water quality data indicate that low permeability layers within the overlying Minnelusa Formation isolate the Madison from the Minnelusa. At some locations distant from the permit area on the core of the Black Hills Uplift, these confining layers may be absent or exhibit poorly confining hydraulic characteristics such that communication between the Madison and Minnelusa occurs. Regionally, the Madison may be in direct communication with the underlying Deadwood aquifer where the Whitewood and Winnipeg confining units are absent; locally,

however, the available data indicate that the Madison Limestone and Deadwood Formation are isolated beneath the permit area (refer to Class V UIC application, Appendix 3.4-A).

3.4.1.5 Deadwood Aquifer

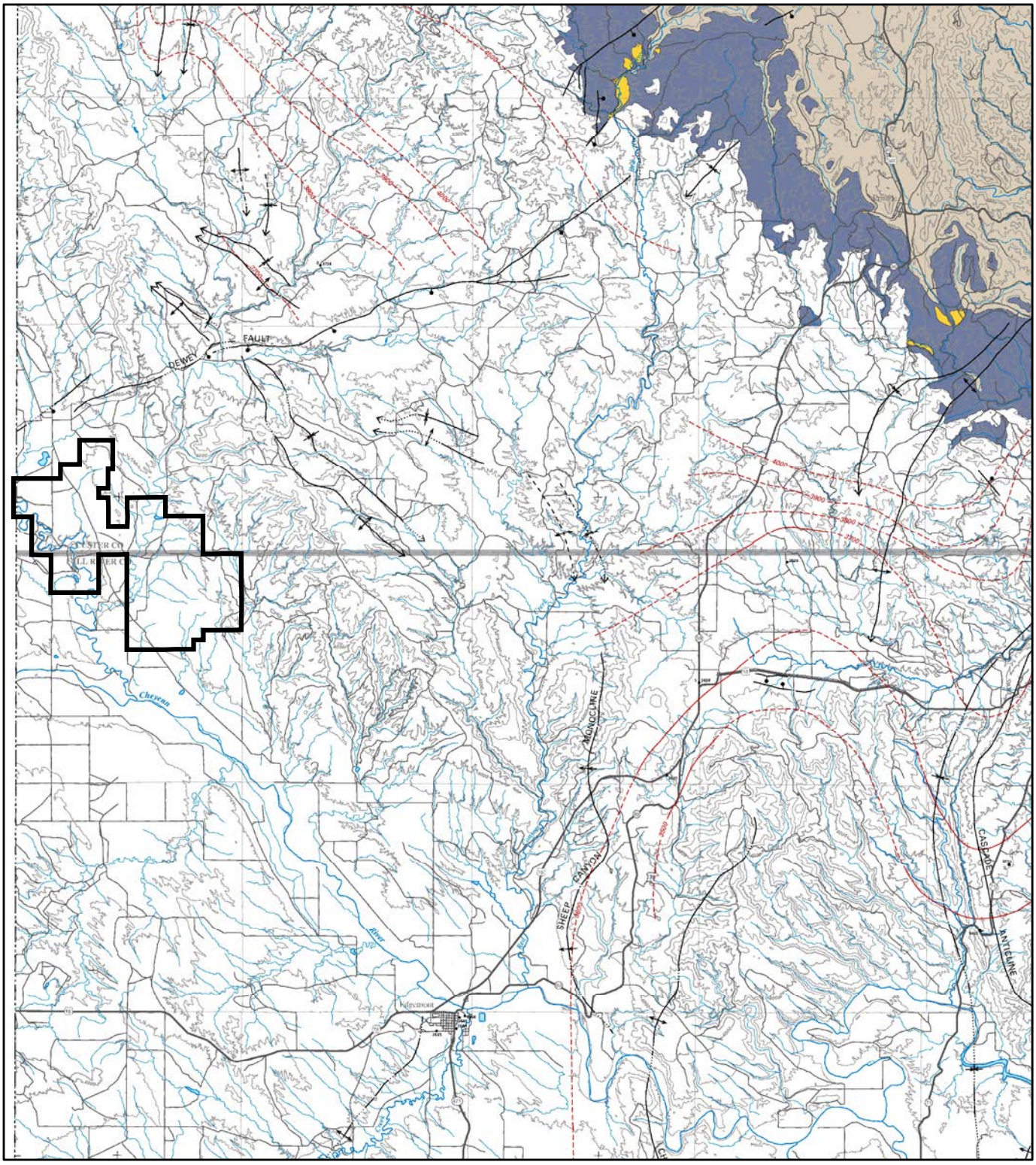
The Cambrian Deadwood Formation overlies the Precambrian basement and consists of basal conglomerates, sandstone, limestone, and mudstone. The Deadwood ranges from zero to 500 feet thick (Driscoll et al., 2002). Rahn (1985) estimated the effective porosity of the Deadwood to be about 5 to 10 percent. In the northern Black Hills, the effective porosity is presumably lower where the formation has undergone hydrothermal alteration. The transmissivity of the Deadwood is estimated to be in the range of 250 to 1,000 ft^2/day (Table 3.4-1; Downey, 1984). Regionally, the Precambrian rocks act as a lower confining unit to the Deadwood although a localized direct connection between the two units can occur at or near the outcrop areas (Williamson and Carter, 2001). Regionally, the Deadwood may be in contact with the overlying Madison aquifer except where the Whitewood and Winnipeg Formations are present and act as semi-confining units (Strobel et al., 1999). As noted, available data indicate that the Madison Limestone and Deadwood Formation are isolated beneath the permit area.

3.4.1.6 Minor Aquifers

Minor aquifers in the Black Hills include the Minnekahta Limestone, Sundance Formation, Unkpapa Sandstone, Newcastle Sandstone, and Quaternary alluvium. Where present and saturated, these units can yield small amounts of water. In isolated locations distant from the permit area, beds within the confining units also may contain water-bearing units (Driscoll et al., 2002). These minor aquifers are generally not widely utilized because of the availability of more reliable water-supply sources.

3.4.1.7 Regional Potentiometric Surfaces

As part of its 1990s study of the hydrologic significance of selected bedrock aquifers, the USGS developed 1:100,000-scale potentiometric contour maps for the Inyan Kara, Minnekahta, Minnelusa, Madison, and the Deadwood (Strobel et al., 2000a thru 2000e). These maps provide a basis for evaluating regional groundwater flow direction and hydraulic gradients in the Black Hills. Figures 3.4-2 and 3.4-3 depict the regional potentiometric contour maps of the Madison and Minnelusa aquifers, respectively. In the development of these potentiometric maps, structural features such as faults and folds were considered. Of significance, no major structural features were identified in or within the immediate vicinity of the permit area other than the



EXPLANATION

- Outcrop of the Madison Limestone or Englewood Formation
- Madison Limestone or Englewood Formation present, but overlain directly by surficial deposits
- Madison Limestone or Englewood Formation absent
- **Fault**—Dashed where approximated, dotted where concealed. Bar and ball on downthrown side.
- **Anticline**—Showing trace of axial plane and direction of plunge. Dashed where approximated, dotted where concealed
- **Syncline**—Showing trace of axial plane and direction of plunge. Dashed where approximated, dotted where concealed
- **Monocline**—Showing trace of axial plane. Dashed where approximated, dotted where concealed
- **Dome**—Symbol size approximately proportional to size of dome. Dome asymmetry indicated by arrow length
- **Potentiometric contour**—Shows altitude at which water would have stood in tightly cased, nonpumping wells. Contour interval 100 or 500 feet where appropriate. Dashed where inferred. Datum is sea level[1]
- **Well**—Number is mean hydraulic head of the well, in feet above sea level. "R" indicates continuous recording wells
- **Spring originating from Madison aquifer**—Number is altitude of the spring, in feet above sea level

[1]Sea level: In this report, the term "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(5).

Feet
0 10,000 20,000
0 2,500 5,000 7,500
Meters

Legend

Permit Boundary

Source: Strobel et al. (2000d)

N

Figure 3.4-2

Regional Potentiometric Contour Map, Madison Limestone

Dewey-Burdock Project

DRAWN BY	S. Hetrick
DATE	24-Sep-2012
FILENAME	AppD_Madison.mxd

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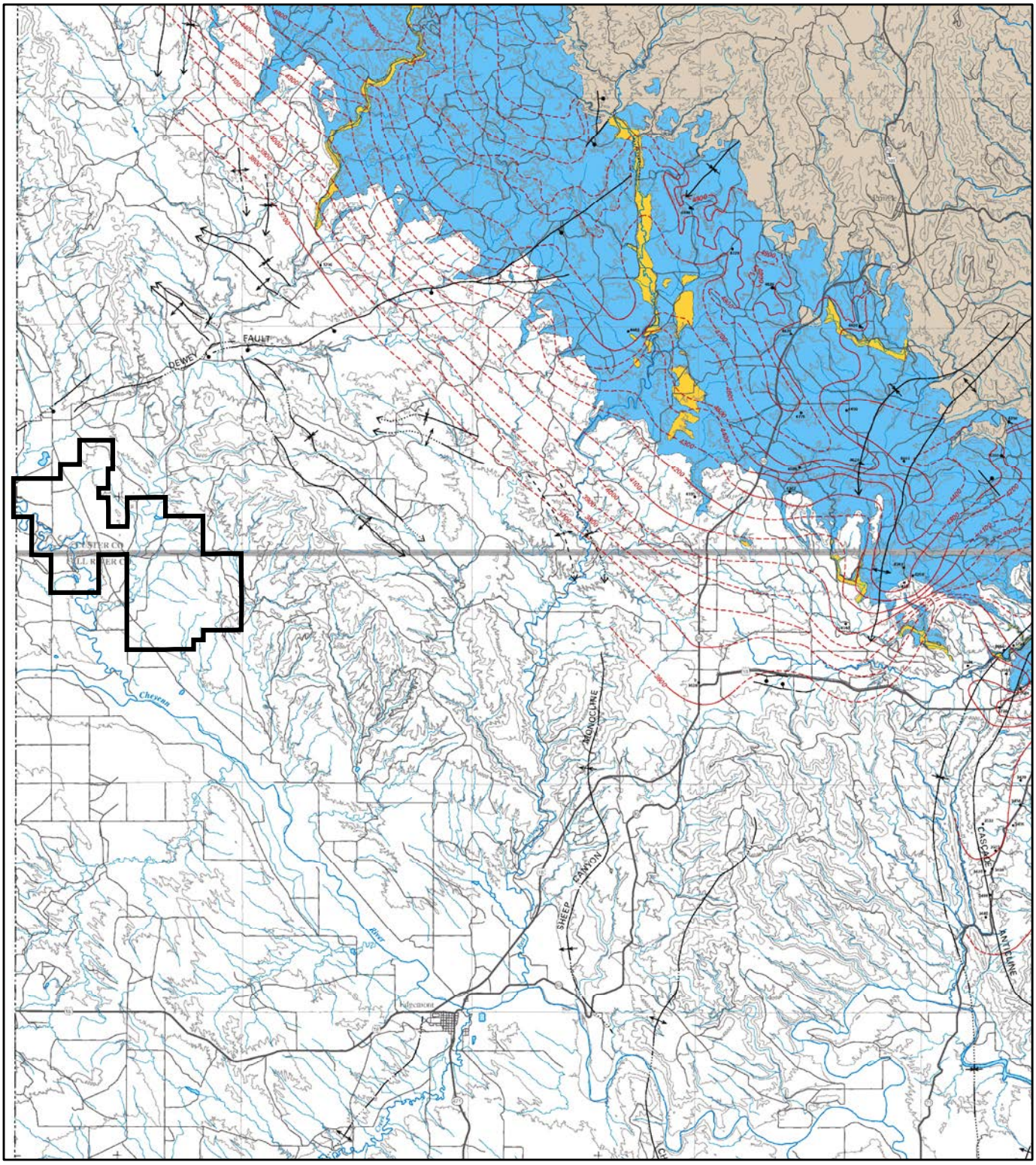

EXPLANATION

- Outcrop of the Minnelusa Formation
- Minnelusa Formation present, but overlain directly by surficial deposits
- Minnelusa Formation absent
- **Fault**—Dashed where approximated, dotted where concealed. Bar and ball on downthrown side
- **Anticline**—Showing trace of axial plane and direction of plunge. Dashed where approximated, dotted where concealed
- **Syncline**—Showing trace of axial plane and direction of plunge. Dashed where approximated, dotted where concealed
- **Monocline**—Showing trace of axial plane. Dashed where approximated, dotted where concealed
- **Dome**—Symbol size approximately proportional to size of dome. Dome asymmetry indicated by arrow length
- 3500 **Potentiometric contour**—Shows altitude at which water would have stood in tightly cased, nonpumping wells. Contour interval 100 feet. Dashed where inferred. Datum is sea level[1]
- **Well**—Number is mean hydraulic head of the well, in feet above sea level. "R" indicates continuous recording wells
- **Spring originating from Minnelusa aquifer**—Number is altitude of the spring, in feet above sea level

[1]Sea level: In this report, the term "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(5).

Feet
0 10,000 20,000
0 2,500 5,000 7,500
Meters

Legend

Permit Boundary

Source: Strobel et al. (2000c)

N

Figure 3.4-3

Regional Potentiometric Contour Map, Minnelusa Formation

Dewey-Burdock Project

DRAWN BY	S. Hetrick
DATE	24-Sep-2012
FILENAME	AppD_Minnelusa.mxd

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Dewey Fault, which is located north of the permit area, and the Long Mountain Structural Zone, which is located approximately 7 miles south of the permit area.

Based on the USGS potentiometric contour maps, regional groundwater flow within the five selected bedrock aquifers is generally consistent and radially outward from the central Black Hills highlands toward the plains. All five of the aquifers are hydraulically unconfined (partially saturated) near their outcrops in the central highlands and become confined by the overlying strata with distance away from the central highlands. Locally, the potentiometric surface of the aquifers may be above land surface.

The Black Hills are relatively arid with the annual precipitation ranging from about 12 to 28 inches regionally and averaging approximately 16 inches in the permit area. While most precipitation can be accounted for as surface runoff and evapotranspiration, regionally, the percentage of precipitation that recharges the aquifers is estimated to vary from 30 percent in the northwestern Black Hills to 2 percent or less in the drier southwestern Black Hills, which includes the permit area.

Other sources of recharge to individual units can occur from leakage between aquifers. In general, the potentiometric elevation increases with depth within the stratigraphic section, which provides an upward potential for groundwater flow and limits the potential for downward recharge, which occurs regionally but not locally.

Most interconnection between aquifers appears to be associated with the thinning or absence of confining units between aquifers. Some investigators have suggested that solutioning and subsequent collapse (i.e., karsting) of the overlying strata may provide a pathway for upward groundwater movement (Gott et al., 1974). This is reported to occur some 6 miles northeast of the permit area, but no evidence of karsting has been observed in the permit area. A detailed analysis of the potential occurrence of breccia pipes and karsting north and east of the permit area is presented in Appendix 3.2-C.

3.4.2 Site Hydrogeology

The main aquifers to be utilized by the Dewey-Burdock Project (the Fall River and Chilson) are recharged locally and are isolated from the deep regional flow system in the Paleozoic formations that typically characterize regional groundwater flow and are the focus of numerous USGS research studies.

In the permit area, the sedimentary rocks dip gently to the southwest at 2 to 6 degrees. As the land surface is generally flatter than the dip of the underlying bedrock strata, younger strata crop out at the ground surface sequentially from east to west.

The structure is illustrated by the structural contour maps on top of the Fall River (Plate 3.2-5), Chilson Member of the Lakota (Plate 3.2-3) and Unkpapa Sandstone (Plate 3.2-1). Based on the logs for thousands of exploration holes, no major faults or other structural features have been identified within the permit area.

3.4.2.1 Site Hydrostratigraphic Units

Refer to Figure 3.2-2 for a regional stratigraphic column and Section 3.2.2.2 for a more detailed discussion of the site stratigraphy. The Fall River Formation and Chilson Member of the Lakota Formation are the principal sources of water in the vicinity of the permit area for domestic, livestock, and agricultural uses. These same formations are the host rocks for the uranium mineralization within the permit area. Within the permit area, the deeper regional aquifers are not used as a source of water supply mainly because of their depth of occurrence, availability of shallower sources, relatively low productivity, and low historical water demands. There are no water supply wells within 2 km of the permit area completed in aquifers below the Sundance Formation. The closest municipal wells are the Edgemont Madison wells, which are approximately 15 miles south-southeast of the center of the permit area.

In the following discussion, the site hydrogeological characterization focuses on groundwater occurrence and the groundwater flow regimes above the Morrison Formation. The Morrison Formation is the lowermost confining unit for ISR operations within the Dewey-Burdock Project (refer to Section 3.2.2.2). Because of the low vertical permeability, thickness and continuity of the Morrison Formation across the entire permit area and due to the existence of an upward hydraulic gradient between the underlying Unkpapa Sandstone and the Inyan Kara, the proposed ISR activities will not impact any of the formations below the Morrison Formation. The only exception is potential pumping from the Madison or another suitable deep formation for aquifer restoration makeup water and for CPP water supply or use of the Minnelusa and/or Deadwood for management of wastewater in Class V disposal wells.

The Morrison Formation is underlain, in turn, by the Unkpapa Sandstone, Sundance Formation and Spearfish Formation. Based on the results of limited exploratory drilling, the Spearfish in the permit area averages approximately 320 feet thick and due to its low vertical permeability is

considered a hydrologic barrier between the overlying Jurassic and Cretaceous aquifers and the underlying Paleozoic aquifers.

The Spearfish Formation is overlain by the Sundance Formation, which consists of a 250 to 450-foot thick sequence of red shale and siltstone. In the permit area, the Sundance consists mainly of shale and sandstone with an average thickness of 280 feet. In turn, the Sundance is overlain by the Unkpapa Sandstone. Where present, the Unkpapa consists of 50 to 80 feet of well-sorted, fine-grained, aeolian sandstone. Since there is not an intervening confining unit separating the two, the Sundance and Unkpapa are generally considered to be a single hydrostratigraphic unit. The Sundance/Unkpapa is used locally as a water supply within the permit area.

3.4.2.1.1 Morrison Formation

The Morrison Formation, because of its low permeability and continuity beneath the permit area, is the lowermost confining unit for the proposed ISR operations. The Morrison averages 100 feet thick and is composed of waxy, calcareous, non-carbonaceous massive shale with numerous limestone lenses and a few thin, fine-grained sandstones. Analyses of core samples within the permit area have shown the vertical permeability of the Morrison clays to be very low and to range from 9×10^{-9} to 3×10^{-8} cm/sec (0.012 to 0.043 millidarcies; see Table 3.4-3).

3.4.2.1.2 Inyan Kara Group

The Jurassic Morrison Formation is unconformably overlain by the Inyan Kara Group, which consists of the Lakota and the Fall River Formations. The sandstone packages within the Fall River Formation and Chilson Member of the Lakota Formation are the host rocks to the uranium mineralization at the Dewey-Burdock Project. The Inyan Kara consists of interbedded sandstone, siltstone, and shale. Based on measured outcrop sections and drill hole data, the Inyan Kara averages about 350 feet thick in the permit area.

The Lakota Formation regionally consists of three members which are, from oldest to youngest, the Chilson, Minnewaste Limestone, and the Fuson members. The Minnewaste Limestone Member is not present in the permit area.

Chilson Member

The Chilson Member consists of a complex of fluvial channel sandstone deposits and their fine-grained lateral equivalents and varies from about 100 to 240 feet thick. The Chilson Member is confined below by the Morrison Formation and above by the Fuson Shale. Analyses of core samples of Chilson sandstones within the permit area indicate these units exhibit high horizontal

permeabilities, ranging from 2.6 x 10^{-3} to 4.1 x 10^{-3} cm/sec (2,697 to 4,161 millidarcies; see Table 3.4-3).

Fuson Member

The Fuson Member is the uppermost member of the Lakota and separates the Chilson Member from the Fall River Formation. As discussed in Section 3.2.2.2, Powertech (USA) has differentiated the Fuson Shale from the Fuson Member of the Lakota Formation for the purpose of characterizing site geology. The Fuson Shale has been mapped by Powertech (USA) and consists of 20 to 80 feet of low-permeability shales and clays, which generally occur at or near the base of the unit (Plate 3.2-8).

The shales and mudstones within the Fuson Shale are highly stratified. Due to this stratification, the vertical permeability is several orders of magnitude smaller than the horizontal permeability. Based on analyses of core samples from the Fuson Shale within the permit area, vertical permeabilities range from about 7.8 x 10^{-9} to 2.2 x 10^{-7} cm/sec (0.008 to 0.228 millidarcies; see Table 3.4-3). Estimates of vertical hydraulic conductivity of the Fuson Shale from the 1979 pumping tests conducted in the Fall River and Chilson near Burdock range from 4.6 x 10^{-8} to 1 x 10^{-7} cm/sec (Boggs and Jenkins, 1980). Well field-scale pumping tests will be conducted after NRC license and LSM permit issuance and the results contained in the well field hydrogeologic data packages (refer to Section 5.3.3.4). This additional testing will provide additional quantification of the low hydraulic conductivity of the confining units.

Fall River Formation

The Fall River Formation is composed of carbonaceous interbedded siltstone and sandstone, channel sandstones, and a sequence of interbedded sandstone and shale. The Fall River ranges from about 120 to 160 feet thick.

The Fall River is confined above by the Graneros Group, a thick sequence of dark shales that varies in thickness from zero, where the Inyan Kara outcrops near the eastern edge of the permit area, to more than 500 feet in the northwestern portion of the permit area. Because of its thickness and low permeability, the Graneros Group precludes vertical migration of water between the Inyan Kara, overlying alluvial aquifers, and the ground surface.

3.4.2.1.3 Graneros Group

The Cretaceous Graneros Group consists of several geologic units, including the Skull Creek Shale, Newcastle Sandstone (where present), Mowry Shale, and Belle Fourche Shale, which act

as a single confining unit overlying the Inyan Kara. In the permit area, the thickness of the Graneros Group ranges from zero at the outcrop of the Fall River to more than 500 feet (Plate 3.2-10). The members comprising the Graneros Group are described in Section 3.2.2.2. Analyses of core samples of the Skull Creek clays indicate low vertical permeabilities on the order of 6.8 x 10^{-9} cm/sec (0.007 millidarcies).

3.4.2.1.4 Terrace Deposits and Quaternary Alluvium

The most recent sedimentary units within the permit area are the Quaternary alluvial deposits present along the major drainages and their tributaries. The alluvium varies from 0 to 50 feet thick and consists of an unconsolidated mixture of silt, clay, sand and gravel.

An isopach map depicting the thickness of the alluvium in the Beaver Creek and Pass Creek drainages is shown on Plate 3.2-11.

3.4.2.2 Groundwater Occurrence and Flow

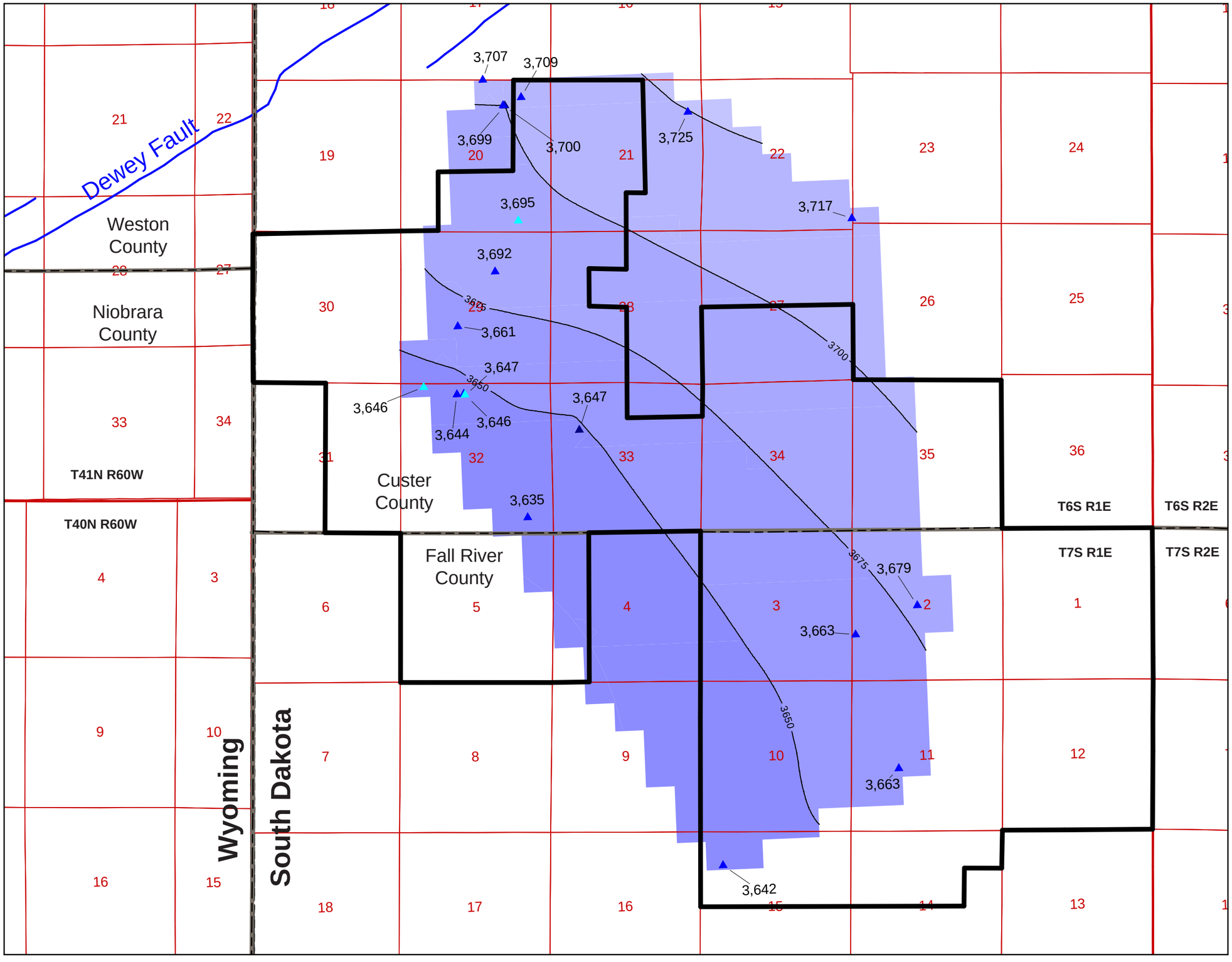
Potentiometric contour maps for the Fall River and the Chilson Member of the Lakota are shown on Figures 3.4-4 and 3.4-5, respectively. These maps were prepared using water level measurements taken over a 5-day period from April 25 through April 29, 2011. The data used to generate Figures 3.4-4 and 3.4-5 are presented in Appendix 3.4-D.

The potentiometric surface map for the Fall River (Figure 3.4-4) shows a relatively uniform hydraulic gradient across the permit area, with the potentiometric levels decreasing to the southwest. The potentiometric surface for the Chilson (Figure 3.4-5) shows a slight flattening of the hydraulic gradient across the northwestern portion of the permit area but with heads also decreasing to the southwest.

3.4.2.2.1 Groundwater Flow Systems

Based on the regional and site-specific hydrogeological characterization, groundwater occurrence and flow in the permit area can be subdivided into three main components, or flow regimes. These include the deep regional flow system, a shallow perched groundwater flow system, and an intermediate groundwater flow system that includes the Fall River and Chilson aquifers.

As described in Driscoll et al. (2002), there are multiple deep regional groundwater flow systems within the Paleozoic section. These regional flow systems are associated with the permeable strata within various geologic formations at depth within the Deadwood, Madison, Minnelusa,



Legend

Well Symbols

- Fall RIver
- Upper Fall River
- Lower Fall RIver
- Potentiometric Contour
- Project Boundary

Note: Potentiometric Contour Elevations in feet above sea level.

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(5).

Feet: 0, 2,000, 4,000, 6,000
Meters: 0, 1,000, 2,000

N

Figure 3.4-4

Potentiometric Contour Map, Fall River Formation

Dewey-Burdock Project

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PREPARER	Hal Demuth
DATE	14-Sep-2012
FILENAME	2012_DB_Fig_3.4-04.ai

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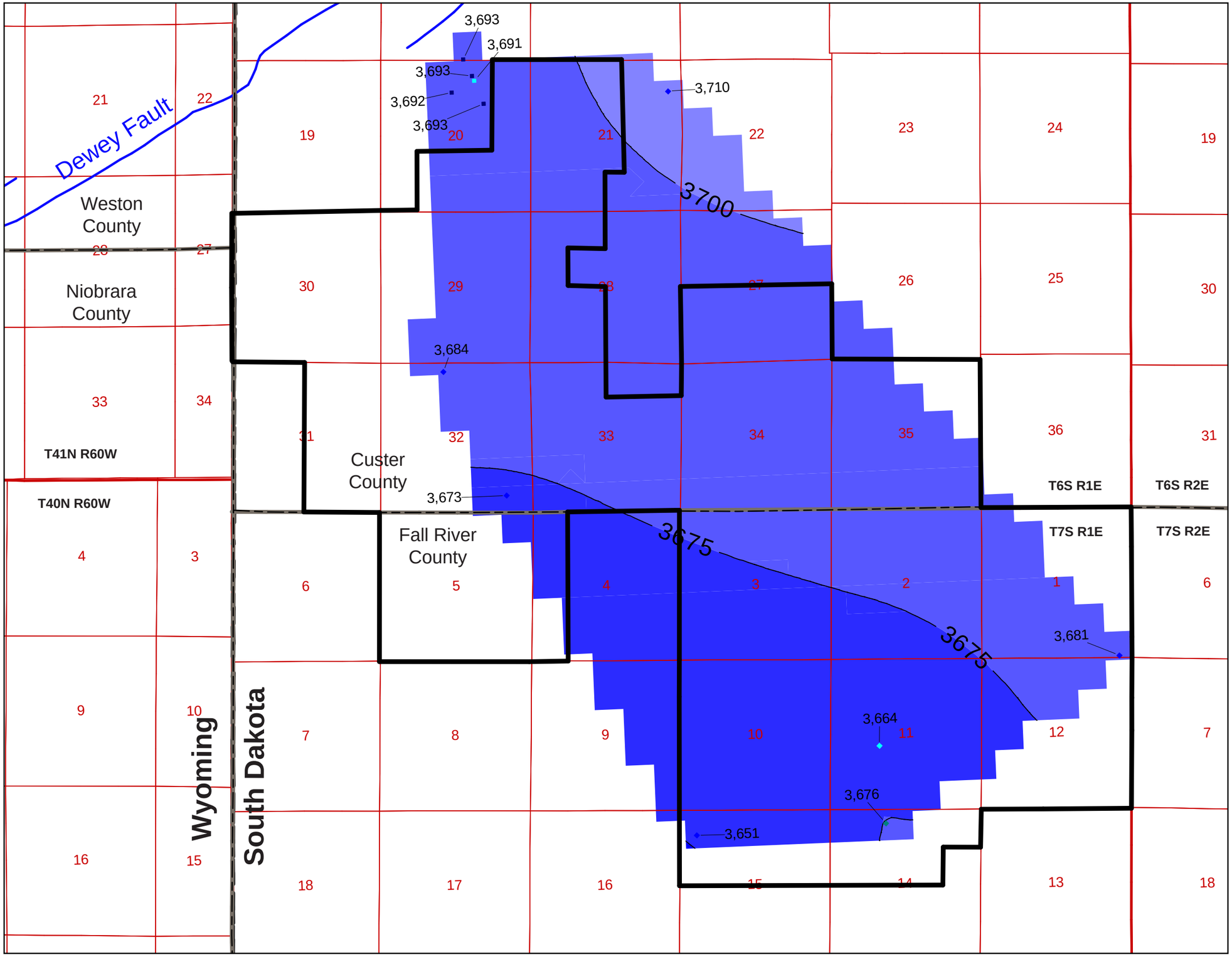

Legend

Well Symbols

- Mid-Lower Lakota
- Lower Lakota
- Chilson
- Upper Chilson
- Middle Chilson
- Potentiometric Contour
- Project Boundary

Note: Potentiometric Contour Elevations in feet above sea level.

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(5).

Feet: 0, 2,000, 4,000, 6,000
Meters: 0, 1,000, 2,000
N

Figure 3.4-5
Potentiometric Contour Map, Chilson Member
Dewey-Burdock Project

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PREPARER	Hal Demuth
DATE	14-Sep-2012
FILENAME	2012_DB_Fig_3.4-05.ai

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Sundance/Unkpapa, and the minor aquifers. These deep regional flow systems and associated aquifers are isolated from the shallower formations that are the target of the proposed ISR operations in the Inyan Kara Group in the permit area by low-permeability layers, or confining beds.

Shallow, perched groundwater systems exist within the alluvium associated with Beaver Creek, Pass Creek, and Bennett Canyon. These alluvial systems are perched above the top of the Graneros on the western portion of the permit area. Groundwater flow within the alluvium is controlled by the configuration of the drainage channel on the top of bedrock and in most situations is generally parallel to surface drainage patterns. In the case of Bennett Canyon, the alluvium directly overlies the Chilson Member of the Lakota. As such, the alluvial groundwater is a potential source of recharge to the underlying Chilson. Bennett Canyon is approximately ½ mile east of the easternmost potential well fields within the permit area.

Intermediate groundwater flow systems exist within the Fall River Formation and the Chilson Member of the Lakota. These intermediate flow systems have their origins in the areas within the eastern portion of the permit area (Fall River) and immediately to the east and north of the permit area where the Fall River and Chilson crop out at the land surface. Both of these flow systems are recharged directly by precipitation that falls on the land surface and by infiltration of surface runoff, primarily in the Pass Creek and Bennett Canyon drainages north and east of the permit area, respectively.

Within the permit area, the Fall River and the Chilson dip gently to the southwest at 2 to 6 degrees away from their outcrop areas. As a result, groundwater flow within the Fall River and the Chilson generally occurs from the northeast to the southwest toward the Powder River Basin. On a broad regional basis, water from lower Cretaceous aquifers including the Inyan Kara eventually moves northeastward to discharge areas in eastern North Dakota and South Dakota (Whitehead, 1996).

3.4.2.2.2 Groundwater Recharge and Discharge

The hydrologic characterization for the permit area included the measurement of water levels in wells completed in the Inyan Kara, overlying alluvium, and the underlying Sundance/Unkpapa. The current data collection programs began in 2007 and are continuing.

Potentiometric surface maps for the Fall River and Chilson (Lakota) are shown on Figures 3.4-4 and 3.4-5, respectively. The water level data collected to date from the Unkpapa within the

permit area do not have sufficient spatial variability or temporal consistency to construct a potentiometric contour map of the Unkpapa. Information available to date shows substantially higher potentiometric head in the Unkpapa than in the Fall River and Chilson. Powertech (USA) anticipates that, with installation of additional wells, the monitoring in the Unkpapa conducted as part of the operational groundwater monitoring network (Section 5.5.2) will provide sufficient information to construct an Unkpapa potentiometric contour map prior to operations.

Alluvial groundwater flow systems occur within the alluvial deposits in the Pass Creek and Beaver Creek drainages, which are within the permit area, and in Bennett Canyon, which is located on and beyond the eastern edge of the permit area. Where these alluvial deposits overlie the Fall River and Chilson in Bennett Canyon, they represent a potential source of recharge to these underlying units.

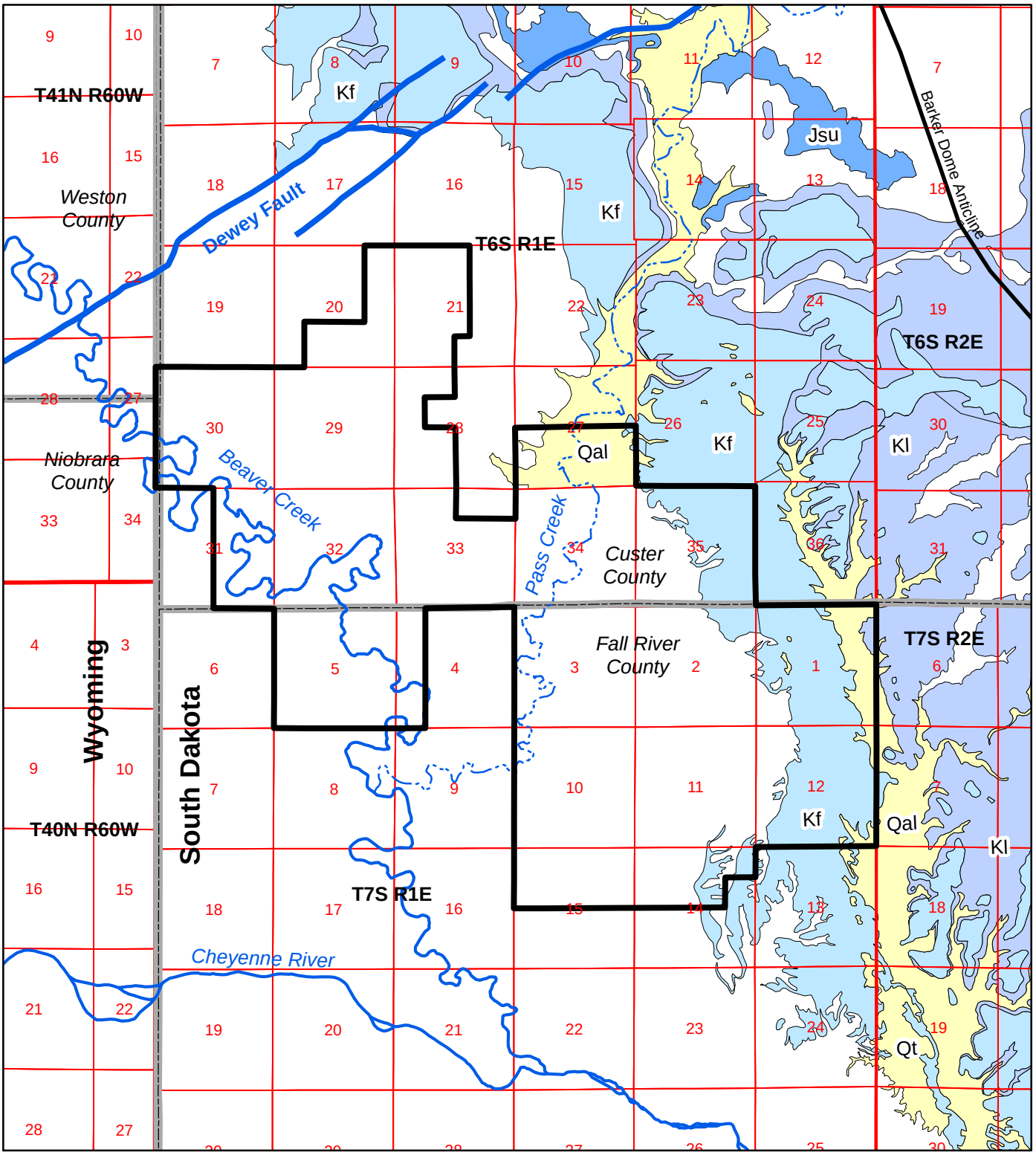
The Pass Creek watershed north of the permit area is a major source of recharge to both the Fall River and Chilson where they are exposed at the land surface or subcrop beneath the alluvium.

The Fall River Formation rises to the north and east and crops out at the ground surface. To the southwest the Fall River Formation dips at a steeper angle than the ground surface and is mantled by the overlying Graneros Group. The primary recharge areas for the Fall River and Lakota (Chilson) are where they are exposed at the ground surface and are shown on Figure 3.4-6. The areas where the Fall River subcrops below the surface alluvium and crops out near the eastern edge of the permit area also are recharge areas for the Fall River sands. A similar area of recharge occurs north of the permit area where Pass Creek alluvium crosses the subcrops of the Fall River and the Chilson. Recharge was observed during runoff events in 2011 where flowing streams disappeared into the Fall River and Chilson sandstones.

The recharge areas for the regional groundwater flow systems within the Minnelusa Formation, Madison Limestone, and Deadwood Formation are in their outcrop areas further to the east on the flanks of the Black Hills Dome. As a result of the rise in elevation, the older formations outcrop closer to the center of the dome at higher elevations and exhibit greater potentiometric elevations. Because of this, the potentiometric levels within the geologic section increase with depth, as noted previously.

3.4.2.2.3 Groundwater/Surface Water Interactions

Powertech performed extensive investigation into all surface water features within the permit area. This included field investigations during the initial baseline monitoring period and the use



This figure is provided to fulfill the requirements of ARSD 74:29:02:11(1).

Legend

- Project Boundary
- Dewey Fault
- Barker Dome Anticline
- Overlying Alluvium and Gravel, Qal and Qt
- Fall River, Kf
- Lakota, Kl
- Sundance/Unkpapa, Jsu

Feet
0 2,000 4,000 6,000
0 1,000 2,000
Meters

N

Figure 3.4-6

Recharge Areas for
Fall River and Lakota Formations

Dewey-Burdock Project

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PREPARER	Hal Demuth
DATE	14-Sep-2012
FILENAME	2012_DB_Fig_3.4-06.mxd

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of color infrared (CIR) imagery. All surface water features and sources of groundwater flow to the surface are believed to have been identified within the permit area.

Extensive site investigations undertaken by Powertech (USA) and others have revealed no known natural springs within the permit area. With one exception, groundwater discharging to the ground surface is limited to flowing artesian wells, which will be controlled and mitigated as described in Section 5.6.3.2. The only feature identified that was indicative of groundwater discharge from exploration drill holes at or near surface was the "alkali area" in the southwestern corner of the Burdock portion of the permit area (N/2 NE/4 Section 15, T7S, R1E). This is an area of known discharge from the Fall River and Chilson to the surface through abandoned exploration holes documented by TVA. The significance of this area as it relates to ISR operations will be evaluated further after NRC license and LSM permit issuance during delineation drilling and well field-scale pumping tests prior to any well field development.

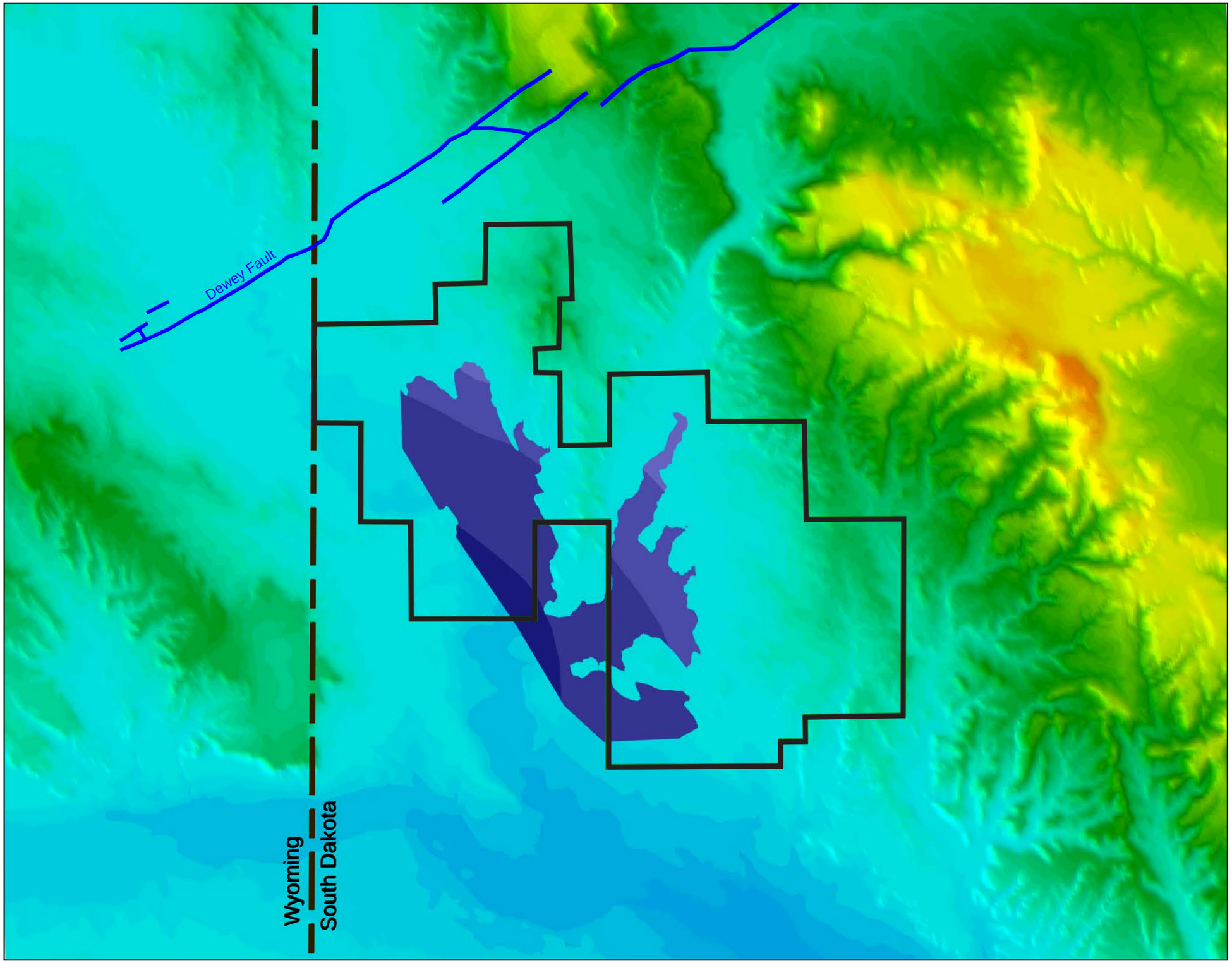
Recharge areas for the Fall River and Chilson are described in the previous section and include outcrop areas and areas where these formations subcrop below the alluvium. Downgradient of the known recharge areas, there is no evidence of surface discharge from the Fall River via seeps or springs. The following paragraphs describe the investigations performed to evaluate potential groundwater/surface water interactions.

Potentiometric Surface Evaluation

Powertech (USA) has evaluated areas where the potentiometric surfaces of the Fall River and Chilson are above the ground surface as an indicator of the potential for groundwater discharge to the alluvium. Those areas within the Beaver Creek and Pass Creek drainages where the potentiometric surfaces for the Fall River and Chilson are above the ground surface are depicted on Figures 3.4-7 and 3.4-8, respectively. Note that the potentiometric surfaces are anticipated to be above ground surface to the west and southwest of the areas depicted on Figures 3.4-7 and 3.4-8; the boundaries shown in these directions are due to the data extents. The potential for groundwater discharge to alluvium from an operating well field is limited to those areas where the well field overlaps alluvium and the potentiometric surface of the Fall River or Chilson is above the base of the alluvium.

Alluvial Drilling Program

An alluvial drilling program was completed in May 2011 to further address potential discharge to the alluvium from underlying aquifers. Nineteen borings were drilled into the alluvium along Beaver Creek and Pass Creek, many of which were dry. Three borings were completed as



Legend

Project Boundary

Potentiometric Surface above Ground Surface

5,250 ft
5,000 ft
4,750 ft
4,500 ft
4,250 ft
4,000 ft
3,750 ft
3,500 ft

Surface Elevation

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(5).

Feet
0 2,500 5,000 7,500 10,000
0 1,000 2,000 3,000
Meters

N

Figure 3.4-7

Area Where Fall River Potentiometric Surface is Above Ground Surface

Dewey-Burdock Project

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FILENAME	2012 DB_Fig_3.4-7.ai

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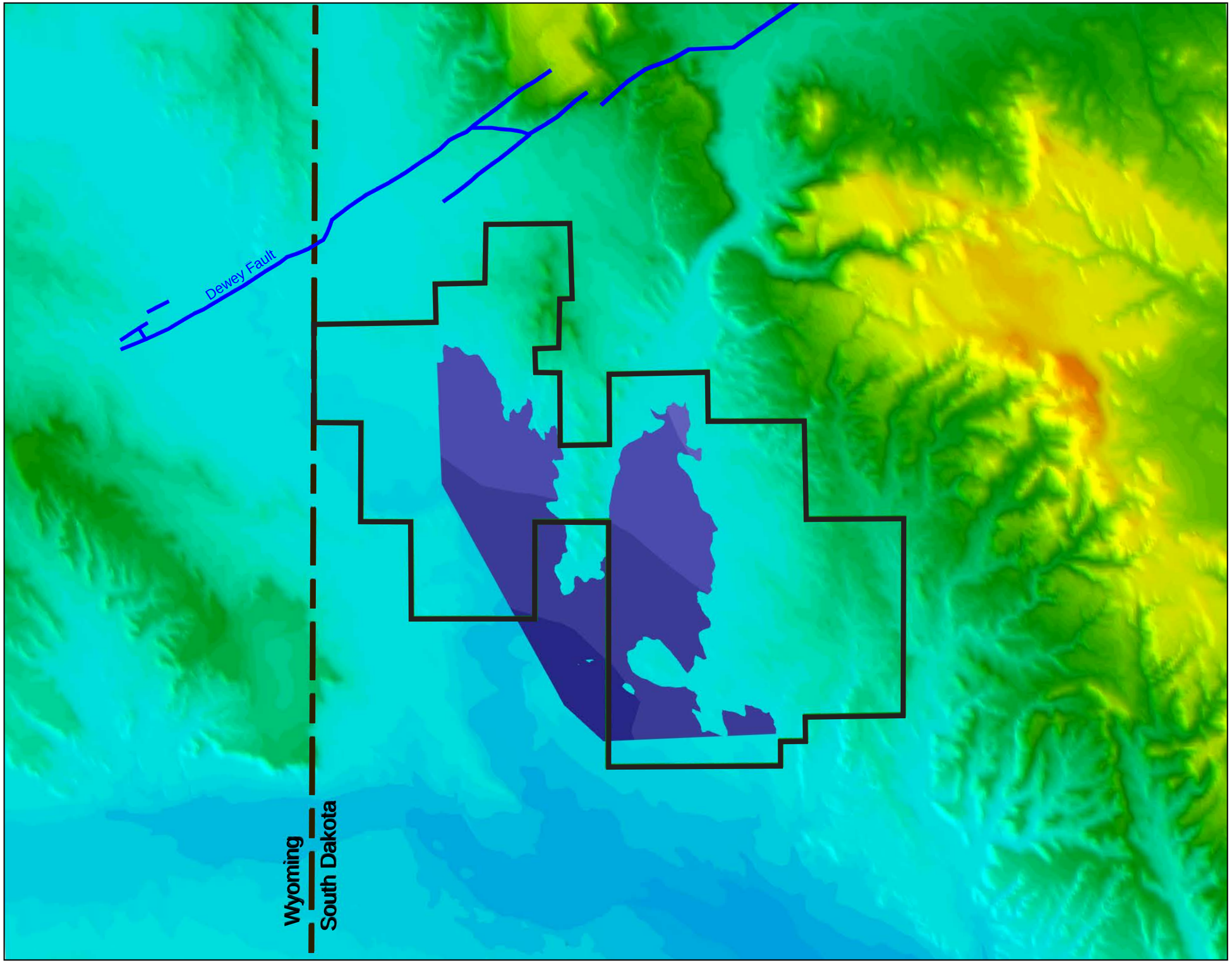

Legend

Project Boundary

Potentiometric Surface above Ground Surface

5,250 ft
5,000 ft
4,750 ft
4,500 ft
4,250 ft
4,000 ft
3,750 ft
3,500 ft

Surface Elevation

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(5).

Feet
0 2,500 5,000 7,500 10,000
0 1,000 2,000 3,000
Meters

N

Figure 3.4-8

Area Where Chilson Potentiometric Surface is Above Ground Surface

Dewey-Burdock Project

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FILENAME	2012_DB_Fig_3.4-08.ai

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alluvial monitor wells. The thickness of the saturated alluvium in these wells ranged from 10 to 12 feet. The alluvium in the Pass Creek drainage up to 50 feet thick; in the Beaver Creek drainage, the alluvium is up to 30 feet thick.

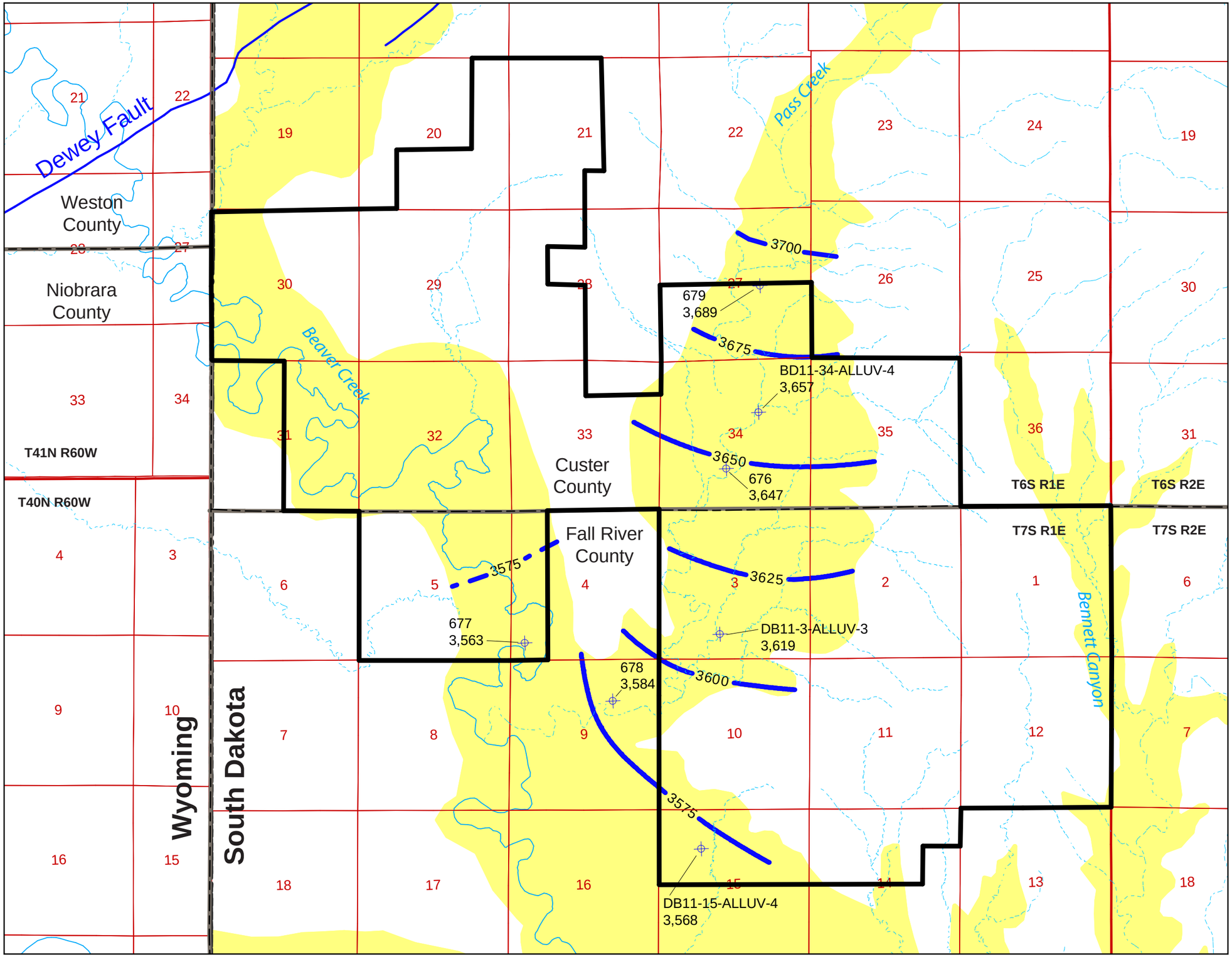
A potentiometric surface contour map for the Pass Creek and Beaver Creek alluvium is shown on Figure 3.4-9. An isopach map for the alluvium is shown on Plate 3.2-11. The potentiometric surface within the alluvium shows typical down-valley gradients consistent with the surface topography. The water level data lack any anomalous readings such as would be expected in the case of bedrock discharge to the alluvium.

Results of the alluvial drilling program (occurrence/lack of water; potentiometric levels and water quality data) did not indicate any areas of discharge to the alluvium from underlying aquifers but rather were consistent with limited recharge occurring from surface waters in the upland portions of the permit area. The results from the May 2011 alluvial drilling program in the Beaver Creek and Pass Creek drainages are consistent with the historical field observations in that neither the past field investigations nor the recent drilling program identified any areas other than the "alkali area" noted above where there was evidence to suggest groundwater discharge into the alluvium or at the ground surface from the underlying bedrock formations.

CIR Imagery

To further evaluate possible groundwater discharge to the alluvium within the Beaver Creek and Pass Creek drainages, CIR satellite imagery was obtained from the National Agriculture Imagery Program (NAIP) of the USDA Farm Services Agency for the permit area and vicinity. The imagery was photographed in 2010 and produced with a resolution of one meter. CIR imagery is commonly used to delineate areas of active vegetative growth; in semiarid regions such as the permit area, such areas often are indicative of enhanced water supply, such as occurs with irrigation or subirrigation.

CIR imagery for the permit area and vicinity is presented in Figure 3.4-10. The CIR imagery was examined visually for any anomalies that may suggest groundwater discharge at or near the surface, such as from upward flow through an open borehole or natural spring. Within the permit area, there are several flowing artesian wells that at times are allowed to discharge groundwater to the surface. These areas generally are visible on the CIR imagery. The "alkali area" has a noticeable signature on CIR (ponded water surrounded by discolored soils) and is depicted on Figures 3.4-11 and 3.4-12.



Legend

- Alluvial Well
- Ephemeral Streams
- Perennial Streams
- Potentiometric Contour
- Inferred Potentiometric Contour
- Project Boundary
- Alluvium

Note: Potentiometric Contour Elevations in feet above sea level.

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(5).

Feet: 0, 2,000, 4,000, 6,000
Meters: 0, 1,000, 2,000

N

Figure 3.4-9

Potentiometric Contour Map, Pass Creek and Beaver Creek Alluvium

Dewey-Burdock Project

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FILENAME	2012_DB_Fig_3.4-09.ai

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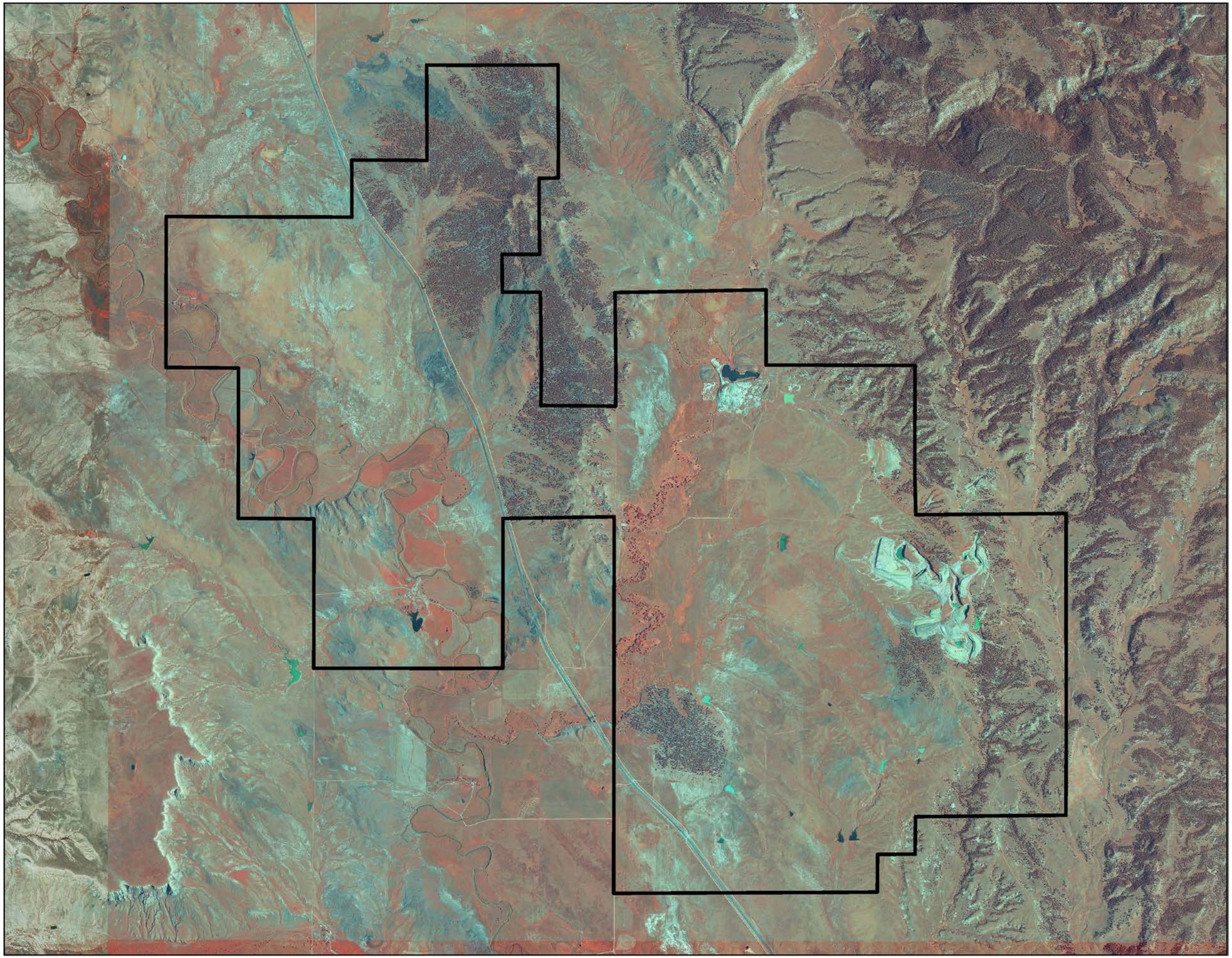

Legend

Project Boundary

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(1).

Feet
0 2,000 4,000 6,000
0 500 1,000 1,500
Meters

N

Figure 3.4-10

Color Infrared Imagery (2010 Data)

Dewey-Burdock Project

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FILENAME	2012_DB_Fig_3.4-10.mxd

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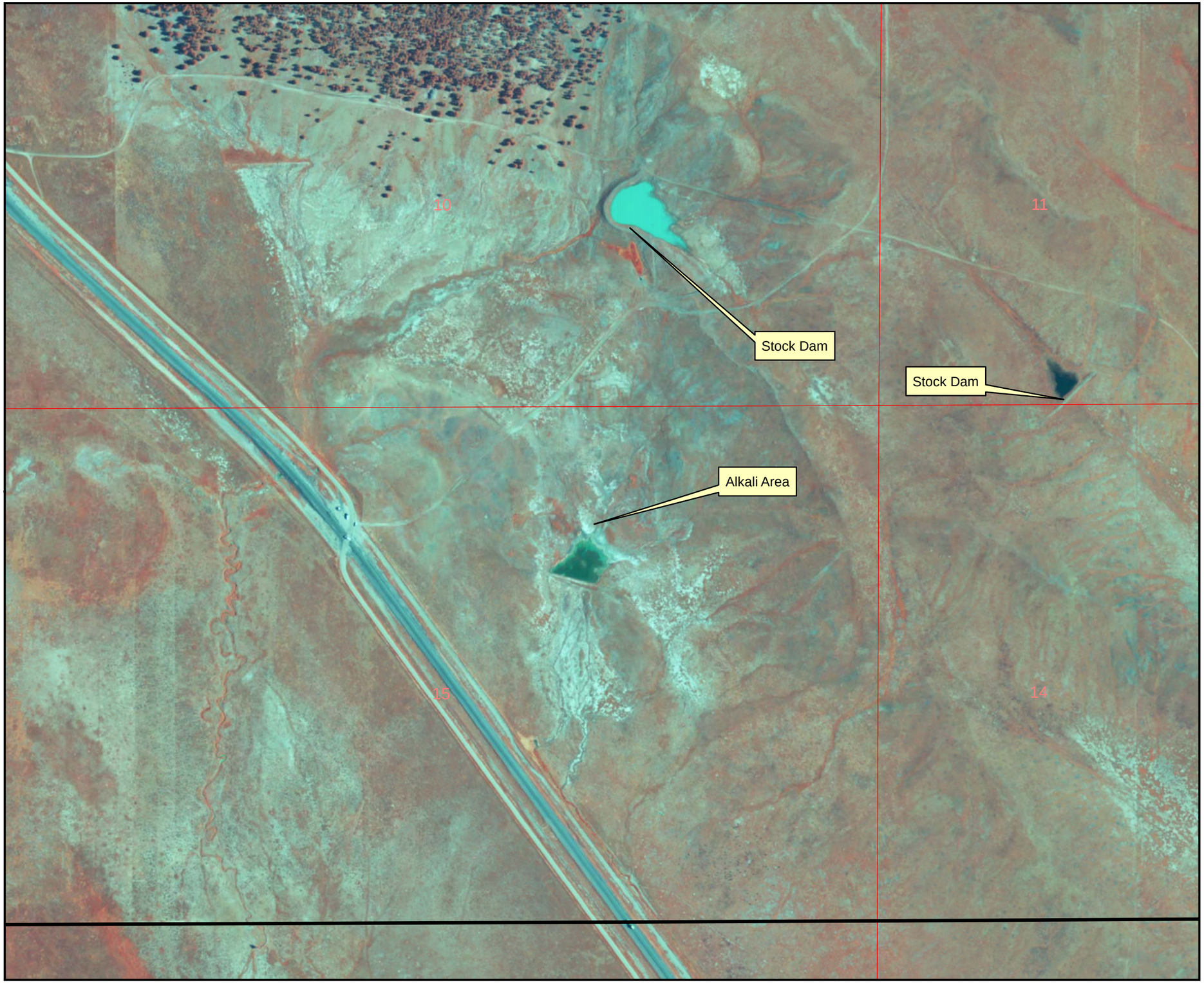
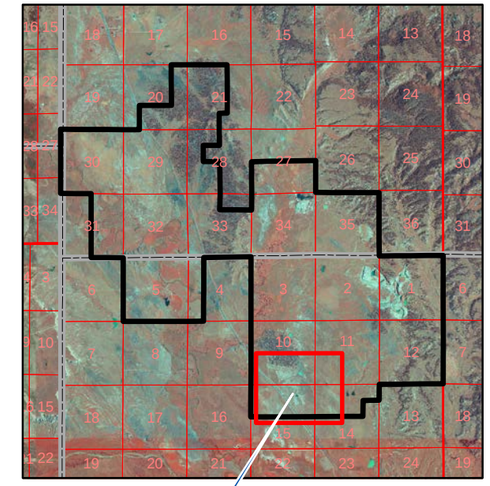


Legend

Project Boundary

Key Map



This figure is provided to fulfill the requirements of ARSD 74:29:02:11(1).

Feet
0 250 500 1,000
0 100 200 300
Meters

N

Figure 3.4-11

Color Infrared Imagery (2010 Data)
Alkali Area near Burdock

Dewey-Burdock Project

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FILENAME	2012_DB_Fig_3.4-11.mxd

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Legend

Project Boundary

Key Map

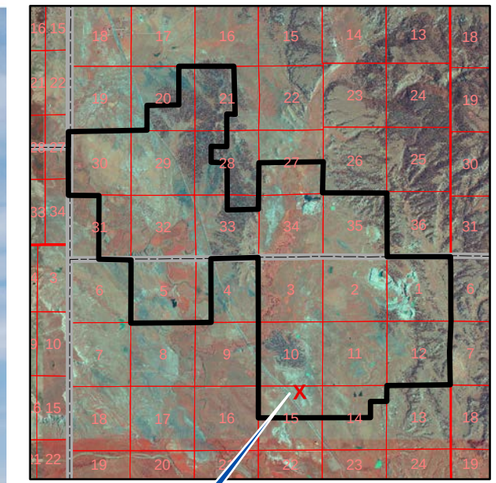

Photo taken at this location
Looking South

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(1).

Scale: None

Figure 3.4-12

Photograph of Alkali Area, Looking South, near Burdock

Dewey-Burdock Project

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PREPARER	Hal Demuth
DATE	14-Sep-2012
FILENAME	2012_DB_Fig_3.4-12.mxd

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The CIR imagery clearly shows two springs outside the permit area near the town of Dewey along the Dewey Fault (Figure 3.4-13). These locations were later verified by Powertech (USA) personnel and the springs were sampled for water quality analysis. Results of those samples indicate the spring water most closely resembles Fall River water quality; those data clearly distinguish the spring water from the alluvium and Unkpapa. The results of this investigation strongly support the use of CIR data to identify areas of groundwater discharge, and with the exception of the "alkali area," support the lack of such discharge from exploration boreholes within the permit area. Powertech (USA) will continue to use CIR imagery to assess the potential for groundwater discharge to the surface or alluvium within the permit area. The obvious evidence of groundwater discharge in the "alkali area" suggests that if similar situations existed at other locations in the permit area they would be readily detectable.

Well Field Delineation Drilling and Pump Testing

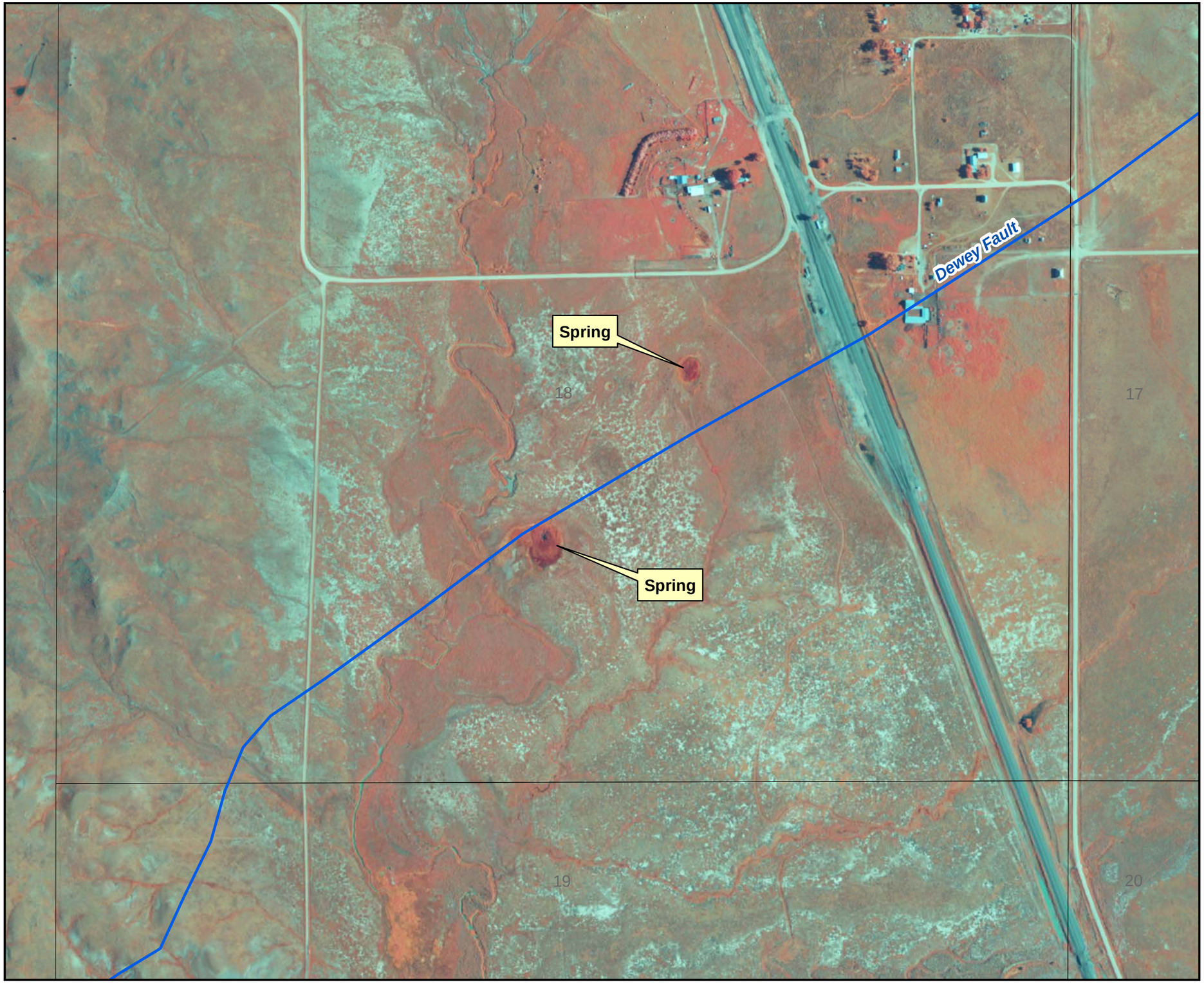
Further evaluation during the planned delineation drilling and well field-scale pump testing prior to the development of each well field will demonstrate adequate confinement to prevent potential upward groundwater movement through unplugged or improperly plugged boreholes or natural geologic features (refer to Section 5.3.3.3).

Historical Mining Areas

As discussed in Section 3.2.4.2, historical mining operations (surface [open pit] and underground) were conducted in the in the vicinity of the Dewey-Burdock Project. All those operations were conducted in the Fall River Formation. In all cases, the mining operations were above the Fuson Shale and in areas that will not be utilized by Powertech (USA) for ISR operations in the Fall River. The approach to well field development with respect to historical mining operations is described in Section 5.3.3.7.

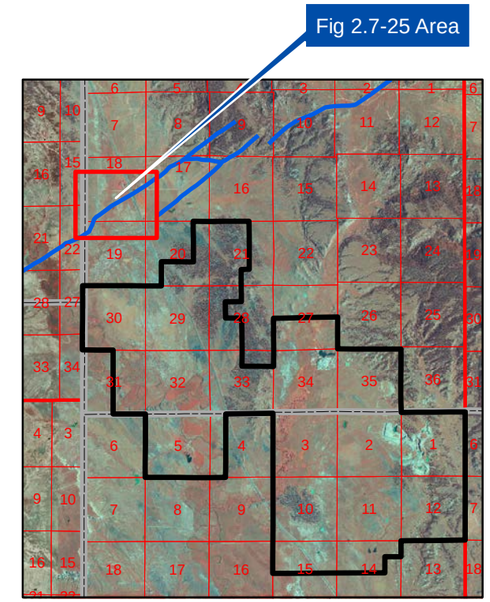
The bottoms of the Darrow pits, with the exception of Pit #2, are above the Fall River potentiometric surface. These Darrow pits are usually dry but occasionally contain water that collects from runoff events. Darrow Pit #2, however, usually contains water suggesting that the base of the pit may be below the potentiometric surface of the Fall River. The pH of the water in Darrow Pit #2 is low (i.e., acidic) suggesting that surface drainage may be influencing the water chemistry in the pit. This implies that at least a portion of the water in Darrow Pit #2 is derived from surface runoff.

The bottom of the Triangle Pit is below the potentiometric surface of the Fall River. The Triangle Pit is therefore hydraulically connected to the Fall River Formation.



Legend

- Dewey Fault
- Project Boundary



Key Map

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(1).

Feet
0 250 500 1,000
0 100 200 300
Meters
N

Figure 3.4-13

Color Infrared Imagery (2010 Data)
Springs near the Town of Dewey

Dewey-Burdock Project

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PREPARER	Hal Demuth
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FILENAME	2012_DB_Fig_3.4-13.mxd

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3.4.2.2.4 Partially Saturated Conditions

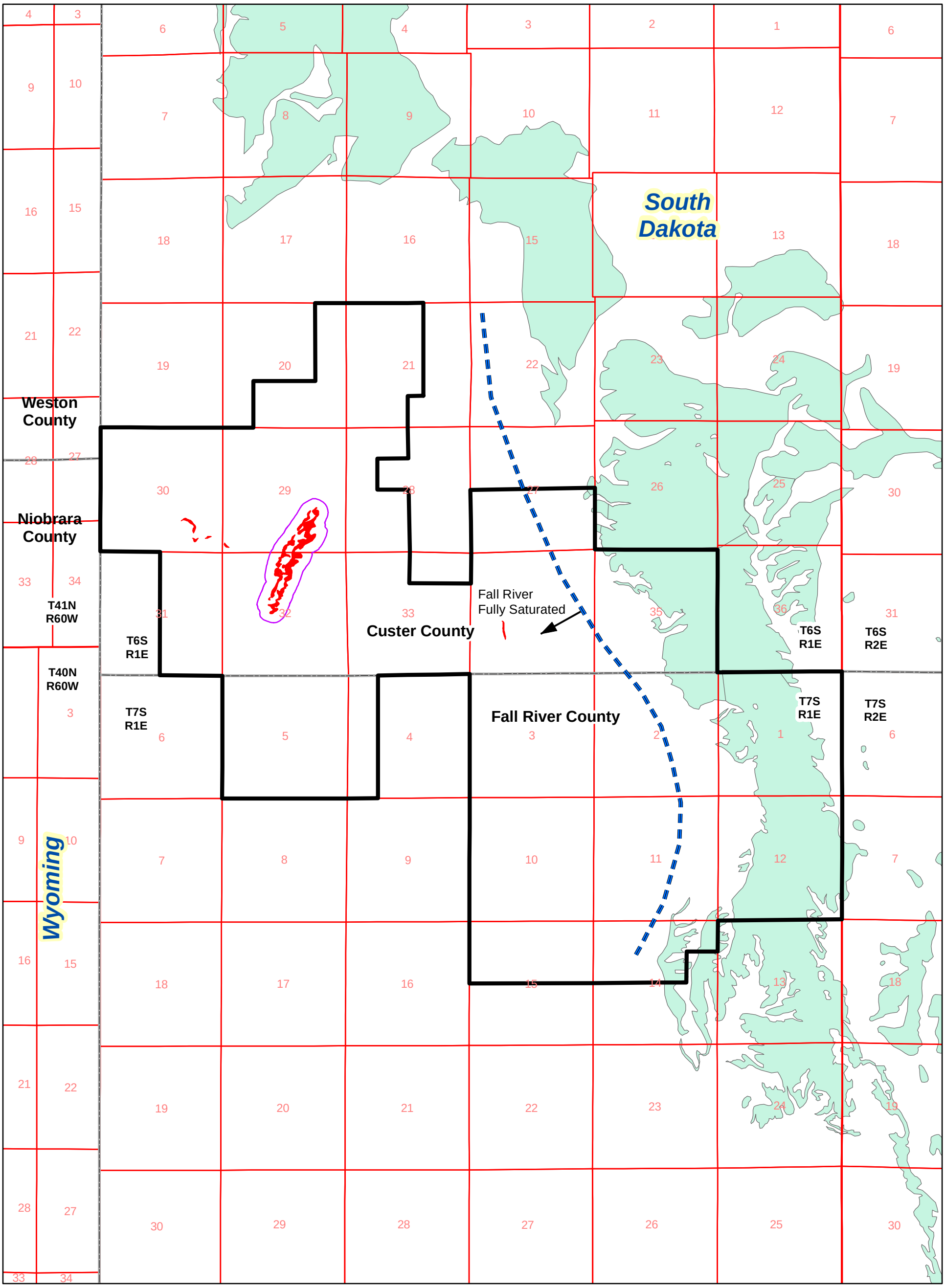
The uppermost portion of the Fall River Formation crops out in the eastern portion of the permit area in the vicinity of the Darrow pits, and the full section crops out further east in Bennett Canyon. In these areas, the Fall River is geologically unconfined. As the Fall River rises to the east, it becomes partially saturated as the top of the formation rises above the groundwater table, as shown on Plate 3.2-13 (Cross Section A-A'). The approximate boundaries between fully saturated and partially saturated conditions in the Fall River and underlying Chilson are shown in Figures 3.4-14 and 3.4-15, respectively. As the Fall River dips basinward to the southwest, the potentiometric surface is above the top of the formation, as shown on Plate 3.2-13. Beneath the Beaver Creek and Pass Creek drainages, the potentiometric surface for the Fall River is above the ground surface.

Similarly, the Chilson Member rises in elevation to the northeast and subcrops beneath the alluvium in Bennett Canyon. The potentiometric surface elevation for the Chilson is projected to be below the top of the formation on the eastern edge of the permit area. Only in this limited area, the Chilson, although geologically confined by the overlying Fuson Shale, is partially saturated (i.e., the water table is below the top of the formation).

Refer to Section 5.3.3.6 for a description of well field development with respect to partially saturated conditions. After NRC license/LSM permit issuance but prior to well field development, delineation drilling and well field pumping tests will be conducted to fully characterize the existing geologic and hydrogeologic conditions and to confirm sufficient head is available to perform normal ISR operations.

3.4.2.2.5 Hydraulic Isolation of Aquifers

Regionally, the Inyan Kara Group is geologically confined. In the permit area, the Graneros Group shale serves as the overlying confining unit above the Fall River in the western portion of the permit area. There are no major aquifers above the Inyan Kara. Below the Inyan Kara, the Morrison Formation serves as a confining unit. In the permit area, results from recent pump tests show that the Morrison effectively confines the underlying Unkpapa aquifer since no measureable drawdown in the Unkpapa was observed while pumping in the Inyan Kara. For a more detailed discussion on the regional and site hydrostratigraphic units see Sections 3.4.1.1 and 3.4.2.1.



This figure is provided to fulfill the requirements of ARSD 74:29:02:11(1).

Legend

- Project Boundary
- Potential Dewey Well Field #1
- Ore Bodies in Fall River
- Fall River Outcrop
- Approximate Edge of Fully Saturated Fall River

Feet: 0, 2,000, 4,000, 8,000

Meters: 0, 1,000, 2,000

N

Figure 3.4-14

Location of Fully Saturated Portion of Fall River Formation

Dewey-Burdock Project

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FILENAME	2012_DB_Fig_3.4-14.ai

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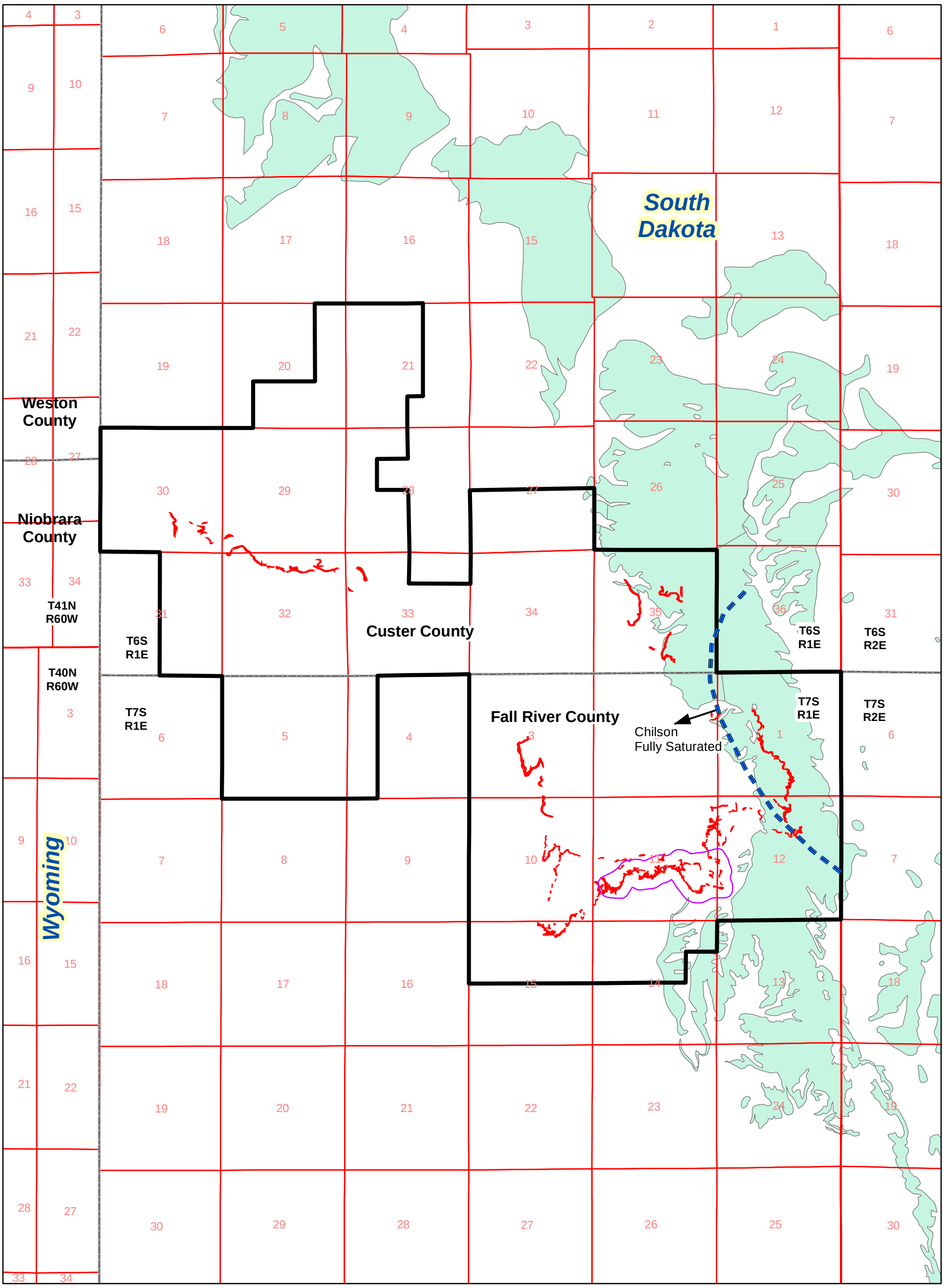

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(1).

Feet
0 2,000 4,000 8,000
0 1,000 2,000
Meters

N

Legend

- Project Boundary
- Potential Burdock Well Field #1
- Ore Bodies in the Chilson Member
- Fall River Outcrop
- Approximate Edge of Fully Saturated Chilson

Figure 3.4-15

Location of Fully Saturated Portion of Chilson

Dewey-Burdock Project

SIGNATURE OF PREPARER	
PREPARER	Hal Demuth
DATE	14-Sep-2012
FILENAME	2012_DB_Fig_3.4-15.ai

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As described in the previous section, the only area where the Fall River Formation is geologically unconfined is in the eastern part of the permit area in the general vicinity of the Darrow pits. Powertech (USA) does not propose to conduct ISR operations in the Fall River in this area (refer to Section 5.3.3.7). The Chilson throughout the permit area is physically and hydraulically isolated from the overlying Fall River Formation by the Fuson Shale.

Based on Powertech (USA)'s borehole and geophysical logs for thousands of exploration holes, the Fuson Shale is continuous and no less than 20 feet thick throughout the entire permit area. An isopach map showing the thickness and continuity of the Fuson Shale throughout the permit area is presented as Plate 3.2-8. The pervasive occurrence and continuity of the Fuson Shale throughout the permit area are shown on the geologic cross sections (Plates 3.2-13 through 3.2-22).

3.4.2.3 Summary of Previous Pumping Tests

This section describes the pumping tests previously conducted by TVA and Powertech (USA). Section 5.3.3.3 describes the pre-operational pump testing that will be conducted for each well field.

3.4.2.3.1 Summary of TVA Pumping Tests

TVA conducted groundwater pumping tests from 1977 through 1982 as part of its uranium mine development project near the towns of Edgemont and Dewey. The results of these tests are summarized in two reports provided in Appendix 3.4-E: "Analysis of Aquifer Test Conducted at the Proposed Burdock Uranium Mine Site" (Boggs and Jenkins, 1980) and "Hydrogeologic Investigations at Proposed Uranium Mine near Dewey, South Dakota" (Boggs, 1983).

Two pumping tests conducted by TVA at the Burdock site in 1977 were unsuccessful. The results of these tests were considered inconclusive because of questionable discharge measurements, improperly constructed observation wells, and malfunctioning pressure gauges. No data from the 1977 tests are available.

TVA conducted two successful pumping tests in 1979 near the Burdock portion of the permit area and one in 1982 about 2 miles north of the Dewey portion of the permit area. The results of these tests are described below.

Burdock Area

The Burdock tests were conducted in 1979 near S. Dewey Road at the location shown on Figure 3.4-16. The Burdock tests consisted of separate pumping tests from the Lakota (Chilson) and Fall River in April and July of 1979. The tests used the same pumping well with packers to alternately isolate screens open to the respective formations. Test durations were 73 hours for the Lakota (Chilson) test and 49 hours for the Fall River test. Pumping rates were about 200 gpm from the Lakota (Chilson) aquifer and 8.5 gpm from the Fall River. The reason for the unexpectedly low pumping rate from the Fall River aquifer was not specified in the TVA report.

Based on review of the testing results by Powertech (USA), significant conclusions from the TVA testing indicate:

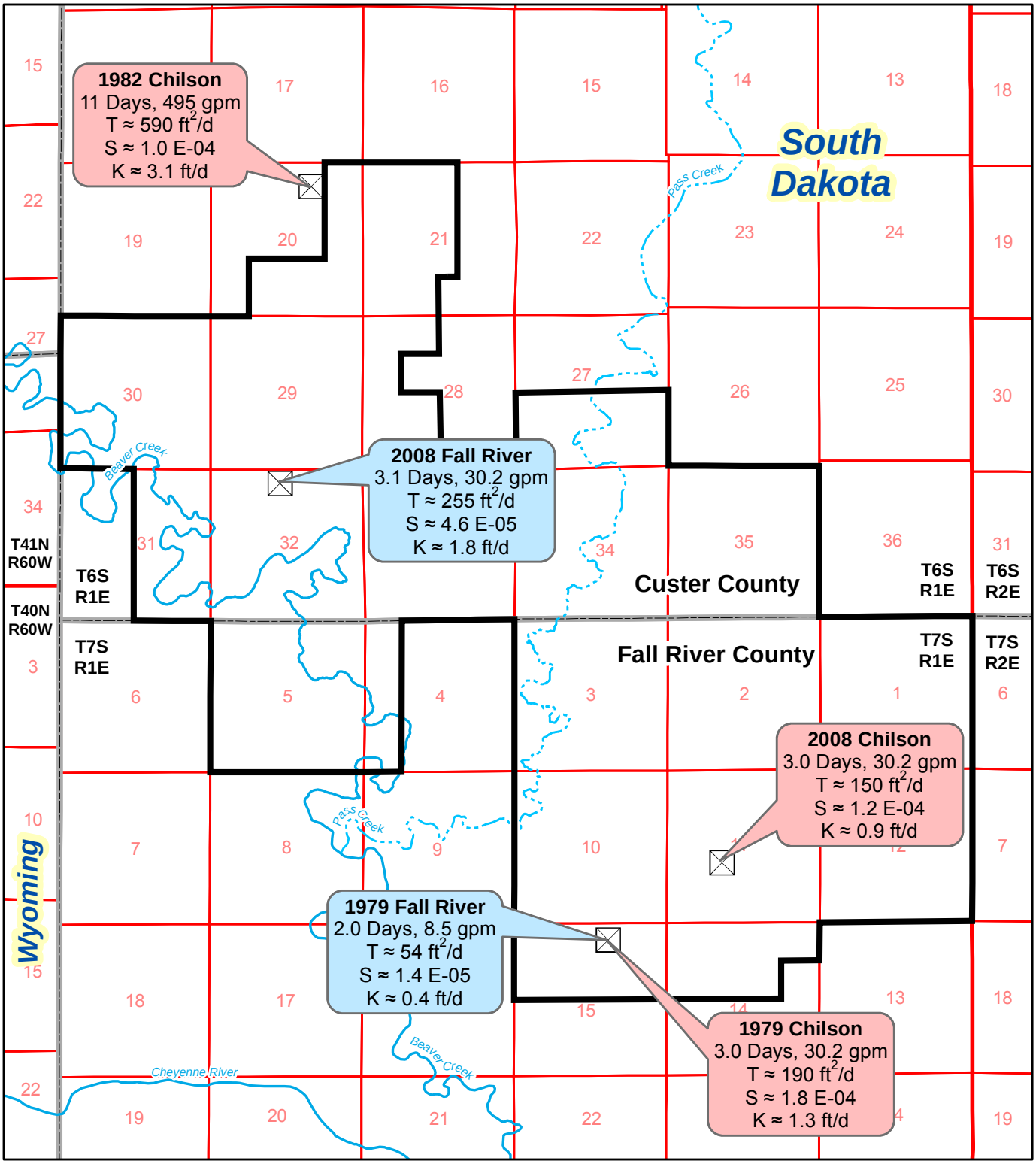
- Transmissivity of the Chilson based on the analysis of late time data averaged about 1,400 gpd/ft (190 ft^2/day) and storativity was determined to be approximately 1.8 x 10^{-4} (dimensionless).
- Transmissivity of the Fall River averaged about 400 gpd/ft (54 ft^2/day) and storativity approximately 1.4 x 10^{-5} (dimensionless).
- The vertical hydraulic conductivity of the Fuson aquitard calculated using the Neuman-Witherspoon ratio method (Neuman and Witherspoon, 1972) ranged from 1 x 10^{-3} to 1 x 10^{-4} ft/day; storativity was not determined, and specific storage was assumed to be about 10^{-6} ft^{-1}.
- The reported "leaky aquifer" response likely is related to (1) Well 668 that is completed in both the Chilson and Fall River and can provide a direct communication pathway, and/or (2) the presence of open boreholes that may provide communication between the Fall River and Lakota (Chilson) in a limited area near the Burdock test, or communication between the Fall River and land surface. The test results do not support a leaky confining zone (Fuson Shale).

Dewey Area

The Dewey test was conducted in 1982 northeast of S. Dewey Road at the location shown on Figure 3.4-16. The test consisted of pumping in the Lakota Formation (Chilson) at an average rate of 495 gpm for 11 days. The significant results are as follows:

- Transmissivity of the Chilson averaged about 4,400 gpd/ft (590 ft^2/day).
- Storativity of the Chilson was about 1.0 x 10^{-4} (dimensionless).

  The vertical hydraulic conductivity of the Fuson aquitard using the Neuman-Witherspoon ratio method (Neuman and Witherspoon, 1972) was 2 x 10^{-4} ft/day; storativity of the Fuson Shale was not determined and specific storage was about 7 x 10^{-7} ft^{-1}.



This figure is provided to fulfill the requirements of ARSD 74:29:02:11(1).

Feet
0 2,500 5,000
0 1,000 2,000
Meters

N

Legend

- Permit Boundary
- Ephemeral Streams
- Perennial Streams

Figure 3.4-16
Location of Historical TVA and Recent Powertech Pumping Tests

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	24-Sep-2012
FILE	PumpTests.mxd

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- A barrier boundary or decrease in transmissivity due to lithologic changes with distance from the test site, or both, were observed; a possible geologic feature corresponding to a barrier was noted to be the Dewey Fault Zone, located about 1.5 miles north of the test site, where the Chilson and Fall River Formations are structurally offset.

3.4.2.3.2 2008 Pumping Tests

In 2008 pumping tests were performed in the Dewey and Burdock portions of the permit area (Figure 3.4-16), along with laboratory tests on related core samples, to assess aquifer properties. A work plan (Knight Piésold, 2008a) was prepared and distributed to interested representatives of state and federal agencies, including DENR and EPA.

A detailed description of the aquifer testing methodology and analysis of the results are contained in the aquifer test report (Knight Piésold, 2008b; Appendix 3.4-F). The report results are briefly summarized in the following sections.

Burdock Area

Summary of Burdock Pumping Test Results

Pump testing was conducted within the lower Lakota (Chilson) at pumping well DB07-11-11C. Three observation wells were monitored in the same horizon. An observation well was also monitored in the upper Chilson. Single observation wells were monitored in the overlying Fall River and underlying Unkpapa. The well was pumped at an average rate of 30.2 gpm for 4,320 minutes (3.0 days).

Drawdown at the pumping well was approximately 91 feet, and between 3.1 feet and 17.0 feet in the lower Lakota (Chilson) observation wells. The upper Lakota (Chilson) well response was delayed, but 3.4 feet of drawdown was observed in this well. Approximately 1 foot of drawdown was observed in the overlying Fall River well and no response was observed in the underlying Unkpapa well.

A summary of aquifer parameters for the 2008 Burdock pumping test (conducted in the Chilson Member of the Lakota Formation) and related laboratory core testing follows:

- Nine determinations of transmissivity (Table 3.4-2) ranged from 120 to 223 ft^2/day with the median value of 150 ft^2/day.
- Based on 170 feet of saturated thickness in the aquifer, hydraulic conductivities range from 0.7 ft/day to 1.3 ft/day, with a median value of 0.9 ft/day.

Table 3.4-2: Summary of Aquifer Hydraulic Characteristics for the Burdock Pumping Test

Well I.D.	Well Type	Radial Dist. (ft)	Interpretation Method	Transmissivity (ft^2/day)	u or u' (unitless)	Storativity (unitless)	Note
Ore zone (lower Chilson Sandstone)							
11-11C	Pumping	0.25 (0.33)	Theis DD(1)	145	-	2.9E-09(a)	-
			CJ DD (3)	150	<0.01	-	-
Pumping Well Efficiency = 65%(3)							
			CJ Recovery (3)	140	<0.01	-	-
15-Nov	Obs #1	243	Theis DD(1)	67	-	1.30E-03	-
			CJ Recovery (3)	100	<0.1	-	-
11-14C	Obs #2	250	Theis DD(1)	128	-	6.80E-05	-
			H-J DD(1)	120	-	6.90E-05	
			Theis Recovery(1)	174	<0.01	-	-
			CJ Recovery (3)	160	<0.01	-	-
2-Nov	Obs #3	1,292	Theis DD(1)	223	-	1.90E-04	-
			H-J DD(1)	185	-	1.70E-04	-
			CJ Recovery (3)	260	<0.15	-	-
Upper Chilson Sandstone							
19-Nov	Obs	50	Theis DD(2)	260	-	1.00E-01	-
			CJ Recovery (3)	190	<0.15	-	-
Fall River (lower sandstone layer)							
17-Nov	Obs	50	Noordbergum Effect and response cannot be interpreted analytically				
Unkpapa Sandstone							
18-Nov	Obs	35	No response during pumping test.				-
Distance Drawdown (11-14C, 11-15, 11-02)(2)				145	<0.08	2.20E-04	r^2 = 0.76 (3 point line)
Pumping Well Efficiency = 61% to 63%							
Summary:	Median			150		1.20E-04	
Average/Geometric Mean(5)				158		1.12E-04	
	TVA(4)			190		1.80E-04	

(1) Calculated by automated curve fitting in AquiferWin32™ software (ESI, 2003).
(2) Knight Piésold spreadsheet after methods in Driscoll (1986).
(3) Spreadsheet methods in U.S. Geol. Surv. Open File Rept. 02-197, Halford and Kuniansky (2002).
(4) Summary values from p. 17 in Boggs and Jenkins (1980).
(5) Average value calculated for Transmissivity, Geometric Mean value calculated for Storativity.
(a) Storativity not valid at pumping well.
(b) Based on 6 inch casing (8 inch borehole).

'158' = Accepted value based on conformance with theory discussed in the text.

- Four storativity determinations (Table 3.4-2) ranged from 6.8 x 10^{-5} to 1.9 x 10^{-4} with the median value of 1.2 x 10^{-4}.
- The radius of influence of the pumping test determined by a distance-drawdown plot was 2,100 feet.
- Laboratory measurements of horizontal and vertical hydraulic conductivity (Table 3.4-3) were made on sandstone layers similar to that tested in the pump test; measured horizontal hydraulic conductivity ranged from 5.9 to 9.1 ft/day, the mean value was 7.4 ft/day and mean ratio of horizontal to vertical hydraulic conductivity in Burdock area sandstone was 2.47:1.
- Laboratory measurements of horizontal and vertical hydraulic conductivity (Table 3.4-3) were made on shale layers from two major confining units for the Lakota (Chilson) in the pump test area with the following results:
    - Fuson Shale: the laboratory core data indicated vertical permeabilities of about 2 x 10^{-7} to 1 x 10^{-8} cm/sec (average 2.7 x 10^{-4} ft/day) for shale samples from within the Fuson Shale.
    - Morrison Shale: the laboratory core data for the shales in the underlying Morrison Formation indicated vertical permeabilities of 9 x 10^{-9} to 3 x 10^{-8} cm/sec (average 6.0 x 10^{-5} ft/day).

Burdock Pumping Test Conclusions

The Burdock pumping test in 2008 may be directly compared to the 1979 TVA test for the Lakota (Chilson) aquifer as the tests were nearly at the same location (Figure 3.4-16). The average transmissivity and storativity values determined from the TVA tests were 190 ft^2/day and 1.8 x 10^{-4} (see p. 17 in Boggs and Jenkins, 1980). Comparing the median transmissivity of 150 ft^2/day and storativity of 1.2 x 10^{-4} determined in the 2008 test to the TVA test, the new aquifer parameters for the lower Chilson are respectively about 80 and 70 percent of the 1979 results. Because transmissivity and storativity depend on aquifer thickness, comparison of the results suggests that there may be some scaling effect between the tests due to the different lengths of screened intervals.

The 1979 TVA test transmissivity of 190 ft^2/day is considered representative of the entire Chilson aquifer for a regional application (Table 3.4-2).

Previous conclusions and interpretations from this pump test submitted to NRC and EPA indicated that the Chilson behaved as a leaky aquifer system (e.g., a drawdown response was observed in the overlying Fall River observation well and the Chilson wells consistent with a leaky system based on a match of the data to the Hantush-Jacob solution). Further review of the

Table 3.4-3: Laboratory Core Analyses at Project Site

Sample Number	Depth (ft)	Confining Stress (psig)	Porosity (%)	Air Intrinsic Permeability(1) ka (mD)	Particle Density (g/cm^3)	Notes	Water Hydraulic Conductivity Kw(2)(3) (cm/s)	Core Kh (ft/day)	Core Kv (ft/day)
DB 07-11-11C Burdock									
1H	252.20	600	10.50	1.040	2.356	Fuson Shale	8.0073E-07		
1V	252.35	600	10.15	0.228	2.356	Fuson Shale	1.7555E-07		
4H	412.30	600	9.68	0.041	2.511	Fuson Shale	3.1567E-08		
4V	412.45	600	9.59	0.015	2.514	Fuson Shale	1.1549E-08		
DB 07-29-1C Dewey									
2H	480.70	600	8.90	0.078	2.613	Skull Creek shale	6.0055E-08		
2V	480.80	600	9.30	0.007	2.610	Skull Creek shale	5.3896E-09		
3H	609.10	600	12.26	0.073	2.603	Fuson Shale	5.6205E-08		
3V	609.10	600	10.84	0.008	2.793	Fuson Shale	6.1595E-09		
DB 07-11-14C Burdock									
5H	423.60	600	29.56	3,207	2.645	Lakota Sand	2.4692E-03	7.0	
5V	423.35	600	30.34	1,464	2.645	Lakota Sand	1.1272E-03		3.2
6H	430.20	600	31.90	4,161	2.640	Lakota Sand	3.2037E-03	9.1	
6V	430.35	600	30.16	939	2.646	Lakota Sand	7.2297E-04		2.1
7H	453.50	600	10.86	1.000	2.519	Morrison Shale	7.6994E-07		
7V	453.45	600	11.82	0.043	2.543	Morrison Shale	3.3107E-08		
DB-07-11-16C Burdock									
8H	420.40	600	30.50	2,697	2.643	Lakota Sand	2.0765E-03	5.9	
8V	420.10	600	30.17	1,750	2.651	Lakota Sand	1.3474E-03		3.8
9H	455.90	600	6.99	0.004	2.536	Morrison Shale	3.0797E-09		
9V	455.45	600	7.65	0.012	2.556	Morrison Shale	9.2392E-09		
10H	503.30	600	12.96	0.697	2.474	Morrison Shale	5.3665E-07		
10V	503.45	600	No data						
DB 07-32-4C Dewey									
11H	573.25	600	29.15	2,802	2.641	Fall River Sand	2.1574E-03	6.1	
11V	573.40	600	29.04	619	2.645	Fall River Sand	4.7659E-04		1.4
Summary									
Average Lakota Sand Kh, Kv								7.4	3.0

(1) Assumed air temperature = 70°F.
(2) Assumed water temperature = 52.8°F, water density = 0.999548 g/cm^3, and water dynamic viscosity = 0.012570 g/cm-s.
(3) $K_w = k_a \times (\rho_w g/\mu_w)$, and 1.0 mD = 0.987×10^{-11} cm^2

site geology and hydrology suggest that those interpretations were not representative of site conditions.

The laboratory core data from samples collected within the permit area indicate an average vertical permeability of 9.3 x 10^{-8} cm/s (2.7 x 10^{-4} ft/day) for shale samples from the Fuson Shale (Table 3.4-3). The shale core permeability values are about one to two orders of magnitude smaller than the pumping test values determined in the 1979 TVA test at Burdock, where the vertical hydraulic conductivity of the Fuson aquitard was calculated using the Neuman-Witherspoon ratio method to be about 1 x 10^{-3} ft/day (see pg. i in Boggs and Jenkins, 1980).

For the Lakota (Chilson) sandstone, the laboratory core data from samples collected within the permit area indicate an average horizontal hydraulic conductivity of 2.5 x 10^{-3} cm/sec (7 ft/day) and range as high as 3.2 x 10^{-3} cm/sec (9.1 ft/day, Table 3.4-3). Pump test results indicate an average horizontal hydraulic conductivity of approximately 0.9 ft/day (3.2 x 10^{-4} cm/s).

Site-wide geologic data (logs, cross-sections and isopach maps) clearly demonstrate the continuity of the Fuson Shale across the permit area. Those data, combined with data from the pump tests and core results, indicate that the leaky behavior observed in the 2008 Chilson test likely is the result of (1) communication between the Chilson and Fall River via Well 668 that is completed in both sands, and/or (2) the presence of open boreholes that may provide communication between the Fall River and Lakota (Chilson) in a limited area near the Burdock test.

Dewey Area

Summary of Dewey Pumping Test Results

Pump testing was conducted in the lower sandstone interval of the Fall River at pumping well DB07-32-3C. This well was pumped at a rate of 30.2 gpm for 3.1 days (4,440 minutes). Three observation wells between 240 and 2,400 feet from the pumping well were monitored in the same horizon. An upper Fall River observation well was also monitored. Single observation wells were monitored in the underlying Lakota (Chilson) and Unkpapa aquifers.

Drawdown at the pumping well was 44.8 feet, and drawdown in the lower Fall River observation wells varied with distance from the pumping well to between 1.5 and 13 feet. Drawdown in the upper Fall River approximately 40 feet from the pumping well was approximately 4 feet. No drawdown response was observed in the underlying Lakota (Chilson) or Unkpapa aquifers.

A summary of aquifer parameters for the 2008 Dewey pumping test (conducted in the Fall River Formation) and related laboratory core testing is as follows:

- Ten determinations of transmissivity (Table 3.4-4) ranged from 180 to 330 ft^2/day with a median value of 255 ft^2/day.
- Based on 140 feet of saturated thickness in the Fall River, hydraulic conductivities range from 1.3 ft/day to 2.4 ft/day, with a median value of approximately 1.8 ft/day.
- Five storativity determinations (Table 3.4-4) ranged from 2.3×10^{-5} to 2.0×10^{-4} with a median value of 4.6×10^{-5}.
- The radius of influence of the pumping test determined by a distance-drawdown plot was 5,700 feet.
- Laboratory measurements of horizontal and vertical hydraulic conductivity (Table 3.4-3) were made on shale samples from the two major confining units overlying and underlying the pump test area with the following results:
    - Skull Creek Shale: laboratory core data for the shale sample from the overlying Skull Creek Shale (Graneros Group) indicate a vertical permeability of 5.4×10^{-9} cm/sec (1.5×10^{-5} ft/day).
    - Fuson Shale: laboratory core data for the shale sample from the underlying Fuson Shale indicate a vertical permeability of 6.2×10^{-9} cm/sec (1.8×10^{-5} ft/day).

Dewey Pumping Test Conclusions

The Dewey pumping test in 2008 in the Fall River aquifer is not directly comparable to the 1982 TVA test because the underlying Lakota (Chilson) aquifer was tested in 1982.

The 2008 test indicated that the lower and upper sandstone portions of the Fall River Formation behave as a single, confined, aquifer with some form of lateral barrier due to changing lithology, such as a channel boundary. The TVA test in 1982 observed a barrier boundary in the underlying Lakota Formation, likely the result of the Dewey Fault Zone. Apparently, both the Chilson and Fall River Formation in the general Dewey area are highly transmissive and show barrier boundaries. These test results are more definitive than the 1982 TVA test concerning the proximity of the barrier boundary, because the 2008 radius of influence was about 1 mile, or about ⅓ to ½ the distance to the fault zone.

Confinement provided by the Fuson Shale between the Fall River and underlying Chilson Member of the Chilson was demonstrated by the 2008 testing. The Chilson and Fall River aquifers at the Dewey test site are hydraulically isolated by the intervening Fuson Shale with nearly 40 feet of head difference between the two units. The laboratory core data indicate a very

Table 3.4-4: Summary of Aquifer Hydraulic Characteristics for the Dewey Pumping Test

Well I.D.	Well Type	Radial Dist. (ft)	Interpretation Method	Transmissivity (ft^2/day)	u or u' (unitless)	Storativity (unitless)	Note
Ore zone (lower Fall River Sandstone)							
32-3C	Pumping	0.25 (0.33)	Theis DD[1]	250	-	1.2E-06[b]	-
			CJ DD[3]	250	<0.01	-	-
Pumping Well Efficiency = 80%(3)							
			CJ Recovery[3]	270	<0.01	-	-
32-5	Obs #1	243	Theis DD[1]	294	-	3.30E-05	--
			Theis Recovery[1]	260	<0.01	-	-
			CJ Recovery[3]	280	<0.01	-	-
32-4C	Obs #2	467	Theis DD[1]	333	-	5.60E-05	-
			CJ Recovery[3]	120[a]	<0.01	-	
29-7	Obs #3	2,400	Theis DD[2]	178	-	2.00E-04	
			CJ Recovery[3]	Insufficient recovery for analysis			-
Fall River Aquifer Stock Well (Screened in top half of Fall River)							
GW-49	Stock	1,400	Theis DD[1]	177	-	2.30E-05	-
			CJ Recovery[3]	110	<0.05	-	-
Upper Fall River Sandstone							
32-9C	Obs	41	Theis DD[1]	217	-	1.60E-02	-
			CJ Recovery[3]	150	<0.05	-	--
Chilson Sandstone Layer							
32-10	Obs	61	No response during pumping test.				--
Unkpapa Sandstone							
32-11	Obs	50	No response during pumping test.				-
Distance Drawdown (32-5, 32-4C, 29-7, GW-49)[2]				218	<0.05	4.60E-05	r^2 = 0.78 (4 point line)
Pumping Well Efficiency = 93% to 95%							
Summary:	Median			255		4.60E-05	
Average/Geometric Mean[4]				251		5.23E-05	

Notes/References: DD = drawdown, CJ = Cooper -Jacob, Obs = Observation Well
(1) Calculated by automated curve fitting in AquiferWin32™ software (ESI, 2003).
(2) Knight Piésold spreadsheet after methods in Driscoll (1986).
(3) Spreadsheet methods in U.S. Geol. Surv. Open File Rept. 02-197, Halford and Kuniansky (2002).
(4) Average value calculated for Transmissivity, Geometric Mean value calculated for Storativity.
(a) Only slope satisfying u 'criterion occurs after intersection with barrier boundary.
(b) Not accepted due to anomalous response at well, see text.

low vertical permeability of 6.2 x 10^{-9} cm/sec (1.8 x 10^{-5} ft/day) for a shale sample from the Fuson Shale within the permit area (Table 3.4-3).

The laboratory core data for the shale sample from the Skull Creek Shale, which overlies the Fall River Formation, indicate a very low vertical permeability of 5.4 x 10^{-9} cm/sec (1.5 x 10^{-5} ft/day), which is representative of an effective aquitard or aquiclude (Table 3.4-3).

For the sandstone of the Fall River Formation, the laboratory core data indicate a horizontal hydraulic conductivity of 6.1 ft/day (2.2 x 10^{-3} cm/s, Table 3.4-3). Based on pump test results, the average horizontal conductivity is approximately 1.8 ft/day (6.4 x 10^{-4} cm/s). Within the lower Fall River Formation, the test results indicate transmissive, rapid response (2 to 3 minutes) between pumping and observation wells up to 467 feet apart with nearly 10 feet of drawdown. Response was nearly 9 feet of drawdown at a 1,400-foot distance. This indicates that the aquifer was stressed to produce good quality analytical results.

3.4.2.4 Groundwater Use

The four principal aquifers used as major sources of water supply in the Black Hills include the Deadwood, Madison, Minnelusa, and Inyan Kara. Each of these aquifers is used to varying degrees, depending on location, depth of occurrence and location related to population.

The estimated groundwater use in Custer and Fall River counties is summarized in Table 3.4-5. Within the permit area, the Inyan Kara Group, which includes the Fall River Formation and Chilson Member of the Lakota Formation, is the principal source of water for livestock, domestic use and other purposes.

Historical records and field investigations conducted within the permit area and surrounding 2-km area were used to develop the well inventory. An initial investigation of the wells was completed in 2007, and additional surveys were conducted in 2011 to evaluate the use and condition of the wells. A total of 109 wells have been identified within 2 km of the permit area. There also are 27 wells with historical records that currently are not present at the surface and 17 wells with historical records that have been visually confirmed as plugged and abandoned. Appendix 3.4-B contains the well inventory summary tables, and Appendix 3.4-C contains the detailed well inventory, well completion records and associated documentation. Plate 3.4-1 depicts existing wells within 2 km of the permit area.

Table 1 in Appendix 3.4-B summarizes the well inventory. Listed wells have one of the following uses:

Table 3.4-5: Estimated Groundwater Use in Custer and Fall River Counties, South Dakota

Water Use Type	Withdrawals (MGD)	
	Custer County	***Fall River County***
Public Supply GW	0.48	1.32
Domestic GW	0.34	0.16
Irrigation GW	0.09	0.13
Livestock GW	0.12	0.25
Mining GW	0.00	0.03
Total GW	1.03	1.89

Source: Kenny et al., 2005
Notes: GW = Groundwater
MGD = Million gallons per day

Domestic: Are currently used or reasonably can be expected to be used for domestic water use (e.g., drinking, washing, sanitary use, etc.), including wells which also are used for livestock watering. This category also includes formerly used domestic wells which through agreements with Powertech (USA) no longer will be used as drinking water wells. (18 wells)

Stock: Watering of livestock is sole use; well cannot be used for domestic water use (i.e., no piping to domestic water system, etc.). (43 wells)

Irrigation: Permitted to be used for irrigation. (1 well)

Monitor: Sole use is for monitoring. (47 wells)

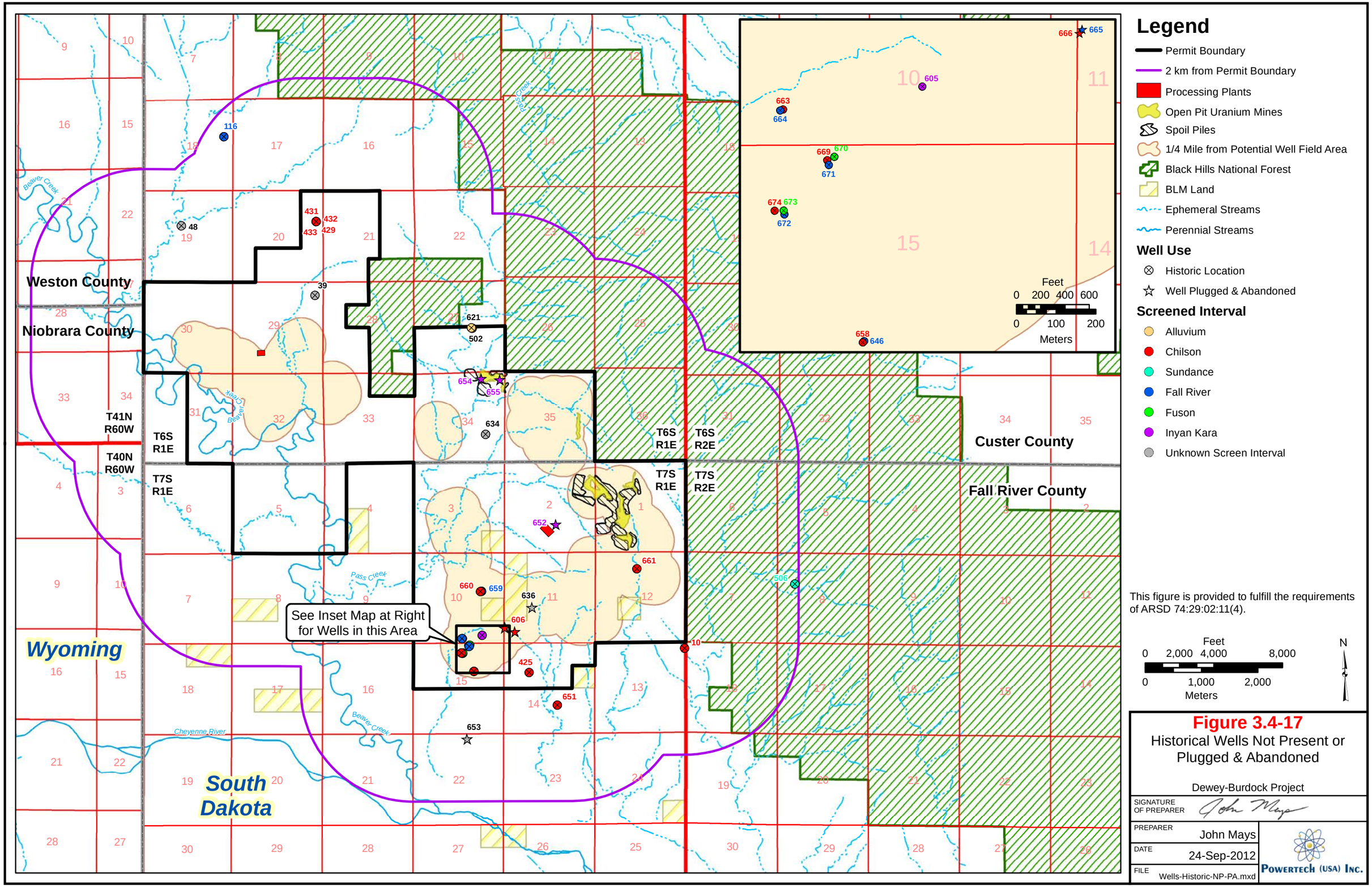
Table 2 in Appendix 3.4-B lists the wells identified in historical records that were not evident at the surface during the field investigations. These wells are depicted on Figure 3.4-17. Several of these wells are suspected of being plugged and abandoned. Powertech (USA) will continue to search for these wells. During design of well fields, pump testing will be designed to locate any such wells and to detect any potential impacts from such wells on the ISR operations.

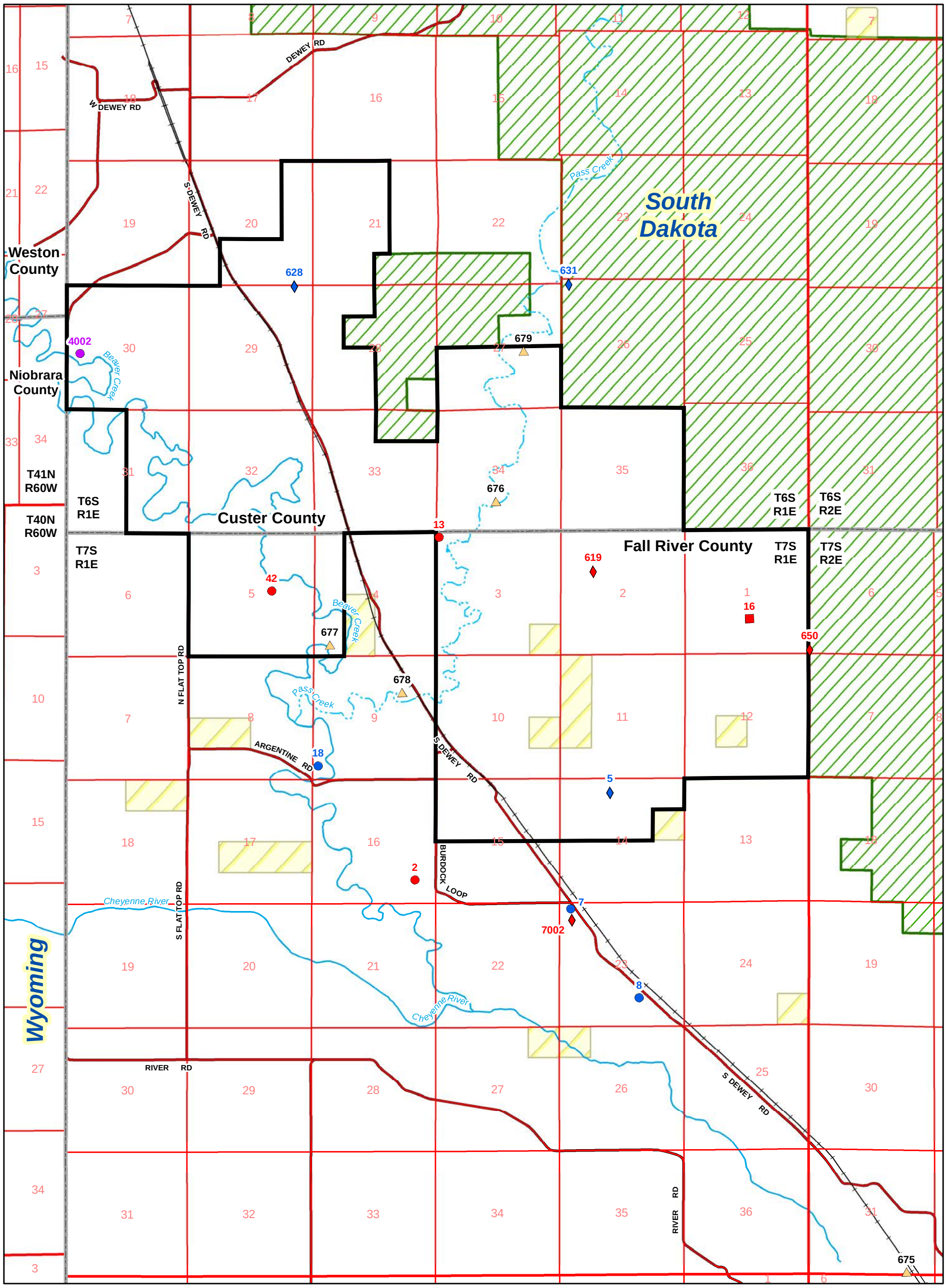
Table 3 in Appendix 3.4-B lists all of the wells within 2 km of the permit area that have been confirmed by Powertech (USA) to have been plugged and abandoned. Each well was visually inspected, and it has been determined that cement was placed within the well bore.

3.4.3 Baseline Groundwater Monitoring Program

Baseline groundwater sampling was conducted in accordance with NRC Regulatory Guide 4.14 (NRC, 1980a) as appropriate to ISR operations. The wells were selected based on type of use, aquifer, and location in relation to the ore bodies. For the NRC license baseline study, 19 wells (14 existing and 5 newly drilled) were selected in response to an NRC suggestion to characterize point of contact water quality and water within overlying, production, and underlying aquifers (Figure 3.4-18, Table 3.4-6). The wells selected for quarterly sampling included domestic wells, stock wells and monitor wells. The subset included wells within the Fall River Formation, Chilson Member of the Lakota Formation, Inyan Kara Group (Fall River and Chilson), and alluvium. Initial baseline sampling of these wells was conducted quarterly, generally from the 3rd Quarter 2007 through the 2nd Quarter 2008.

Following consultation with DENR, Powertech sampled 14 additional wells on a monthly basis (Figure 3.4-19, Table 3.4-7). Of these 14 wells, 6 wells are in the Dewey area, 6 wells are in the Burdock area and 2 wells are north of the permit area. The goal of the monthly sampling program was to select wells upgradient, within, and downgradient of the proposed ISR activities.


Legend
Permit Boundary
2 km from Permit Boundary
Processing Plants
Open Pit Uranium Mines
Spoil Piles
1/4 Mile from Potential Well Field Area
Black Hills National Forest
BLM Land
Ephemeral Streams
Perennial Streams
Well Use
Historic Location
Well Plugged & Abandoned
Screened Interval
Alluvium
Chilson
Sundance
Fall River
Fuson
Inyan Kara
Unknown Screen Interval
Weston County
Niobrara County
Custer County
Fall River County
Wyoming
South Dakota
T41N R60W
T40N R60W
T6S R1E
T6S R2E
T7S R1E
T7S R2E
Beaver Creek
Pass Creek
Cheyenne River
See Inset Map at Right for Wells in this Area
Feet
0 200 400 600
0 100 200
Meters
0 2,000 4,000 8,000
0 1,000 2,000
Meters
N
This figure is provided to fulfill the requirements of ARSD 74:29:02:11(4).
Figure 3.4-17
Historical Wells Not Present or Plugged & Abandoned
Dewey-Burdock Project
SIGNATURE OF PREPARER
PREPARER John Mays
DATE 24-Sep-2012
FILE Wells-Historic-NP-PA.mxd
POWERTECH (USA) INC.



This figure is provided to fulfill the requirements of ARSD 74:29:02:07.

Legend

- Permit Boundary
- BNSF Railroad
- County Roads
- Ephemeral Streams
- Perennial Streams
- BLM Land
- Black Hills National Forest

Screened Interval

- Alluvium
- Fall River
- Inyan Kara
- Chilson

Well Use

- Monitor
- Stock
- Domestic
- Domestic Non-Drinking Water

Feet: 0 2,000 4,000 8,000

Meters: 0 1,000 2,000

N

Figure 3.4-18
Baseline Water Quality
Quarterly Sampled Wells

Dewey-Burdock Project

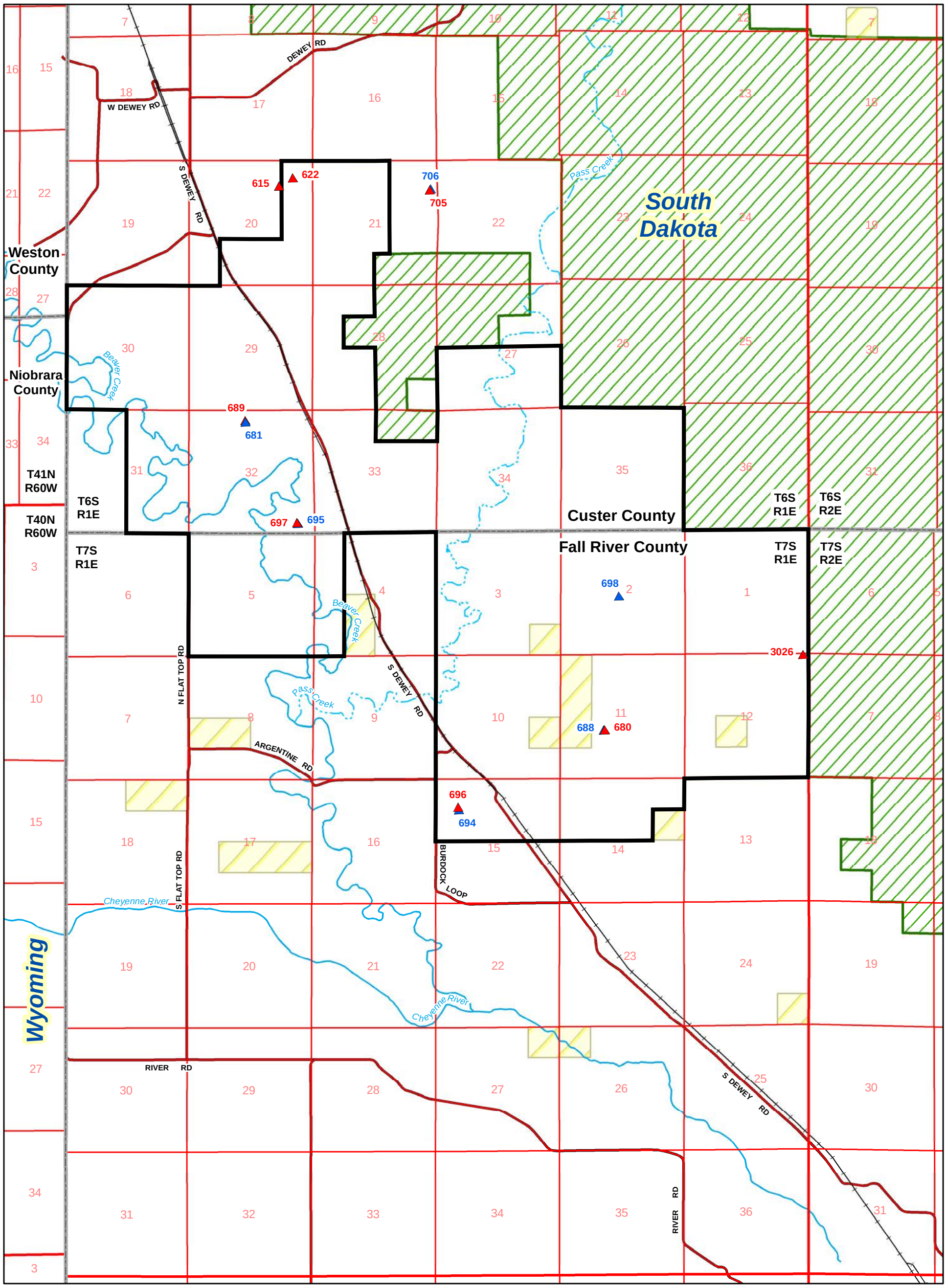
SIGNATURE OF PREPARER	
PREPARER	Richard Blubaugh
DATE	11-Sep-2012
FILE	Wells-BLQtrGndH2OQlty.mxd

POWERTECH (USA) INC.

Table 3.4-6: Quarterly Sampled Groundwater Quality Well Data

Hydro ID	Twn (N)	Rng (E)	Sec	Qtr Qtr	Easting[1]	Northing[1]	Screened Location[2]	Well Use
2	7	1	16	SESE	1026724	423922	Chilson	Domestic
5	7	1	14	NENW	1035181	427284	Fall River	Stock
7	7	1	23	NWNW	1033304	422417	Fall River	Domestic
8	7	1	23	SWSE	1036052	418515	Fall River	Domestic
13	7	1	3	NWNW	1028360	438470	Chilson	Domestic
16	7	1	1	NESW	1041428	434446	Chilson	Domestic[3]
18	7	1	9	SWSW	1022812	428960	Fall River	Domestic
42	7	1	5	SWNE	1021144	436481	Chilson	Domestic
619	7	1	2	SENW	1034866	436729	Chilson	Stock
628	6	1	20	SESE	1022496	449718	Fall River	Stock
631	6	1	26	SWSW	1034177	449309	Fall River	Stock
650	7	1	1	SESE	1043781	433331	Chilson	Stock
675	7	2	31	SWSE	1046941	406352	Alluvium	Monitor
676	6	1	34	SESW	1030846	439891	Alluvium	Monitor
677	7	1	4	SWSW	1023527	434077	Alluvium	Monitor
678	7	1	9	SWNE	1026522	431925	Alluvium	Monitor
679	6	1	27	NWSE	1032294	446245	Alluvium	Monitor
4002	6	1	30	NWSW	1013414	446931	Inyan Kara	Domestic
7002	7	1	23	NWNW	1033333	421931	Chilson	Stock

Notes:
[1] Coordinate system is NAD 27 South Dakota State Plane South.
[2] Inyan Kara indicates that screened interval includes both Chilson and Fall River.
[3] Well 16 is a domestic, non-drinking water well. This is a formerly used domestic well which through agreement with Powertech (USA) no longer will be used as a drinking water well.



This figure is provided to fulfill the requirements of ARSD 74:29:02:07.

Legend

- Permit Boundary
- BNSF Railroad
- County Roads
- Ephemeral Streams
- Perennial Streams
- BLM Land
- Black Hills National Forest

Aquifer

- Fall River Monitor Well
- Chilson Monitor Well

Feet: 0, 2,000, 4,000, 8,000
Meters: 0, 1,000, 2,000

N

Figure 3.4-19
Baseline Water Quality Monthly Sampled Wells

Dewey-Burdock Project

SIGNATURE OF PREPARER	
PREPARER	Richard Blubaugh
DATE	24-Sep-2012
FILE	Wells-BLQtrGndH2OMthly.mxd

POWERTECH (USA) INC.

Table 3.4-7: Monthly Sampled Groundwater Quality Well Data

Hydro ID	Twn (N)	Rng (E)	Sec	Qtr Qtr	Easting[1]	Northing[1]	Screened Location	Well Use
615	6	1	20	NWNE	1022172	453708	Chilson	Monitor
622	6	1	20	NENE	1022776	454033	Chilson	Monitor
680	7	1	11	NESW	1035078	429969	Chilson	Monitor
681	6	1	32	NENW	1020330	443725	Fall River	Monitor
688	7	1	11	NESW	1035027	429974	Fall River	Monitor
689	6	1	32	NENW	1020316	443789	Chilson	Monitor
694	7	1	15	NWNW	1028717	426836	Fall River	Monitor
695	6	1	32	SESE	1022385	439312	Fall River	Monitor
696	7	1	15	NWNW	1028538	427141	Chilson	Monitor
697	6	1	32	SESE	1022350	439347	Chilson	Monitor
698	7	1	2	NESW	1035909	435651	Fall River	Monitor
705	6	1	21	NENE	1028624	453314	Chilson	Monitor
706	6	1	21	NENE	1028589	453276	Fall River	Monitor
3026	7	1	12	NENE	1043638	432833	Chilson	Monitor

Note: [1] Coordinate system is NAD 27 South Dakota State Plane South.

Figure 3.4-20 depicts the location of the wells in relation to proposed ISR activities. As part of the 2008 pump tests, one water quality sample was collected from 10 additional wells (49, 682, 684-687 and 690-693 in Table 3.4-8). One sample also was collected from two new Unkpapa domestic wells (703 and 704 in Table 3.4-8). One sample also was collected from well 704 after it was completed in the Chilson.

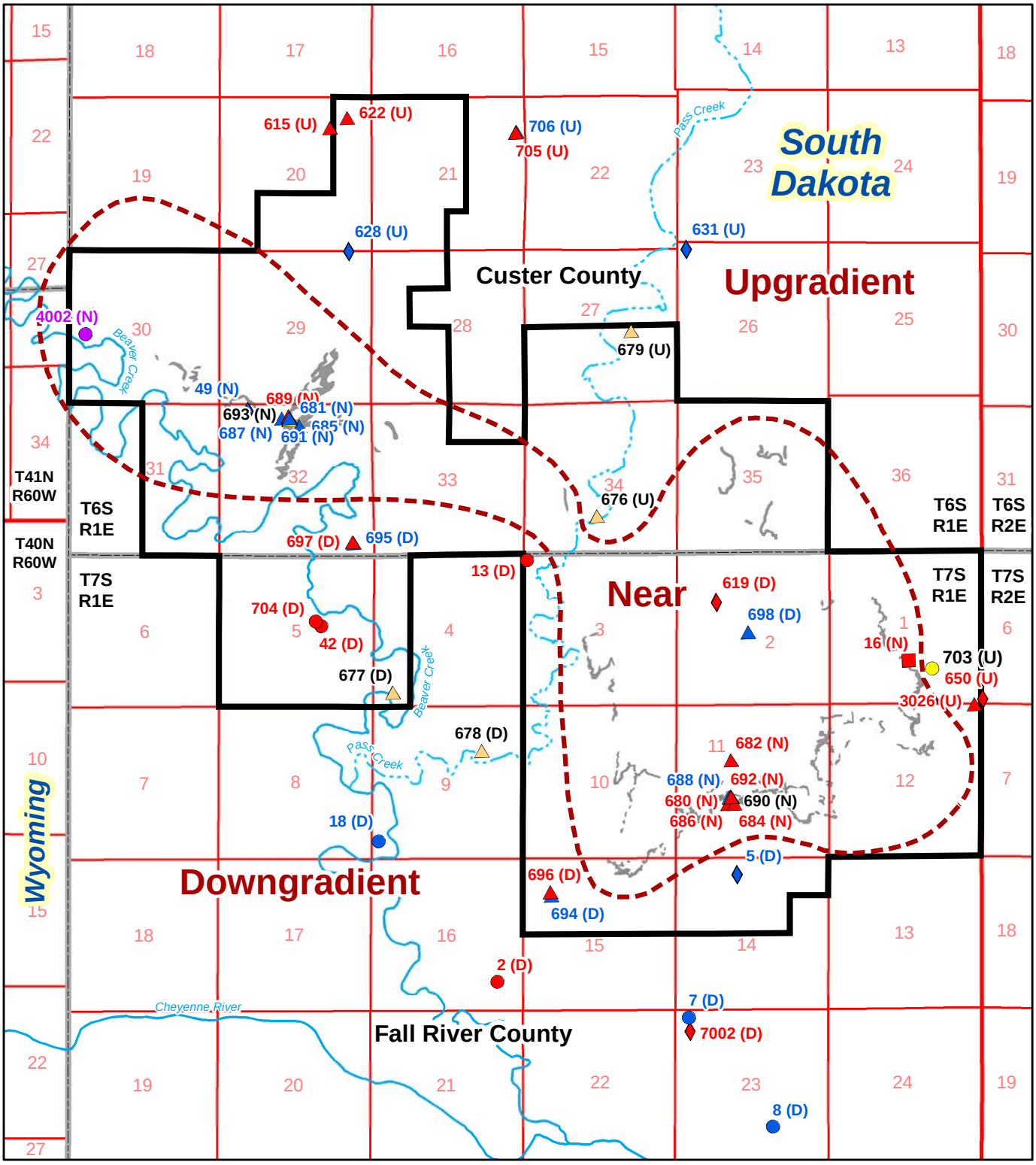
Groundwater samples were analyzed for constituents listed in Table 3.4-9, which was developed based on NUREG-1569 (NRC, 2003) groundwater parameters, Regulatory Guide 4.14 (NRC, 1980a) parameters, and added parameters from a constituent list review with DENR. A comparison between Table 3.4-9 and the baseline water quality parameter requirements in SDCL 45-6B-7(9) shows that only one parameter from SDCL 45-6B-7(9) was not measured in baseline samples: hydrocarbon potential. This parameter is not applicable to baseline groundwater quality in the aquifers monitored (alluvium, Fall River, Chilson, and Unkpapa), nor will any hydrocarbons be introduced into groundwater during ISR operations.

Static water levels were measured at most wells prior to sample collection using a pressure gauge for free-flowing wells or an electric water level tape for non-flowing wells. Non-flowing wells had permanent pumps installed in order to obtain samples. Continuous free-flowing wells were sampled before pressure measurements were made and were not purged before sampling. It was assumed that free-flowing well water quality represented formation water. Pumped wells were purged of at least 3 well casing volumes and until field water quality parameters had stabilized.

Additional steps taken during groundwater sampling include the following:

- Sampling procedures involved labeling each sample bottle with site ID, date, and time of sampling, triple rinsing with sample water, then filling and capping.
- Radon sample bottles were filled and capped immediately and with no headspace.
- Field replicate samples, consisting of a second set of samples collected at the same time following the same protocols as the sample set, were collected periodically to determine data accuracy.
- Field blanks were collected by transporting deionized water supplied by the contract laboratory to the field during regular sampling, then transferred to collection bottles in the field in order to subject the blank water to the same transportation, handling, storage, and field conditions as regular samples. All samples were immediately placed in coolers on ice after collection.

Water quality sondes used to collect field parameter measurements were calibrated periodically using N.I.S.T.-traceable standards.



This figure is provided to fulfill the requirements of ARSD 74:29:02:07.

Legend

- Permit Boundary
- Ephemeral Streams
- Perennial Streams

Well Use

- Monitor
- Stock
- Domestic
- Domestic Non-Drinking Water

- Ore Bodies

Screened Interval

- Alluvium
- Chilson
- Fall River
- Inyan Kara
- Unkpapa

Feet: 0, 2,500, 5,000
Meters: 0, 1,000, 2,000

Gradient Indicators

(U) - Upgradient
(N) - Near
(D) - Downgradient

N

Figure 3.4-20
Wells Upgradient, Near and Downgradient of Proposed ISR Activities
Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	25-Sep-2012
FILE	Wells-UpDownGrad.mxd

POWERTECH (USA) INC.

Table 3.4-8: Additional Well Data

Hydro ID	Twn (N)	Rng (E)	Sec	Qtr Qtr	Easting[1]	Northing[1]	Screened Location	Well Use
49	6	1	32	NWNW	1018932	444022	Fall River	Stock
682	7	1	11	SENW	1035139	431257	Chilson	Monitor
684	7	1	11	NESW	1035191	429744	Chilson	Monitor
685	6	1	32	NWNE	1020690	443409	Fall River	Monitor
686	7	1	11	NESW	1034970	429749	Chilson	Monitor
687	6	1	32	NENW	1020081	443724	Fall River	Monitor
690	7	1	11	NESW	1035114	429970	Unkpapa	Monitor
691	6	1	32	NENW	1020364	443698	Fall River	Monitor
692	7	1	11	NESW	1035075	430014	Chilson	Monitor
693	6	1	32	NENW	1020327	443661	Unkpapa	Monitor
703	7	1	1	SWSE	1041621	434334	Unkpapa	Domestic
704	7	1	5	SWNE	1020966	436647	Unkpapa/Chilson[2]	Domestic

Notes: [1] Coordinate system is NAD 27 South Dakota State Plane South.
[2] Well was originally completed in the Unkpapa and later in the Chilson.

Table 3.4-9: Baseline Groundwater Quality Parameter List

Constituent	Units	Analytical Method
Field Parameters		
Water Level Elevation	ft AMSL	Field
Field Temperature	°C	Field
Field pH	s.u.	Field
Field Dissolved Oxygen	mg/L	Field
Field Conductivity	umhos/cm	Field
Field Turbidity	NTU	Field
Physical Properties		
Conductivity @ 25°C	umhos/cm	A2510 B
Oxidation-Reduction Potential	mV	A2580 B
pH	s.u.	A4500-H B
Sodium Adsorption Ration (SAR)	unitless	Calculated
Solids, Total Dissolved (TDS) @ 180°C	mg/L	A2540 C
Common Elements and Ions		
Alkalinity, Total as $CaCO_3$	mg/L	A2320 B
Bicarbonate as HCO_3	mg/L	A2320 B
Carbonate as CO_3	mg/L	A2320 B
Calcium	mg/L	E200.7
Chloride	mg/L	E300.0
Fluoride	mg/L	E300.0
Magnesium	mg/L	E200.7
Nitrogen, Ammonia as N	mg/L	A4500-NH3 G
Nitrogen, Nitrate as N	mg/L	E300.0
Nitrogen, Nitrite as N	mg/L	E300.0
Potassium	mg/L	E200.7
Silica, Dissolved	mg/L	E200.7
Sodium	mg/L	E200.7
Sulfate	mg/L	E300.0
Metals - Dissolved		
Aluminum	mg/L	E200.8
Arsenic	mg/L	E200.8
Barium	mg/L	E200.8
Boron	mg/L	E200.7
Cadmium	mg/L	E200.8
Chromium	mg/L	E200.8
Copper	mg/L	E200.8
Iron	mg/L	E200.7
Lead	mg/L	E200.8
Manganese	mg/L	E200.8
Mercury	mg/L	E200.8
Molybdenum	mg/L	E200.8
Nickel	mg/L	E200.8
Selenium	mg/L	A3114 B
Silver	mg/L	E200.8
Thorium-232	mg/L	E200.8
Uranium	mg/L	E200.8
Vanadium	mg/L	E200.8
Zinc	mg/L	E200.8

Table 3.4-9: Baseline Groundwater Quality Parameter List (Cont'd)

Constituent	Units	Analytical Method
Metals – Dissolved Speciated		
Selenium-IV	mg/L	A3114 B
Selenium-VI	mg/L	A3114 B
Metals – Suspended		
Uranium	mg/L	E200.8
Metals – Total		
Antimony	mg/L	E200.8
Arsenic	mg/L	E200.8
Barium	mg/L	E200.8
Beryllium	mg/L	E200.8
Boron	mg/L	E200.7
Cadmium	mg/L	E200.8
Chromium	mg/L	E200.8
Copper	mg/L	E200.8
Iron	mg/L	E200.7
Lead	mg/L	E200.8
Manganese	mg/L	E200.7
Mercury	mg/L	E245.1
Molybdenum	mg/L	E200.7
Nickel	mg/L	E200.7
Selenium	mg/L	E200.8; E3114 B
Silver	mg/L	E200.8
Strontium	mg/L	E200.8
Thallium	mg/L	E200.8
Uranium	mg/L	E200.8
Zinc	mg/L	E200.8
Radionuclides – Dissolved		
Gross Alpha	pCi/L	E900.0
Gross Beta	pCi/L	E900.0
Gross Gamma	pCi/L	E900.0
Lead-210	pCi/L	E909.0M
Polonium-210	pCi/L	RMO-3008
Radium-226	pCi/L	E903.0
Thorium-230	pCi/L	E907.0
Radionuclides – Suspended		
Lead-210	pCi/L	E909.0M
Polonium-210	pCi/L	RMO-3008
Radium-226	pCi/L	E903.0
Thorium-230	pCi/L	E907.0

Table 3.4-9: Baseline Groundwater Quality Parameter List (Cont'd)

Constituent	Units	Analytical Method
Radionuclides – Total		
Lead-210	pCi/L	E900.0
Polonium-210	pCi/L	RMO-3008
Radium-226	pCi/L	E903.0
Radon-222	pCi/L	D5072-92
Thorium-230	pCi/L	E907.0
Data Quality		
A/C Balance (± 5)	%	A1030 E
Anions	meq/L	A1030 E
Cations	meq/L	A1030 E
Solids, Total Dissolved Calculated	mg/L	A1030 E
TDS Balance (0.80 – 1.20)	dec. %	A1030 E

3.4.4 Groundwater Quality

Water quality summary tables providing groundwater quality results for all aquifers are provided in Appendix 3.4-G, and analytical data are provided in Appendix 3.4-H.

Consistent with NRC guidance in Section 2.7.4 of NUREG-1569 (NRC, 2003), groundwater and surface water analytical data are presented in tables on a date-by-date, parameter-by-parameter, and well-by-well basis. The following describes the presentation of data in Appendix 3.4-G.

All field-measured parameters, including water level elevations for groundwater sampling locations, are presented with the corresponding laboratory data. For concentrations reported as non-detect by the laboratory, the data are reported as "< RL" where RL is the laboratory reporting limit. The summary tables present the minimum, maximum and mean concentrations for each parameter at each sample location. Means were calculated using a value of ½ of the RL when non-detect data occurred. Maximum values were calculated as the highest detected value for each constituent at each well, even where a detected concentration is lower than a previous RL.

Groundwater quality summary tables are provided at the beginning of Appendix 3.4-G describing the mean, standard deviation, minimum, and maximum values for each constituent in the four zones monitored. The monitored zones, in descending order, are the alluvium, Fall River Formation, Chilson Member of the Lakota Formation, and Unkpapa Sandstone.

Table 3.4-10 provides a summary of the range of water quality within each formation. The ranges shown represent the range of the average concentrations for the wells in each monitoring zone. They do not represent the minimum and maximum absolute sample concentrations for any one well. The alluvial wells are characterized by high TDS concentrations ranging from 2,525 to 9,325 mg/L. TDS concentrations in the Fall River ranged from 774 to 2,250 mg/L, and TDS concentrations in the Chilson ranged from 708 to 2,358 mg/L. The Unkpapa generally had the lowest concentrations of dissolved constituents, with TDS concentrations ranging from 1,300 to 1,400 mg/L.

Table 3.4-11 compares the sample results with South Dakota human health standards. The results for each monitored zone are discussed below. Laboratory data packages are provided in Appendix 3.4-H.

Table 3.4-10: Summary of Water Quality by Formation

Constituent	Units	Alluvium	Fall River	Chilson	Unkpapa
Field Parameters					
Water Level Elevation	ft AMSL	3482.6 - 3685.5	3574.6 - 3725.1	3647.9 - 3709.7	NM
Field Temperature	°C	10.10 - 12.03	11.1 - 14.9	9.4 - 15.4	11.9 - 20.1
Field pH	s.u.	6.8 - 7.4	6.7 - 8.4	6.9 - 8.3	9.2 - 11.1
Field Dissolved Oxygen	mg/L	0.8 - 9.4	0.07 - 5.4	0.1 - 3.3	NM
Field Conductivity	umhos/cm	2,670 - 11,260	1,223 - 2,623	958 - 2,750	2,083 - 2,500
Field Turbidity	NTU	3.8 - 799	0.1 - 13.1	0.4 - 29.3	9.2 - 13.2
Physical Properties					
Conductivity @ 25°C	umhos/cm	2,460 - 11,375	1,201 - 2,870	1,055 - 2,688	1,570 - 2,420
Oxidation-Reduction Potential	mV	193 - 253	129 - 258	32 - 236	88 - 220
pH	s.u.	7.2 - 7.6	7.1 - 8.5	7.1 - 8.1	9.0 - 11.4
Sodium Adsorption Ratio	unitless	0.9 - 16.3	1.0 - 11.4	0.9 - 10.2	9.1 - 17
TDS @ 180°C	mg/L	2,525 - 9,325	774 - 2,250	708 - 2,358	1,300 - 1,400
Common Elements and Ions					
Alkalinity, Total as $CaCO_3$	mg/L	145 - 497	117 - 197	71 - 261	38 - 148
Carbonate as CO3	mg/L	<5	<5 - 7.9	<5 - 3.1	<5 - 12
Bicarbonate as HCO_3	mg/L	177 - 606	143 - 240	87 - 318	32 - 180
Calcium	mg/L	425 - 515	30 - 368	35 - 386	23 - 73.7
Chloride	mg/L	12 - 1,625	9.5 - 47	5.0 - 17.5	16 - 70
Fluoride	mg/L	0.23 - 0.64	0.3 - 0.5	0.1 - 0.6	0.3 - 0.8
Magnesium	mg/L	97.6 - 442	10.5 - 134	11.8 - 124	<0.5 - 35.2
Nitrogen, Ammonia as N	mg/L	<0.1 - 0.3	<0.1 - 0.4	<0.1 - 0.6	0.3 - 1.6
Nitrogen, Nitrate as N	mg/L	0.06 - 1.2	<0.1 - 0.06	<0.1 - 0.08	<0.1 - 0.2
Nitrogen, Nitrite as N	mg/L	<0.1	<0.1	<0.1 - 0.15	<0.1
Potassium	mg/L	11.3 - 24.9	7.1 - 16	7.2 - 21	6.8 - 14
Sodium	mg/L	76.9 - 1,965	87 - 503	47 - 283	342 - 437
Sulfate	mg/L	1,485 - 4,425	425 - 1,443	389 - 1,509	807 - 886
Silica	mg/L	8.5 - 13.6	5.2 - 11.2	1.2 - 8.6	<0.2 - 5
Metals - Dissolved					
Aluminum	mg/L	<0.1	<0.1	<0.1 - 0.19	<0.1
Arsenic	mg/L	<0.001 - 0.001	<0.001 - 0.002	<0.01 - 0.016	<0.001
Barium	mg/L	<0.1	<0.1	<0.1	<0.1
Boron	mg/L	0.4 - 1.4	<0.1 - 0.43	<0.1 - 0.15	0.3 - 1
Cadmium	mg/L	<0.005	<0.005 - <0.01	<0.005 - <0.01	<0.005
Chromium	mg/L	<0.05	<0.05	<0.05	<0.05
Copper	mg/L	<0.01	<0.01	<0.01 - 0.025	<0.01
Iron	mg/L	<0.03 - 0.55	<0.03 - 2.58	<0.03 - 6.2	<0.03 - 0.06
Lead	mg/L	<0.001	<0.001 - 0.0011	<0.001 - 0028	<0.001
Manganese	mg/L	0.01 - 3.11	0.03 - 2.41	0.04 - 1.5	<0.01
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001
Molybdenum	mg/L	<0.1	<0.1	<0.1 - 0.067	<0.1
Nickel	mg/L	<0.05	<0.05 - 0.03	<0.05 - 0.024	<0.05
Selenium	mg/L	0.001 - 0.013	<0.001 - 0.0014	<0.001 - 0.0014	<0.001
Silver	mg/L	<0.005	<0.005 - <0.01	<0.005 - <0.01	<0.005

Table 3.4-10: Summary of Water Quality by Formation (Cont'd)

Constituent	Units	Alluvium	Fall River	Chilson	Unkpapa
Metals - Dissolved					
Thorium-232	mg/L	<0.005	<0.005	<0.005	<0.005
Uranium	mg/L	0.014 - 0.055	<0.0003 - 0.11	<0.0003 - 0.034	<0.0003 - 0.0003
Vanadium	mg/L	<0.1 - 0.088	<0.1 - 0.06	<0.1 - 0.05	<0.1
Zinc	mg/L	<0.01 - 0.013	<0.01 - 0.0125	<0.01 - 0.06	<0.01- 0.03
Metals – Dissolved – Speciated					
Selenium-IV	mg/L	<0.001	<0.001 - 0.0007	<0.001 - 0.0005	<0.001
Selenium-VI	mg/L	<0.001 - 0.012	<0.001 - 0.0007	<0.001 - 0.0010	<0.001
Metals – Suspended					
Uranium	mg/L	0.001 - 0.020	<0.0003 - 0.0031	<0.0003 -	<0.0003
Metals - Total					
Antimony	mg/L	<0.003	<0.003	<0.003 - 0.002	<0.003
Arsenic	mg/L	0.001 - 0.011	0.0008 - 0.0038	0.001 - 0.023	<0.001
Barium	mg/L	<0.1 - 0.275	<0.1	<0.1 - 0.067	<0.1
Beryllium	mg/L	<0.001 - 0.002	<0.001 - <0.005	<0.001 - 0.0005	<0.001
Boron	mg/L	0.175 - 1.5	<0.1 - 0.45	<0.001 - 0.17	0.4 - 1.1
Cadmium	mg/L	<0.001 - <0.005	<0.005	<0.005	<0.005
Chromium	mg/L	<0.05 - 0.038	<0.05	<0.05	<0.05
Copper	mg/L	<0.01 - 0.063	<0.01	<0.01 - 0.043	<0.01
Iron	mg/L	0.03 - 33.3	0.04 - 4.8	0.08 - 15.3	0.68 - 1.48
Lead	mg/L	<0.001 - 0.03	<0.001 - 0.002	<0.001 - 0.026	<0.001 - 0.019
Manganese	mg/L	0.46 - 3.21	0.03 - 2.49	0.04 - 1.74	<0.01 - 0.04
Mercury	mg/L	<0.0001 - 0.0002	<0.001	<0.001	<0.0002 - <0.001
Molybdenum	mg/L	<0.1 - 0.03	<0.01 - 0.03	<0.01 - 0.075	<0.1
Nickel	mg/L	<0.05 - 0.063	<0.05	<0.05	<0.05
Selenium	mg/L	0.003 - 0.014	<0.001 - 0.001	<0.001 - 0.0019	<0.001 - 0.005
Silver	mg/L	<0.005	<0.005 - <0.02	<0.005 - <0.02	<0.005
Strontium	mg/L	7.6 - 10.8	0.65 - 6.2	0.7 - 7.5	2.1 - 2.6
Thallium	mg/L	<0.001	<0.001	<0.001 - 0.0006	<0.001
Uranium	mg/L	0.016 - 0.064	<0.0003 - 0.11	<0.0003 - 0.02	<0.0003
Zinc	mg/L	<0.01 - 0.16	<0.01 - 0.01	<0.01 - 0.13	<0.01 - 0.2
Radionuclides - Dissolved					
Gross Alpha	pCi/L	18.5 - 63.0	5.6 - 1,505	3.6 - 4,991	-3 - 42.6
Gross Beta	pCi/L	-7.5 - 18.1	3.2 - 484	7.8 - 1,629	-5 - 14.2
Gross Gamma	pCi/L	280 - 697	216 - 4,994	70 - 15,530	0 - 1,100
Lead-210	pCi/L	0.93 - 3.65	-1.9 - 29.7	-5.6 - 19.3	1 - 1.8
Polonium-210	pCi/L	0.9 - 1.4	0.02 - 2.36	0.02 - 2.03	-0.02 - 0.7
Radium-226	pCi/L	0.13 - 1.2	1.2 - 388	1.2 - 1,289	0.04 - 0.6
Thorium-230	pCi/L	0.08 - 0.18	0.01 - 0.13	0.04 - 0.20	0.0 - 0.1
Radionuclides - Suspended					
Lead-210	pCi/L	-2.1 - 0	-1.5 - 11.8	-1.65 - 22.1	-5.7 - 1.1
Polonium-210	pCi/L	0.3 - 0.8	0.03 - 2.2	0.02 - 4.1	-0.015 - 0.1
Radium-226	pCi/L	0.4 - 3.9	-0.2 - 7.9	-0.15 - 6.3	-0.4 - 0.2
Thorium-230	pCi/L	0.1 - 1.1	-0.07 - 1.29	-0.14 - 0.3	-0.2 - 0.3

Table 3.4-10: Summary of Water Quality by Formation (Cont'd)

Constituent	Units	Alluvium	Fall River	Chilson	Unkpapa
Radionuclides - Total					
Lead-210	pCi/L	<1 - 14	<1	<1 - 57	NM
Polonium-210	pCi/L	<1	<1 - 6.4	<1 - 13	NM
Radium-226	pCi/L	<0.2 - 2.5	<0.2 - 15.2	1.1 - 120	NM
Radon-222	pCi/L	522 - 1,413	277 - 278,030	197 - 180,750	153 - 424
Thorium-230	pCi/L	<0.2 - 1.9	<0.2	<0.2	NM

Table 3.4-11: Groundwater Quality Comparison with South Dakota Human Health Standards

Parameter	Arsenic, Dissolved	Gross Alpha, Dissolved	Radium-226, Dissolved	Radon-222	Uranium, Dissolved	Chloride	pH	Sulfate	TDS
ARSD 74:54:01:04 Standard	0.01	15	5*	300	0.03	250	6.5-8.5	500	1,000
Units	mg/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	s.u.	mg/L	mg/L
Fall River Wells									
Hydro ID									
5	---	---	---	**X**	---	---	---	**X**	**X**
7	---	**X**	**X**	**X**	---	---	---	**X**	**X**
8	---	---	---	**X**	---	---	---	**X**	**X**
18	---	**X**	**X**	**X**	---	---	---	**X**	**X**
628	---	**X**	**X**	**X**	---	---	**X**	**X**	**X**
631	---	**X**	**X**	**X**	---	---	---	**X**	**X**
681	---	**X**	**X**	**X**	---	---	---	**X**	**X**
688	---	**X**	**X**	**X**	---	---	**X**	**X**	**X**
694	---	**X**	---	**X**	---	---	**X**	**X**	**X**
695	---	**X**	**X**	**X**	---	---	---	**X**	**X**
698	---	**X**	**X**	**X**	**X**	---	---	**X**	**X**
706	---	**X**	---	**X**	---	---	---	**X**	**X**
% exceeding std. in one or more samples:	0% (0/12)	83% (10/12)	67% (8/12)	100% (12/12)	8% (1/12)	0% (0/12)	25% (3/12)	100% (12/12)	100% (12/12)
Chilson Wells									
Hydro ID									
2	---	---	---	**X**	---	---	---	**X**	**X**
13	---	**X**	---	**X**	---	---	---	**X**	**X**
16	---	**X**	**X**	**X**	---	---	---	**X**	**X**
42	---	**X**	**X**	**X**	**X**	---	---	**X**	**X**
615	**X**	**X**	**X**	**X**	---	---	---	**X**	**X**
619	---	**X**	**X**	**X**	---	---	---	**X**	**X**
622	---	**X**	**X**	**X**	---	---	---	**X**	**X**
650	---	---	---	---	---	---	---	**X**	**X**
680	**X**	**X**	**X**	**X**	**X**	---	---	**X**	**X**
689	---	**X**	**X**	**X**	---	---	---	**X**	**X**
696	---	**X**	---	**X**	---	---	---	**X**	**X**
697	---	**X**	**X**	**X**	---	---	---	**X**	**X**
705	---	---	---	**X**	---	---	**X**	**X**	**X**
3026	**X**	**X**	**X**	**X**	---	---	---	**X**	**X**
7002	---	**X**	**X**	**X**	---	---	---	**X**	**X**
% exceeding std. in one or more samples:	20% (3/15)	80% (12/15)	67% (10/15)	93% (14/15)	13% (2/15)	0% (0/12)	7% (1/15)	100% (15/15)	100% (15/15)

Notes: **X** denotes that one or more analyses exceed the human health standard.

* Standard applies to radium-226 and radium-228 combined.

Table 3.4-11: Groundwater Quality Comparison with South Dakota Human Health Standards (Cont'd)

Parameter	Arsenic, Dissolved	Gross Alpha, Dissolved	Radium-226, Dissolved	Radon-222	Uranium, Dissolved	Chloride	pH	Sulfate	TDS
ARSD 74:54:01:04 Standard	0.01	15	5*	300	0.03	250	6.5-8.5	500	1,000
Units	mg/L	pCi/L	pCi/L	pCi/L	mg/L	mg/L	s.u.	mg/L	mg/L
Alluvial Wells									
Hydro ID									
675	---	**X**	---	**X**	**X**	---	---	**X**	**X**
676	---	**X**	---	**X**	**X**	---	---	**X**	**X**
677	---	**X**	---	**X**	**X**	**X**	---	**X**	**X**
678	---	**X**	---	**X**	**X**	---	---	**X**	**X**
679	---	**X**	---	**X**	---	---	---	**X**	**X**
% exceeding std. in one or more samples:	0% (0/5)	100% (5/5)	0% (0/5)	100% (5/5)	80% (4/5)	20% (1/5)	0% (0/5)	100% (5/5)	100% (5/5)
Unkpapa Wells									
Hydro ID									
690	---	---	---	---	---	---	**X**	**X**	**X**
693	---	---	---	**X**	---	---	**X**	**X**	**X**
703	---	**X**	---	---	---	---	**X**	**X**	**X**
704	---	---	---	---	---	---	**X**	**X**	**X**
% exceeding std. in one or more samples:	0% (0/4)	25% (1/4)	0% (0/4)	25% (1/4)	0% (0/4)	0% (0/4)	100% (4/4)	100% (4/4)	100% (4/4)

Notes: **X** denotes that one or more analyses exceed the human health standard.
* Standard applies to radium-226 and radium-228 combined.

3.4.4.1 Alluvial Water Quality

As shown in Table 3.4-10, the alluvial water quality is characterized by moderate pH (7.2 - 7.6) and moderate to high TDS (2,525 - 9,325 mg/L). Table 3.4-12 summarizes the average major ion chemistry in the alluvial wells. Cation chemistry is variable, with calcium the dominant cation in 40% of wells (2 of 5) and sodium in 20% of wells (1 of 5). Two wells did not have a dominant cation (i.e., all less than 50%). Sulfate was the dominant anion in 100% of wells. Bicarbonate concentrations were low in all alluvial wells, and chloride concentrations were low in 80% of wells (4 of 5). A notable exception is Well 677, which had an average chloride concentration of 1,625 mg/L.

A comparison between the alluvial water quality and ARSD 74:54:01:04 human health standards (Table 3.4-11) shows that 100% of the wells yielded one or more samples with concentrations of gross alpha, radon-222, sulfate and TDS above the standards. 80% of the wells also exceeded the uranium standard in one or more sample, and 20% exceeded the chloride standard in one or more sample. With 100% of alluvial wells exceeding the gross alpha and radon-222 standards, radionuclide concentrations were relatively high in the alluvial wells compared to the South Dakota standards. However, the maximum concentrations in the Fall River and Chilson were significantly higher than those in the alluvium. For example, the highest average gross alpha concentration was 1,505 pCi/L in the Fall River and 4,991 pCi/L in the Chilson, compared to 63 pCi/L in the alluvium. Similarly, the highest average radon-222 concentration was 278,030 pCi/L in the Fall River and 180,750 pCi/L in the Chilson, compared to 1,413 pCi/L in the alluvium.

3.4.4.2 Fall River Water Quality

The water quality in the Fall River Formation is characterized by moderate TDS (774 to 2,250 mg/L), relatively consistent major ion chemistry, and high radionuclide concentrations. Table 3.4-13 summarizes the average major ion chemistry of the Fall River wells. Sodium is the dominant cation in 75% of wells (9 of 12). Of the remaining three wells, two exhibited calcium dominance and one well did not have a dominant cation. All of the Fall River baseline wells exhibited strong sulfate dominance, with sulfate accounting for 72% to 92% of the anion concentration (in meq/L).

A comparison between the Fall River water quality and ARSD 74:54:01:04 human health standards (Table 3.4-11) shows that 100% of the wells yielded one or more samples with concentrations of radon-222, sulfate and TDS above the standards. Additional standards

Table 3.4-12: Major Ion Chemistry - Alluvium

Major Cations							
Hydro ID	Calcium		Magnesium		Sodium		Dominant Cation
	meq/L	%	meq/L	%	meq/L	%	
675	21.2	25%	30.5	37%	31.8	38%	---
676	25.7	66%	9.5	24%	3.9	10%	calcium
677	23.3	16%	33.4	23%	85.5	60%	sodium
678	21.3	25%	36.3	43%	26.6	32%	---
679	22.7	67%	8.0	24%	3.3	10%	calcium
Major Anions							
Hydro ID	Bicarbonate/ Carbonate		Chloride		Sulfate		Dominant Anion
	meq/L	%	meq/L	%	meq/L	%	
675	7.7	9%	1.9	2%	73.4	88%	sulfate
676	4.5	11%	0.4	1%	36.1	88%	sulfate
677	9.9	7%	45.8	31%	92.2	62%	sulfate
678	9.6	11%	1.9	2%	72.6	86%	sulfate
679	2.9	8%	0.3	1%	30.9	91%	sulfate

Note: Concentrations in milliequivalents per liter represent the average concentration for each well.

Table 3.4-13: Major Ion Chemistry - Fall River Formation

Major Cations							
Hydro ID	Calcium		Magnesium		Sodium		Dominant Cation
	meq/L	%	meq/L	%	meq/L	%	
5	6.2	19%	4.1	13%	21.9	68%	sodium
7	1.8	12%	1.2	8%	11.9	80%	sodium
8	2.7	19%	1.9	14%	9.6	67%	sodium
18	1.7	12%	1.0	7%	12.0	82%	sodium
628	2.0	11%	1.4	8%	13.9	81%	sodium
631	15.9	58%	7.5	27%	4.0	15%	calcium
681	3.1	22%	2.0	14%	9.2	64%	sodium
688	2.3	19%	1.6	13%	8.3	68%	sodium
694	1.5	10%	0.9	6%	12.3	84%	sodium
695	3.8	23%	2.2	13%	10.5	64%	sodium
698	18.4	55%	11.0	33%	3.8	11%	calcium
706	8.3	47%	3.9	22%	5.6	31%	---
Major Anions							
Hydro ID	Bicarbonate/ Carbonate		Chloride		Sulfate		Dominant Anion
	meq/L	%	meq/L	%	meq/L	%	
5	2.4	7%	0.7	2%	30.1	91%	sulfate
7	3.4	22%	0.3	2%	11.6	76%	sulfate
8	3.4	23%	0.3	2%	11.0	75%	sulfate
18	3.6	25%	0.4	3%	10.7	73%	sulfate
628	3.0	16%	1.3	7%	14.7	77%	sulfate
631	3.3	11%	0.3	1%	25.8	88%	sulfate
681	3.5	25%	0.4	3%	10.1	72%	sulfate
688	2.7	23%	0.3	3%	8.9	75%	sulfate
694	3.6	26%	0.4	3%	10.1	72%	sulfate
695	3.5	22%	0.3	2%	12.1	76%	sulfate
698	2.3	8%	0.3	1%	28.5	92%	sulfate
706	3.9	21%	0.3	1%	14.1	77%	sulfate

Note: Concentrations in milliequivalents per liter represent the average concentration for each well.

exceeded in one or more samples included gross alpha (83% of wells), radium-226 (67% of wells), uranium (8% of wells), and pH (25% of wells).

While many of the Fall River Formation baseline wells were outside of the ore zone and yielded low to non-detectable radionuclide concentrations, the maximum radionuclide concentrations were often relatively high. For example, the highest average gross alpha concentration (dissolved) was 1,505 pCi/L in well 698, and the highest average radon-222 concentration was 278,030 pCi/L in well 681.

3.4.4.3 Chilson Water Quality

The water quality in the Chilson Member of the Lakota Formation is characterized by moderate TDS (708 - 2,358 mg/L), relatively consistent major ion chemistry, and often high radionuclide concentrations. Table 3.4-14 summarizes the average major ion chemistry of the Chilson wells. Sodium is the dominant cation in 53% of wells (8 of 15). Four wells (27%) exhibited calcium dominance and three wells (20%) did not have a dominant cation. All of the Chilson baseline wells exhibited strong sulfate dominance, with sulfate accounting for 71% to 92% of the anion concentration (in meq/L).

A comparison between the Chilson water quality and ARSD 74:54:01:04 human health standards (Table 3.4-11) shows that 100% of the wells yielded one or more samples with concentrations of sulfate and TDS above the standards. Additional standards exceeded in one or more samples included dissolved arsenic (20% of wells), gross alpha (80% of wells), radium-226 (67% of wells), radon-222 (93% of wells), uranium (13% of wells), and pH (7% of wells).

Many of the Chilson wells yielded relatively high average radionuclide concentrations. For example, the highest average gross alpha concentration (dissolved) was 4,991 pCi/L in well 680, and the highest average radon-222 concentration was 180,750 pCi/L in well 42.

3.4.4.4 Unkpapa Water Quality

The water quality in the Unkpapa Sandstone is characterized by high pH (9.0 to 11.4), moderate and relatively consistent TDS (1,300 to 1,400 mg/L), relatively consistent major ion chemistry, and relatively low radionuclide concentrations. Table 3.4-15 summarizes the average major ion chemistry of the Unkpapa wells. Sodium is the dominant cation in 100% of wells (4 of 4), and sulfate is the dominant anion in 100% of wells (4 of 4).

Table 3.4-14: Major Ion Chemistry - Chilson Member of the Lakota Formation

Major Cations							
Hydro ID	Calcium		Magnesium		Sodium		Dominant Cation
	meq/L	%	meq/L	%	meq/L	%	
2	2.6	16%	1.4	9%	12.3	75%	sodium
13	3.1	24%	2.0	16%	7.6	60%	sodium
16	5.9	50%	3.8	32%	2.1	18%	calcium
42	1.7	12%	1.0	7%	11.6	81%	sodium
615	3.7	33%	1.8	16%	5.8	51%	sodium
619	16.0	55%	9.4	32%	3.8	13%	calcium
622	4.1	29%	2.4	17%	7.7	54%	sodium
650	8.3	41%	6.5	32%	5.3	26%	---
680	19.2	54%	10.2	29%	6.0	17%	calcium
689	2.3	21%	1.3	12%	7.7	68%	sodium
696	4.9	31%	3.0	19%	7.7	49%	---
697	2.6	20%	1.4	11%	9.2	70%	sodium
705	4.2	30%	2.6	18%	7.1	51%	sodium
3026	19.0	52%	9.3	26%	8.2	22%	calcium
7002	11.5	44%	7.3	28%	7.6	29%	---
Major Anions							
Hydro ID	Bicarbonate/ Carbonate		Chloride		Sulfate		Dominant Anion
	meq/L	%	meq/L	%	meq/L	%	
2	4.2	25%	0.3	2%	12.4	73%	sulfate
13	3.2	23%	0.3	2%	10.0	74%	sulfate
16	3.1	24%	0.1	1%	9.4	74%	sulfate
42	3.6	25%	0.3	2%	10.3	72%	sulfate
615	2.8	25%	0.1	1%	8.2	74%	sulfate
619	2.3	8%	0.3	1%	26.9	91%	sulfate
622	3.5	25%	0.3	2%	10.2	73%	sulfate
650	1.4	6%	0.5	2%	20.6	92%	sulfate
680	5.0	15%	0.4	1%	28.2	84%	sulfate
689	3.0	27%	0.1	1%	8.1	72%	sulfate
696	4.0	27%	0.3	2%	10.7	71%	sulfate
697	3.3	26%	0.2	2%	9.4	72%	sulfate
705	2.7	19%	0.2	2%	11.1	79%	sulfate
3026	3.5	10%	0.5	1%	31.4	89%	sulfate
7002	5.2	19%	0.3	1%	22.4	80%	sulfate

Note: Concentrations in milliequivalents per liter represent the average concentration for each well.

Table 3.4-15: Major Ion Chemistry - Unkpapa Sandstone

Major Cations							
Hydro ID	Calcium		Magnesium		Sodium		Dominant Cation
	meq/L	%	meq/L	%	meq/L	%	
690	2.1	11%	2.1	11%	14.9	78%	sodium
693	3.7	16%	2.9	13%	16.5	72%	sodium
703	3.6	18%	0.0	0%	16.1	82%	sodium
704	1.1	5%	1.2	6%	19.0	89%	sodium
Major Anions							
Hydro ID	Bicarbonate/ Carbonate		Chloride		Sulfate		Dominant Anion
	meq/L	%	meq/L	%	meq/L	%	
690	0.8	4%	0.8	5%	16.8	91%	sulfate
693	1.3	6%	1.1	5%	18.5	88%	sulfate
703	3.0	15%	0.5	2%	17.2	83%	sulfate
704	1.5	7%	2.0	9%	18.2	84%	sulfate

Note: Concentrations in milliequivalents per liter represent the average concentration for each well.

A comparison between the Unkpapa water quality and ARSD 74:54:01:04 human health standards (Table 3.4-11) shows that 100% of the wells yielded one or more samples with concentrations of pH, sulfate and TDS above the standards. Additional standards exceeded in one or more samples included gross alpha (25% of wells) and radon-222 (25% of wells).

Radionuclide concentrations were generally lower in the Unkpapa than the alluvium, Fall River or Chilson. With the exception of one well exceeding each of the gross alpha and radon-222 standards in one or more samples, radionuclide concentrations in the Unkpapa were below South Dakota standards.

3.4.4.5 Comparison between Historical and Recent Water Quality

An analysis was conducted to determine if the well chemistry data collected in the permit area by TVA between May 1979 and April 1984 is representative of current water quality conditions and could therefore be used to expand the current Powertech (USA) data set. Nine wells were selected for analysis based on TVA and Powertech (USA) data sets being available for each well, time period, and constituent (Figure 3.4-21). All nine wells are completed into the Inyan Kara Group. Five of the wells are completed into the Chilson, three in the Fall River, and one in both the Chilson and Fall River.

Powertech (USA) and TVA data comparison consisted of two phases: (1) computing basic statistics on selected data, and (2) plotting Piper diagrams. The same set of wells was used in both analyses. Table 3.4-16 lists wells, the aquifer they are completed into, and the number of sample results available for analysis from monitoring programs done by TVA and Powertech (USA). Table 3.4-17 shows the constituents sampled for during TVA data collection and those used in the comparison analysis either with statistics or Piper diagrams. Data selection process, analysis details, and results from statistical analyses and Piper plots are summarized independently in the following sections.

The following procedures were followed in completing the analyses:

- The analytical data were reviewed to define the chemical constituents that were sampled during both monitoring programs with a focus on bulk properties.
- The reported values of alkalinity, specific conductance, pH, and TDS were compared from nine wells that were sampled during both project periods.
- Statistics calculated included mean, minimum, and maximum.

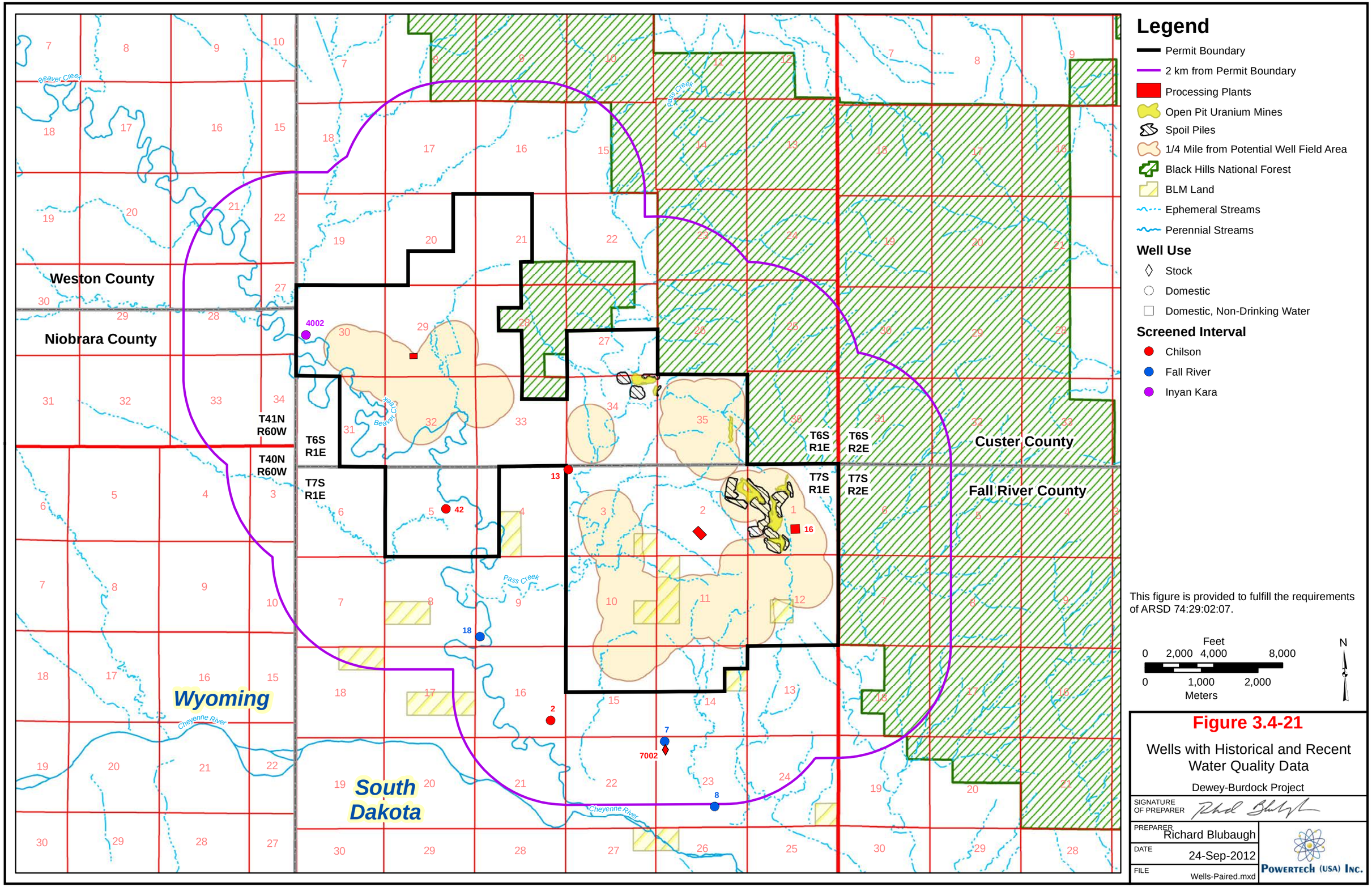


Figure 3.4-21

Wells with Historical and Recent Water Quality Data

Dewey-Burdock Project

SIGNATURE OF PREPARER	
PREPARER	Richard Blubaugh
DATE	24-Sep-2012
FILE	Wells-Paired.mxd

POWERTECH (USA) INC.

Table 3.4-16: TVA and Powertech (USA) Sampling History

Well No.	Aquifer	Number of TVA Samples (1979 - 1984)	Number of Powertech (USA) Samples (2006 - 2008)
2	Chilson	10	4
7	Fall River	2	5
8	Fall River	11	4
13	Chilson	11	5
16	Chilson	3	5
18	Fall River	11	5
42	Chilson	10	5
4002	Inyan Kara[1]	5	4
7002	Chilson	11	4

Note: [1] Inyan Kara indicates that screened interval includes both Chilson and Fall River.

Table 3.4-17: Parameters Analyzed During TVA Water Quality Monitoring

Test Analyte/Parameter	Units	Notes	Used in Historical/Recent Comparison
Physical Properties			
pH	pH units	Field and laboratory	**X**
TDS	mg/L		**X**
Total Suspended Solids (TSS)	mg/L		
Water Level	ft		
Specific Conductance	µmhos/cm	Field and laboratory	**X**
Hardness	mg/L as $CaCO_3$		
Common Elements and Ions			
Calcium	mg/L		**X**
Alkalinity	mg/L as $CaCO_3$		**X**
Bicarbonate (as HCO_3)	mg/L		**X**
Carbonate (as $CaCO_3$)	mg/L		**X**
Chloride	mg/L		**X**
Magnesium	mg/L		**X**
Potassium	mg/L		**X**
Sodium	mg/L		**X**
Sulfate	mg/L		**X**
Nitrogen	mg/L		
Phosphate	mg/L		
Silicon-SiO_2	mg/L		
Cation/Anion Balance	%		
Trace Metals			
Arsenic, As	mg/L	Dissolved	
Boron, B	mg/L	Dissolved	
Iron, Fe	mg/L	Dissolved	
Manganese, Mn	mg/L	Dissolved	
Lead, Pb	mg/L	Dissolved	
Selenium, Se	mg/L	Dissolved, speciated	
Uranium, U	mg/L	Total	
Vanadium, V	mg/L		
Zinc, Zn	mg/L	Dissolved	
Radionuclides			
Radium-226	pCi/L	Total	

- Comparison was made by graphical representation of the mean value of reported parameters from TVA and Powertech (USA) data.

The number of samples analyzed during the current monitoring program limited the sample size available for statistical analysis. Therefore the analytical techniques available were limited to less rigorous qualitative and quantitative techniques. Comparison statistics reported are mean, minimum, and maximum, with relative percent difference (RPD) calculated for each statistic, where RPD is the absolute difference divided by the average (Table 3.4-18). Complete groundwater quality data results are available in Appendix 3.4-G (Powertech (USA) results) and Appendix 3.4-I (TVA results).

A plot comparing average alkalinity between TVA and Powertech (USA) data is given in Figure 3.4-22. Average alkalinity decreased slightly for all wells sampled except for well 16 and well 7002, which had essentially the same mean alkalinity in both time periods. The average absolute difference of the mean value of alkalinity was approximately 5% in the two data sets.

Figure 3.4-23 is a plot of average specific conductance compared between historical TVA and current Powertech (USA) data. Average specific conductance increased slightly for all wells except for well 16 and well 7002. The average absolute difference of the mean value of specific conductance was approximately 5% in the two data sets.

Figure 3.4-24 compares the average pH values in the two data sets. Average pH increased slightly in all but two wells (well 7 and well 7002). However, the average absolute difference was only 2%.

Figure 3.4-25 compares historical TVA and current Powertech (USA) mean TDS. The TDS values from the two different sampling periods were very similar. The greatest difference was less than 10%, and the average difference was only 4%.

Piper diagrams were constructed for the group of wells with both historical and recent samples to determine if the general water quality type has changed over the course of the last 30 years (Figures 3.4-26 through 3.4-36). Piper diagrams are a useful tool to evaluate overall water quality as they provide a visual representation of the proportional concentrations of major ions. These figures consist of two trilinear diagrams (one each for cations and anions) and a comprehensive quadrilateral diagram. The trilinear diagrams illustrate the relative concentrations of cations (left diagram) and anions (right diagram) in each sample plotted as percent of total in milliequivalents per liter (meq/l). Cations included on the diagram include sodium (Na^+) plus

Table 3.4-18: Comparison of Statistics for Selected Constituents between Historical TVA Data and Current Powertech (USA) Data

		Mean			Minimum			Maximum		
	Well	Powertech	TVA	RPD	Powertech	TVA	RPD	Powertech	TVA	RPD
Alkalinity, mg/L as $CaCO_3$	2	211	220	4%	208	200	4%	214	242	12%
	7	171	181	6%	170	171	1%	176	191	8%
	8	169	178	5%	164	166	1%	178	194	9%
	13	159	173	8%	142	160	12%	170	196	14%
	16	153	152	1%	148	144	3%	160	157	2%
	18	180	196	9%	176	180	2%	184	238	26%
	42	178	188	5%	174	179	3%	180	204	13%
	4002	141	158	11%	138	144	4%	144	202	34%
	7002	261	261	0%	250	210	17%	280	300	7%
Specific Conductance, umhos/cm	2	1580	1548	2%	1500	1450	3%	1670	1750	5%
	7	1542	1338	14%	1440	1325	8%	1650	1350	20%
	8	1458	1385	5%	1420	1285	10%	1560	1450	7%
	13	1292	1274	1%	1140	1100	4%	1420	1400	1%
	16	1063	1162	9%	925	1150	22%	1260	1175	7%
	18	1428	1379	3%	1360	1300	5%	1470	1420	3%
	42	1408	1353	4%	1310	1200	9%	1510	1400	8%
	4002	1223	1161	5%	1130	1100	3%	1340	1195	11%
	7002	2328	2339	0%	2200	1925	13%	2480	2500	1%
pH	2	7.90	7.7	3%	7.85	7.16	9%	7.93	8.2	3%
	7	8.11	8.5	5%	8.05	8.3	3%	8.17	8.7	6%
	8	7.95	7.87	1%	7.93	7.59	4%	7.97	8.5	6%
	13	7.90	7.76	2%	7.75	7.48	4%	8.05	8.1	1%
	16	7.46	7.34	2%	7.38	7.31	1%	7.57	7.39	2%
	18	8.09	7.94	2%	8.02	7.69	4%	8.11	8.4	4%
	42	8.02	7.94	1%	7.95	7.67	4%	8.08	8.4	4%
	4002	7.83	7.75	1%	7.65	7.51	2%	8.02	8.5	6%
	7002	7.36	7.44	1%	7.22	7.14	1%	7.56	8	6%
Total Dissolved Solids, mg/L	2	1100	1043	5%	1100	1004	9%	1100	1113	1%
	7	990	1081	9%	960	1058	10%	1000	1104	10%
	8	975	965	1%	940	860	9%	1000	1130	12%
	13	878	886	1%	850	792	7%	890	1006	12%
	16	814	846	4%	760	796	5%	940	894	5%
	18	960	909	5%	940	520	58%	990	1118	12%
	42	950	939	1%	930	888	5%	980	1033	5%
	4002	823	773	6%	790	740	7%	850	805	5%
	7002	1875	1843	2%	1800	1690	6%	1900	1970	4%

RPD (Relative Percent Difference) = absolute difference divided by the average

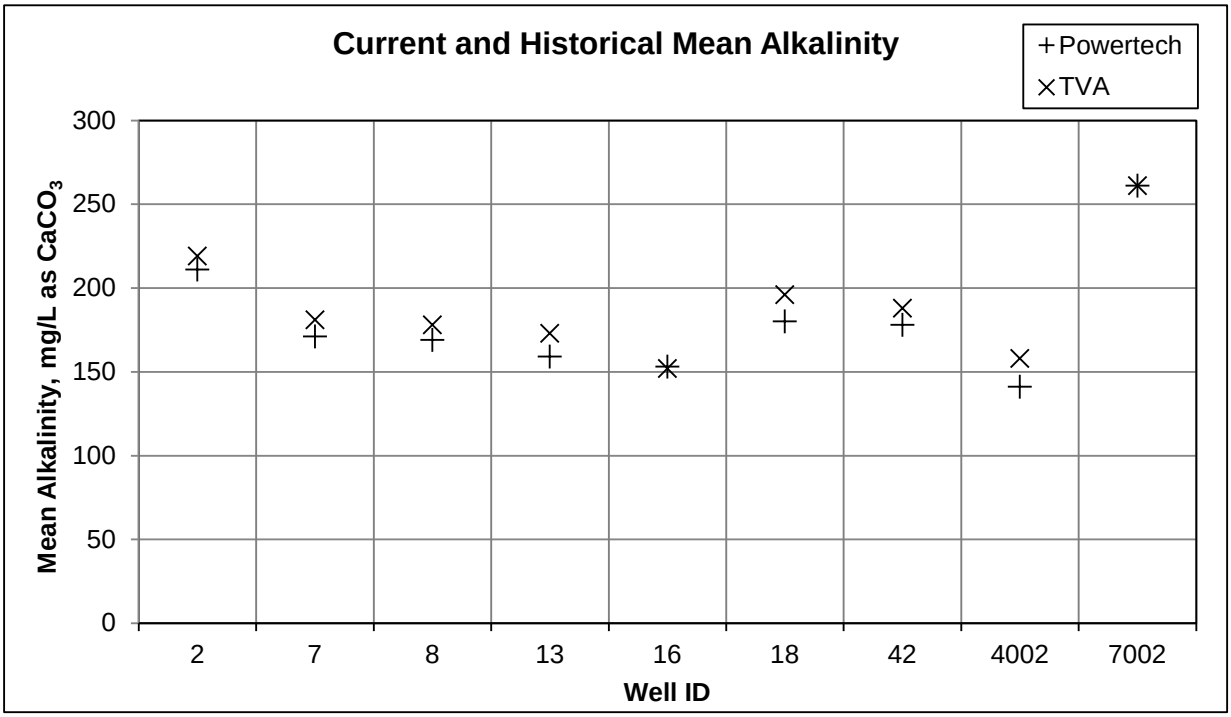


Figure 3.4-22: Mean Alkalinity Comparison between Historical and Current Data

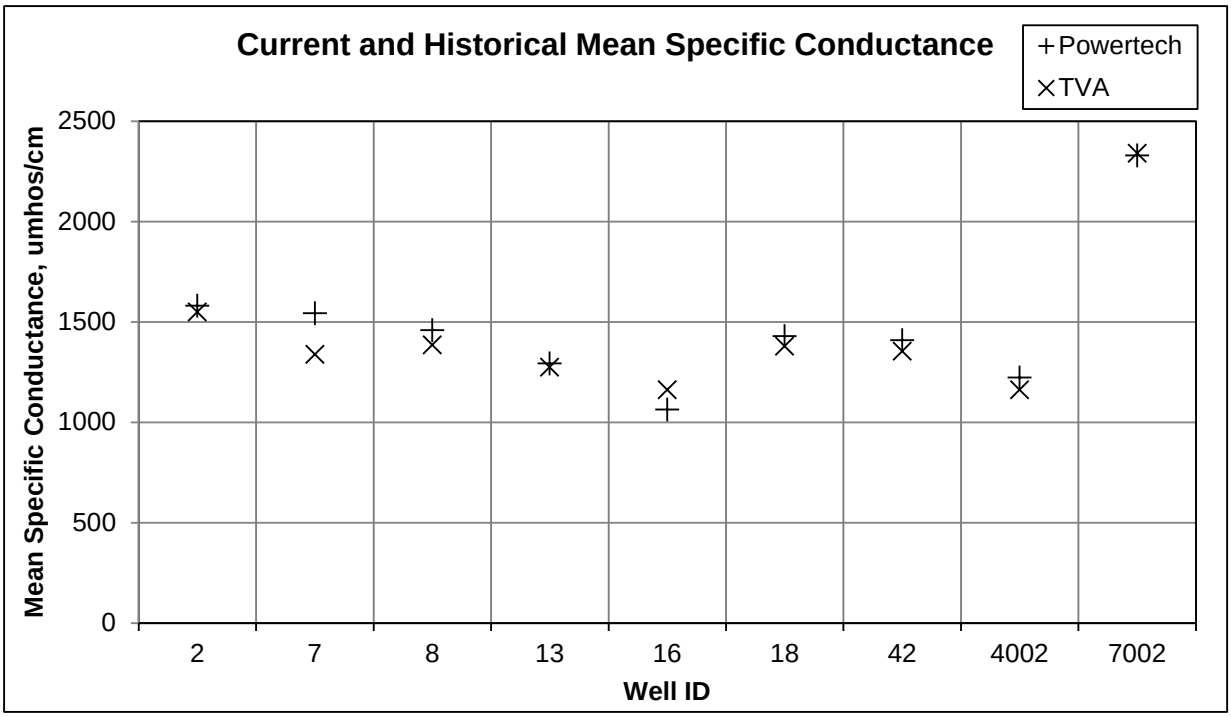


Figure 3.4-23: Mean Specific Conductance Comparison between Historical and Current Data

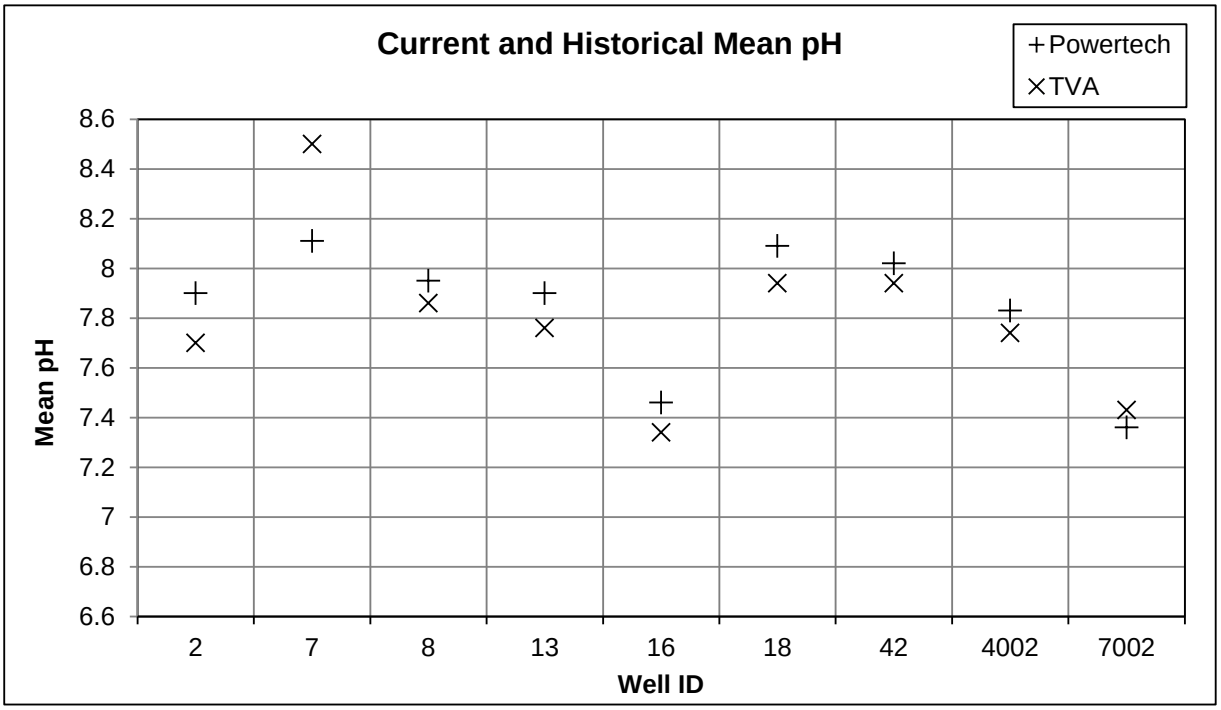


Figure 3.4-24: Mean pH Comparison between Historical and Current Data

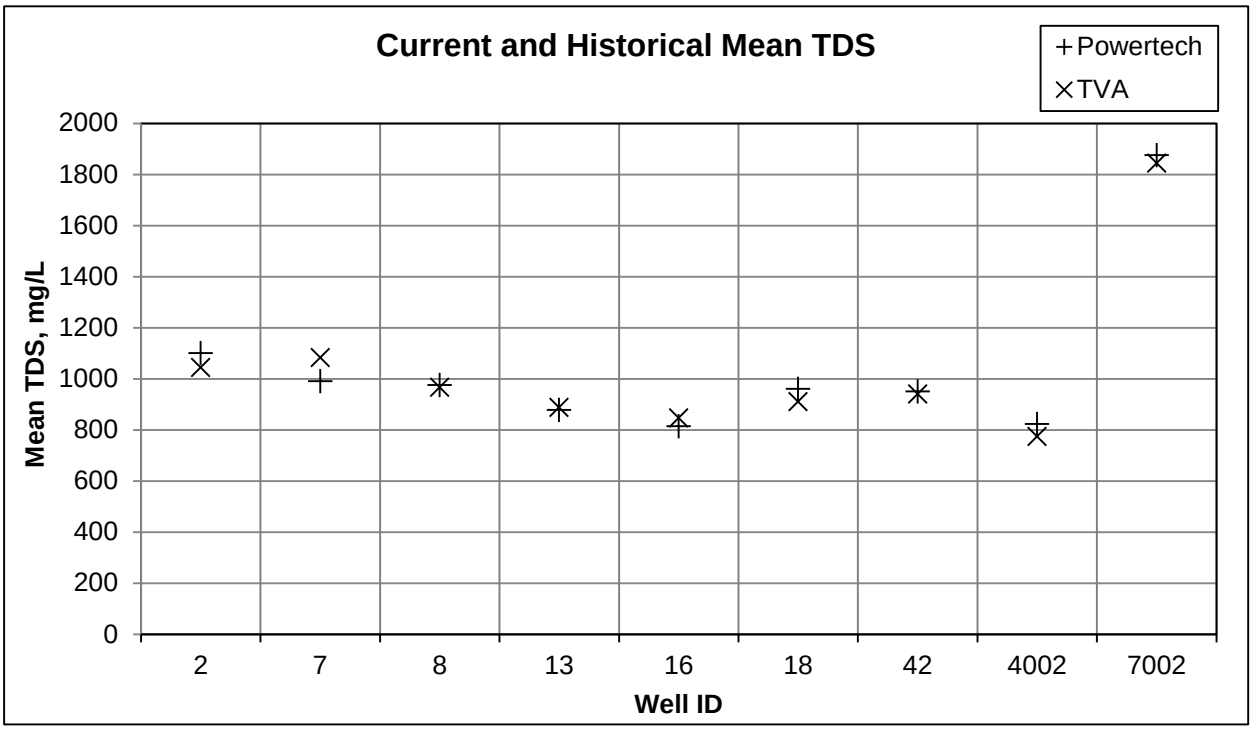


Figure 3.4-25: Mean TDS Comparison between Historical and Current Data

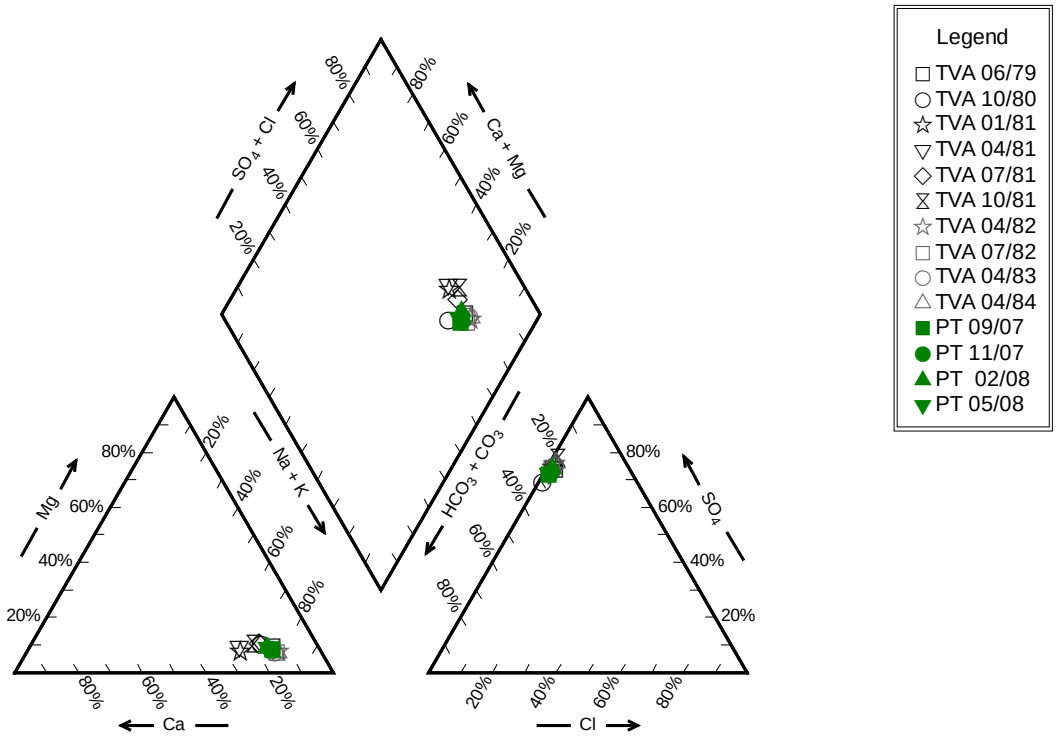


Figure 3.4-26: Piper Diagram of Historical and Current Data for Well 2

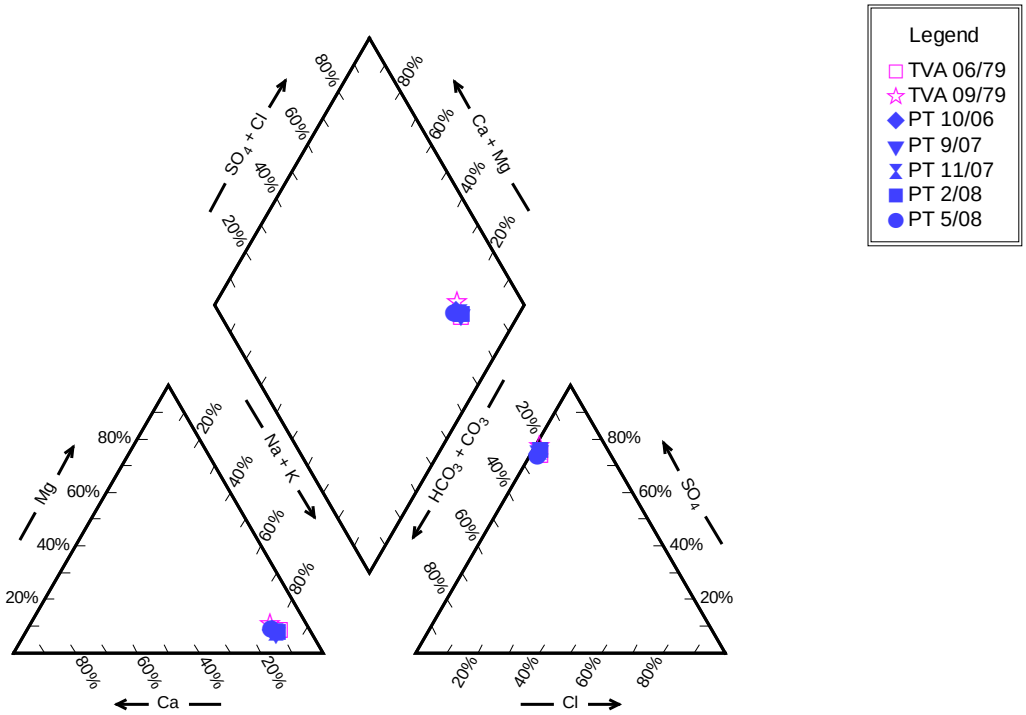


Figure 3.4-27: Piper Diagram of Historical and Current Data for Well 7

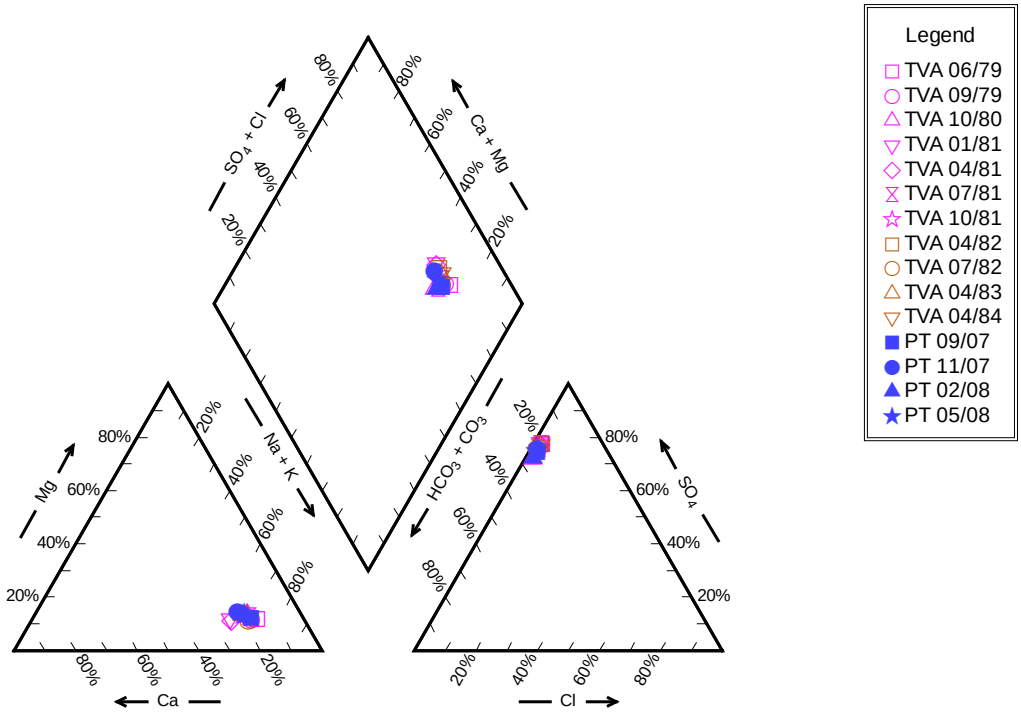


Figure 3.4-28: Piper Diagram of Historical and Current Data for Well 8

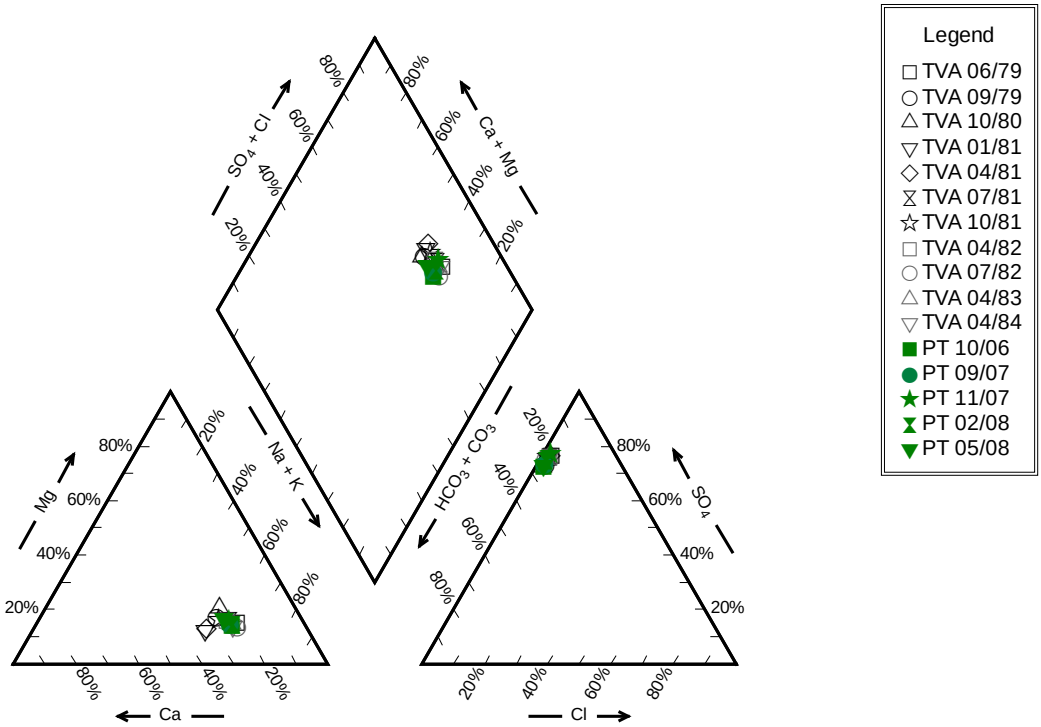


Figure 3.4-29: Piper Diagram of Historical and Current Data for Well 13

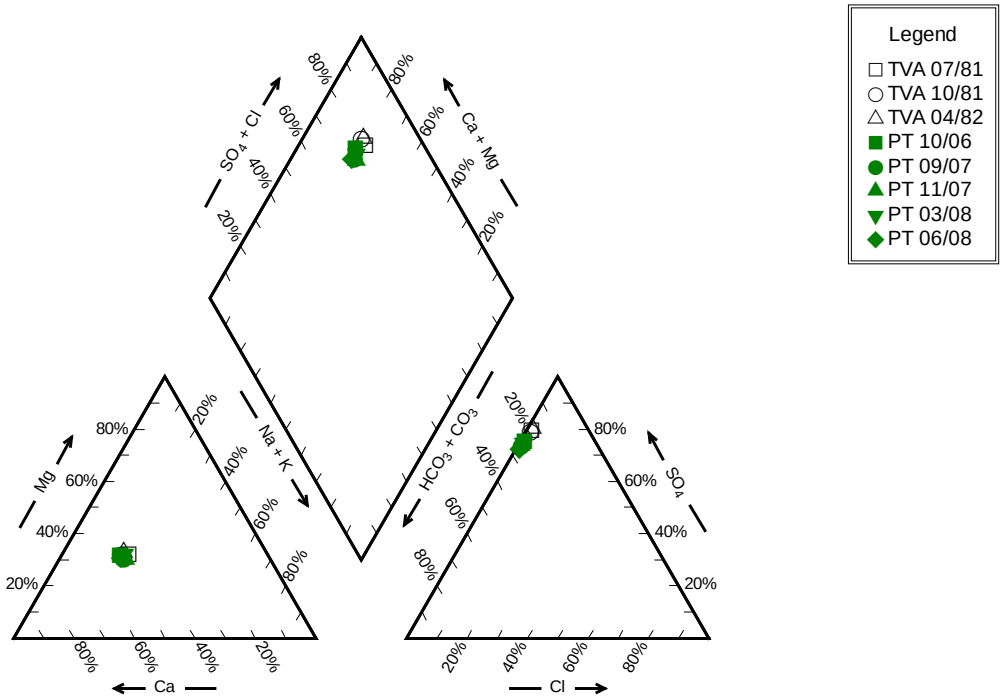


Figure 3.4-30: Piper Diagram of Historical and Current Data for Well 16

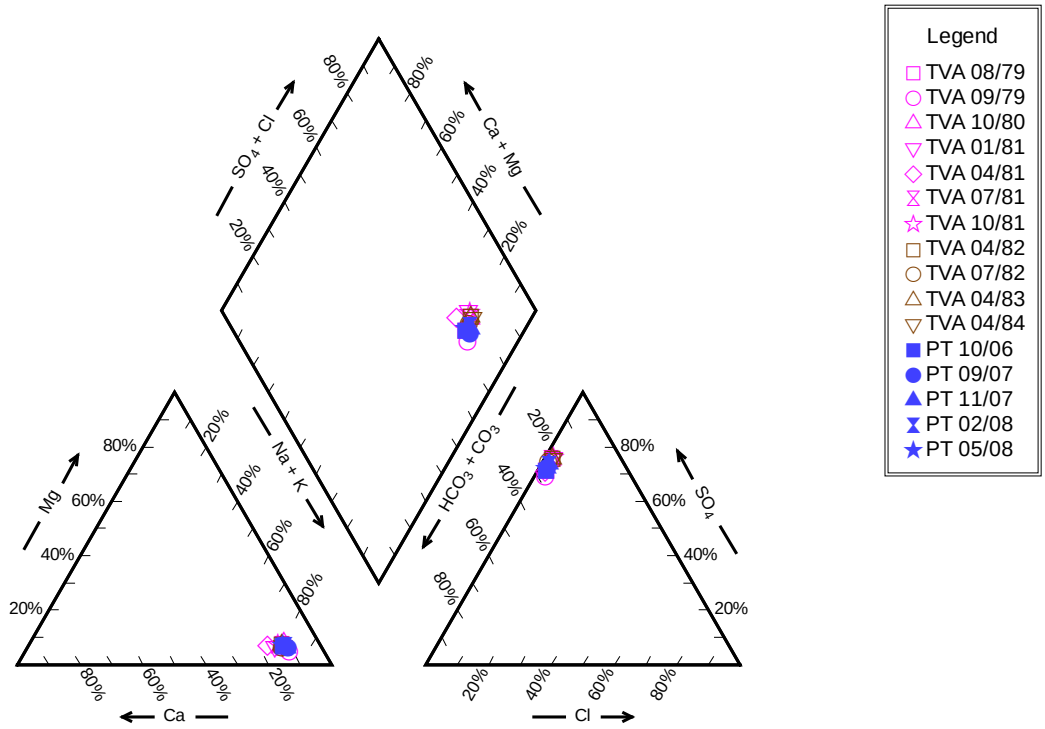


Figure 3.4-31: Piper Diagram of Historical and Current Data for Well 18

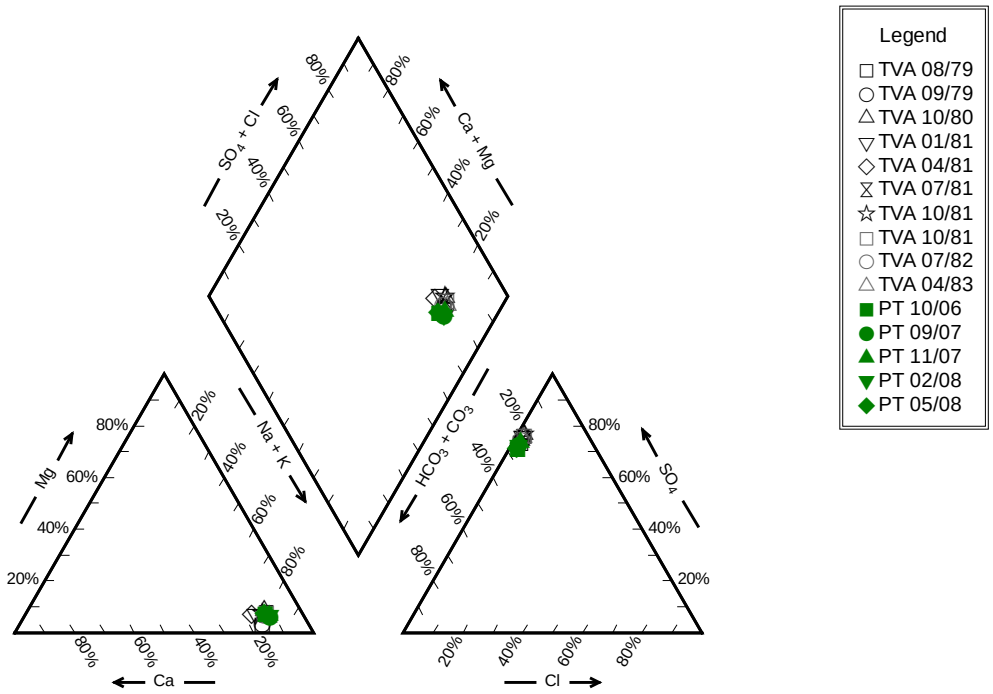


Figure 3.4-32: Piper Diagram of Historical and Current Data for Well 42

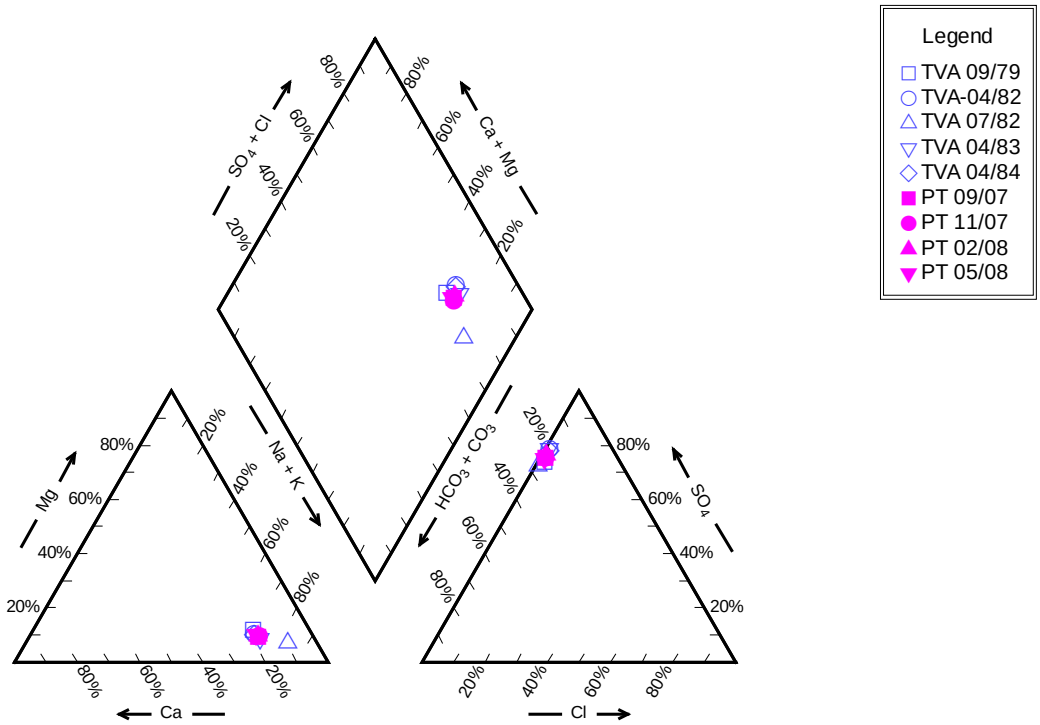


Figure 3.4-33: Piper Diagram of Historical and Current Data for Well 4002

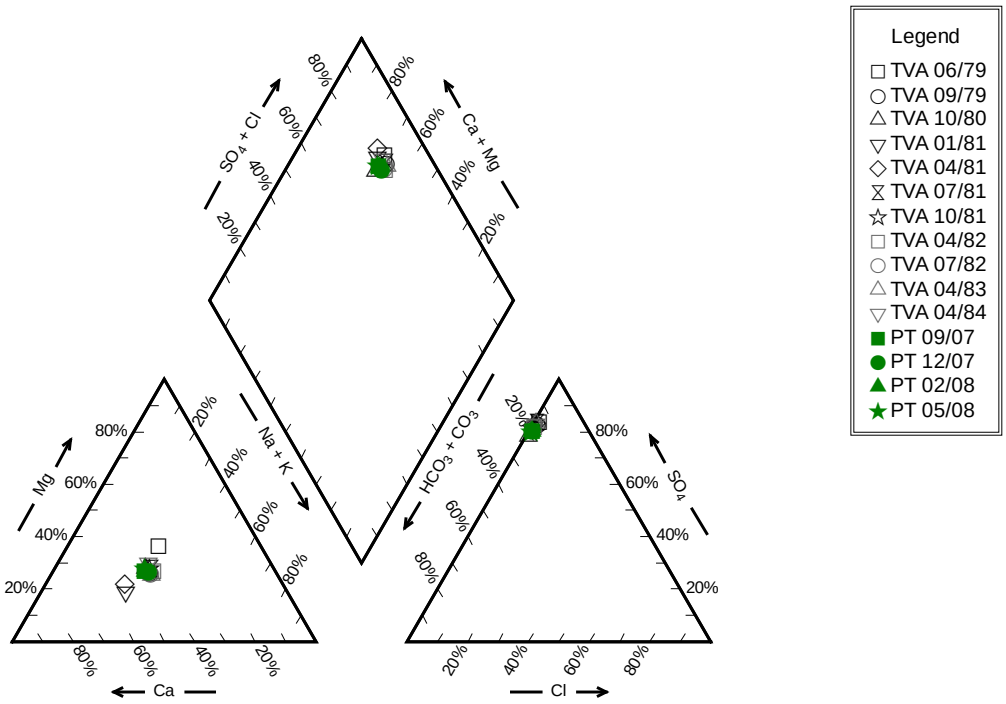


Figure 3.4-34 Piper Diagram of Historical and Current Data for Well 7002

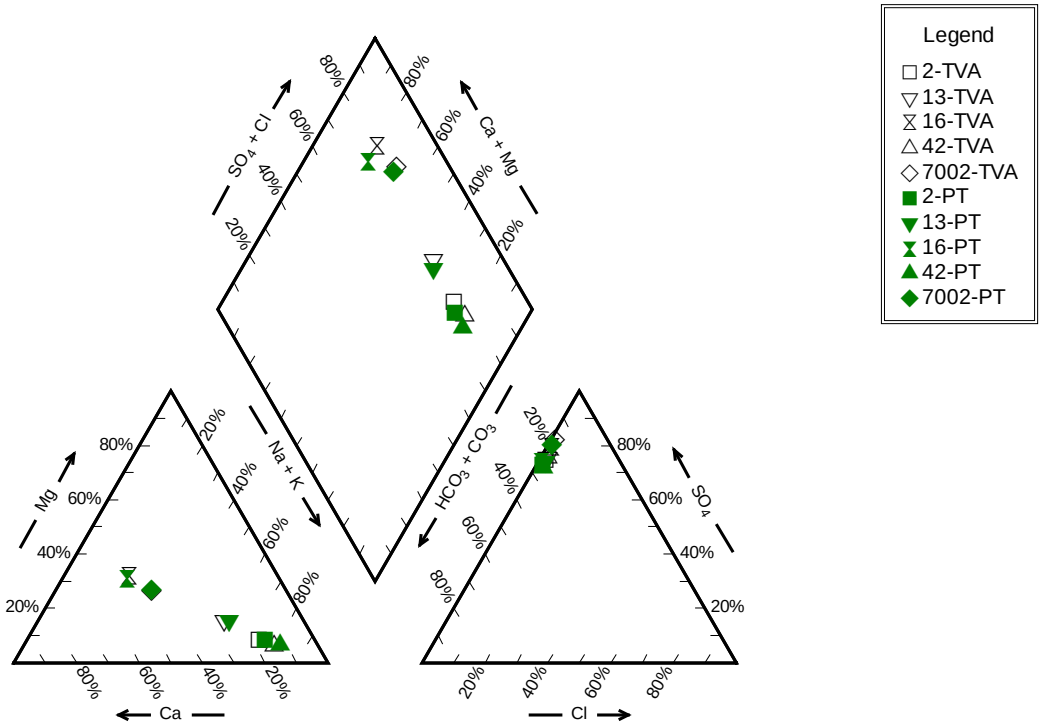


Figure 3.4-35: Piper Diagram of Historical and Current Data for Chilson Wells

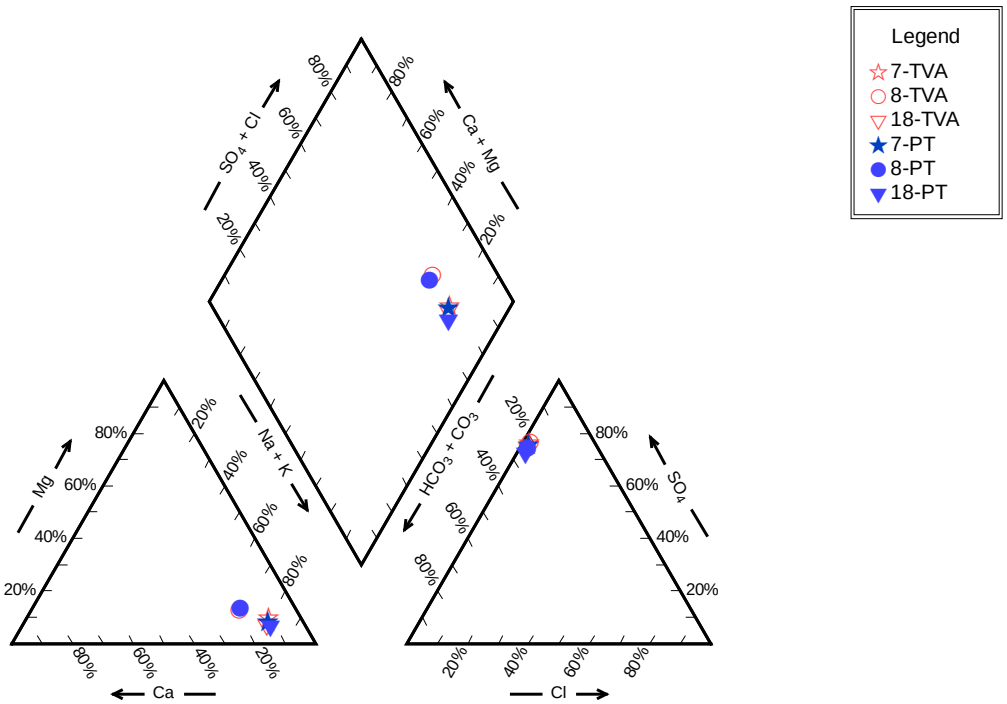


Figure 3.4-36: Piper Diagram of Historical and Current Data for Fall River Wells

potassium (K^+), calcium (Ca^{2+}), and magnesium (Mg^{2+}). Anions plotted include bicarbonate (HCO_3^-) plus carbonate (CO_3^{2-}), sulfate (SO_4^{2-}), and chloride (Cl^-). Each sample is represented by a point in each trilinear diagram. The quadrilateral field at the top of the Piper diagram is designed to show both anion and cation groups and is used to assign a general water type.

Figures 3.4-26 through 3.4-34 display the proportional concentrations of major ions symbolized by well. These diagrams illustrate that samples for each well generally form a cluster in each of the trilinear diagrams in each Piper diagram. Thus it can be said that major ion chemistry has remained consistent across TVA and Powertech (USA) samples and between historical and recent sampling periods.

Figures 3.4-35 and 3.4-36 display the proportional concentrations of average major ion concentrations grouped by formation. Figure 3.4-35 shows that major ion chemistry in the Chilson Member of the Lakota Formation has remained very consistent from historical TVA to recent Powertech (USA) sampling events. This anion chemistry is relatively consistent among various Chilson wells, with sulfate accounting for approximately 70 to 80% and bicarbonate approximately 20 to 30% of the anions. Cation chemistry varies among the Chilson wells. Wells 16 and 7002 cation concentrations were predominantly calcium, while sodium was dominant in the remaining wells. Distance from recharge areas is believed to be the main influence on water type, with wells located closer to the outcrop exhibiting relatively higher concentrations of calcium and magnesium, and wells farther from the outcrop exhibiting relatively higher concentrations of sodium.

Although a rigorous statistical analysis was not performed due to the sample size of the Powertech (USA) and TVA well chemistry data, the general water quality parameters in the aquifers has demonstrated consistency over time. Therefore, the Powertech (USA) data set can be supplemented with the previously collected TVA data to expand the knowledge of baseline water quality conditions and the time period of data collection from one to almost 30 years. Future monitoring is anticipated to demonstrate the continuing stability of water chemistry.

3.4.5 Spring Survey

Based on the extensive site investigations that have been undertaken by Powertech (USA) and others, there are no known natural springs within the permit area (see Section 3.4.2.2.3).

3.5 Surface Water

3.5.1 Regional Surface Water Hydrology

The permit area is approximately 16.5 mi^2 and lies in southwestern Custer County and northwestern Fall River County in South Dakota (Figure 3.5-1). Precipitation incorporates both rainfall and snow which can differ greatly based on elevation of the area and time of year. According to historical precipitation data, the upper elevations of the Black Hills can receive up to 24 inches annually, while most of the lower plains receive significantly less (Driscoll et al., 2002).

The permit area is in the Southern Black Hills, which includes two physiographic divisions that are characterized as the Black Hills and the Great Plains divisions. The Black Hills Division generally consists of steep formations of metamorphosed and intensely compacted sedimentary rocks, which form a perimeter around an intrusion of Precambrian igneous and crystalline rocks.

The sedimentary layers consist of aquifer formations that typically have high permeability, which allows for the transportation and storage of water. Aquifers are usually separated by an aquitard layer that restricts the vertical transport of water from one aquifer to the next. The aquifers generally receive a large amount of recharge from stream losses and infiltration. The infiltration rates can vary greatly due to variations in slope and soil and can have a significant impact on the base flow of natural streams (Driscoll et al., 2002).

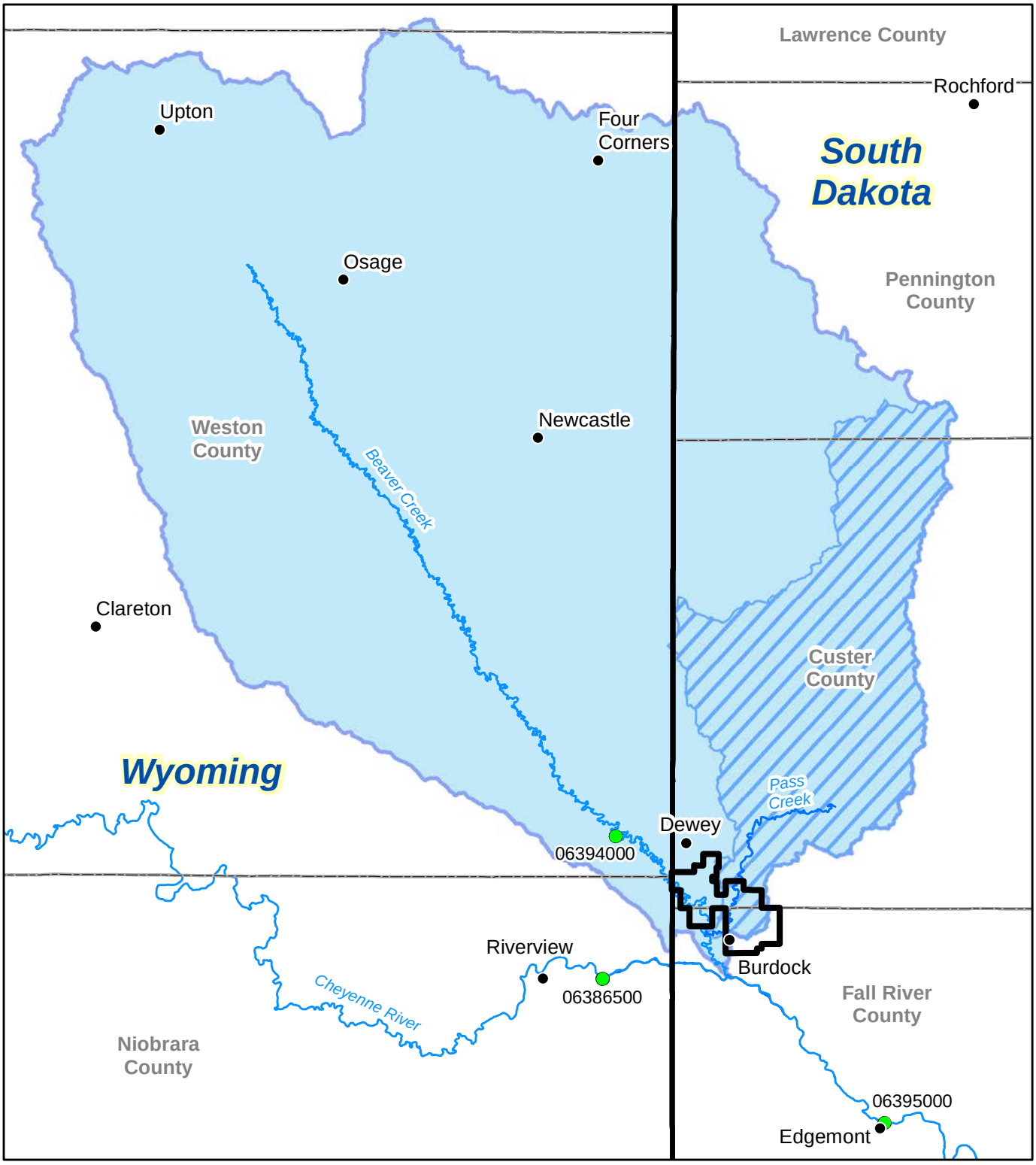
The Great Plains Division is characterized by relatively flat, rolling hills which are divided by low-sloping streams. The streams generally have well-developed natural drainage areas that flow primarily from northwest to southeast in this vicinity toward the east-flowing Cheyenne River.

3.5.2 Site Surface Water Hydrology

The local hydrology and surface water resources are described for the permit area and for the two main drainage systems that pass through the permit area (Beaver Creek and Pass Creek) (Figure 3.5-1).

3.5.2.1 Topography

The permit area is characterized by low to moderately sloping brush land with areas of moderately steep ridges. The elevation ranges from approximately 3,600 to 3,900 feet within the permit area. The slopes range from 0 to 92 percent, with an average slope of nearly 6 percent.



This figure is provided to fulfill the requirements of ARSD 74:29:02:11(3).

Legend

- Towns
- County Boundaries
- Permit Boundary
- Rivers and Streams
- Beaver Creek Watershed
- Pass Creek Sub-Watershed
- USGS Streamflow Gaging Station

Miles: 0 4 8
Kilometers: 0 5 10 15

N

Figure 3.5-1

Regional Map of the Beaver Creek Basin and Pass Creek Subbasin

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	14-Sep-2012
FILE	CreekBasins.mxd

POWERTECH (USA) INC.

The average slope in the vicinity of the proposed CPP and satellite facility are each approximately 3 percent. The premine topography is presented on Figure 3.1-1 and Plates 5.3-1 and 5.3-2.

3.5.2.2 Drainage Basins

The permit area lies primarily within the Beaver Creek Basin and is drained by both Beaver Creek and Pass Creek. The Pass Creek watershed is a subbasin within the Beaver Creek basin, but the two watersheds were characterized as separate basins. The Beaver Creek system flows through the northwestern section of the permit area from the northwest to the southeast. The Pass Creek system flows south through the central portion of the permit area and joins Beaver Creek south of the permit area. Three miles south of this confluence, Beaver Creek converges with the Cheyenne River (Figure 3.5-1), which eventually flows into the Missouri River.

The nearest stream gage on the Cheyenne River upstream of its confluence with Beaver Creek is USGS gage 06386500 near Spencer, WY. The nearest stream gage downstream of the confluence of Beaver Creek and the Cheyenne River is USGS gage 06395000 at Edgemont. This gage captures the contribution of flow to the Cheyenne River from Beaver Creek and Pass Creek between Spencer, WY and Edgemont, SD. Figure 3.5-2 shows an annual hydrograph for gage 06386500 from 1948 to 2008, and Figure 3.5-3 shows an annual hydrograph for gage 06395000 from 1903 to 2008. The lines in Figures 3.5-2 and 3.5-3 indicate the upper bound flow values for the 25th, 50th, and 95th flow percentiles for each of the 365 days per year. For example (in Figure 3.5-3), based on all of the January 1st flow values during 1903 to 2008 (106 data points), the flow was less than 1 cfs on 25 percent of those days (26 days), less than 4 cfs on 50 percent of those days (53 days) and less than 30 cfs on 95 percent of those days (101 days). Therefore, the graphs indicate how variable the stream flow tends to be at various times during the year (e.g., more variable during a typical July than a typical November).

3.5.2.2.1 Beaver Creek Basin

The Beaver Creek Basin is 1,360 square miles, excluding the Pass Creek subbasin. It extends from a few miles northwest of Upton, WY to about 8 miles southeast of Dewey, SD and lies within Weston, Niobrara and Crook counties in Wyoming, and within Pennington, Custer and Fall River counties in South Dakota. Beaver Creek is a perennial stream with ephemeral tributaries. Discharge data for Beaver Creek are collected at USGS gage 06394000 near Newcastle, WY (Figure 3.5-1). Figure 3.5-4 shows an annual hydrograph with the 25th, 50th and 95th flow percentiles for this gage from 1944 to 1998. Figure 3.5-5 shows monthly average flow

data for this gage from 1944 to 1998. The box plot also shows the minimum, maximum, lower quartile and upper quartile values for each month.

3.5.2.2.2 Pass Creek Watershed

The Pass Creek watershed, characterized as a subbasin of the larger Beaver Creek Basin, comprises most of the east-southeast portion of the Beaver Creek Basin and is almost fully contained in South Dakota. The Pass Creek watershed is 230 square miles and is located in Custer, Fall River, and Pennington counties in South Dakota and a very small portion of Weston County in Wyoming. Pass Creek is dry except for brief periods of runoff following major storms and snowmelt. There is no permanent stream flow gage stationed along Pass Creek.

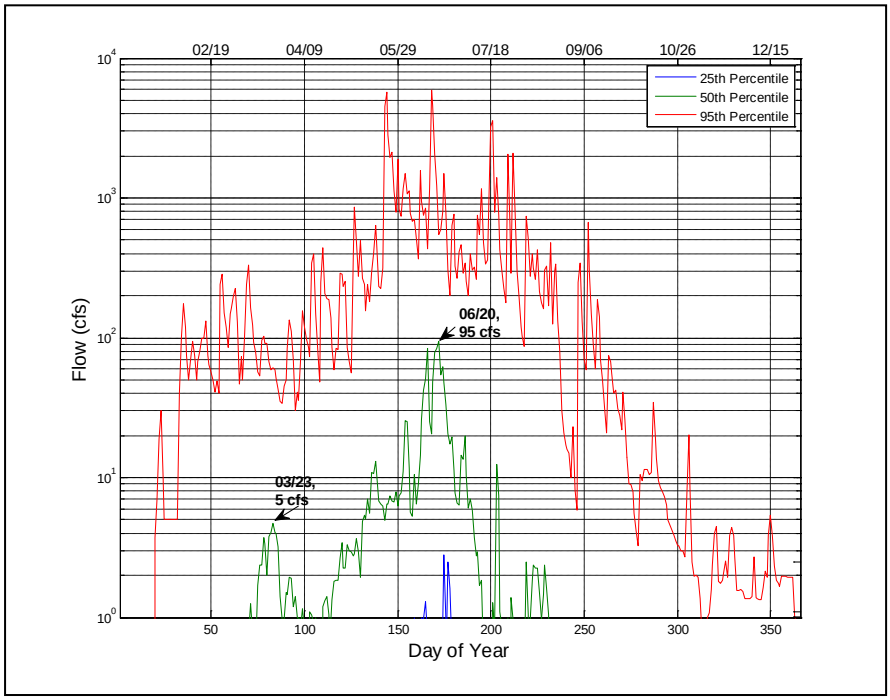


Figure 3.5-2: Annual Hydrograph for USGS Gage 06386500 on the Cheyenne River near Spencer, WY from 1948 to 2008

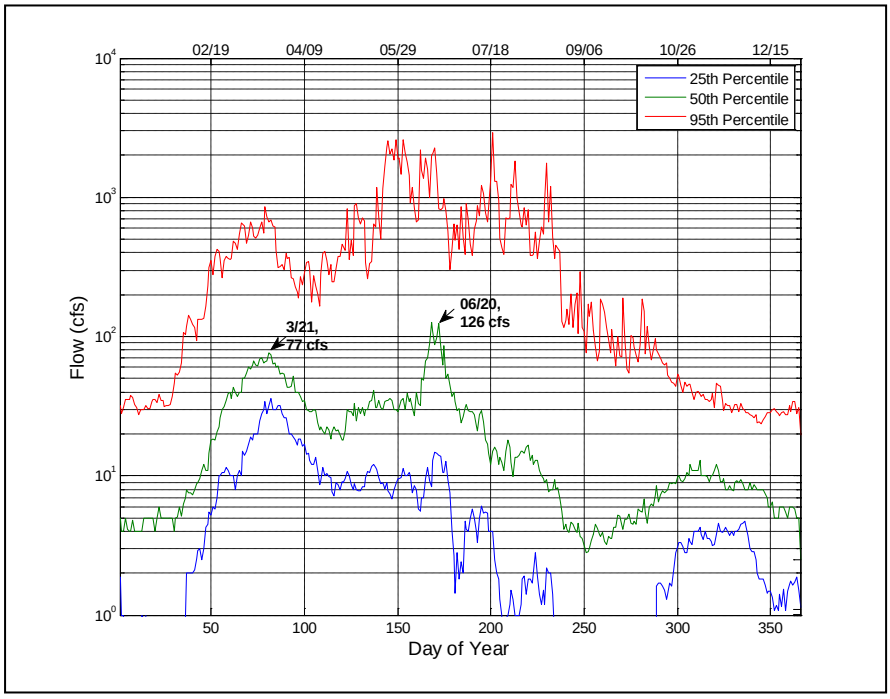


Figure 3.5-3: Annual Hydrograph for USGS Gage 06395000 on the Cheyenne River at Edgemont, SD from 1903 to 2008

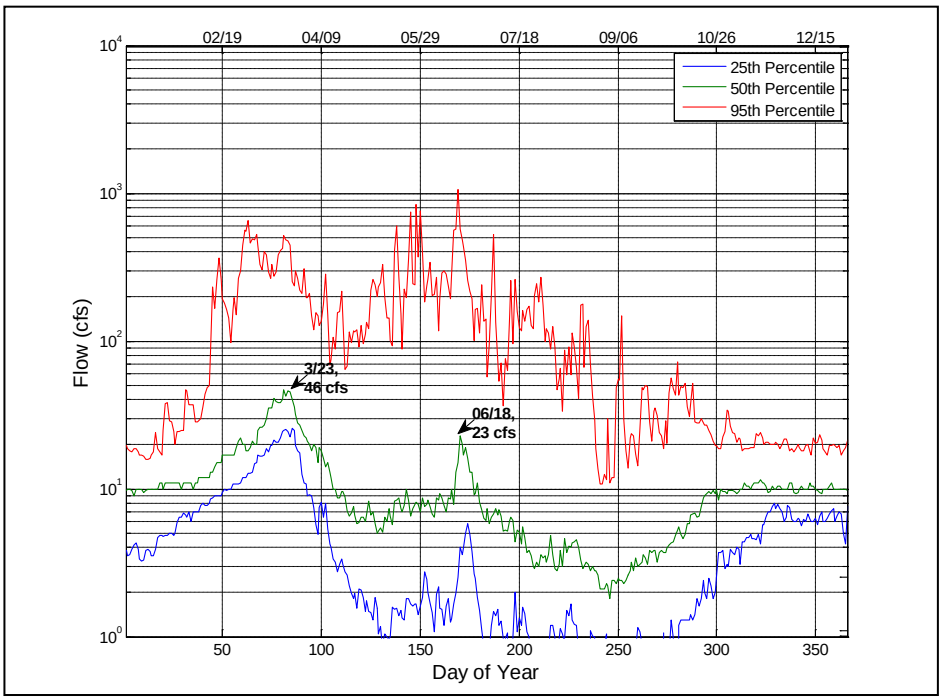


Figure 3.5-4: Annual Hydrograph for USGS Gage 06394000 on Beaver Creek near Newcastle, WY from 1944 to 1998

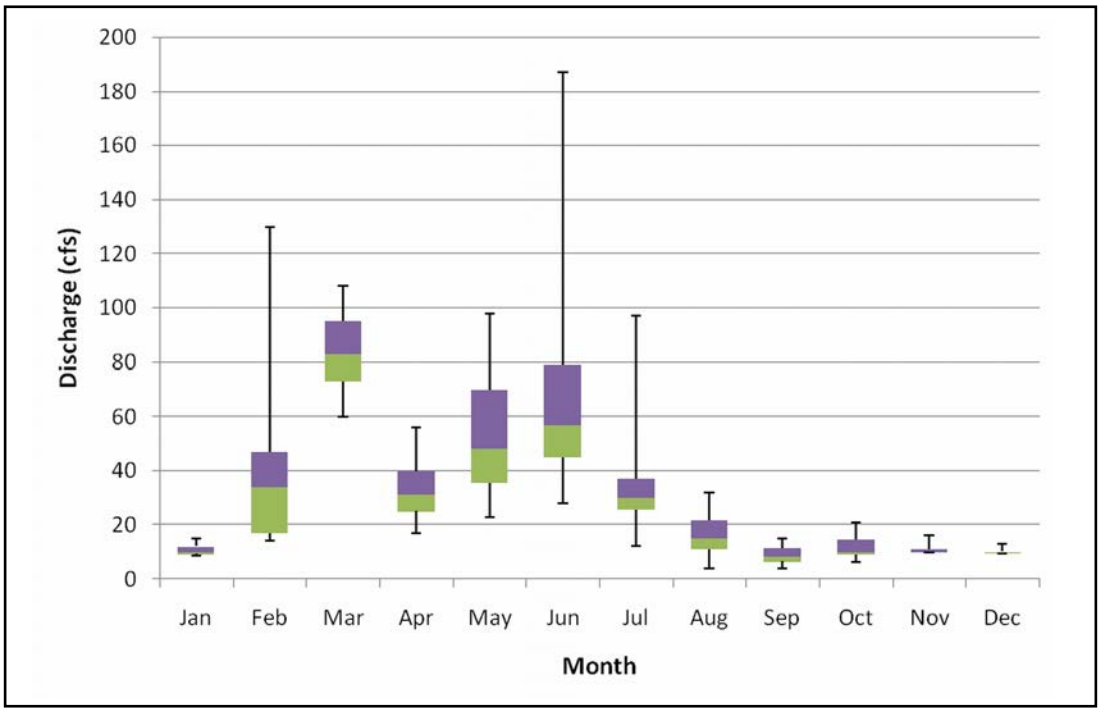


Figure 3.5-5: Monthly Average Flows at USGS Gage 06394000 on Beaver Creek near Newcastle, WY from 1944 to 1998

3.5.2.2.3 Permit Area

The northwestern portion of the permit area drains to Beaver Creek and ephemeral tributaries. The north-central and east-central portions of the permit area drain via Pass Creek and smaller, ephemeral tributaries. The southeastern portion of the permit area drains into the Cheyenne River through Bennett Canyon. The permit area contains many ephemeral streams and drainage channels, particularly in the eastern portion, that are typically dry. Stream flow only occurs in these channels after significant precipitation or snowmelt events.

The inventory of surface water impoundments within and adjacent to the permit area is provided in the surface water quality discussion in Section 3.5.4. These include stock dams and historical mine pits. Many of the impoundments contain water only temporarily following precipitation events or snowmelt. As described in Section 3.4.2.2.3, extensive site investigations undertaken by Powertech (USA) and others have revealed no known natural springs within the permit area.

3.5.2.2.4 Proximity of Surface Water Features to Proposed ISR Facilities

Beaver Creek is the primary surface water resource in the permit area. Pass Creek is a secondary surface water resource in the permit area, since it is dry except during infrequent runoff or snowmelt events. The remaining surface water resources in the permit area are small, ephemeral stream channels and small impoundments.

Section 5.3.9 describes the construction of ISR facilities in relation to surface water features. Where possible, facilities will be located out of the 100-year flood inundation boundaries. Facilities which must be located within such boundaries will be protected from flood damage by the use of straw bales, collector ditches, and/or berms.

3.5.2.3 Surface Water Hydrologic Analysis

3.5.2.3.1 General Approach

The potential for flood or erosion damage in the permit area was evaluated by developing a design flood using statistical methods and a computer model for watershed hydrology. Peak discharge of the design flood was then transformed to a water level using a computer model for stream hydraulics. This approach provides a floodplain map that shows the maximum area inundated by the design flood, as well as detailed information on the depth and velocity of flood water at points of interest in the study area. The 100-year event was used for the design flood, along with a much less likely flood referred to as an upper-bound flow or an extreme flow.

The 100-year event represents an appropriate level of risk for the evaluation of flood potential near the permit area facilities. The extreme flow event was used to demonstrate the additional extent of land that would be inundated between the 100-year event and floods that have an extremely low probability of occurring. The uncertainty in the analysis and the flood potential at various locations in the permit area are evident when the two scenarios are compared. If a floodplain map shows a small increase in the area of land inundated by the 100-year and the extreme flows, compared to the distance and elevation difference between the edge of the 100-year floodplain and the nearest structure of concern, then the risk analysis is robust and the potential for flood damage to the nearest structure is extremely low. However, if a floodplain map shows a large increase in the area of land inundated between the 100-year and the extreme flows, compared to the distance and elevation difference between the edge of the 100-year floodplain and the nearest structure of concern, then the risk analysis may be too sensitive to the design event selected (i.e., the 100-year flood) and the potential for a flood to damage the nearest structure could be too high. This approach avoids attempts to quantify the 500-year or 1,000-year flood event, for example, which involves significant uncertainty because the time period of the observed hydrologic data is too short for such a long return period.

The 100-year flows were developed using hydrologic analyses for Beaver Creek, Pass Creek and ephemeral tributaries. These flows were then transformed to maximum water levels using a stream channel hydraulic model. Upper-bound flows, or extreme flows, were developed for Beaver Creek and Pass Creek and used for comparison with the 100-year event. Floodplain maps showing the proximity of primary facility zones to the maximum level of floodwater were generated for each scenario.

3.5.2.3.2 Hydrologic Analysis – Beaver Creek

USGS gage 06394000 is located along Beaver Creek near the permit area (Figure 3.5-1). Statistical methods were used to estimate the design flows. Three software programs were used: National Flood Frequency (NFF) Program 3.2 (Ries and Crouse, 2002), PKFQWin 5.0 (Flynn et al., 2006), and a Matlab Flood Frequency Analysis program (Rao and Hamed, 2000).

The NFF program uses sub-watershed areas, geographical information, and precipitation averages to estimate flood events based on regional regression analyses. The PKFQWin and Matlab programs use the 55 years of historical peak flow at gage 06394000 to estimate flood events. The NFF and PKFQWin methods compute estimated floods ranging from 2- to 500-year frequencies. Beyond that range, a fourth-order polynomial trend line was used to estimate an extreme condition flood with a relative return period of approximately 500 years to 1,500 years.

The sub-watershed areas required by the NFF program were established using ArcHydro 9.2, a GIS watershed delineation tool. The watershed boundaries were in Regions Two (Central Basin and Northern Plains) and Four (Eastern Mountains). Watershed areas for these regions are 971 and 387 square miles, respectively. The analysis for Region Four also required values for mean March precipitation (1.05 inches) – obtained from the National Oceanic and Atmospheric Administration (NOAA) – and latitude of the basin outlet (43.6 degrees north). The discharge results from the NFF program with return periods ranging from 2 to 500 years are given in Figure 3.5-6. The figure also shows the fourth-order polynomial trend line used to extrapolate the NFF results to an extreme condition flood. The flood estimates from the NFF approach are listed in Table 3.5-1.

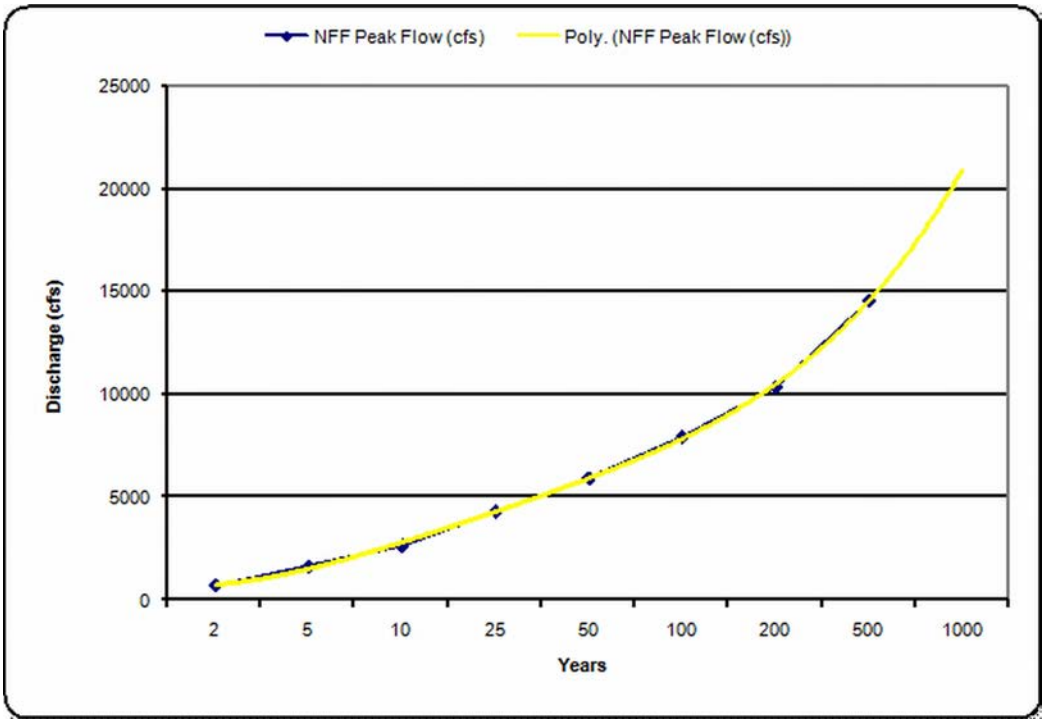
The Matlab program used seven distributions to analyze the historical peak flows. The program ran a test hypothesis on the estimated flood events using the Klomo-Smirnov and Chi-squared procedures. Of the seven distributions, the Klomo-Smirnov method was accepted for the Log Pearson Type III distribution. The flood estimates from the Matlab programs are shown in Table 3.5-2.

PKFQWin used a Pearson Type III distribution with a weighted and generalized skew, and computed slightly higher results than the NFF program. The PKFQWin results are shown in Table 3.5-3.

The flood estimates for Beaver Creek are summarized in Table 3.5-4. The final flow values selected for the floodplain analysis of Beaver Creek were 7,990 cfs and 23,000 cfs, representing the 100-year and extreme condition floods, respectively. These values were chosen because they represent the most conservative design flow estimates.

3.5.2.3.3 Hydrologic Analysis – Pass Creek

There are no gage sites along Pass Creek or its tributaries (Hell Canyon, West Hell Canyon, Sourdough Draw, and Tepee Canyon) to provide accurate flow data. To obtain design flow values for the stream channel of Pass Creek within the permit area, a rainfall runoff model was used along with design rainfall to generate stream flows with a range of exceedance probabilities. The 100-year event was used as the primary condition for evaluating the risk of flooding and erosion in the Pass Creek area. An upper bound or extreme condition was represented by 50 percent of an estimated probable maximum flood, for comparison with the 100-year event.



Note: Obtained from the NFF program and extrapolated with a 4th order polynomial trend-line to estimate an extreme condition flood.

Figure 3.5-6: Beaver Creek Flood Estimates

Table 3.5-1: NFF Flood Estimate Results for Beaver Creek

Recurrence Interval (years)	Peak Flow (cfs)
2	700
5	1,660
10	2,640
25	4,320
50	5,930
100	7,950
200	10,400
500	14,600
Extreme Condition	22,000

Table 3.5-2: Matlab Flood Estimate Results for Beaver Creek

Recurrence Interval (years)	Peak Flow (cfs)
100	6,570
200	7,910
Extreme Condition	11,500

Table 3.5-3: PKFQWin Flood Estimate Results for Beaver Creek

Recurrence Interval (years)	Weighted Peak Flow (cfs)	Generalized Peak Flow (cfs)
5	1,840	1,870
10	2,750	2,700
25	4,340	4,070
50	5,940	5,350
100	7,980	6,870
200	10,560	8,680
500	15,030	11,600
Extreme Condition	23,000	17,000

Table 3.5-4: Summary Flood Estimate for Beaver Creek

Recurrence Interval (years)	PKFQWin Estimate (cfs)	NFF Estimate (cfs)	MATLAB Estimate (cfs)
100	7,990	7,950	6,570
Extreme Condition	23,000	22,000	11,500

The Hydrologic Modeling System (HEC-HMS) is designed to simulate the precipitation-runoff processes of dendritic watershed systems. The Geospatial Hydrologic Modeling Extension (HEC-GeoHMS) is a software package for use with ArcGIS. HEC-GeoHMS analyzes digital terrain information and transforms the drainage paths and watershed boundaries into a hydrologic data structure that represents the watershed response to precipitation.

In order to use the HEC-HMS model a high resolution DEM was developed. Contour data from the USGS 1:24,000 topographic maps were used with ArcGIS to create a grid of elevation data. Plotting stream elevation values against distance downstream indicated that adjacent stream vertices were within 2 feet of each other, providing good accuracy for this type of analysis.

The HEC-GeoHMS basin model of the Pass Creek watershed was imported into HEC-HMS and the meteorological models and control specifications were created. The 100-year/24-hour storm and the probable maximum precipitation (PMP) were used as the driving precipitation events. Estimates for the 100-year/24-hour storm were obtained from the national depth-duration-frequency maps (U.S. Department of Commerce) (Table 3.5-5). The PMP estimate was obtained from HMR-51 depth-area-duration maps (Schreiner and Riedel, 1978) (Table 3.5-6). The comprehensive approach of HMR-52 (Hansen et al., 1982) for developing a probable maximum flood (PMF) was not used. Instead, a simplified approach was developed using the PMP estimate as with conventional rainfall runoff modeling techniques. The resulting flood is therefore referred to as an estimated probable maximum flood (estimated PMF) and represents an appropriate extreme event for comparison with the 100-year event. Figure 3.5-7 shows a graphical representation of the PMP estimates for the Pass Creek watershed's geographical location. The depths and durations for the PMP on the Pass Creek watershed are shown in Table 3.5-7.

Two control specifications (time periods used to capture the response of a watershed from a precipitation event) were created for the HEC-HMS model of the Pass Creek watershed. The first used a 4-day duration with 15-minute time intervals for the 100-year/24-hour storm, and the second used a 7-day duration with 6-hour time intervals for the PMP.

The loss and transform methods used in the HEC-HMS model of the Pass Creek watershed were the SCS Curve Number and SCS Unit Hydrograph, respectively. Both of these methods rely heavily on a curve number (CN) which is a characterization of soil type, land use and cover, and antecedent soil moisture. These parameters were estimated based on a field inspection of the Pass Creek watershed on May 21, 2008, on the Soil Survey Geographic (SSURGO) Database

Table 3.5-5: Depth-Duration Data for the 100-Year Storm Event

Duration	Depth (in)
5 min	0.79
15 min	1.58
60 min	2.50
2 hour	3.00
3 hour	3.20
6 hour	3.60
12 hour	4.10
24 hour	4.80

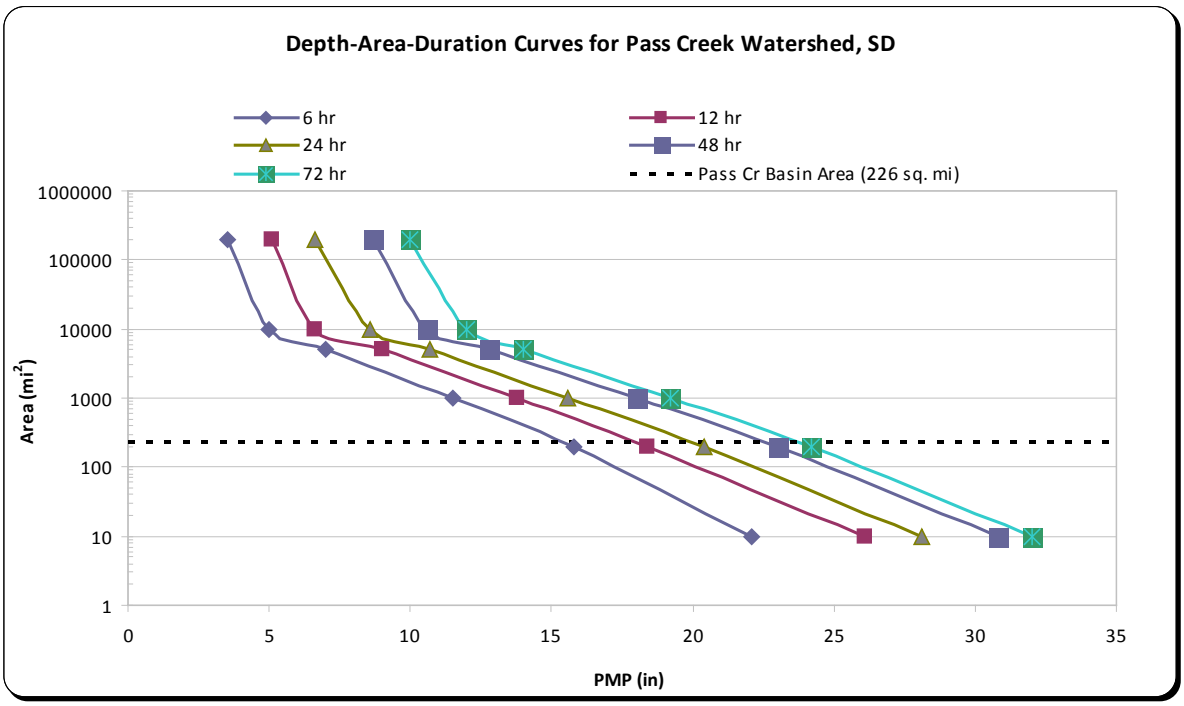
Table 3.5-6: Probable Maximum Precipitation (PMP)

Area (mi^2)	Duration (hr)				
	6	12	24	48	72
10	22.1	26.1	28.1	30.8	32
200	15.8	18.4	20.4	23	24.2
1,000	11.5	13.8	15.6	18	19.2
5,000	7	9	10.7	12.8	14
10,000	5	6.6	8.6	10.6	12
200,000	3.5	5.1	6.6	8.7	10

Source: HMR-51 (Schreiner and Riedel, 1978)
Note: Data in inches

Table 3.5-7: Interpolated Estimates for the Probable Maximum Precipitation (PMP) for the Pass Creek Watershed

Area (mi^2)	Duration (hr)				
	6	12	24	48	72
226	15.7	18.3	20.2	22.8	24.0



Source: developed from PMP estimates obtained from HMR-51 (Schreiner and Riedel, 1978)

Figure 3.5-7: Depth-Area-Duration Curves for the Pass Creek Watershed

and on county land use data. Parameters for the loss and transform methods include CN, storage (S), initial abstraction (I_a) and lag time (t_l).

Curve numbers were assigned to different sub-watershed sectors, and area-weighted CNs were developed for the entire Pass Creek watershed for standard conditions (CN = 57) and for conservative conditions (CN = 63). An impervious area of 5 percent also was estimated based on field investigations. The CN of 63 was used in the model, providing a conservative approach because the higher CN would result in a larger percentage of rainfall becoming runoff.

The parameter values used in the loss and transform methods of the model were a CN of 63, S equal to 5.87 inches, I_a of 1.18 inches and t_l equal to about 1,231 minutes. The values of S, I_a and t_l are based on the CN in that their values are heavily influenced by the value of the CN.

The output results for both precipitation events in the HEC-HMS model of the Pass Creek watershed are shown in Table 3.5-8. Due to the extreme condition represented by the PMP meteorological model, the estimated PMF was reduced by a factor of 0.5. This resulted in a 50 percent estimated PMF peak discharge of approximately 32,800 cfs.

The final flow values used for input to the HEC-RAS model of Pass Creek were 5,620 cfs and 32,800 cfs, representing the 100-year and extreme condition floods, respectively. These flow values resulted from a conservative approach to parameter estimation and modeling. The model used the higher CN and a single basin versus many smaller subbasins with routing. This combination results in a larger instantaneous peak flow entering the stream channel of Pass Creek within the permit area. The extreme condition flood is included only to illustrate the extent of the floodplain during an extremely low probability flood event and its relation to the primary facility zones. The estimated PMF and 50 percent of the estimated PMF are extremely rare events and represent conditions much more severe than the design scenarios discussed in NRC regulatory guidance (e.g., NUREG-1569) for uranium ISR facilities.

3.5.2.3.4 Floodplain Analysis – Beaver Creek and Pass Creek

The stream channels of both Beaver Creek and Pass Creek within the permit area were modeled using the Hydraulic Engineering Center River Analysis System (HEC-RAS) and the Geospatial River Analysis Extension (HEC-GeoRAS) to determine the spatial representation of the floodplains resulting from the simulated 100-year flood and extreme condition flood. HEC-RAS software simulates one-dimensional steady and unsteady river hydraulics. The system can

Table 3.5-8: Discharge Results for the Single Basin Model of the Pass Creek Watershed

Event	Peak Discharge (cfs)
100-year, 24-hour	5,620
Estimated PMF	65,600
50% Estimated PMF	32,800

handle a full network of channels, a dendritic system, or a single river reach. HEC-RAS is capable of modeling subcritical, supercritical, and mixed flow regime water surface profiles.

HEC-GeoRAS is a set of ArcGIS tools specifically designed to process geospatial data for use with HEC-RAS. The extension enables efficient creation of a HEC-RAS import file containing geometric data from an existing digital terrain model (DTM) and a National Hydrography Dataset (NHD) flowlines shapefile. Results exported from HEC-RAS may also be processed using HEC-GeoRAS to create layers and floodplain maps in ArcMap.

The HEC-RAS model is based largely on a framework of geometric data which provides a representation of the physical characteristics of a river. For both Beaver Creek and Pass Creek, HEC-GeoRAS was used to extract the necessary elevation and geometric data for the channel and floodplain from the same DEM developed for the HEC-HMS analysis. The process for each creek was nearly the same except for the extra details required to characterize the two bridges spanning Pass Creek just downstream of the southern portion of the permit area. The road and railroad bridges had the potential to cause backwater effects and were therefore included in the Pass Creek analysis though they were outside of the permit area. The geometry and elevation data of both bridges were measured on April 12, 2008.

The geometry files generated with HEC-GeoRAS in ArcGIS were imported into HEC-RAS and inspected for completeness. For each creek, ineffective flow areas were added where necessary and Manning's n values were assigned for the left overbank, the channel, and the right overbank. Conservative Manning's n values were established during a field inspection of the Beaver Creek and Pass Creek channels within the permit area on May 21, 2008 (Table 3.5-9). Photos E and F, taken during the site inspection, show Beaver Creek and Pass Creek stream channels along with their floodplains.

Data entry for the bridges in the downstream section of Pass Creek was manually performed. Low-flow calculation methods for the road bridge and railroad bridge included the energy and momentum methods. Pressure and weir methods were used for high flow computation of the road bridge while energy only was used for the railroad bridge.

Two steady-flow profiles were created for each creek: the 100-year flood and the extreme condition flood (a 500-year to 1500-year flood for Beaver Creek and 50 percent of the estimated PMF for Pass Creek). Flow estimates generated from PKFQWin and HEC-HMS were entered

Table 3.5-9: Manning's n Values for the Beaver Creek and Pass Creek Channels

Creek	Manning's n Value		
	Left Overbank	Channel	Right Overbank
Beaver Creek, upstream	0.060	0.045	0.060
Beaver Creek, downstream	0.053	0.040	0.053
Pass Creek	0.065	0.050	0.065

Note: based on field observations

Note: location is in the northern extent of the permit area along the South Dewey Road, looking west

Photo E: Beaver Creek Stream Channel and Floodplain

Note: location is in the southwest extent of the permit area, just east of the confluence with Beaver Creek. Photo taken from the road bridge along South Dewey Road, looking east.

Photo F: Pass Creek Stream Channel and Floodplain

for each profile of Beaver Creek and Pass Creek, respectively. Downstream boundary conditions used normal depth with updated slopes of the energy grade lines.

Floodplain Analysis – Results

The HEC-RAS analysis involved an iterative procedure of creating a model run – based on an input geometry file and a steady flow profile(s) – and reviewing output summary tables and warning and error messages. From this process, the geometry file was revised multiple times by adding cross sections to adequately balance the energy losses throughout the model for each creek.

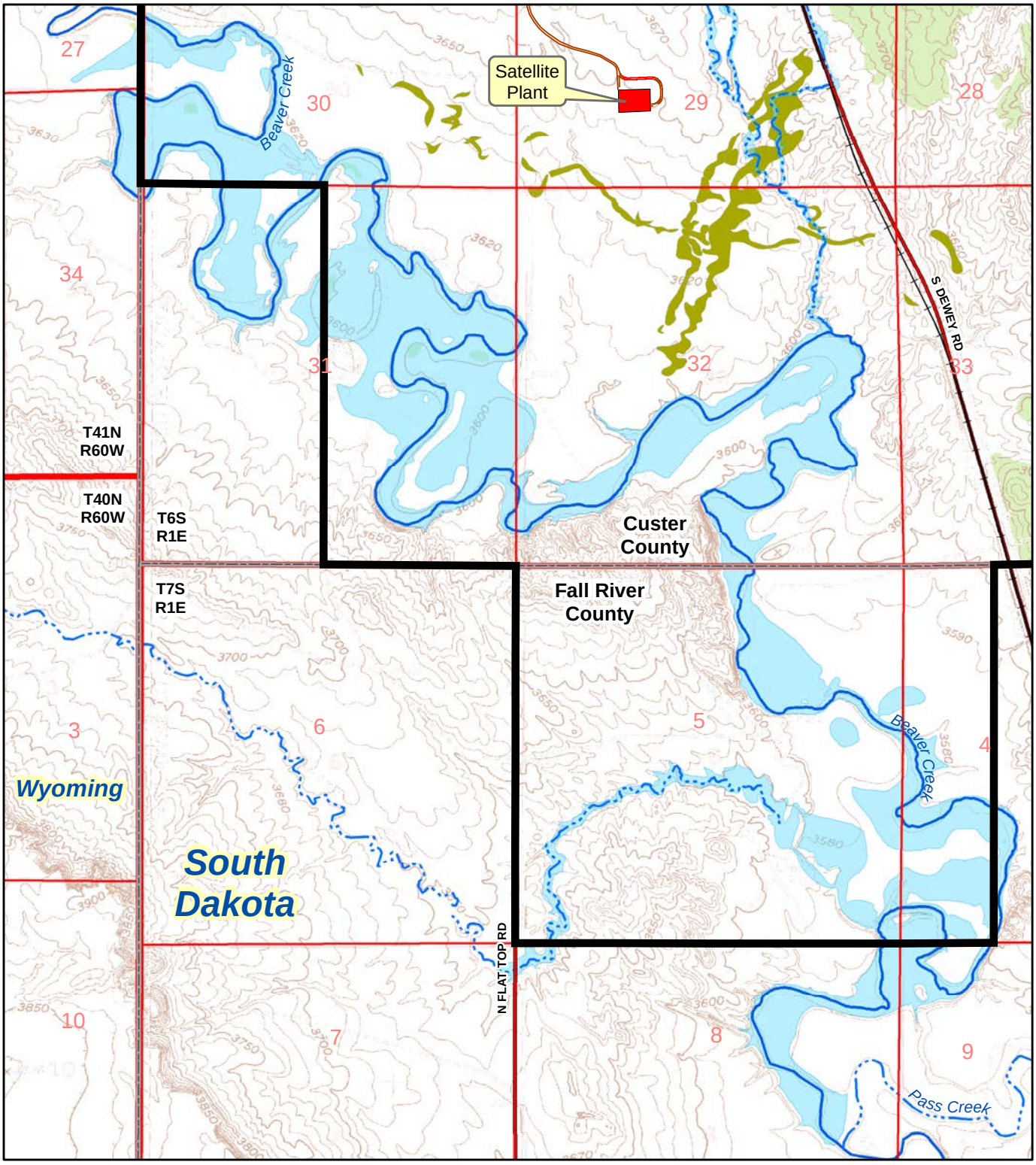
The final model results for the spatial representation of the 100-year floodplains for Beaver Creek and Pass Creek within the permit area are shown in Figures 3.5-8 and 3.5-9, respectively. These figures also depict the modeled 100-year flood inundation areas for ephemeral tributaries within the permit area as described in Section 3.5.2.3.5. Section 5.3.9 discusses the location of proposed facilities and potential well field areas in relation to the modeled 100-year flood inundation areas.

The final model results for the spatial representation of the extreme condition floodplains for Beaver Creek and Pass Creek within the permit area are shown in Figures 3.5-10 and 3.5-11, respectively. The figures indicate the relationship of the maximum extent of the extreme condition floodplain to the locations of the primary facility zones and the known ore bodies. The sole purpose of including the extreme condition flood in the analysis for flood and erosion potential is to illustrate that there is very little additional land area inundated by the extreme condition floods compared to the 100-year floods. The risk of flood or erosion damage to the permit area facilities from Beaver and Pass Creeks is extremely low.

The inundation maps of Pass Creek indicate that one known ore body in Section 34, T6S, R1E would become inundated during a 100-year or extreme flood event. It is estimated that the water depth would be 15 feet for the 100-year flood and approximately 25 feet for the extreme condition flood.

3.5.2.3.5 Flooding and Erosion in Local Drainages

Smaller ephemeral drainages within the permit area were modeled to evaluate potential for flooding. Model results are included in Appendix 3.5-A. As described in this appendix, HEC-HMS models were used to calculate peak discharges for various storm events for the drainages within the permit area, and HEC-RAS models were used to predict the 100-year flood inundation



This figure is provided to fulfill the requirements of ARSD 74:29:02:11(3).

Legend

- Permit Boundary
- Ore Bodies
- Access Roads
- BNSF Railroad
- Ephemeral Streams
- Perennial Streams
- 100-year Flood Boundary

Feet: 0, 1,000, 2,000, 4,000

Meters: 0, 500, 1,000

N

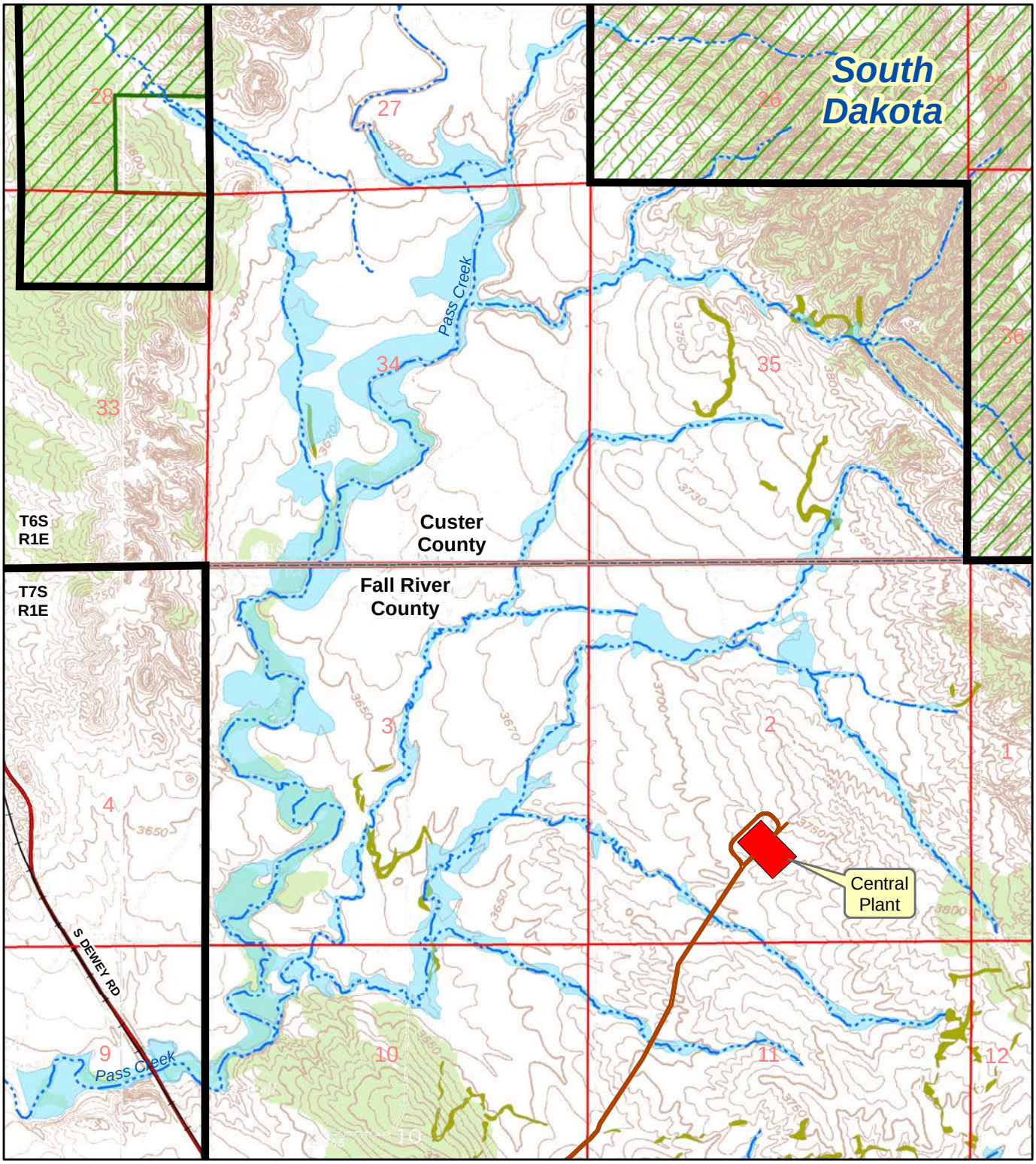
Figure 3.5-8

100-Year Inundation Map for Beaver Creek and Tributaries

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	14-Sep-2012
FILE	Flood100-BeaverCr.mxd

POWERTECH (USA) INC.



This figure is provided to fulfill the requirements of ARSD 74:29:02:11(3).

Legend

- Permit Boundary
- Ore Bodies
- Access Roads
- BNSF Railroad
- Ephemeral Streams
- Perennial Streams
- 100-year Flood Boundary

Feet
0 1,000 2,000 4,000
0 500 1,000
Meters

N

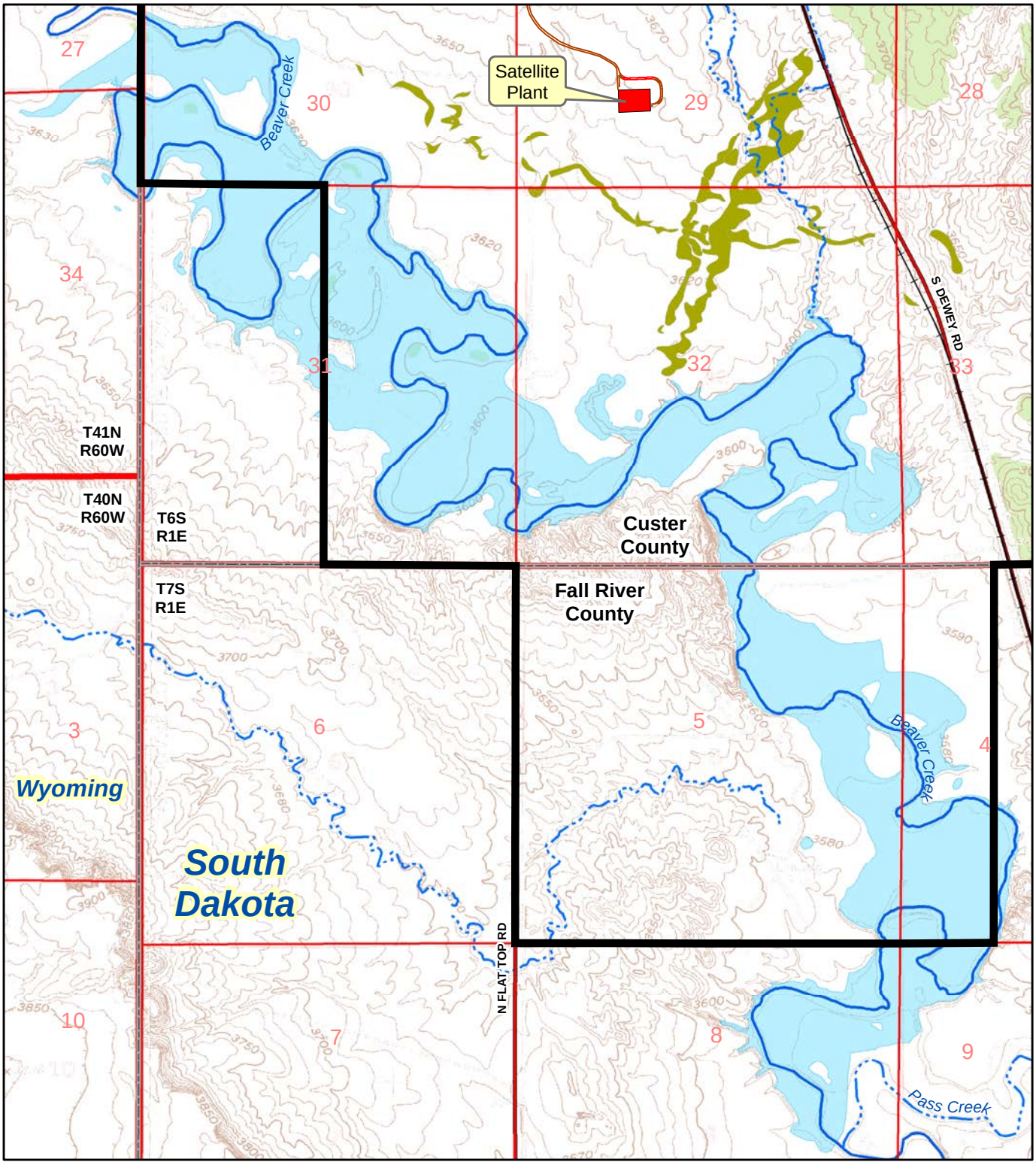
Figure 3.5-9

100-Year Inundation Map for Pass Creek and Tributaries

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	14-Sep-2012
FILE	Flood100-PassCr.mxd

POWERTECH (USA) INC.



This figure is provided to fulfill the requirements of ARSD 74:29:02:11(3).

Legend

- Permit Boundary
- Ore Bodies
- Access Roads
- BNSF Railroad
- Ephemeral Streams
- Perennial Streams
- Extreme Condition Flood Boundary

Feet: 0, 1,000, 2,000, 4,000

Meters: 0, 500, 1,000

N

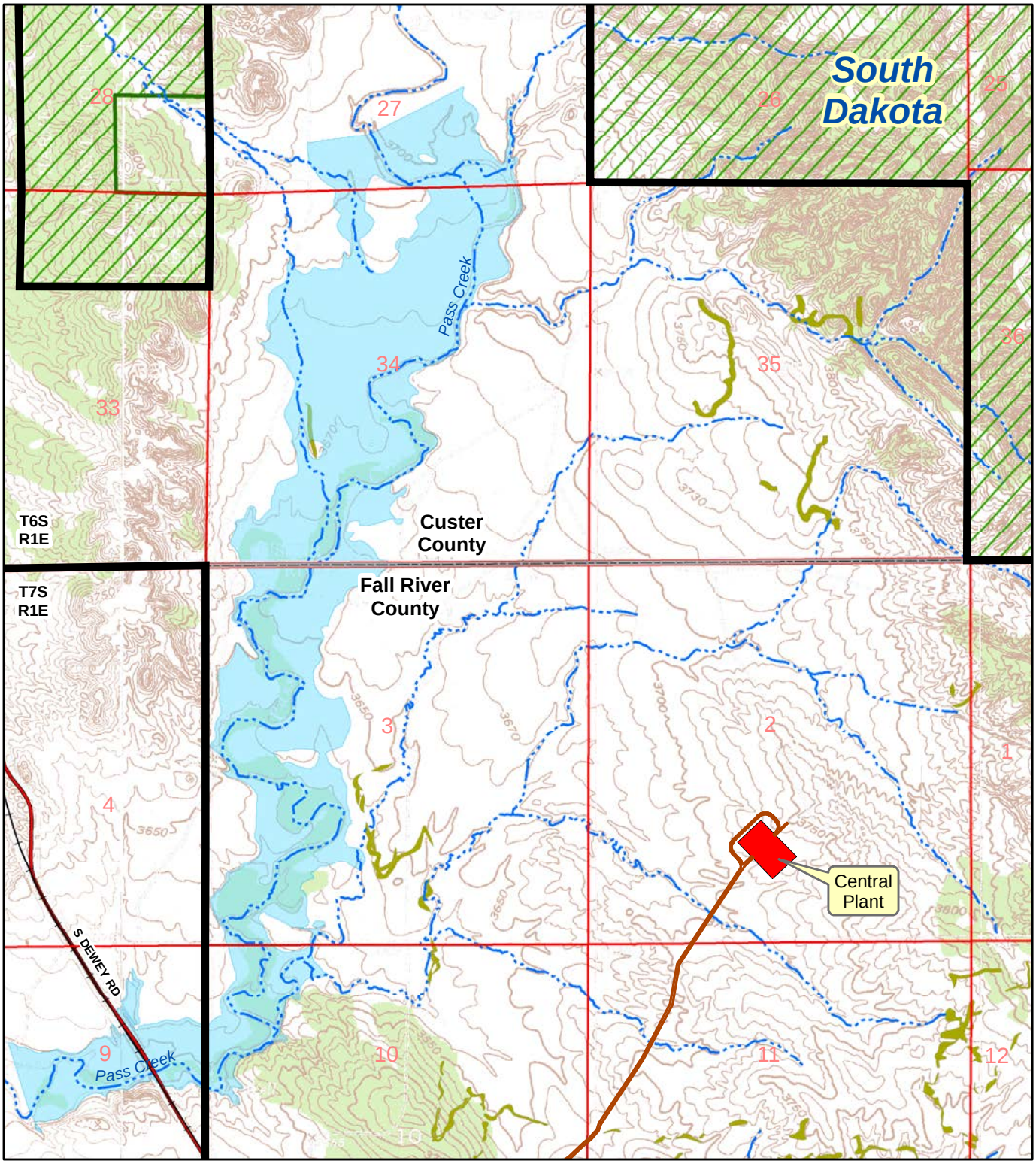
Figure 3.5-10

Extreme Condition Inundation Map for Beaver Creek

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	14-Sep-2012
FILE	FloodExt-BeaverCr.mxd

POWERTECH (USA) INC.



This figure is provided to fulfill the requirements of ARSD 74:29:02:11(3).

Legend

- Permit Boundary
- Ore Bodies
- Access Roads
- BNSF Railroad
- Ephemeral Streams
- Perennial Streams
- Extreme Condition Flood Boundary

Feet
0 1,000 2,000 4,000
0 500 1,000
Meters

N

Figure 3.5-11

Extreme Condition Inundation Map for Pass Creek

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	14-Sep-2012
FILE	FloodExt-PassCr.mxd

POWERTECH (USA) INC.

boundaries for the channels within the permit area. The inundation boundaries are depicted on Figures 3.5-8 and 3.5-9.

3.5.2.3.6 Assessment of Levels of Surface Water Bodies

The typical seasonal ranges of levels of surface water bodies within the permit area were assessed. Surface water bodies within the permit area are surface impoundments such as ponds and historical mine pits. Historical stage data for these surface water bodies is unavailable, and the stage data that has been collected is very limited. The available data for this assessment was collected at 10 sites from October 2, 2007 to July 18, 2008. A summary of this data is shown in Table 3.5-10, which was populated according to site location. Impoundment locations are shown on Figure 3.5-12 in Section 3.5.3. Stage data at 1 of the 10 sites was collected only once while every other site had at least 2 records. The largest positive and negative changes in water levels over the period of collection were 2.43 feet and -0.48 foot, respectively. The smallest change overall was 0.04 foot. The largest rate of change in water level was 0.011 foot per day or about 0.13 inch per day. The surface water bodies with the largest change in water level were near the Darrow Mine pits (Sub06 and Sub07). These water level changes were recorded at sites with at least two records and a minimum time span of 206 days, which represents the most sufficient data available to characterize the seasonal ranges for water levels of the surface water bodies within the permit area. Further discussion about the interaction between groundwater and surface water bodies is provided in Section 3.4.2.2.3.

3.5.3 Baseline Surface Water Monitoring Program

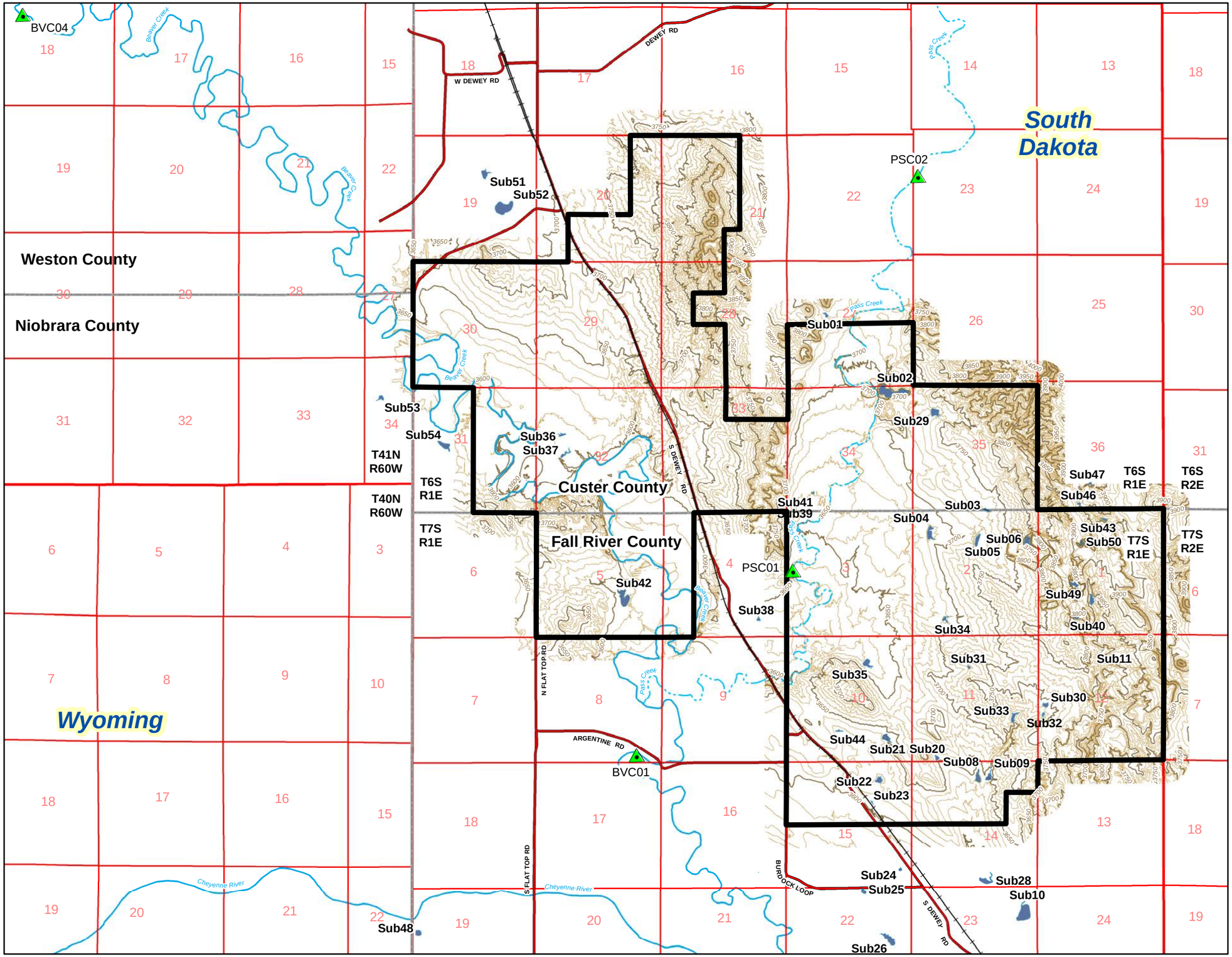
The perennial and ephemeral streams and impoundments in the permit area were sampled within, upstream and downstream of the proposed permit boundary. This section describes the baseline surface water sampling program, including stream and impoundment sites sampled, sampling methods, sampling schedule, and parameters analyzed. Water quality results are discussed in Section 3.5.4.

3.5.3.1 Stream Sampling

As part of the baseline monitoring program stream sampling sites were established on Beaver Creek, Pass Creek, the Cheyenne River, Bennett Canyon, and unnamed tributaries. The baseline monitoring program included monthly visits to each site. Grab samples were collected from the sites on Beaver Creek and the Cheyenne River, when available, while automated samplers were installed at the sites on Pass Creek, Bennett Canyon and an unnamed tributary south of the permit area. Figure 3.5-12 shows the location of the baseline stream and impoundment sampling

Table 3.5-10: Summary of Water Level Data Collected at Surface Water Bodies

Site	Data Records	Time Interval of Greatest Stage Change (days)	Stage Change (ft)	Stage Change Rate (ft/day)
Sub01	1	NA		
Sub02	3	229	0.75	-0.0033
Sub03	3	229	-0.48	-0.0021
Sub04	3	215	0.54	0.0025
Sub06	3	206	2.3	0.0112
Sub07	4	234	2.43	0.0104
Sub08	2	206	0.04	0.0002
Sub09	2	89	0.52	0.0058
Sub10	2	234	1.35	0.0058
Sub11	5	89	0.63	0.0071



Legend

- Permit Boundary
- BNSF Railroad
- County Roads
- Ephemeral Streams
- Perennial Streams
- Pre-operational Sampling Locations
- Impoundments

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(3).

Note: 10' topographic contours generated by Merrick & Co., 2008 aerial topographic survey.

Feet: 0 2,000 4,000 8,000
Meters: 0 1,000 2,000

N

Figure 3.5-12

Baseline Surface Water Sampling Locations

Dewey-Burdock Project

SIGNATURE OF PREPARER	
PREPARER	Richard Blubaugh
DATE	14-Sep-2012
FILE	BaseSurfH2OSampLoc.mxd

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sites except for CHR05 and BEN01, which are not within the scale of Figure 3.5-12. These sites are shown on Plate 5.5-1. Table 3.5-11 describes which stream sites were sampled during each sampling event and provides a reason why samples could not be collected at some locations.

The surface water quality sample constituent list was developed based on NRC guidance and a constituent list review with DENR. The following methodology was applied to collection of surface water samples:

- Field methods for sampling surface waters followed DENR Standard Operating Procedures for Field Samplers, Volume I (DENR, 2005).
    - Field methods included measuring and recording field water quality parameters including dissolved oxygen, turbidity, pH, specific conductance, and temperature with a water quality probe.
    - Sample bottles and preservative were supplied by EPA-certified Energy Laboratories in Rapid City. Bottles not containing preservative were rinsed three times with sample water before sample collection. Bacteriological sample bottles were not rinsed prior to filling.
    - Samples were field-preserved (where required) and immediately placed on ice and delivered within 24 hours to Energy Laboratories in Rapid City along with proper chain-of-custody forms.
    - A replicate and a blank sample were collected for every 10 water quality samples collected.
- Sites on Beaver Creek and Pass Creek were visited monthly and sampled when water was present.
- Although it does not pass through the permit boundary, the Cheyenne River also was sampled monthly upstream and downstream of confluences with streams passing through the permit boundary.
- Passive samplers ("single-stage samplers") designed to collect samples during ephemeral flow events were installed and used in Pass Creek (PSC01 and PSC02), Bennett Canyon (BEN01), and an unnamed tributary to the Cheyenne River (UNT01).

3.5.3.2 Impoundment Sampling

Powertech (USA) sampled surface water impoundments within the permit area, including stock dams and mine pits. Surface water impoundments were identified originally on topographic maps and aerial photographs. Subsequently a field survey was completed in July 2007 to fully identify and gather impoundment location data. A summary of impoundment sampling for the

Table 3.5-11: Baseline Stream Sampling Summary

Site	Type/Name	Sample Type	Jul-2007	Aug-2007	Sept-2007	Oct-2007	Nov-2007	Dec-2007	Jan-2008	Feb-2008	Mar-2008	Apr-2008	May-2008	Jun-2008	Jul-2008
BVC01	Beaver Creek Downstream	Grab	X	X	X	X	X	X	X	1	X	X	X	X	3
BVC04	Beaver Creek Upstream	Grab	X	X	X	X	X	X	X	1	X	X	X	X	3
PSC01	Pass Creek Downstream	Passive Sampler	X	2	2	2	2	2	2	2	2	2	2	2	X
PSC02	Pass Creek Upstream	Passive Sampler	X	2	2	2	2	2	2	2	2	2	2	2	X

Notes:

X - Sample collected
1-2 - No sample collected due to:
1 - Ice
2 - Passive sampler did not indicate precipitation event
3 - 12-month baseline sampling period had been completed

regional baseline surface water monitoring program is provided in Table 3.5-12. The table includes 46 impoundments. During the regional baseline monitoring program, 11 of the 46 impoundments were visited on a quarterly basis. Table 3.5-12 illustrates which of these impoundments were sampled during each quarterly sampling event or provides a reason why a sample could not be collected.

As described in Section 5.5.3, Powertech (USA) proposes to sample 24 impoundments during operation of the Dewey-Burdock Project. Justification for the impoundments not proposed for operational monitoring is provided in Table 3.5-12 and typically is due to the impoundment not being located downgradient of proposed facilities.

3.5.4 Surface Water Quality

The following sections describe the results of baseline stream and impoundment sampling in and around the permit area. Surface water quality summary tables for each sampling location are provided in Appendix 3.5-B. Analytical results are provided in Appendix 3.5-C.

3.5.4.1 Stream Sampling Results

Table 3.5-13 summarizes the results of baseline stream sampling on Beaver Creek, Pass Creek, and the Cheyenne River. Following is a summary of sampling results for each of the major streams. Results for minor streams, including Bennett Canyon (BEN01) and the unnamed tributary to the Cheyenne River (UNT01), are provided in Appendix 3.5-B (summary tables) and Appendix 3.5-C (analytical results).

Beaver Creek

The Beaver Creek field parameters varied significantly seasonally, with temperature ranging from about 0 to 28°C (32 to 82°F), field conductivity ranging from 733 to 7,678 µmhos/cm, and turbidity ranging from 1.7 to 1,790 NTU. Fecal coliform bacteria ranged from <2 to 5,700 CFU/100 mL.

Salinity (as TDS) in Beaver Creek ranged from 520 to 6,100 mg/L. This was made up predominantly of sodium and sulfate, with significant contributions from calcium and chloride. Chloride concentrations were notably high in many of the Beaver Creek samples. The chloride concentration was above 500 mg/L in 50% of the samples (11 of 22) and above 1,000 mg/L in 23% of samples (5 of 22). This high chloride concentration may suggest anthropogenic influence such as produced water discharge from oil and gas operations upstream from the permit area.

Table 3.5-12: Regional Baseline Impoundment Sampling

Site	Type/Name	Baseline Sampling				Downgradient of Proposed Facilities*
		3Q07	4Q07	1Q08	2Q08	
Sub01	Stock Pond	1	1	X	X	No
Sub02	Triangle Mine Pit	X	X	X	X	No
Sub03	Mine Dam	1	X	1	X	Yes
Sub04	Stock Pond	1	X	1	X	Yes
Sub05	Mine Dam	1	1	1	1	Yes
Sub06	Darrow Mine Pit Northwest	X	X	X	X	Yes
Sub07	Stock Dam	X	X	X	X	Yes
Sub08	Stock Pond	X	X	X	X	Yes
Sub09	Stock Pond	1	1	X	X	Yes
Sub10	Stock Pond		1	X	X	Yes
Sub11	Stock Pond	X	X	X	X	Yes
Sub20	Stock Pond					Yes
Sub21	Stock Pond					Yes
Sub22	Stock Pond					Yes
Sub23	Stock Pond					No
Sub24	Stock Pond			X		No
Sub25	Stock Pond					No
Sub26	Stock Pond					No
Sub27	Stock Pond					Yes
Sub28	Stock Pond					Yes
Sub29	Stock Pond					Yes
Sub30	Stock Pond					Yes
Sub31	Stock Pond					Yes
Sub32	Stock Pond					Yes
Sub33	Stock Pond					Yes
Sub34	Stock Pond					Yes
Sub35	Stock Pond					Yes
Sub36	Stock Pond					Yes
Sub37	Stock Pond					Yes
Sub38	Stock Pond					No
Sub39	Stock Pond					No
Sub40	Darrow Mine Pit Southeast					Yes
Sub41	Stock Pond					Yes
Sub42	Stock Pond					No
Sub43	Stock Pond					No
Sub44	Stock Pond					No
Sub45	Stock Pond					No
Sub46	Stock Pond					No
Sub47	Stock Pond					No
Sub48	Stock Pond					No
Sub49	Darrow Mine Pit					Yes
Sub50	Darrow Mine Pit					Yes
Sub51	Stock Pond					No
Sub52	Stock Pond					No
Sub53	Stock Pond					No
Sub54	Stock Pond					No

* Potentially subject to surface runoff from satellite facility, CPP, ponds, potential land application areas, pipelines, or potential well field areas.

Notes: X – Sample collected
1 – No sample collected due to impoundment being dry during quarterly visit

Table 3.5-13: Stream Water Quality

Constituent	Units	Beaver Creek	Pass Creek	Cheyenne River
Field Parameters				
Field Temperature	°C	-0.1 - 27.6	13.6 - 17.1	-0.1 - 27
Field pH	s.u.	7.5 - 8.9	8.1	7.4 - 8.4
Field Dissolved Oxygen	mg/L	6.5 - 13.7	9.5 - 10.3	3.7 - 13.1
Field Conductivity	umhos/cm	733 - 7,678	1,696 - 1,844	350 - 7,847
Field Turbidity	NTU	1.7 - 1,790	1,672 - 1,780	1 - 1,798
Microbiological				
Bacteria, Fecal Coliform	CFU/100 mL	<2 - 5,700	3,700 - 7,500	<2 - 3,500
Physical Properties				
Conductivity @ 25°C	umhos/cm	514 - 7,540	1,240 - 1,840	367 - 7,530
pH	s.u.	7.7 - 8.8	7.2 - 7.3	7.6 - 8.3
Sodium Adsorption Ratio (SAR)	unitless	1.9 - 13	<0.1	1.2 - 15
TDS @ 180 °C	mg/L	520 - 6,100	1,100 - 1,700	340 - 7,200
TSS @ 105 °C	mg/L	<5 - 4,600	140 - 3,700	<5 - 4,900
Common Elements and Ions				
Alkalinity, Total as $CaCO_3$	mg/L	78 - 220	50 - 62	80 - 352
Bicarbonate as HCO_3	mg/L	85 - 268	61 - 76	98 - 429
Carbonate as CO3	mg/L	<5	<5	<5
Calcium	mg/L	52 - 499	270 - 510	30 - 525
Chloride	mg/L	9 - 1,730	1.6 - 2.8	2 - 912
Fluoride	mg/L	<0.1 - 0.9	0.14 - 0.2	<0.1 - 0.7
Magnesium	mg/L	13 - 210	10.1 - 30.5	9 - 380
Nitrogen, Ammonia as N	mg/L	<0.1	0.1 - 0.2	<0.1 - 0.1
Nitrogen, Nitrate as N	mg/L	<0.1 - 0.6	0.56 - 0.77	<0.1 - 0.6
Potassium	mg/L	5 - 15	6 - 12.4	5 - 26
Sodium	mg/L	89 - 1,240	1.7 - 6.3	28 - 1,530
Sulfate	mg/L	286 - 2,670	645 - 1,400	86 - 4,520
Silica	mg/L	<1 - 15.5	1.7 - 16.5	2.6 - 14.1
Metals - Dissolved				
Aluminum	mg/L	<0.1	<0.1	<0.1
Arsenic	mg/L	<0.001 - 0.002	0.002	<0.001 - 0.001
Barium	mg/L	<0.1 - 0.1	<0.1 - 0.1	<0.1
Boron	mg/L	0.2 - 0.6	<0.1	<0.1 - 0.4
Cadmium	mg/L	<0.005	<0.005	<0.005
Chromium	mg/L	<0.01	<0.01 - 0.02	<0.05
Copper	mg/L	<0.01	<0.01	<0.01
Iron	mg/L	<0.03 - 0.18	<0.03 - 0.1	<0.03 - 0.15
Lead	mg/L	<0.001	<0.001	<0.001
Manganese	mg/L	<0.01 - 0.83	0.03 - 0.04	<0.01 - 3.01
Mercury	mg/L	<0.001	<0.001	<0.001
Molybdenum	mg/L	<0.1	<0.1	<0.1
Nickel	mg/L	<0.01 - 0.01	<0.01 - 0.03	<0.01 - 0.01
Selenium	mg/L	<0.001 - 0.004	<0.005	<0.0001 - 0.003

Table 3.5-13: Stream Water Quality (cont'd)

Constituent	Units	Beaver Creek	Pass Creek	Cheyenne River
Metals - Dissolved				
Silver	mg/L	<0.005	<0.005	<0.005
Thorium-232	mg/L	<0.005	<0.005	<0.005
Uranium	mg/L	0.002 - 0.027	0.0007 - 0.005	0.002 - 0.037
Vanadium	mg/L	<0.1	<0.1	<0.1
Zinc	mg/L	<0.01	<0.01	<0.01 - 0.02
Metals – Dissolved – Speciated				
Selenium-IV	mg/L	<0.001 - 0.002	<0.001	<0.001
Selenium-VI	mg/L	<0.001 - 0.004	<0.001	<0.001 - 0.002
Metals – Suspended				
Thorium-232	mg/L	<0.001 - 0.013	<0.001 - 0.002	<0.001 - 0.035
Uranium	mg/L	<0.0003 - 0.003	0.0004 - 0.0009	<0.0003 - 0.0067
Metals - Total				
Aluminum	mg/L	<0.1 - 99.3	58.7 - 85.9	<0.1 - 170
Arsenic	mg/L	<0.001 - 0.048	0.003 - 0.031	<0.001 - 0.029
Barium	mg/L	<0.1 - 1.1	0.2 - 0.8	<0.1 - 0.9
Boron	mg/L	<0.1 - 0.6	<0.1 - 0.3	<0.1 - 0.6
Cadmium	mg/L	<0.005	<0.005	<0.005
Chromium	mg/L	<0.05 - 0.19	<0.05 - 0.17	<0.05 - 0.19
Copper	mg/L	<0.01 - 0.11	<0.01 - 0.1	<0.01 - 0.1
Iron	mg/L	0.05 - 137	0.28 - 128	0.06 - 108
Lead	mg/L	<0.001 - 0.088	0.002 - 0.074	<0.001 - 0.118
Manganese	mg/L	0.05 - 1.82	0.12 - 2.55	0.1 - 2.94
Mercury	mg/L	<0.001	<0.001	<0.001
Molybdenum	mg/L	<0.1	<0.1	<0.1
Nickel	mg/L	<0.05 - 0.15	<0.05 - 0.15	<0.05 - 0.1
Selenium	mg/L	<0.001 - 0.004	<0.001 - 0.003	<0.001 - 0.003
Silver	mg/L	<0.005	<0.005	<0.005
Thorium-232	mg/L	<0.005 - 0.04	0.012 - 0.02	<0.005 - 0.046
Uranium	mg/L	0.003 - 0.026	0.0012 - 0.025	0.0043 - 0.0378
Vanadium	mg/L	<0.1 - 0.4	<0.1 - 0.1	<0.1 - 0.3
Zinc	mg/L	<0.01 - 0.54	0.02 - 0.34	<0.01 - 0.47
Metals – Total – Speciated				
Selenium-IV	mg/L	<0.001 - 0.001	<0.001	<0.001
Selenium-VI	mg/L	<0.001 - 0.004	<0.001	<0.001 - 0.003
Radionuclides - Dissolved				
Lead-210	pCi/L	<1 - 26	1.7 - 2.2	<1 - 6.6
Polonium-210	pCi/L	<1 - 3	0.2 - 0.7	<1 - 2.4
Radium-226	pCi/L	<0.2 - 2	0 - 0.1	<0.2 - 1.4
Thorium-230	pCi/L	<0.2 - 1.7	0	<0.2 - 0.3
Radionuclides – Suspended				
Lead-210	pCi/L	<1 - 15.3	-0.8 - 0.9	<1 - 22
Polonium-210	pCi/L	<1 - 3.7	0.3	<1 - 4.1
Radium-226	pCi/L	<0.2 - 3.1	-0.2 - 0.1	<0.2 - 4
Thorium-230	pCi/L	<0.2 - 3.4	0.2 - 0.5	<0.2 - 3.8

Table 3.5-13: Stream Water Quality (cont'd)

Constituent	Units	Beaver Creek	Pass Creek	Cheyenne River
Radionuclides - Total				
Gross Alpha	pCi/L	2.3 - 65.8	1.9 - 8.8	4 - 35.3
Gross Beta	pCi/L	<2 - 48.1	-7 - 15.1	<2 - 38
Gross Gamma	pCi/L	<20 - 1,310	0	<20 - 1,140
Lead-210	pCi/L	<1 - 35	0 - 3	<1 - 22
Polonium-210	pCi/L	<1 - 4.4	0.5 - 1	<1 - 4.6
Radium-226	pCi/L	<0.2 - 5.1	<0.2 - 0.7	<0.2 - 5.1
Thorium-230	pCi/L	<0.2 - 3.4	0.2 - 0.5	<0.2 - 3.8

Beaver Creek dissolved metals concentrations were typically low, with notable detections for boron, iron, manganese, and uranium. Total metal concentrations often were higher than dissolved concentrations, suggesting that some of the metals were associated with sediment or precipitates. Notable total metal detections included aluminum, arsenic, iron, lead, manganese, uranium and zinc.

Total radionuclide concentrations in Beaver Creek were relatively high in some samples. Maximum concentrations included 65.8 pCi/L gross alpha, 48.1 pCi/L gross beta, and 1,310 pCi/L gross gamma.

Pass Creek

Due to lack of precipitation-driven runoff, only four water quality samples were collected on Pass Creek, all of which were collected in July (2007 and 2008). Table 3.5-13 demonstrates less variability in Pass Creek water quality than Beaver Creek. This is attributed at least in part to the limited seasonal variation between samples. Field temperature ranged from about 13 to 17°C (55 to 63°F), field conductivity ranged from 1,696 to 1,844 µmhos/cm, and turbidity ranged from 1,672 to 1,780 NTU.

Pass Creek salinity (as TDS) ranged from 1,100 to 1,700 mg/L. Dissolved solids were almost entirely made up of calcium and sulfate. Magnesium, sodium and bicarbonate concentrations were much lower than calcium and sulfate, and sodium and chloride concentrations were very low (typically less than 5 mg/L). Dissolved metal concentrations were low or undetectable. Notable total metal detections included aluminum, arsenic, barium, iron, lead, manganese, nickel, uranium and zinc.

Total radionuclide concentrations in Pass Creek included gross alpha up to 8.8 pCi/L and gross beta up to 15.1 pCi/L.

Cheyenne River

Similar to Beaver Creek, the field water quality in Cheyenne River samples varied significantly seasonally, with temperature ranging from about 0 to 27°C (32 to 81°F), field conductivity ranging from 350 to 7,847 µmhos/cm and turbidity ranging from 1 to 1,798 NTU. Fecal coliform bacteria ranged from <2 to 3,500 CFU/100 mL. The fecal coliform bacteria concentration was less than 400 CFU/100 mL in 90% of samples (19 of 21). Dissolved Oxygen concentrations ranged from 3.7 to 13.1 mg/L.

Salinity (as TDS) in Cheyenne River samples ranged from 340 to 7,200 mg/L. Major ion chemistry was dominated primarily by sodium and sulfate, with increasing calcium concentrations from CHR01 to CHR05 (upstream to downstream). The average calcium concentration at CHR01, which is upstream from the confluence with Beaver Creek, was 270 mg/L. This increased to an average concentration of 463 mg/L downstream of the Beaver Creek confluence. Chloride concentrations similarly increased from an average of 129 mg/L at CHR01 to an average of 409 mg/L at CHR05. The maximum chloride concentration at CHR01 was 249 mg/L, while 3 of 12 (25%) of CHR05 samples yielded chloride measurements above 500 mg/L.

Dissolved metal concentrations typically were low or undetectable with notable detections of boron, iron, manganese and uranium. Total metal concentrations were typically higher than dissolved metal concentrations, with notable metal detections including arsenic, boron, iron, manganese, uranium, vanadium and zinc.

Total radionuclide concentrations in Cheyenne River samples ranged from non-detect to some relatively high concentrations, including maximum concentrations of 35.3 pCi/L gross alpha, 38 pCi/L gross beta, and 1,140 pCi/L gross gamma.

3.5.4.1.1 Comparison with Surface Water Standards

Tables 3.5-14 through 3.5-17 compare results and statistical summaries for samples collected at the Beaver Creek and Cheyenne River sites to DENR surface water quality standards in ARSD 74:51:01:48. Both the Cheyenne River and Beaver Creek stream segments near the permit area have beneficial uses for warmwater semipermanent fish life propagation water and limited contact recreation waters according to ARSD 74:51:03:08. Months without data indicate either a completely frozen stream or absence of water. Other surface water quality sites do not have enough data to justify running statistical analyses on measurements.

Analysis of Beaver Creek sampling results shows some exceedances of the ARSD 74:51:01:48 standard for total suspended solids (TSS), while other parameters all fell into the compliance range. TSS was higher than the monthly average standard of 90 mg/L in 6 of 22 measurements (27%), and higher than the 158 mg/L daily maximum standard in 4 of 22 measurements (18%). All other parameters were within the compliance range, including pH, dissolved oxygen, ammonia, and temperature. Krantz and Larson (2006) modeled temperatures in Beaver Creek and report from a temperature-sensitivity analysis that air temperature is the primary controlling factor for stream temperatures in Beaver Creek.

Table 3.5-14: BVC01 Comparison to DENR Standards

Date	BVC01 (Downstream of Permit Area)				
	Temperature (°F)	**Field pH (s.u.)**	**Dissolved Oxygen (mg/L)**	**Total Ammonia Nitrogen as N (mg/L)**	**Total Suspended Solids (mg/L)**
DENR Criteria[1]	≤ 90	≥ 6.5 - ≤ 9.0	≥ 5.0	pH Dependent Criteria	≤ 90 monthly avg. ≤ 158 daily max.
7/24/2007	NM	NM	NM	NM	27
8/20/2007	81.6	8.91	12.29	NM	51
9/26/2007	62.1	8.87	10.95	NM	31
10/17/2007	53.9	8.58	11.13	<0.1	<5
11/19/2007	38.4	8.20	12.20	<0.1	20
12/11/2007	31.9	7.94	11.21	<0.1	10
1/11/2008	31.9	7.67	10.07	<0.1	12
3/9/2008	32.3	8.24	13.57	<0.1	12
4/14/2008	60.9	8.15	9.20	<0.1	17
5/26/2008	55.1	7.95	6.86	<0.1	4,600
6/17/2008	74.9	8.13	10.39	<0.1	100
N	10	10	10	8	11
Mean	52.3	8.26	10.79	<0.1	443
Median	54.5	8.18	11.04	<0.1	24
Std. Dev.	18.2	0.41	1.85	<0.1	1,379
Min.	31.9	7.67	6.86	<0.1	<5
Max.	81.6	8.91	13.57	<0.1	4,600

Note: [1] ARSD 74:51:01:48 criteria for warmwater semipermanent fish life propagation waters.

Table 3.5-15: BVC04 Comparison to DENR Standards

Date	BVC04 (Upstream of Permit Area)				
	Temperature (°F)	**Field pH (s.u.)**	**Dissolved Oxygen (mg/L)**	**Total Ammonia Nitrogen as N (mg/L)**	**Total Suspended Solids (mg/L)**
DENR Criteria[1]	≤ 90	≥ 6.5 - ≤ 9.0	≥ 5.0	pH Dependent Criteria	≤ 90 monthly avg. ≤ 158 daily max.
7/24/2007	NM	NM	NM	NM	100
8/20/2007	81.0	8.82	12.31	NM	160
9/28/2007	51.4	7.60	6.85	NM	47
10/17/2007	50.1	8.46	10.45	<0.1	16
11/19/2007	41.2	8.18	12.39	<0.1	16
12/11/2007	31.9	7.86	11.01	<0.1	10
1/11/2008	31.8	7.74	11.37	<0.1	25
3/9/2008	31.9	8.12	13.74	<0.1	270
4/14/2008	62.5	8.27	12.21	<0.1	32
5/26/2008	55.5	8.09	6.54	<0.1	2,200
6/17/2008	77.3	7.52	9.55	<0.1	55
N	10	10	10	8	11
Mean	51.5	8.07	10.64	<0.1	266
Median	50.8	8.11	11.19	<0.1	47
Std. Dev.	18.1	0.40	2.38	<0.1	646
Min.	31.8	7.52	6.54	<0.1	10
Max.	81.0	8.82	13.74	<0.1	2,200

Note: [1] ARSD 74:51:01:48 criteria for warmwater semipermanent fish life propagation waters.

Table 3.5-16: CHR01 Comparison to DENR Standards

Date	CHR01 (Upstream of Permit Area)				
	Temperature (°F)	**Field pH (s.u.)**	**Dissolved Oxygen (mg/L)**	**Total Ammonia Nitrogen as N (mg/L)**	**Total Suspended Solids (mg/L)**
DENR Criteria[1]	≤ 90	≥ 6.5 - ≤ 9.0	≥ 5.0	pH Dependent Criteria	≤ 90 monthly avg. ≤ 158 daily max.
7/31/2007	NM	NM	NM	NM	54
9/5/2007	79.4	8.44	13.08	NM	54
9/26/2007	60.8	8.02	10.48	NM	35
10/17/2007	55.6	8.02	5.17	<0.1	12
11/19/2007	42.2	7.47	3.74	<0.1	8
3/9/2008	45.1	8.11	12.84	<0.1	400
4/16/2008	58.9	8.32	8.13	<0.1	8
5/26/2008	56.0	8.17	7.77	<0.1	4,400
6/17/2008	80.6	8.27	7.85	<0.1	110
7/31/2007	NM	NM	NM	NM	54
9/5/2007	79.4	8.44	13.08	NM	54
N	8	8	8	6	9
Mean	59.8	8.10	8.63	<0.1	565
Median	57.5	8.14	7.99	<0.1	54
Std. Dev.	14.0	0.29	3.35	<0.1	1,443
Min.	42.2	7.47	3.74	<0.1	8
Max.	80.6	8.44	13.08	<0.1	4,400

Note: [1] ARSD 74:51:01:48 criteria for warmwater semipermanent fish life propagation waters.

Table 3.5-17: CHR05 Comparison to DENR Standards

Date	CHR05 (Downstream of Permit Area)				
	Temperature (°F)	**Field pH (s.u.)**	**Dissolved Oxygen (mg/L)**	**Total Ammonia Nitrogen as N (mg/L)**	**Total Suspended Solids (mg/L)**
DENR Criteria[1]	≤ 90	≥ 6.5 - ≤ 9.0	≥ 5.0	pH Dependent Criteria	≤ 90 monthly avg. ≤ 158 daily max.
7/31/2007	NM	NM	NM	NM	14
9/5/2007	78.1	8.16	12.20	NM	6
9/26/2007	65.9	8.01		NM	23
10/17/2007	58.0	8.12	10.08	<0.1	8
11/19/2007	43.2	8.16	11.03	<0.1	16
12/11/2007	31.9	7.95	11.14	<0.1	7
1/11/2008	31.8	7.65	9.22	<0.1	<5
2/12/2008	32.4	7.42		<0.1	9
3/9/2008	32.0	8.24	12.92	<0.1	220
4/14/2008	53.8	8.10	9.92	<0.1	19
5/26/2008	55.9	8.19	7.69	<0.1	4,900
6/17/2008	74.1	8.24	7.63	<0.1	95
N	11	11	9	9	12
Mean	50.7	8.02	10.20	<0.1	443
Median	53.8	8.12	10.08	<0.1	16
Std. Dev.	17.5	0.26	1.83	<0.1	1,405
Min.	31.8	7.42	7.63	<0.1	<5
Max.	78.1	8.24	12.92	<0.1	4,900

Note: [1] ARSD 74:51:01:48 criteria for warmwater semipermanent fish life propagation waters.

Analysis of Cheyenne River sampling results shows similar exceedances for the TSS standard, with 6 of 21 samples (29%) exceeding the 90 mg/L monthly average standard and 4 of 21 (19%) exceeding the 158 mg/L daily maximum standard. In addition, 1 of 18 dissolved oxygen measurements (6%) was below the minimum standard of 5 mg/L. All other parameters were within the compliance range, including pH, ammonia, and temperature.

3.5.4.2 Impoundment Sampling Results

Table 3.5-18 compares the impoundment sampling results for several key water quality parameters. This table shows significant variability in impoundment water quality. Most of the variability is associated with the type of impoundment and its proximity to the historical open-pit mines in the permit area. A summary of water quality by type is presented below.

Triangle Mine Pit

The water quality in the Triangle Mine Pit (Sub02) is characterized by moderately high TDS (2,900 to 3,900 mg/L), slightly alkaline pH (7.8 to 8.1), and calcium-sulfate type water.

Darrow Mine Pit

The water quality in the Darrow Mine Pit Northwest (Sub06) is characterized by moderate to high TDS (4,500 to 8,600 mg/L), low pH (3.2 to 3.5), and magnesium-sulfate type water. The low pH suggests that surface drainage from previously disturbed mine pits may be influencing the water chemistry in the pit.

Impoundments Downgradient of Historical Mine Pits

The impoundments downgradient of historical mine pits or surface disturbance associated with historical mining include those identified in Table 3.5-18 as mine dams (Sub03 and Sub05) and some of the stock ponds or stock dams downgradient of historical mining operations (Sub04 and Sub07). The water quality in these impoundments is characterized by low to moderate TDS (180 to 1,700 mg/L), low pH (3.8 to 5.0), very low alkalinity, and calcium-sulfate or calcium/magnesium-sulfate major ion chemistry. Total radionuclide concentrations ranged from 3 to 19.9 pCi/L gross alpha, 13 to 51.3 pCi/L gross beta, 0 to 1,290 pCi/L gross gamma, and 0 to 4 pCi/L radium-226.

Other Impoundments

Other impoundments included stock reservoirs not located downgradient of historical mining activities (Sub01, Sub08, Sub09, Sub10, Sub11, and Sub24). The water quality in these

Table 3.5-18: Impoundment Water Quality Summary

Site	Type/Name	N	TDS (mg/L)	pH (s.u.)	Alkalinity (mg/L as $CaCO_3$)	TSS (mg/L)	Water Type
Sub01	Stock Pond	2	300 - 990	7.1 - 7.7	38 - 84	100 - 280	Na/Ca-SO_4 to Na/Ca-HCO_3
Sub02	Triangle Mine Pit	4	2,900 - 3,900	7.8 - 8.1	90 - 102	<5 - 10	Ca-SO_4
Sub03	Mine Dam	2	820 - 970	4.4 - 4.6	<5	6 - 26	Ca-SO_4
Sub04	Stock Pond	2	450 - 1,700	4.7 - 4.9	<5	<5 - 23	Ca-SO_4
Sub05	Mine Dam	0	Impoundment was dry during each sample event				
Sub06	Darrow Mine Pit Northwest	4	4,500 - 8,600	3.2 - 3.5	<5 - 82	5 - 14	Mg-SO_4
Sub07	Stock Dam	4	180 - 680	3.8 - 5.0	<5	<5 - 32	Ca/Mg-SO_4
Sub08	Stock Pond	4	1,300 - 3,400	7.5 - 9.4	102 - 246	<5 - 14	Na-SO_4
Sub09	Stock Pond	2	250 - 280	7.9 - 8.3	28 - 80	100 - 190	Ca/Mg-SO_4 to Ca/Mg-HCO_3
Sub10	Stock Pond	2	410 - 2,100	7.0 - 8.2	38 - 54	220 - 250	Ca/Mg/Na-SO_4
Sub11	Stock Pond	4	90 - 220	6.0 - 7.0	6 - 122	61 - 120	Ca/HCO_3 to Ca/SO_4
Sub24	Stock Pond	1	3,800	7.5	88	17	Na-SO_4

impoundments is characterized by low to moderately high TDS (90 to 3,400 mg/L), neutral to high pH (6.0 to 9.4), variable alkalinity (6 to 246 mg/L as $CaCO_3$), and variable major ion chemistry. Two of six impoundments (33%) were sodium dominant, three of six (50%) had incomplete cation dominance, and one of six (17%) was calcium dominant. Anion chemistry was approximately evenly divided between bicarbonate and sulfate. Total radionuclide concentrations ranged from <1 to 16.3 pCi/L gross alpha, 5.1 to 36.5 pCi/L gross beta, 0 to 1,100 pCi/L gross gamma, and <0.2 to 1.2 pCi/L radium-226.

3.6 Meteorology, Climatology and Air Quality

3.6.1 Meteorology and Climatology

The permit area is located in an area in southwestern South Dakota that can be characterized as a semiarid or steppe climate. It lies adjacent to the southwestern extension of the Black Hills. The area experiences abundant sunshine, low relative humidity, and sustained winds which lead to high evaporative demand. There are also large diurnal and annual variations in temperature.

Precipitation in the permit area is generally light or mild. Migratory storm systems that originate in the Pacific Ocean release a majority of their moisture over the Rocky or Cascade Mountains. Major precipitation events can occur when these systems regain moisture already present in the area or moisture adverted from the Gulf of Mexico. Localized summer convective storms, caused by the Black Hills, can produce heavy precipitation events.

To complete the site-specific analysis, a weather station was installed in coordination with the South Dakota State Climatology office and in accordance with NRC regulatory guidance at approximately the center of the permit area in July 2007. This site collects temperature, humidity, solar radiation, wind speed/direction, barometric pressure, and precipitation at 1-minute, 5-minute, and hourly time steps. The site-specific analysis presented herein was conducted over one year from July 18, 2007 to July 17, 2008. This corresponds to the required one-year monitoring period for the NRC license application.

Along with the site weather station, data compiled from several sites surrounding the permit area (listed in Table 3.6-1 and shown in Figure 3.6-12) were obtained from the High Plains Regional Climate Center (HPRCC), South Dakota State University (SDSU), and the Wyoming Refining Company (WRC) compliance site at Newcastle, Wyoming. These data were used to represent the long-term meteorological conditions of the project region. These sites were used to characterize regional trends of temperature, snowfall and precipitation along with growing,

Table 3.6-1: Meteorological Stations Included in Climatology Analysis

Name	Data Source	X (°W)	Y (°N)	Z (ft)	Years of Operation
Redbird	NCDC[(a)]	104.17	43.15	3,890	1948–2006
Oral	SDSU[(b)]	103.16	43.24	2,960	1971–2007
Oelrichs	NCDC	103.14	43.11	3,340	1948–2007
Newcastle	NCDC	104.14	43.51	4,380	1918–2006
Edgemont	NCDC	103.49	43.18	3,440	1948–2007
Custer	NCDC	103.36	43.46	5,330	1926–2007
Ardmore	NCDC	103.39	43.04	3,550	1948–2007
Angostura	NCDC	103.26	43.22	3,140	1948–2007
Jewel Cave	SDSU	103.49	43.43	5,298	2004–2008
Newcastle	IML[(c)]	104.21	43.85	4,333	2002-2011

Source: HPRCC, 2008; SDSU, 2008
(a) National Climatic Data Center.
(b) SDSU Climate Web site.
(c) IML Air Science, compliance monitoring results.

heating, and cooling degree days. The site that best represents the long-term precipitation and temperature of the permit area is the Edgemont site, which is the closest in proximity and elevation to the permit area. The Newcastle, Wyoming WRC compliance site was the only site with adequate representative data to characterize wind speed/direction.

Data were analyzed at each site by time of day, month, and season of the year. The seasons for this analysis are defined as: winter (December, January, February), spring (March, April, May), summer (June, July, August), and fall (September, October, November).

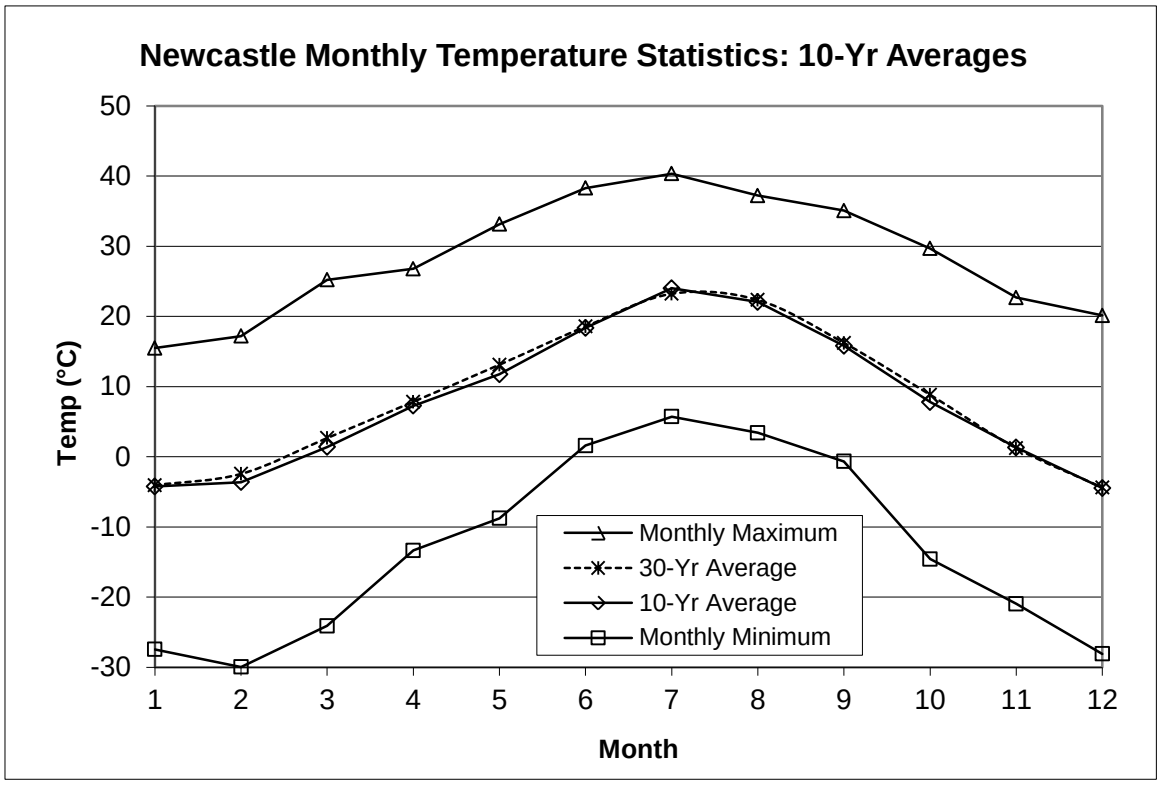
3.6.1.1 Regional Overview

Meteorological data from the WRC compliance site at Newcastle, Wyoming were assembled and analyzed to determine whether the baseline monitoring year's data (July 18, 2007 to July 17, 2008) were representative of longer-term (approximately 10-year) meteorological conditions in the area. The Newcastle site began monitoring on January 1, 2002, and meteorological data were available through August 31, 2011. The parameters analyzed were temperature, wind speed, wind direction, and standard deviation of wind direction. A comprehensive discussion of wind patterns at Newcastle is presented in Section 3.6.1.1.4 and Appendix 3.6-A.

The average daily temperature over the baseline monitoring year at Newcastle was 51.9°F, which is slightly warmer than the 10-year average (historical) daily temperature of 47.2°F. Figure 3.6-1 compares monthly temperature statistics for the two periods. It can be seen that both the average and extreme monthly temperatures for the baseline year are within a few degrees of the longer-term averages. The 10-year graph also includes 30-year average temperatures for Newcastle, obtained from the Western Regional Climate Center, demonstrating the 10-year average temperatures at the WRC site to be nearly identical to the 30-year average temperatures at the NWS Coop Site #486660 in Newcastle.

The average daily wind speed at Newcastle over the baseline monitoring year was 7.0 miles per hour (mph), very close to the 10-year historical average of 6.8 mph. Figure 3.6-2 compares the monthly average and maximum wind speeds for the short and long-term periods.

During the baseline monitoring year, Newcastle received 17.3 inches of precipitation, about 15% above the 100-year average annual precipitation of 15.1 inches. (Western Regional Climate Center, Coop Site #486660).



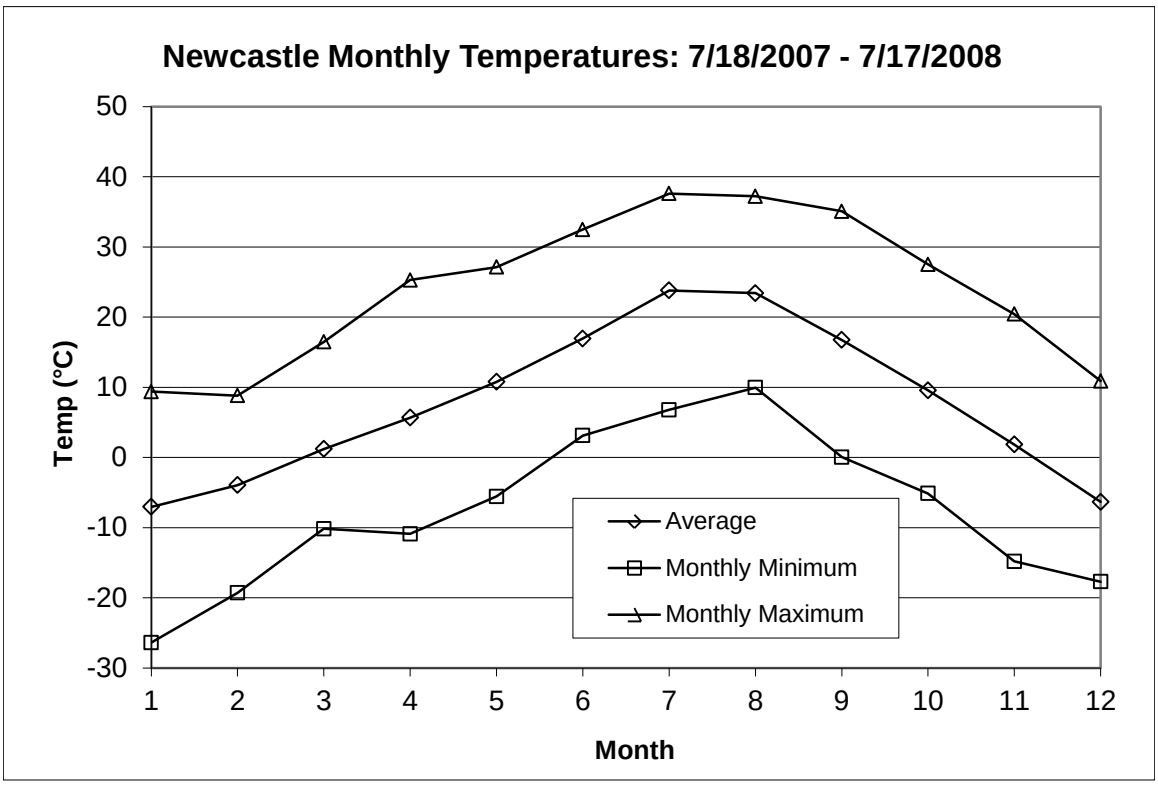
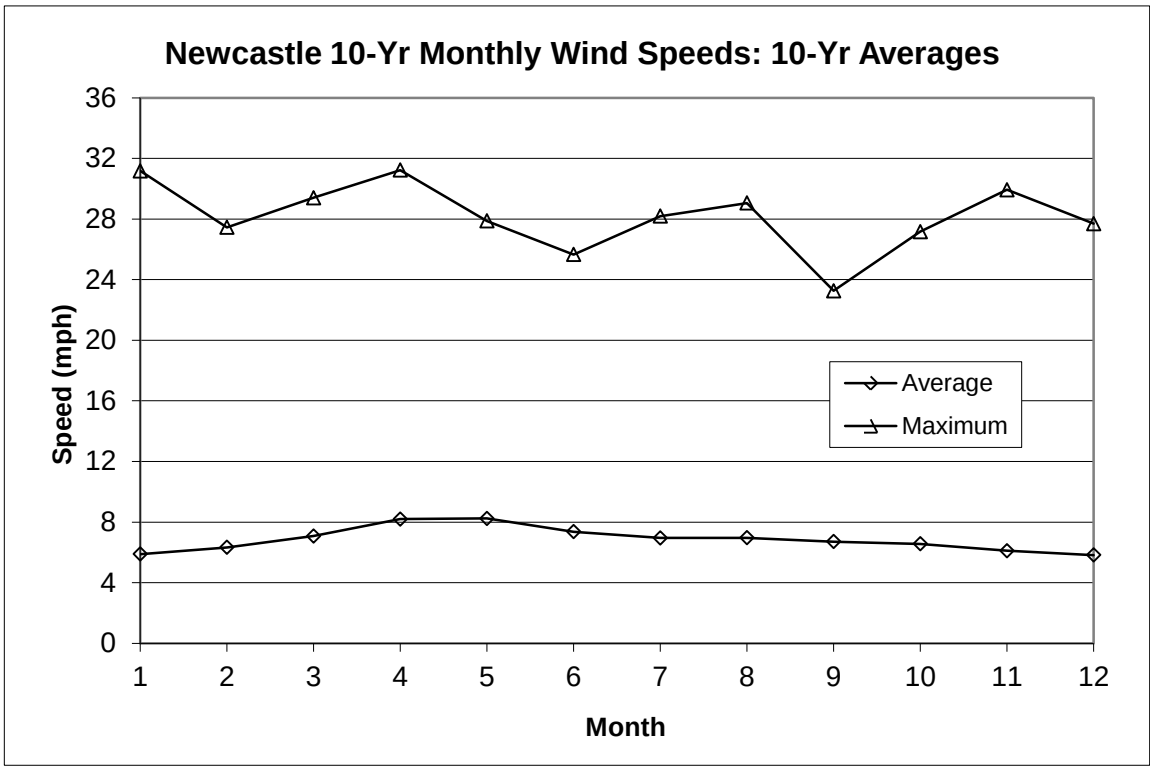


Figure 3.6-1: Short and Long-Term Temperatures at the Newcastle, Wyoming WRC Compliance Site



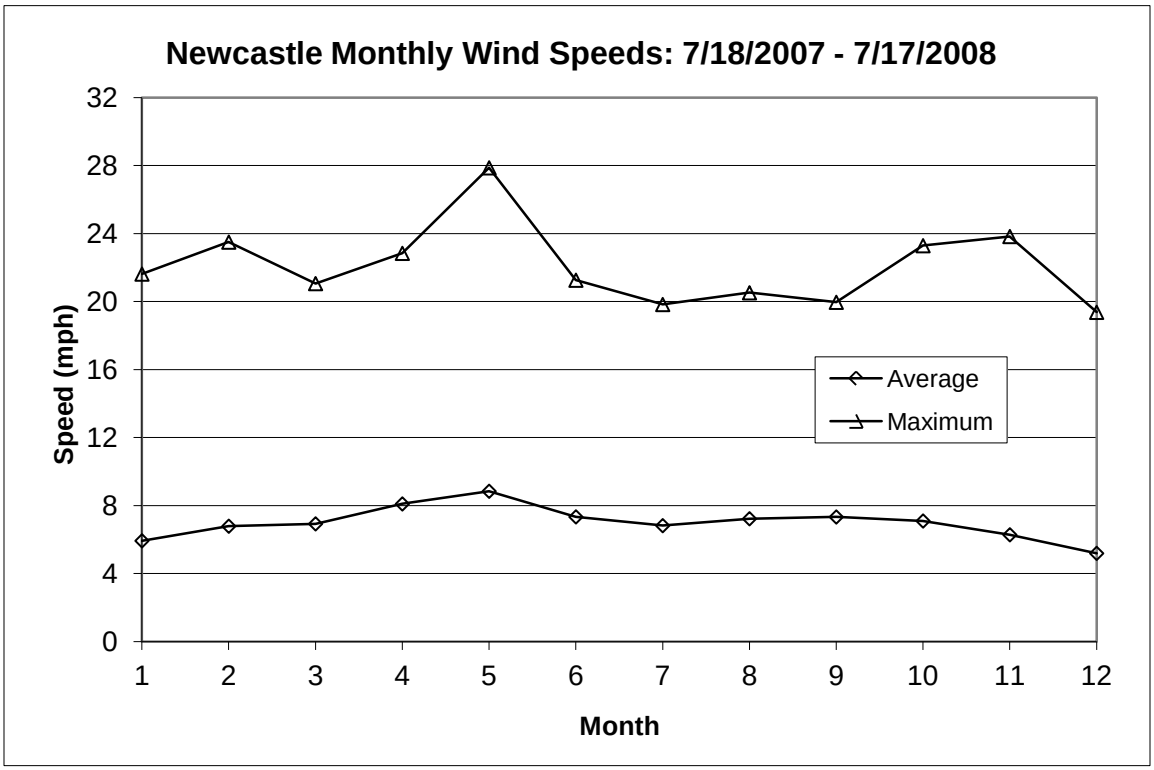


Figure 3.6-2: Short and Long-Term Wind Speeds at the Newcastle, Wyoming WRC Compliance Site

3.6.1.1.1 Temperature

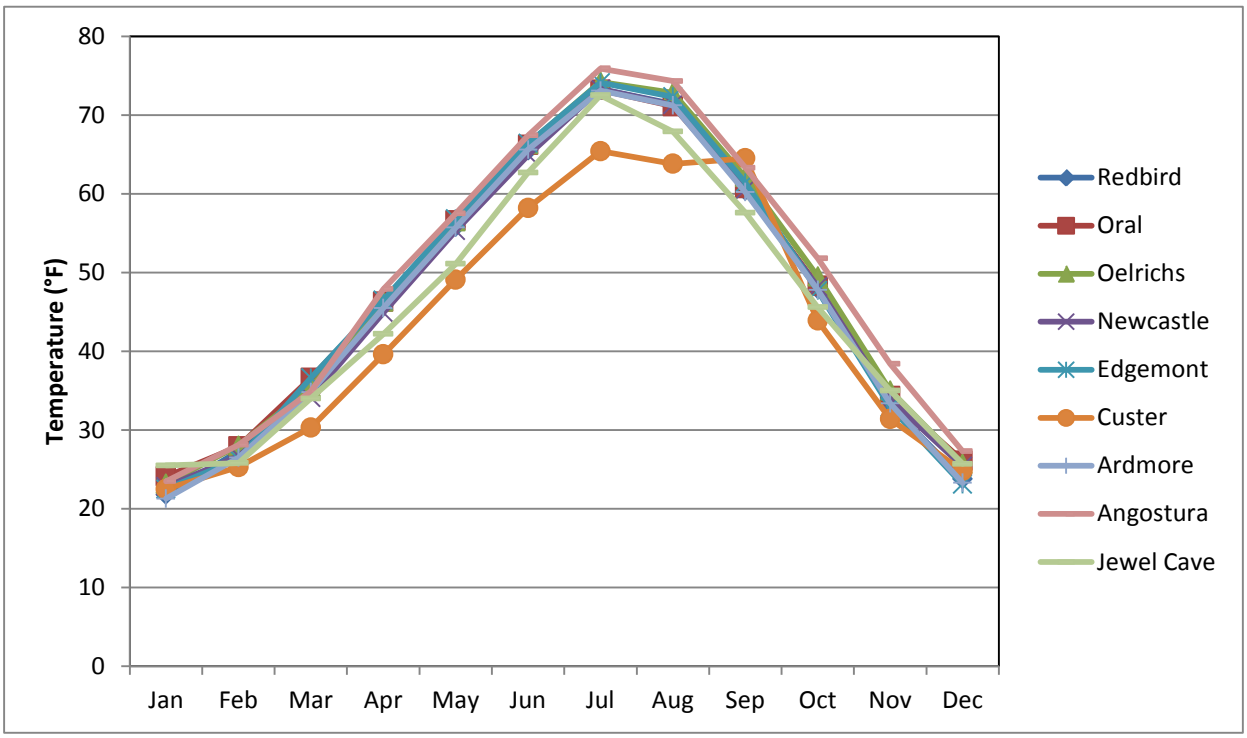
Long-term temperature statistics were also obtained from regional NWS sites. The annual average temperature in this region is 46.7°F. Figure 3.6-3 and Table 3.6-2 display the monthly, annual, and seasonal average temperatures. This region has some of its warmest days in the summer months with the hottest month being July (average temperature of 72.8°F). The coldest month of the year is January, with an average temperature of 23.0°F. The differences seen between sites can be attributed to elevation. Custer and Jewel Cave have the lowest average temperature primarily because these sites are nearly 1,000 feet higher in elevation than all other sites.

Figures 3.6-4 and 3.6-5 show the average monthly maximum and minimum temperatures in the region. The average monthly maximum temperature is 60.7°F, while the average monthly minimum temperature is 32.7°F, as shown in Tables 3.6-3 and 3.6-4. The highest average maximum monthly temperatures in the region usually fall during the month of July (88.3°F). The lowest average minimum monthly temperatures can be found in January, with a regional average of 10.4°F.

Figure 3.6-6 displays diurnal temperature variations by season for the Newcastle WRC site over the last 10 years. The figure shows large variations in average diurnal temperatures, especially during the summer months.

3.6.1.1.2 Relative Humidity

Relative humidity measures the ratio of moisture in the air to saturated moisture content at a certain temperature. This parameter was recorded for the Newcastle WRC site. Figure 3.6-7 displays the relationship of relative humidity to the season and time of day for this site. The figure shows that the summer has the lowest relative humidity, averaging 45.5 percent, while winter has the highest relative humidity, averaging 67.7 percent. Both seasonal and diurnal variations in relative humidity are largely attributed to air temperature. Since cooler air will hold less moisture, relative humidity tends to be higher during the winter and at night.



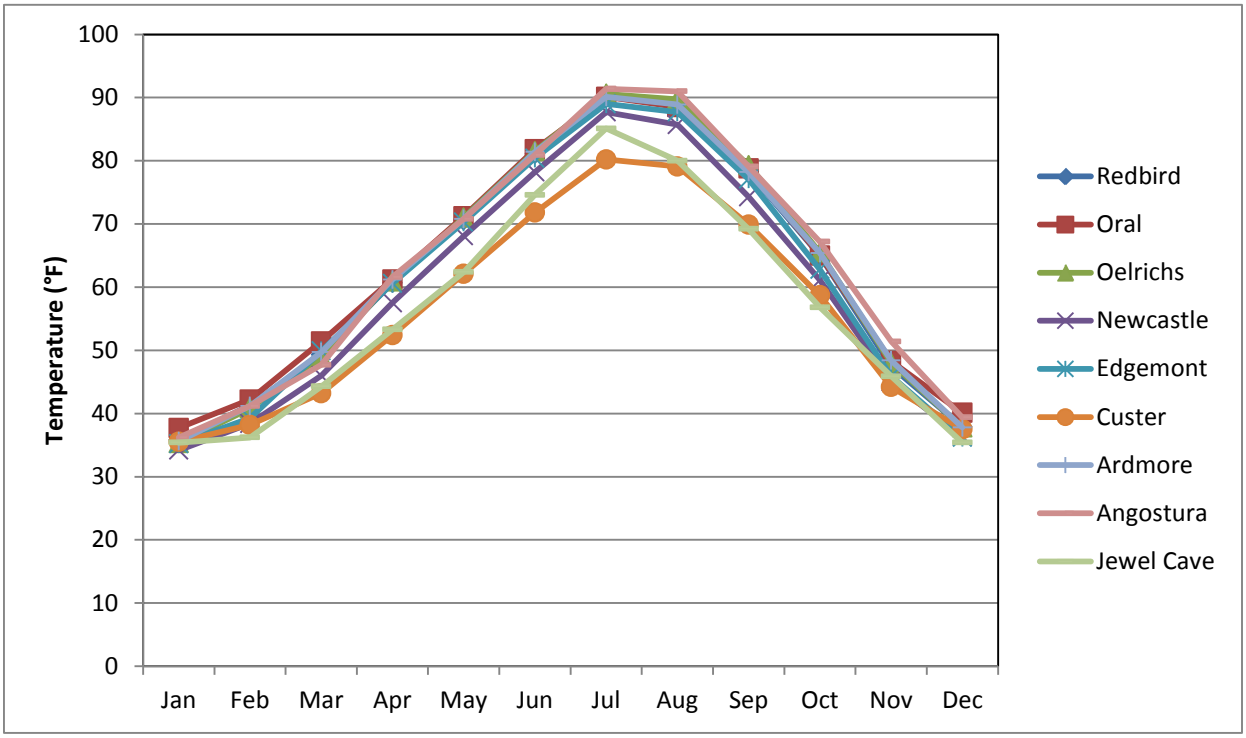
Source: HPRCC, 2008; SDSU, 2008

Figure 3.6-3: Average Monthly Temperatures for Regional Sites

Table 3.6-2: Average Monthly, Annual, and Seasonal Average Temperatures for Regional Sites

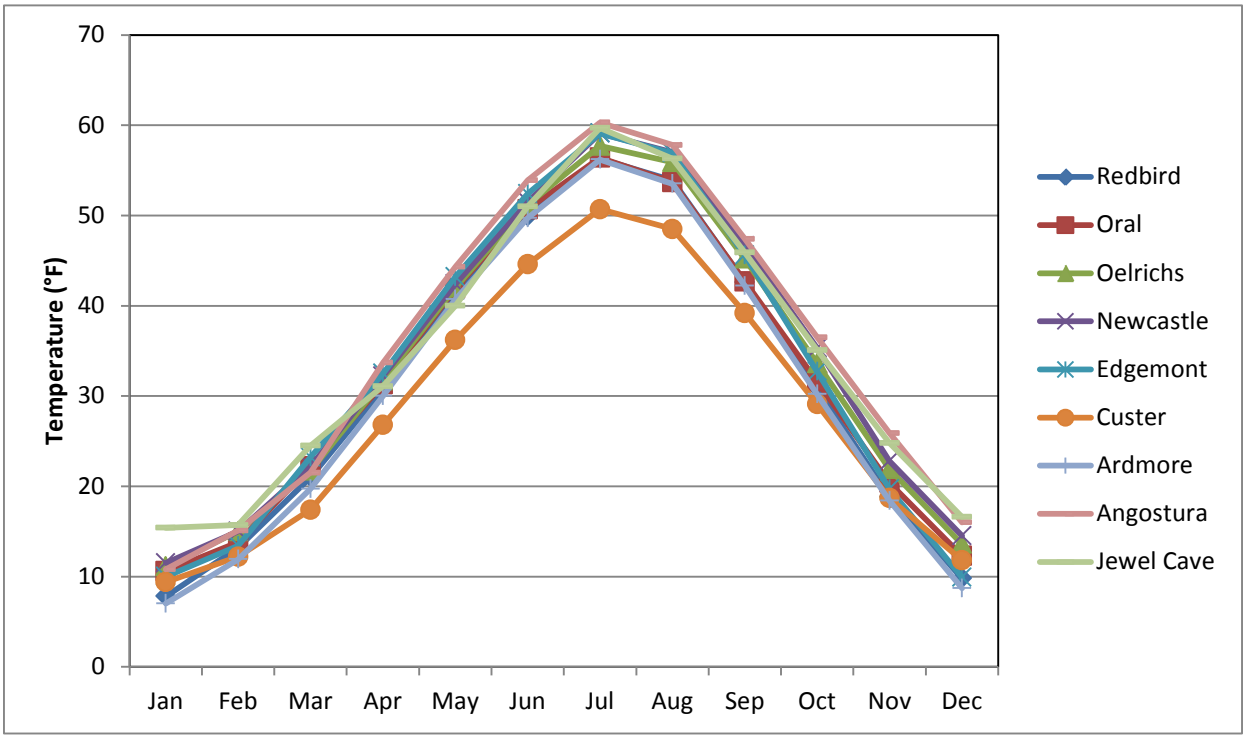
Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Winter	Spring	Summer	Fall
Redbird	21.8	27.3	35.1	45.8	55.8	65.5	73.3	71.4	60.4	47.9	33.1	23.8	46.8	24.3	45.6	70.1	47.2
Oral	24.1	27.9	36.6	46.3	56.6	66.2	73.2	71.1	60.7	48.3	34.3	26.1	47.6	26.1	46.5	70.2	47.8
Oelrichs	23.2	28.0	35.4	46.3	56.5	66.3	74.2	72.8	62.1	49.5	35.0	25.7	47.9	25.7	46.1	71.1	48.9
Newcastle	22.8	26.7	34.1	44.9	55.3	64.9	73.3	71.3	60.5	48.2	33.9	25.4	46.8	25.0	44.7	69.8	47.5
Edgemont	22.5	26.3	36.6	46.5	56.8	66.4	74.1	72.3	61.4	47.7	32.9	23.1	47.2	24.0	46.6	70.9	47.3
Custer	22.5	25.3	30.3	39.6	49.1	58.2	65.4	63.8	64.5	43.9	31.4	24.8	42.4	24.2	39.7	62.5	43.3
Ardmore	21.3	26.5	34.8	45.5	55.7	65.6	73.1	71.2	60.2	47.8	33.4	23.3	46.5	23.7	45.3	70.0	47.1
Angostura	23.5	28.1	34.9	47.9	57.5	67.4	75.9	74.3	63.3	51.8	38.4	27.3	49.2	26.3	46.8	72.5	51.2
Jewel Cave	25.5	25.8	34.0	42.2	51.1	62.7	72.5	67.9	57.6	45.6	35.0	25.7	45.5	25.7	42.4	67.7	46.1
Regional Average	23.0	26.9	34.6	45.0	54.9	64.8	72.8	70.7	61.2	47.9	34.2	25.0	46.7	25.0	44.9	69.4	47.4

Source: HPRCC, 2008; SDSU, 2008



Source: HPRCC, 2008; SDSU, 2008

Figure 3.6-4: Average Monthly Maximum Temperatures for Regional Sites



Source: HPRCC, 2008; SDSU, 2008

Figure 3.6-5: Average Monthly Minimum Temperatures for Regional Sites

Table 3.6-3: Average Monthly, Annual, and Seasonal Maximum Temperatures for Regional Sites

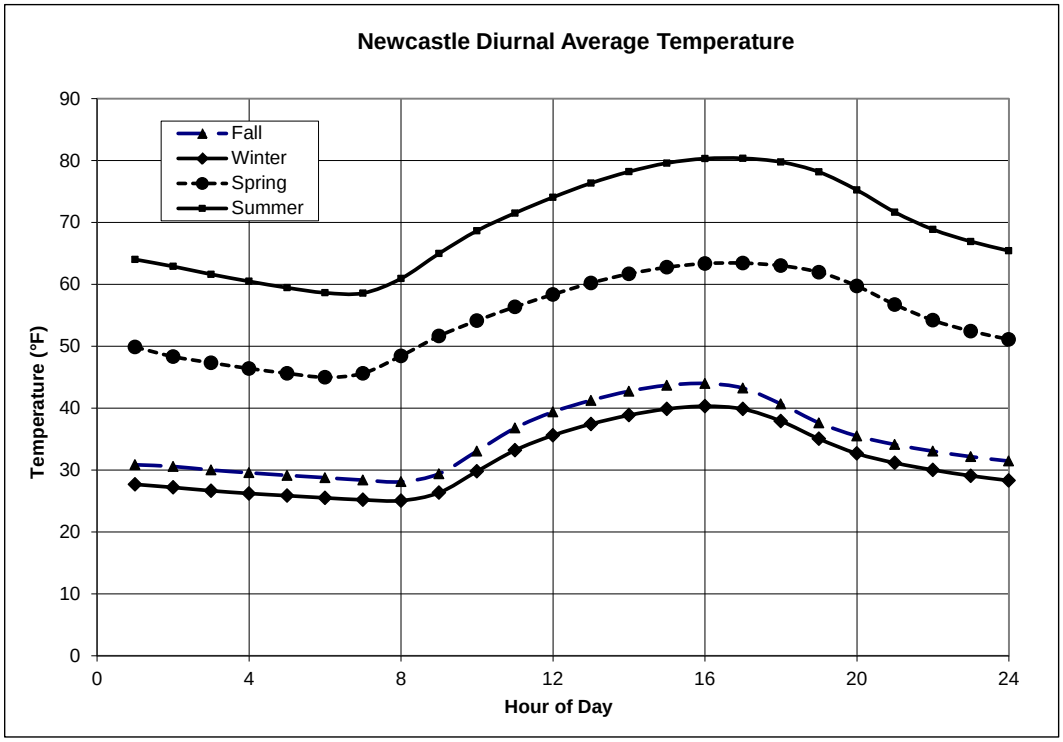
Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Winter	Spring	Summer	Fall
Redbird	35.8	41.3	49.3	60.7	70.6	81.1	90.2	88.9	78.2	65.0	47.4	37.9	62.2	38.3	60.2	86.7	63.5
Oral	37.7	42.2	51.4	61.2	71.2	81.8	90.1	88.5	78.8	65.0	48.3	40.1	63.0	40.0	61.3	86.8	64.0
Oelrichs	35.3	40.8	49.0	60.9	71.0	81.5	90.6	89.7	79.3	65.5	48.0	37.8	62.5	38.0	60.3	87.3	64.2
Newcastle	34.2	38.4	46.0	57.5	68.1	78.2	87.7	85.7	74.3	61.1	45.0	36.3	59.4	36.3	57.2	83.9	60.1
Edgemont	35.2	39.3	49.9	60.6	70.3	80.4	89.0	87.7	77.1	62.8	45.9	36.2	61.2	36.9	60.3	85.7	61.9
Custer	35.5	38.2	43.2	52.4	62.1	71.8	80.2	79.1	69.9	58.7	44.2	37.5	56.1	37.1	52.5	77.0	57.6
Ardmore	35.6	41.2	49.7	61.2	70.8	81.4	90.1	88.9	78.2	65.4	48.4	37.8	62.4	38.2	60.5	86.8	64.0
Angostura	36.2	41.2	47.7	61.6	70.8	80.9	91.4	91.0	79.1	67.2	51.4	39.4	63.2	38.9	60.0	87.8	65.9
Jewel Cave	35.4	36.2	44.3	53.3	62.4	74.6	85.1	80.0	69.2	56.8	45.9	35.4	56.5	35.6	53.3	79.9	57.3
Regional Average	35.7	39.9	47.8	58.8	68.6	79.1	88.3	86.6	76.0	63.1	47.2	37.6	60.7	37.7	58.4	84.7	62.1

Source: HPRCC, 2008; SDSU, 2008

Table 3.6-4: Average Monthly, Annual, and Seasonal Minimum Temperatures for Regional Sites

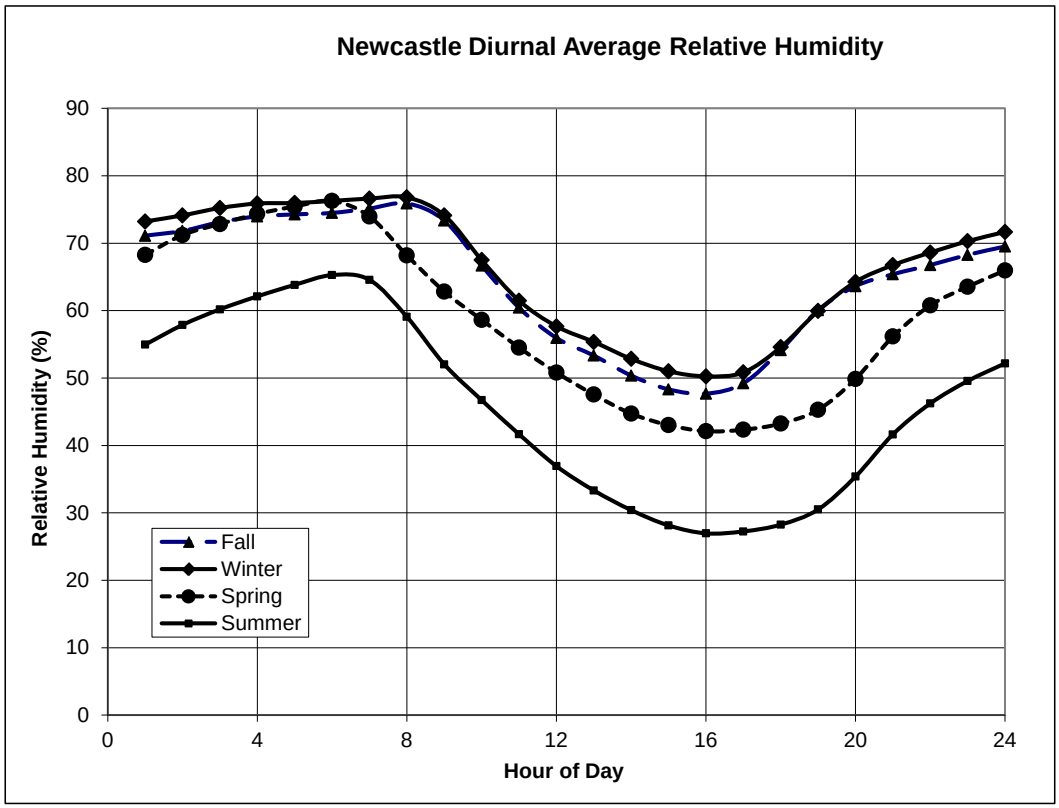
Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Winter	Spring	Summer	Fall
Redbird	7.8	13.2	21.0	30.8	41.1	49.9	56.3	53.9	42.6	30.9	18.8	9.8	31.4	10.3	31.0	53.4	30.8
Oral	10.6	13.8	22.2	31.3	41.9	50.7	56.4	53.7	42.7	31.6	20.4	12.3	32.3	12.2	31.8	53.6	31.6
Oelrichs	11.1	15.0	21.7	31.7	42.0	51.2	57.7	55.9	45.2	33.6	21.9	13.6	33.4	13.3	31.8	54.9	33.6
Newcastle	11.5	15.0	22.2	32.2	42.4	51.5	59.1	57.0	46.6	35.3	22.8	14.5	34.2	13.6	32.3	55.9	34.9
Edgemont	10.0	13.4	23.2	32.5	43.2	52.4	59.1	56.9	45.6	32.7	19.7	9.9	33.2	11.1	33.0	56.1	32.7
Custer	9.4	12.2	17.4	26.8	36.2	44.6	50.7	48.5	39.2	29.1	18.7	11.8	28.7	11.1	26.8	47.9	29.0
Ardmore	7.0	11.9	19.7	30.0	40.7	49.7	56.2	53.5	42.2	30.2	18.4	8.7	30.7	9.2	30.2	53.1	30.2
Angostura	10.8	15.1	21.5	33.7	44.3	53.9	60.3	57.8	47.4	36.5	25.9	16.0	35.3	14.0	33.2	57.3	36.6
Jewel Cave	15.4	15.7	24.5	31.1	40.0	51.0	59.7	56.3	45.9	35.1	24.8	16.6	34.7	15.9	31.9	55.7	35.3
Regional Average	10.4	13.9	21.5	31.1	41.3	50.5	57.3	54.8	44.2	32.8	21.3	12.6	32.7	12.3	31.3	54.2	32.7

Source: HPRCC, 2008; SDSU, 2008



Source: IML Air Science, 2011

Figure 3.6-6: Newcastle, Wyoming, Seasonal Diurnal Temperature Variations



Source: IML Air Science, 2011

Figure 3.6-7: Newcastle, Wyoming, Seasonal Diurnal Relative Humidity Variations

3.6.1.1.3 Precipitation

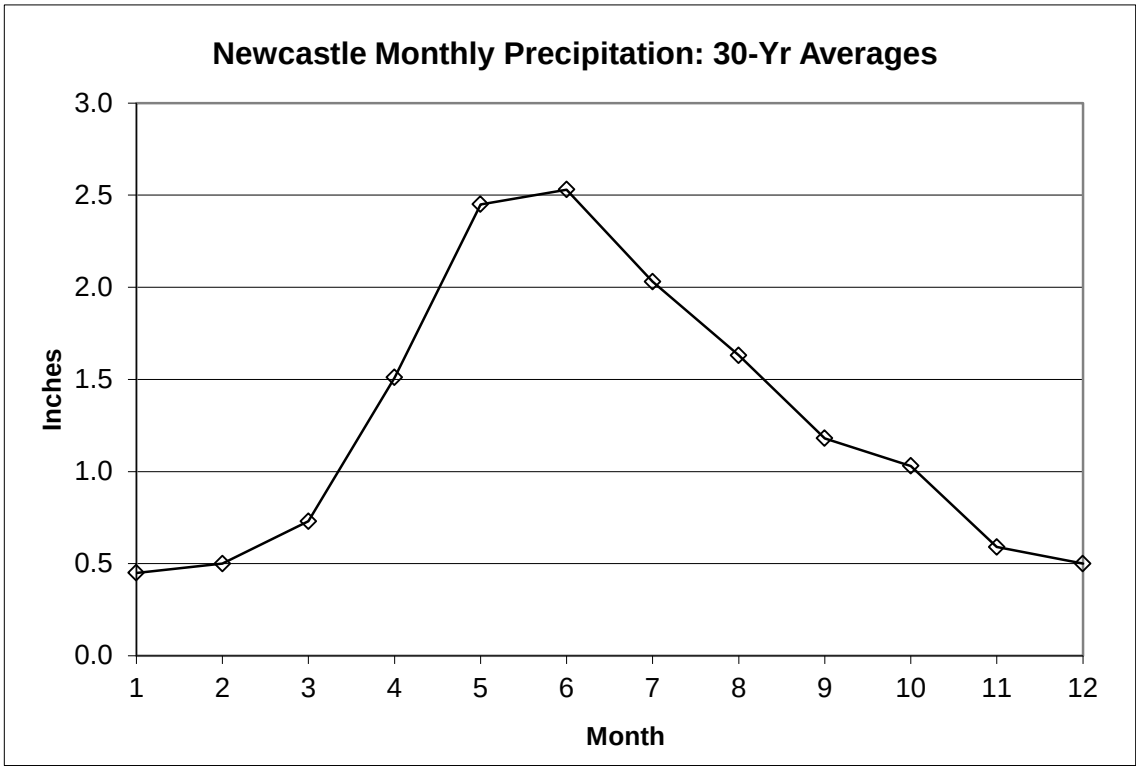
Figure 3.6-8 shows average monthly precipitation at the Newcastle NWS Coop site for the past 30 years. For comparison, Figure 3.6-9 shows monthly precipitation totals for the baseline monitoring year. It can be seen that unusually high precipitation was measured in the months of May and July of 2008.

Figure 3.6-10 and Table 3.6-5 show average monthly and seasonal precipitation amounts for all of the available meteorological monitoring sites in the area. This area can be very dry at times with a regional annual average precipitation of 16.5 inches. Most of the precipitation occurs during May, June, and July (48 percent of the annual). Typically, May is the wettest month of the year for this region with an average total of 2.8 inches. Winter receives roughly 8 percent of the total annual precipitation. January is the driest month of the year with an average accumulation of 0.36 inch of precipitation.

This region receives an average of 38 inches of snowfall each year. As shown in Figure 3.6-11, most snowfall occurs during the month of March with a regional average of 8.5 inches. Custer receives the most annual snowfall (48 inches). This can be attributed to the higher elevation and the influence of the surrounding Black Hills (Figure 3.6-12).

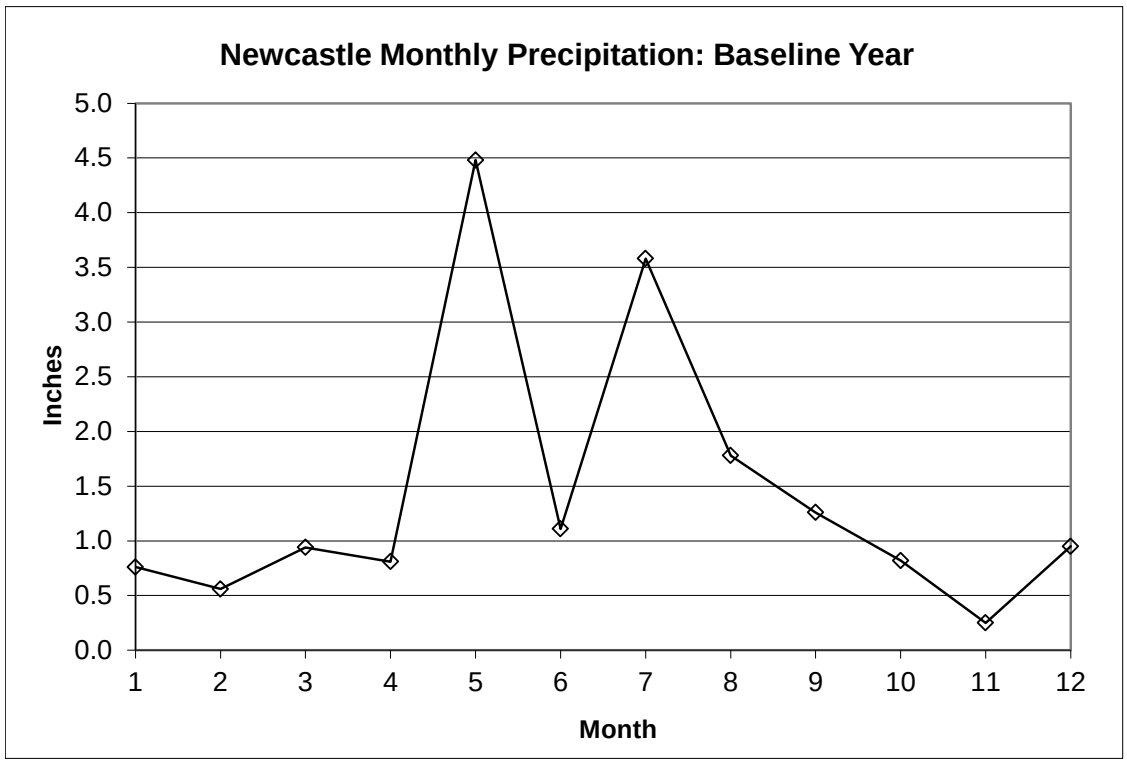
3.6.1.1.4 Wind Patterns

A meteorological station in Newcastle, Wyoming was used to evaluate long-term representativeness of the data collected at the site. The closest NWS station to the project site with hourly wind data is Chadron, Nebraska. Chadron was eliminated from consideration as it is more than 60 miles from the permit area and is lower in elevation. The wind patterns are substantially different, most likely due to the effect of the Black Hills on the Dewey-Burdock site. For demonstrating that baseline monitoring is representative of long-term conditions, particular emphasis is placed on wind speed, wind direction and atmospheric stability, as these parameters impact the modeling of potential radiological impacts from the Dewey-Burdock Project (MILDOS-AREA modeling) as well as air quality monitoring locations. While the Newcastle meteorological station is not strictly representative of the Dewey-Burdock site, it is sufficiently close in distance and geography to infer the regional relationship between the baseline monitoring period (7/18/2007 to 7/17/2008) and long-term conditions. The following describes how the baseline monitoring period is representative of long-term meteorological conditions in the region.



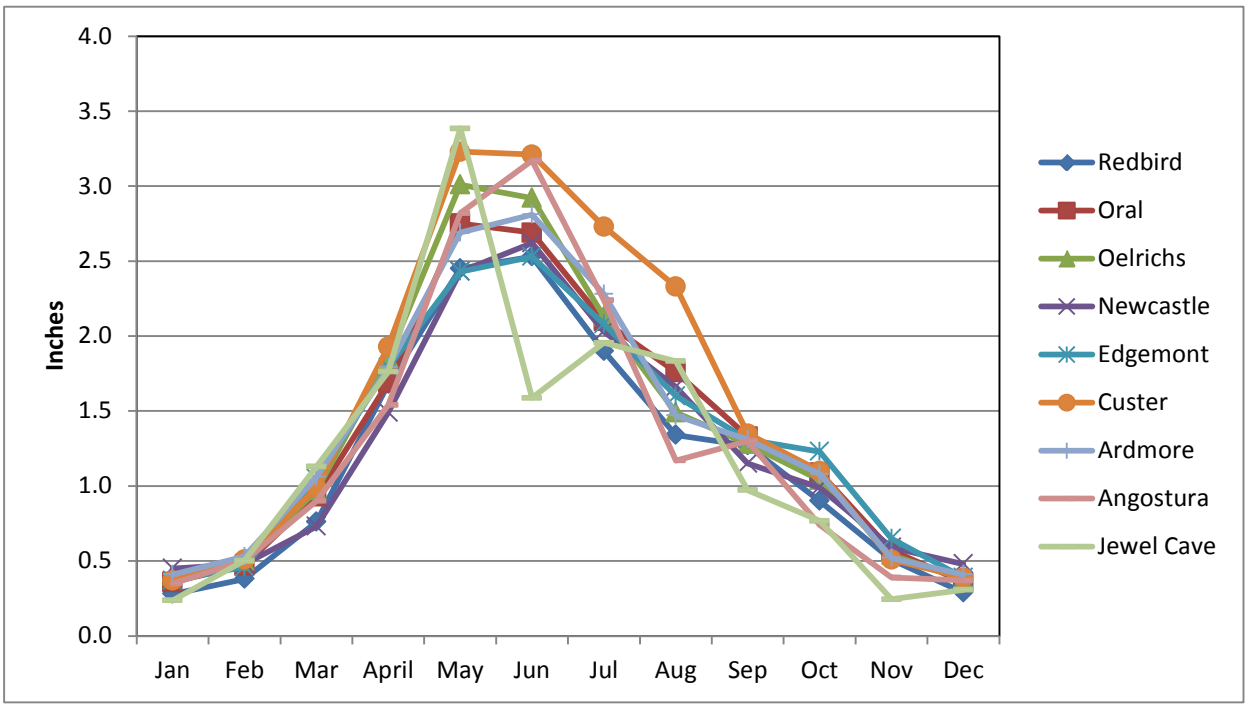
Source: IML Air Science, 2011

Figure 3.6-8: Average Monthly Precipitation for Newcastle, Wyoming



Source: IML Air Science, 2011

Figure 3.6-9: Baseline Year Monthly Precipitation for Newcastle, Wyoming



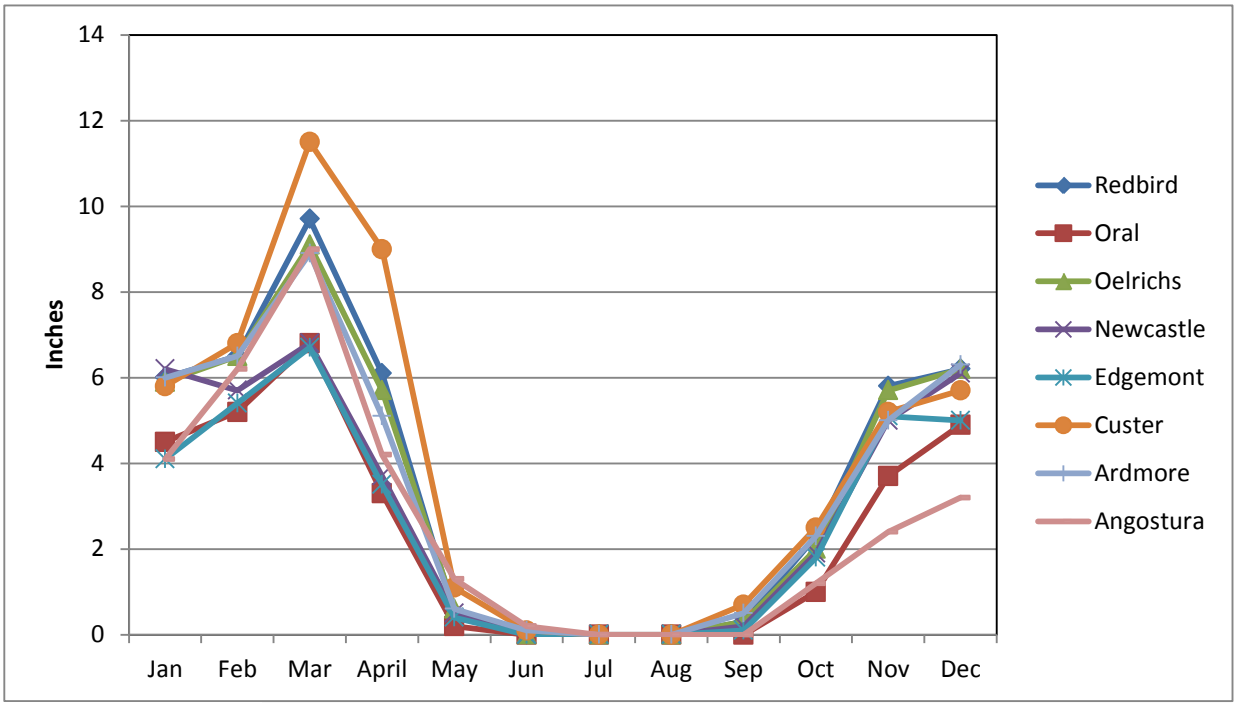
Source: HPRCC, 2008; SDSU, 2008

Figure 3.6-10: Average Monthly Precipitation for Regional Sites

Table 3.6-5: Average Seasonal and Annual Precipitation for Regional Sites

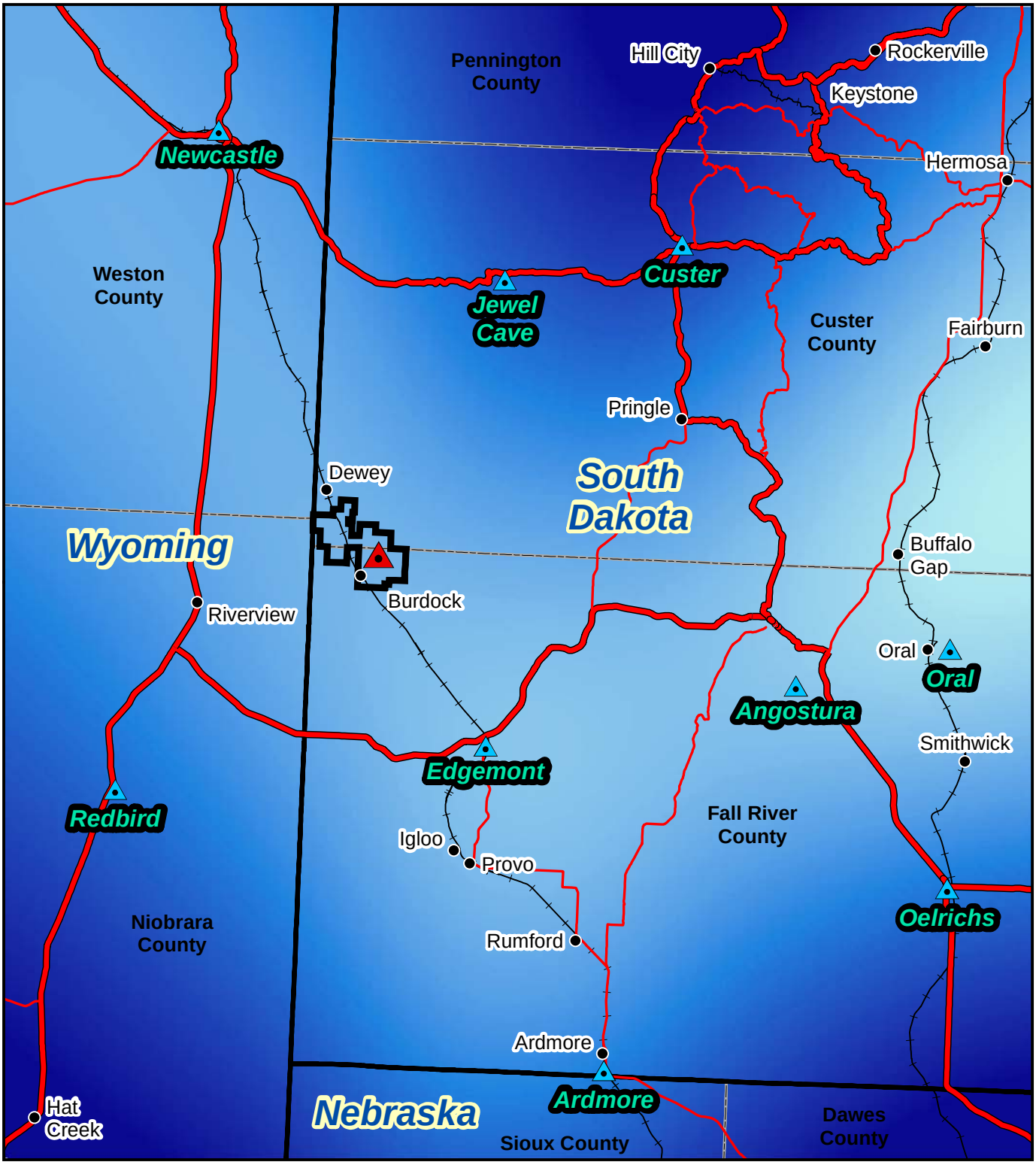
Name	Annual	Winter	Spring	Summer	Fall
Redbird	14.29	0.95	4.89	5.77	2.68
Oral	16.10	1.19	5.37	6.54	3.00
Oelrichs	16.50	1.28	5.83	6.54	2.85
Newcastle	15.11	1.41	4.65	6.32	2.73
Edgemont	15.87	1.22	5.26	6.20	3.19
Custer	18.66	1.27	6.15	8.28	2.96
Ardmore	16.35	1.34	5.54	6.56	2.91
Angostura	15.51	1.22	5.26	6.59	2.44
Jewel Cave	20.00	6.30	6.30	5.40	2.00
Region Average	16.49	1.80	5.47	6.47	2.75

Source: HPRCC, 2008; SDSU, 2008



Source: SDSU, 2008

Figure 3.6-11: Average Monthly Snowfall at Regional Sites



This figure is provided to fulfill the requirements of ARSD 74:29:02:11(1).

Miles
0 5 10 20
0 10 20 30
Kilometers

Legend

- Towns
- Permit Boundary
- Dewey-Burdock MET Station
- Meteorological Sites

Transportation
- US Highway
- State Highway
- Railroad

Snowfall (Inches)
- 61 (High)
- 44
- 27 (Low)

N

Figure 3.6-12

Average Annual Snowfall

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	24-Sep-2012
FILE	AnnualSnowfall.mxd

POWERTECH (USA) INC.

Figures 3.6-13 and 3.6-14 show wind roses at the Newcastle WRC site for the nearly 10 years of monitoring and for the one year corresponding to the Dewey-Burdock baseline monitoring period. Figure 3.6-15 presents a graphical representation of wind speed frequencies.

The long-term representativeness can be demonstrated quantitatively by isolating wind speed and wind direction variables to correlate short-term and long-term frequency distributions. IML Air Science has developed a statistical methodology for assessing the degree to which the distributions of wind speed class and wind direction frequencies from one year of monitoring at a particular location represent the long-term distributions at that same location.

For the joint frequency wind distribution used in the MILDOS-AREA model, wind speeds are divided into six classifications ranging from mild (0 – 3 mph) to strong (> 24 mph) as illustrated in Figure 3.6-15. Likewise, wind directions are divided into 16 categories corresponding to the compass directions illustrated in Figure 3.6-16.

The percent of the time that winds occur in each of the six wind speed categories can be calculated to produce a wind speed frequency distribution. The percent of the time that winds blow from each of the 16 directions can be calculated to produce a wind direction frequency distribution. For each parameter, the 1-year and 10-year distributions can then be compared. Linear regression analysis provides a useful tool to assess the degree of correlation between short and long-term distributions.

Figure 3.6-17 presents this correlation for the wind speed distributions at Newcastle. Each point represents one of the six wind speed classes. The x coordinate corresponds to the percent of the 1-year period during which the wind speed fell in a given class, while the y coordinate corresponds to the percent of the 10-year period during which the wind speed fell in that same class.

The regression line (red) in Figure 3.6-17 represents the least-squares fit to the six data points. The corresponding R^2 value of 99.3% implies very strong linear correlation. The linear slope of 0.98 further implies that short and long-term wind speed frequencies are substantially equivalent.

A similar analysis can be performed for wind direction frequencies. Figure 3.6-18 presents this correlation at Newcastle. Each point represents one of the 16 wind direction categories. The x coordinate corresponds to the percent of the 1-year period during which the wind blew from a given direction, while the y coordinate corresponds to the percent of the 10-year period during which the wind blew from that same direction.

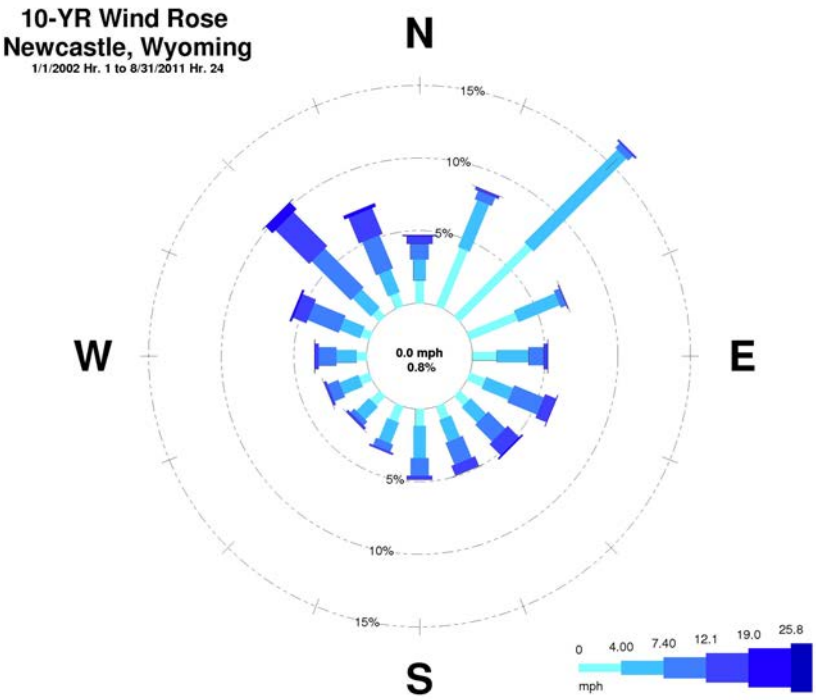


Figure 3.6-13: Newcastle 10-year Wind Rose

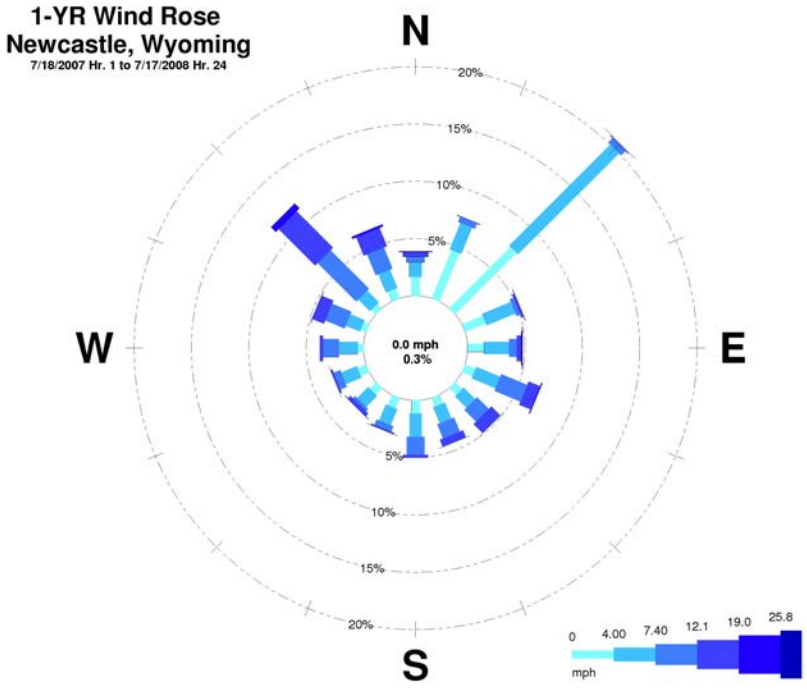
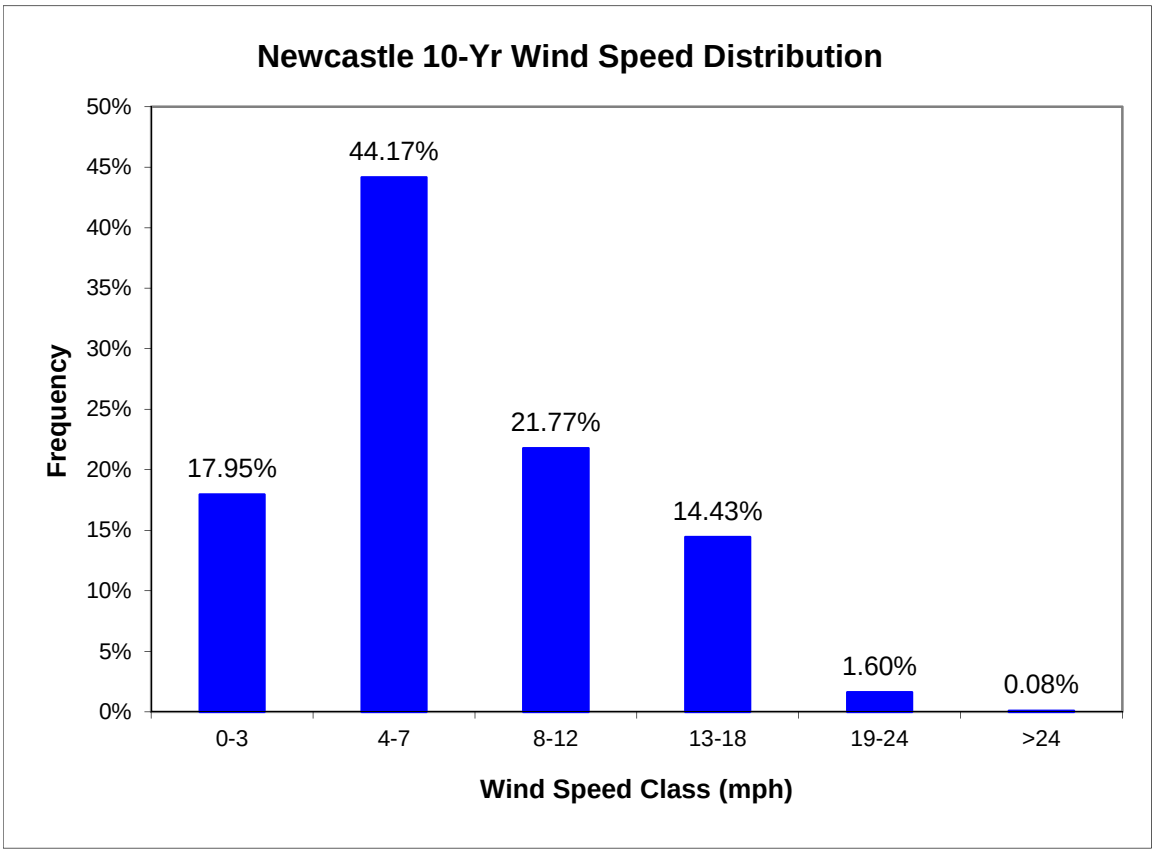


Figure 3.6-14: Newcastle 1-year Wind Rose



Source: IML Air Science, 2011

Figure 3.6-15: Wind Class Frequency Distribution for Newcastle, Wyoming from January 1, 2002 through August 31, 2011

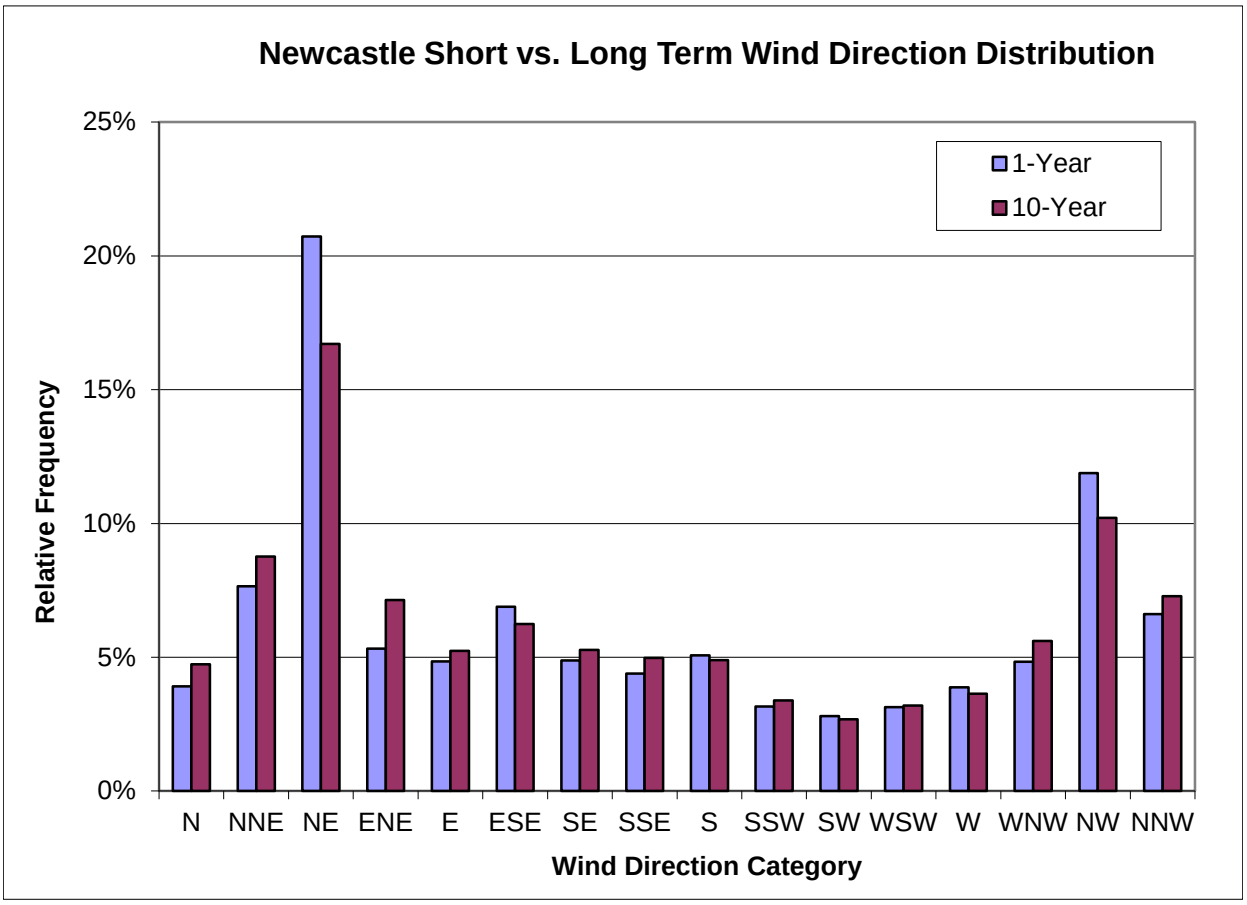


Figure 3.6-16: Newcastle Wind Direction Distributions

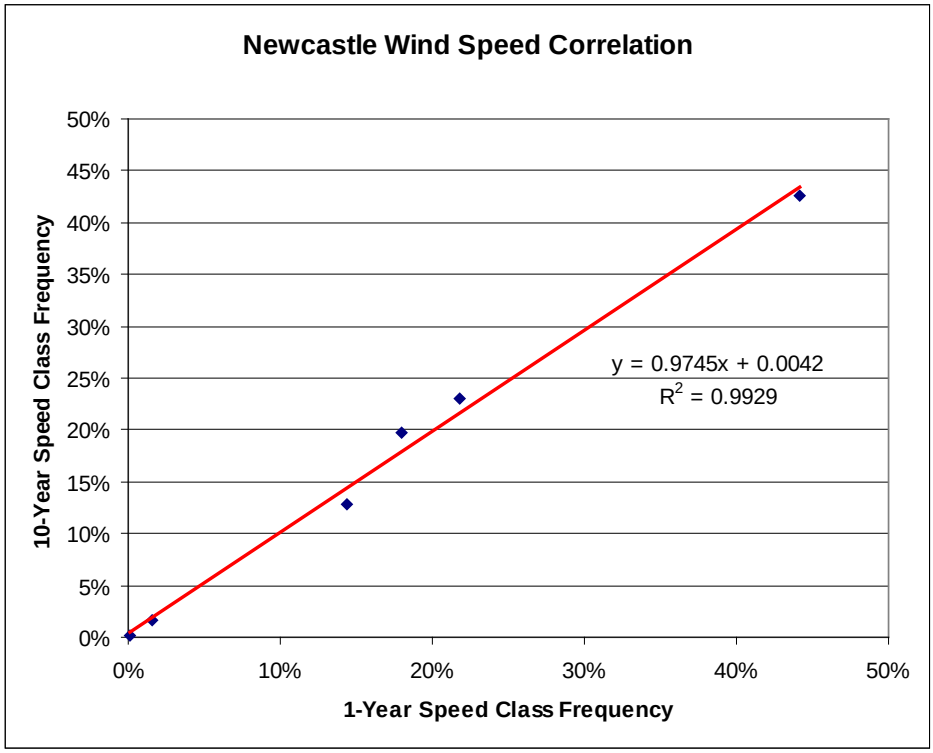


Figure 3.6-17: Newcastle Wind Speed Correlation

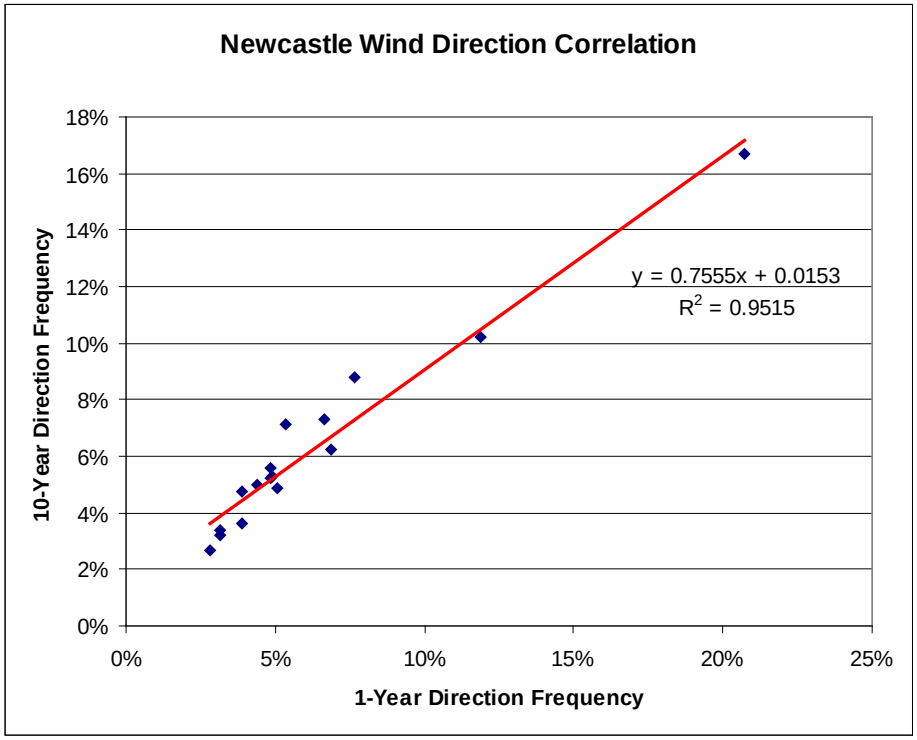


Figure 3.6-18: Newcastle Wind Direction Correlation

The regression line (red) in Figure 3.6-18 represents the least-squares fit to the 16 data points. The corresponding R^2 value of 95.2% implies very strong linear correlation. The linear slope of 0.76 further implies that short and long-term wind speed frequencies are similar.

Figures 3.6-17 and 3.6-18 offer conclusive evidence that the 2007-2008 baseline monitoring year adequately represents the last 10 years at Newcastle. Since the one-year wind data serve as reliable predictors of the long-term wind conditions at Newcastle, and since the Dewey-Burdock site experiences similar regional weather patterns, it is proposed here that the one-year baseline monitoring represents long-term meteorological conditions at the Dewey-Burdock site.

This same methodology can be used to determine whether or not Newcastle weather data are strictly representative of the Dewey-Burdock site. Figure 3.6-19 compares the wind direction distributions for the baseline monitoring year at the two sites. With an R^2 of 5.2%, Figure 3.6-19 indicates no correlation of wind direction frequencies between the two sites. Compared with the strong temporal correlation at the Newcastle site (short and long-term as demonstrated above), there appears to be very little spatial correlation between the two sites.

This result is heavily influenced by what appears to be an outlier. The NE sector constitutes 3.5% of the winds at the Dewey-Burdock site and 20.7% of the winds at Newcastle. This difference may stem from local topographic effects. Newcastle is situated in a “bowl” at the base of the Black Hills, and is subject to mild convection winds that tend to blow down the mountain from evening to early morning hours. This common phenomenon is related to differential air temperatures that cycle diurnally, with the cooler mountain air sinking to the adjoining valleys at night. Figure 3.6-20 shows the long-term wind rose for Newcastle for daytime hours only (9:00 a.m. to 5:00 p.m.). During these hours the NE component is substantially diminished relative to Figure 3.6-13, presumably due to the absence of down-slope convection breezes. It is reasonable to assume that the Dewey-Burdock site, situated several miles farther from the mountains than Newcastle, would not experience the same degree of diurnal convection breezes.

If the NE component is removed from each frequency distribution, a mild correlation between the two sites emerges. Figure 3.6-21 presents the same regression analysis as Figure 3.6-19, except with the NE outlier removed. While the much higher R^2 value of 60% still suggests no more than a weak correlation, it supports the premise that both sites are influenced by similar regional weather patterns. Hence, the conclusion that using the baseline year to represent long-term conditions is valid at either the Newcastle or the Dewey-Burdock site, but not between the two sites.

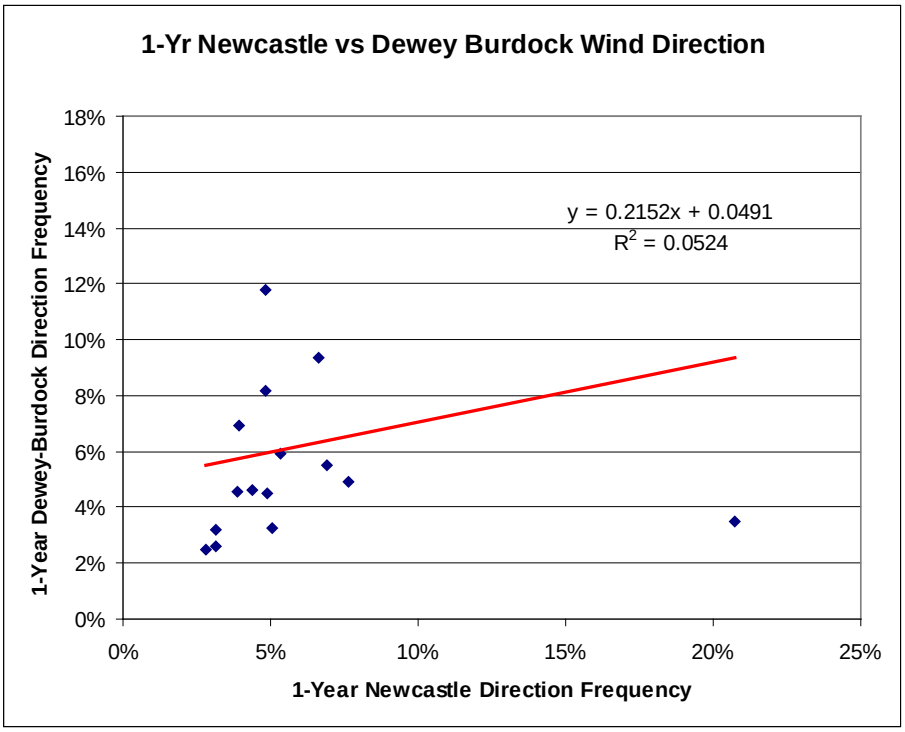


Figure 3.6-19: 1-year Newcastle vs. Dewey-Burdock Wind Direction

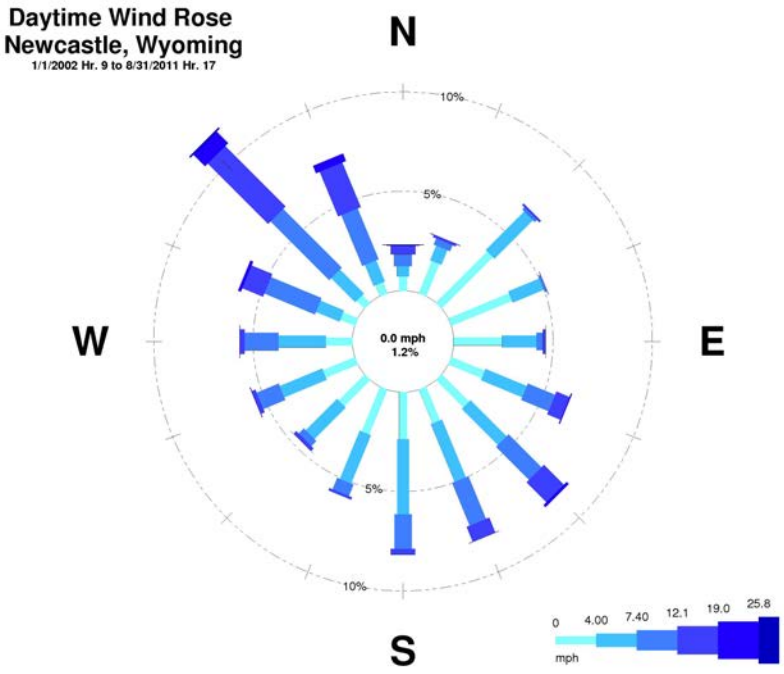


Figure 3.6-20: Newcastle Daytime Wind Rose

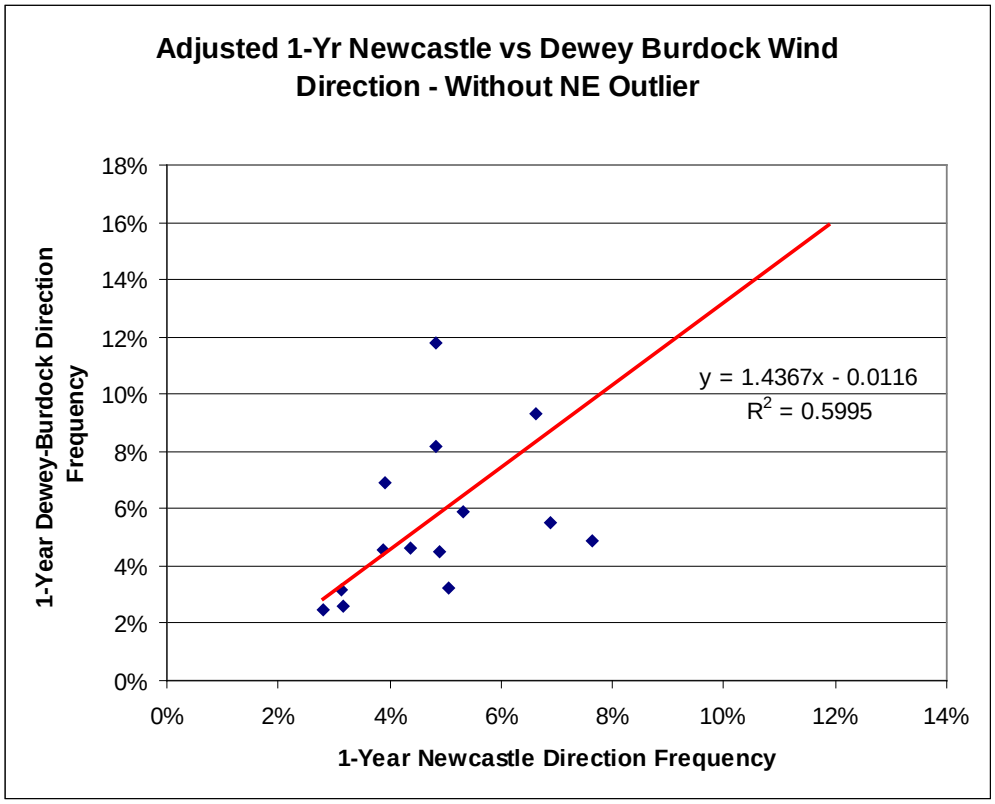


Figure 3.6-21: Adjusted 1-year Newcastle vs. Dewey-Burdock Wind Direction – Without NE Outlier

Figure 3.6-22 compares the baseline year wind roses from Newcastle, Dewey-Burdock, and Chadron. With the exception of the NE component discussed above, the Newcastle wind rose resembles that of Dewey-Burdock. On the other hand, the Chadron wind rose reflects an entirely different wind regime. The meteorological differences between Chadron and these other two sites may be attributed to the much greater distance from Chadron to the Black Hills, its lower elevation (3,280 ft), and the increased influence of Great Plains weather patterns.

3.6.1.1.5 Cooling, Heating and Growing Degree Days

The graphs shown in Figures 3.6-23, 3.6-24, and 3.6-25 summarize the growing degree, cooling degree, and heating degree days for the nine meteorological sites in the area. The data show a similar pattern for all three parameters throughout the sites with the exception of the Jewel Cave and Custer sites, the differences at which are likely caused by the higher relative elevation of these two sites.

Figure 3.6-26 presents these three measures for Newcastle on the same graph. All degree days calculations used a base temperature of 55°F. Heating and cooling degree days are included to show deviation of the average daily temperature from the chosen base temperature. The number of heating degree days is computed by taking the average of the high and low temperature occurring that day and subtracting it from the base temperature. The number of growing degree days and cooling degree days is computed in the opposite fashion where the base temperature is subtracted from the average of the high and low temperature for the day. Negative values are disregarded for both calculations.

3.6.1.1.6 Evapotranspiration

The American Society of Civil Engineers (ASCE) Standardized Reference Evapotranspiration Equation was used to calculate daily evapotranspiration (ET) using a tall reference crop coefficient. Note that these calculations were performed to estimate regional ET only; as described in Appendix 5.3-A and the GDP, hydrologic modeling of the land application systems conservatively assumed no crop (bare soil). The weather parameters needed to calculate ET using this method are daily maximum and minimum temperature, maximum and minimum relative humidity, total solar radiation, and average wind speed. The Oral site was the only one in the region with all these weather parameters being sampled and was, therefore, the site used for this analysis. The data were available from May 8, 2003, to July 20, 2008. Figure 3.6-27 displays a graph of the average accumulated ET for each month. Most ET occurs during the summer months of June, July, and August with an average monthly accumulation of 10.3 inches.

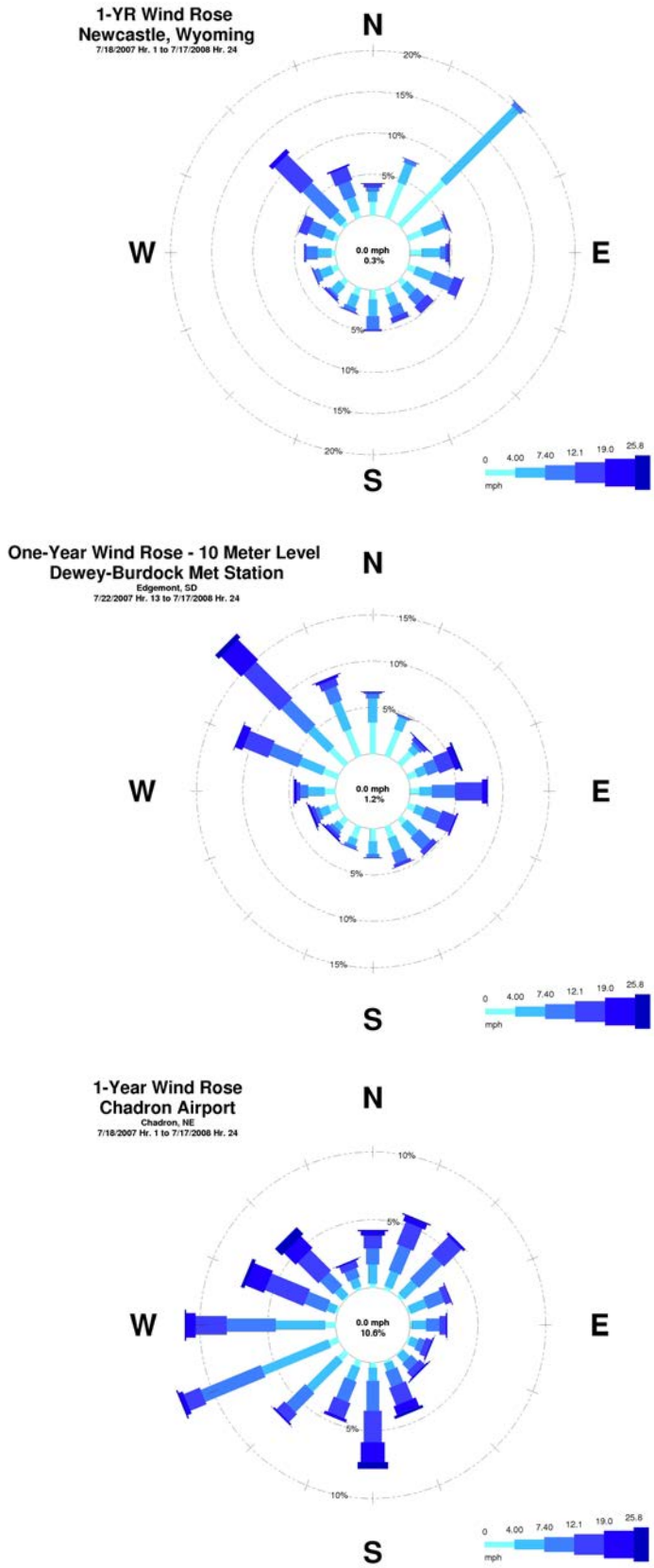
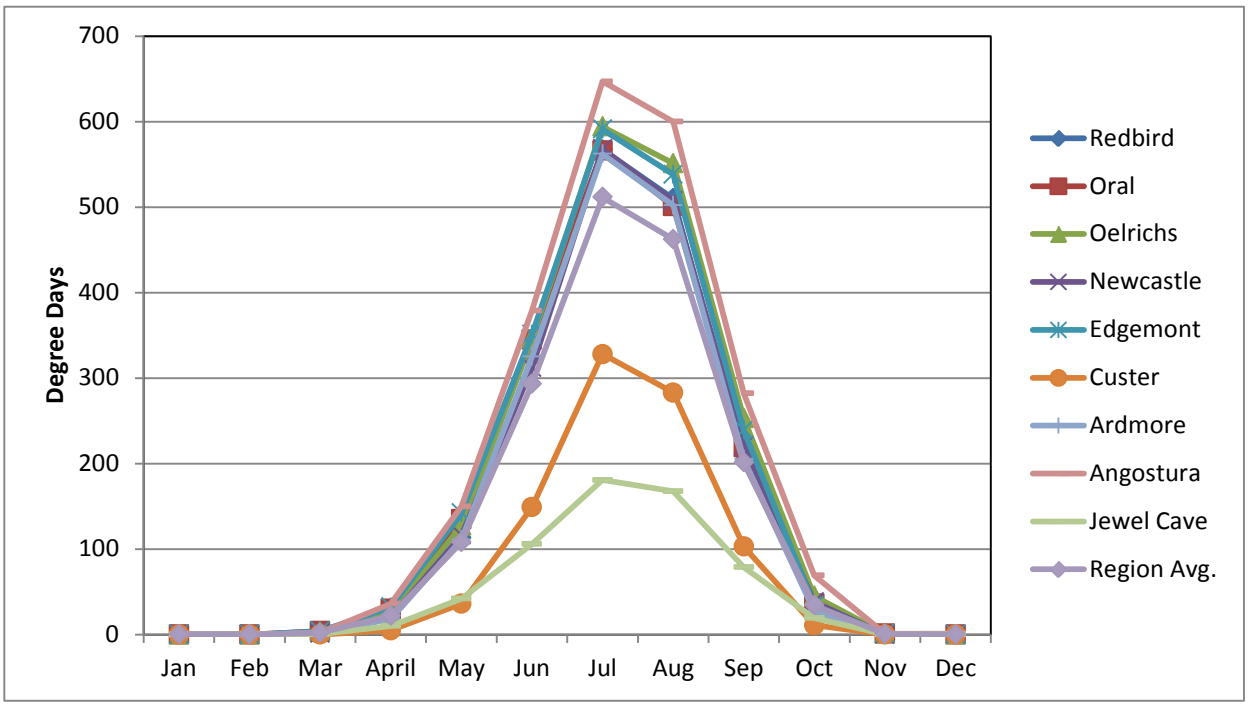
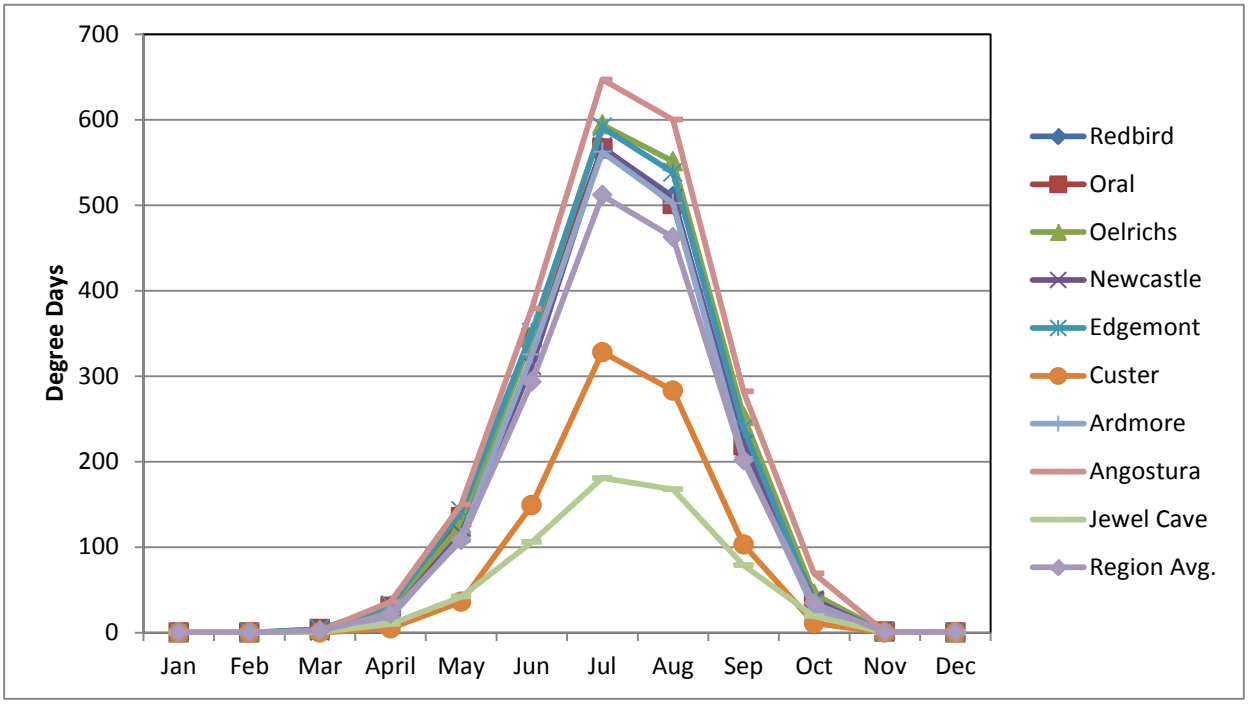


Figure 3.6-22: Comparative Wind Roses



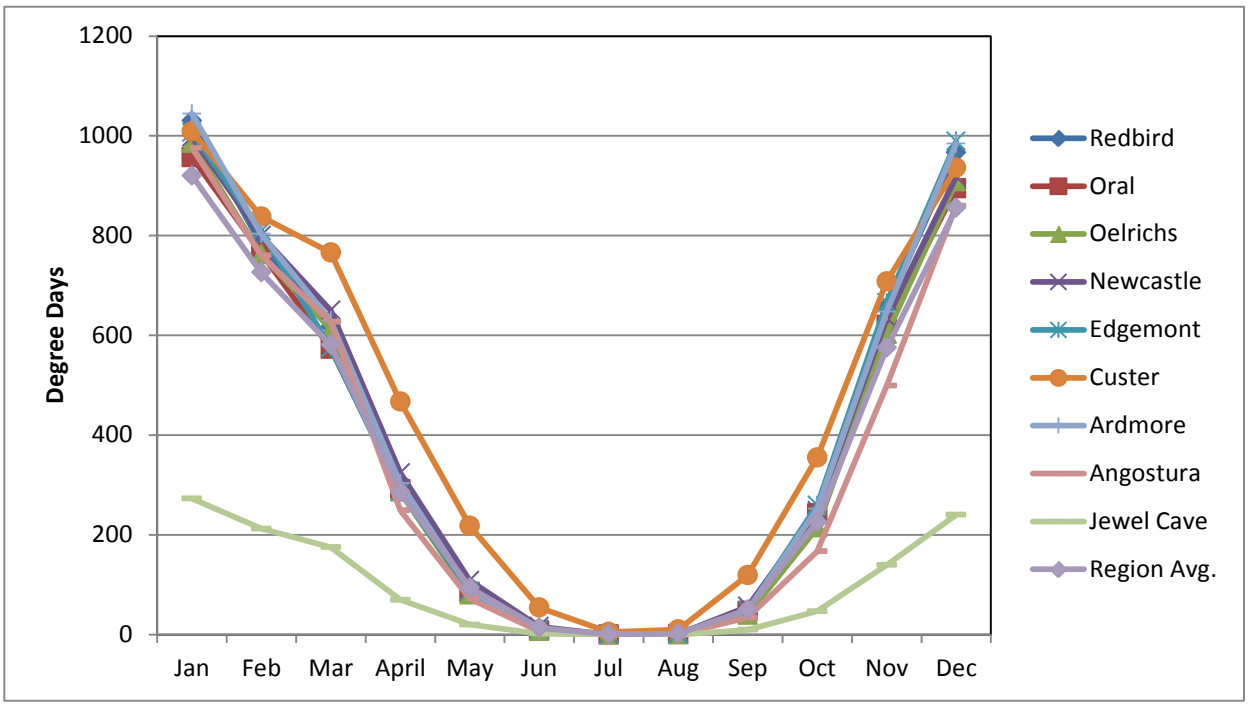
Source: HPRCC, 2008; SDSU, 2008

Figure 3.6-23: Growing Degree Days for Regional Sites



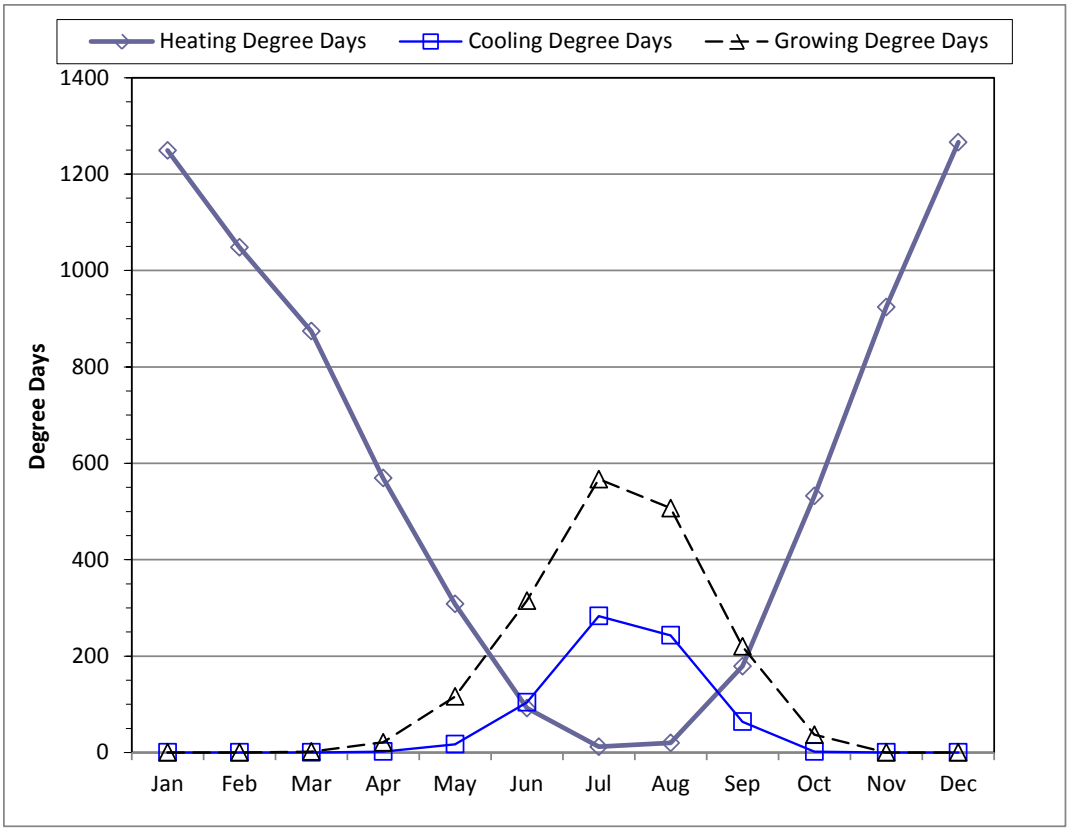
Source: HPRCC, 2008; SDSU, 2008

Figure 3.6-24: Cooling Degree Days for Regional Sites



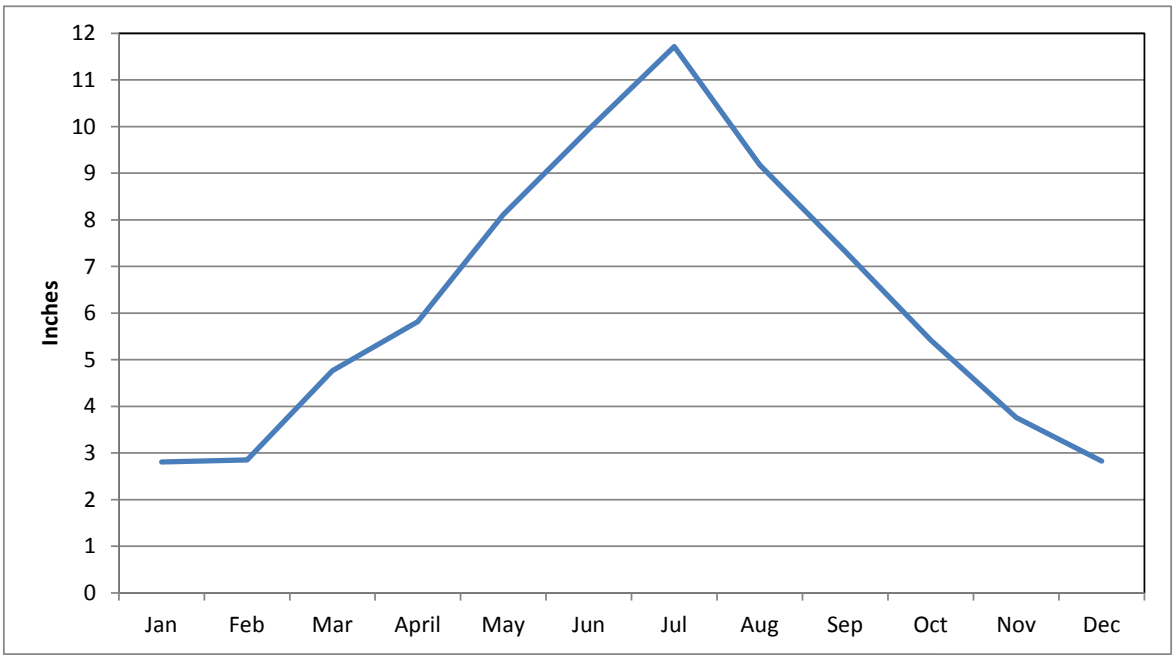
Source: HPRCC, 2008; SDSU, 2008

Figure 3.6-25: Heating Degree Days for Regional Sites



Source: WRCC, 2011

Figure 3.6-26: Degree Days for Newcastle NWS Site



Source: HPRCC, 2008; SDSU, 2008

Figure 3.6-27: Average Monthly Accumulated Evapotranspiration for Oral, South Dakota

During the winter months, low ET (2.8 inches) occurs because of low temperatures and low solar radiation.

No ET data were available for the Newcastle site. The nearest relevant evaporation data in Wyoming were obtained from the Wyoming Water Research Center (WWRC) for Casper, Wyoming (Figure 3.6-28). Casper experiences solar radiation values similar to Newcastle. Higher winds and lower rainfall at Casper suggest that ET should be higher than at Newcastle.

The lake evaporation rates in Figure 3.6-28 are computed from pan evaporation measurements by applying a 0.70 multiplier, which is typical practice in this region. The WWRC source document states that "the potential evapotranspiration estimates are sometimes considered to be equivalent to lake evaporation." Therefore, the lake evaporation provides a surrogate measure of ET in Casper.

It will be noted by comparing Figures 3.6-27 and 3.6-28 that projected ET values are significantly higher at Oral, South Dakota than at Casper, Wyoming. This could be attributed to the use of a tall reference crop coefficient at the Oral, South Dakota site. Regardless, the Newcastle site is expected to more closely resemble Casper, Wyoming.

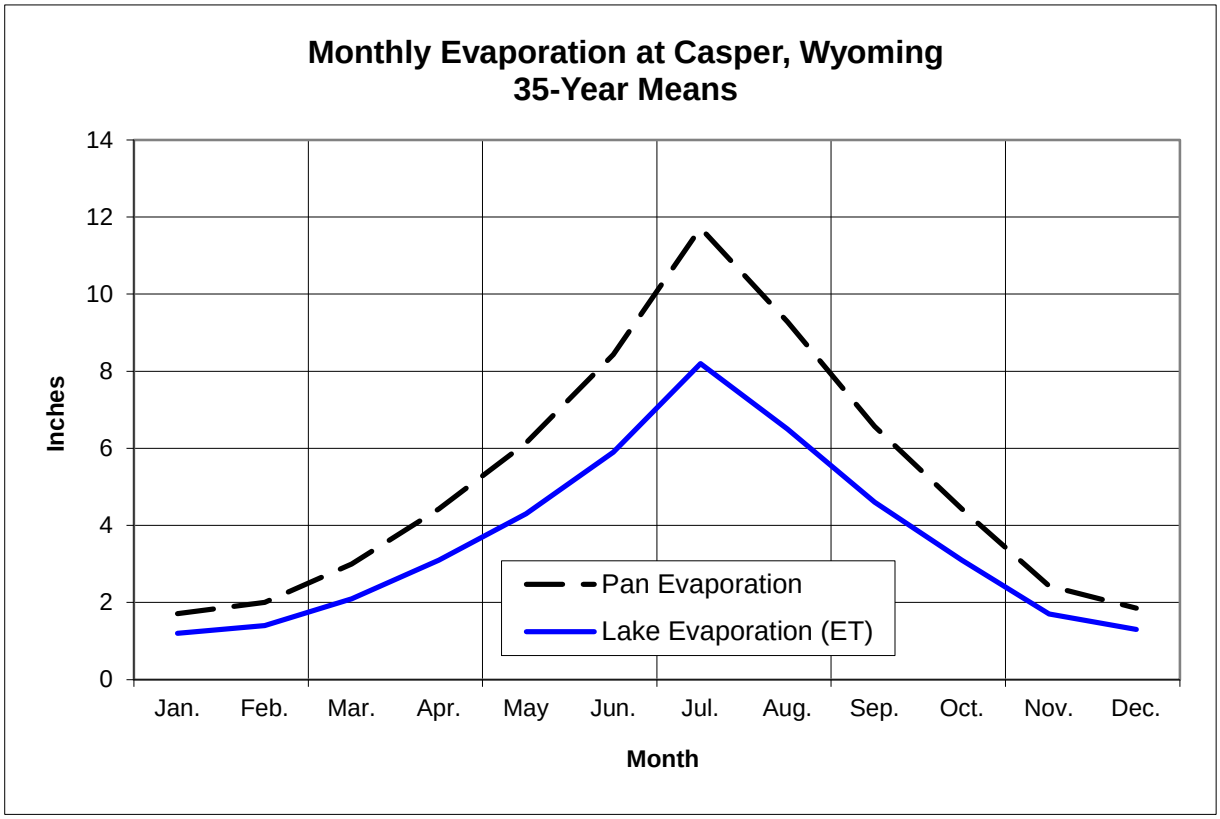
3.6.1.2 Site-Specific Analysis

The site-specific analysis was completed using data collected from a weather station installed in approximately the center of the proposed permit boundary. The station is located on a site that is representative of the area within the boundary. Twelve months of data from July 18, 2007 to July 17, 2008 are used for this analysis.

This site was installed in cooperation with the South Dakota State Climatology office according to the standards they use to install their Automatic Weather Data Network (AWDN) stations. The parameters being sampled at the site are air temperature, solar radiation, humidity, precipitation, and wind speed/direction at both 3- and 10-meter heights (9.8 and 32.8 feet). Table 3.6-6 lists the model number and specifications of the sensors that were installed. All results of the statistical analysis, completed using Minitab software version 14.0 for the parameters analyzed, are included in Appendix 3.6-B.

3.6.1.2.1 Temperature

The average hourly temperature over the year for the site was 45.5°F. A maximum temperature of 104°F was reached on both July 21, 2007 and August 13, 2007, while the minimum



Source: Wyoming Water Research Center, 1985

Figure 3.6-28: Average Monthly Evaporation for Casper, Wyoming

Table 3.6-6: Specifications for Weather Instruments Installed to Perform Site-Specific Analysis

Instrument	Model	Manufacturer	Accuracy/ Threshold	Operating Temperature	Required Standard
Precipitation	VR6101	Vaisala	0.01 inch	-40°C to 60°C	0.1 inch
Wind Direction	024A	Met-One	±5 degrees/1 mph	-50°C to 70°C	±5 degrees
Wind Speed	014A	Met-One	0.25 mph/1 mph (0.11 m/s)	-50°C to 70°C	1.0 mph (0.5 m/s)
Temperature and RH	HMP45C	Vaisala	Temp: ±2% for 10-90% RH: ±3% of 90-100% RH	-40°C to 60°C	Consistent with current state of the art
Solar Radiation	LI200X	Lt-Cor	Absolute error in natural daylight is ±5% max; ±3% typical	-40°C to 65°C	Consistent with current state of the art

temperature for the period of record was –28°F on January 22, 2008. A boxplot of the average temperature by month is shown in Figure 3.6-29. July was the warmest month with a median temperature of 76°F with a first quartile of 69°F and a third quartile value of 85°F. Conversely, December and January were the coolest months with a median temperature of 15°F.

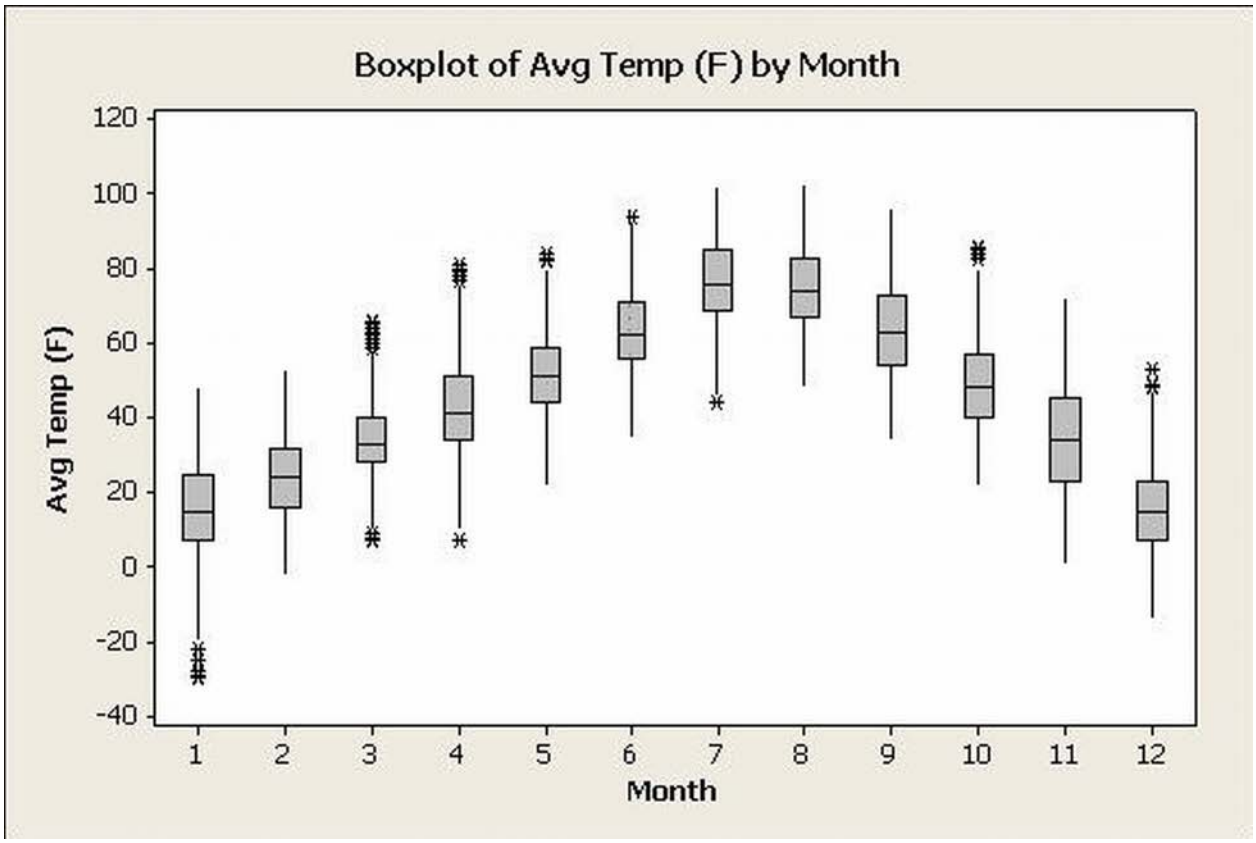
There were large variations in seasonal and diurnal temperature (Figure 3.6-30). In the summer season, average temperatures were from 60°F at 6 a.m. to 83.6°F at 5 p.m. In the winter season, temperatures averaged 11°F between 7 a.m. and 8 a.m. and rose to nearly 27°F at 4 p.m. The diurnal variations are the result of the lack of relative humidity in the atmosphere at the site, which causes the earth's surface to rapidly absorb and release the energy supplied by the sun.

Figure 3.6-31 shows a probability plot of average hourly temperature for the year. Temperatures above or below 46°F were expected at the site 50 percent of the time, and temperatures dipped below the freezing mark (32°F) 31 percent of the time.

3.6.1.2.2 Wind Patterns

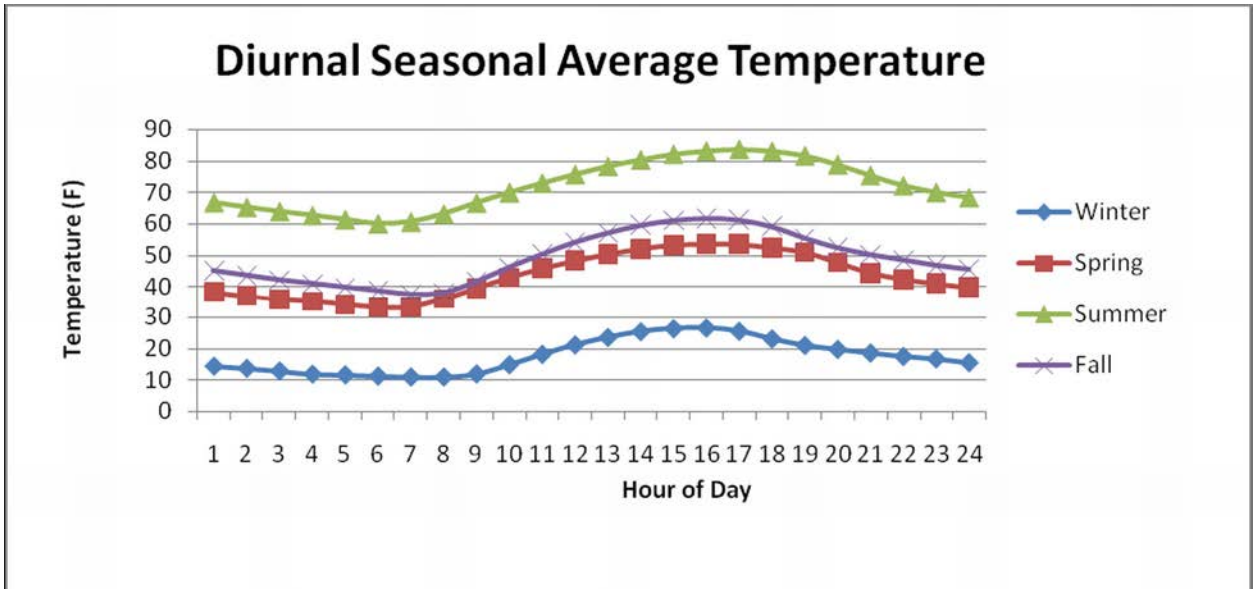
Wind speed and direction were measured in the field using Met-One 014A and 024A model sensors. Wind data analysis outputs are included in Appendix 3.6-C. The average wind speed over the period of record was approximately 9 mph, while calm winds occurred only 1.2 percent of the time.

As shown in Table 3.6-7, over a third of the winds (34 percent) come from the north-northwest, northwest and west-northwest. Approximately 24 percent of all winds were less than 3.5 mph. Northwesterly, west-northwesterly and north-northwesterly winds were prevalent in the winter months. Easterly, east-northeasterly and east-south easterly winds were prevalent in summer months. Figures 3.6-32 and 3.6-33 show the quarterly wind roses for the Dewey-Burdock permit area. The period from January through March was used for the 1st Quarter, April through June for 2nd Quarter, July through September for 3rd Quarter and October through December for 4th Quarter. The 3rd Quarter wind rose reflects hourly data from both 2007 and 2008. Figure 3.6-34 shows the annual wind rose for the project site, with northwesterly and west-northwesterly winds dominating. Figure 3.6-35 shows that December had the least amount of wind with an average wind speed of 5 mph. In contrast, May was the windiest month with an average wind speed of 12 mph.



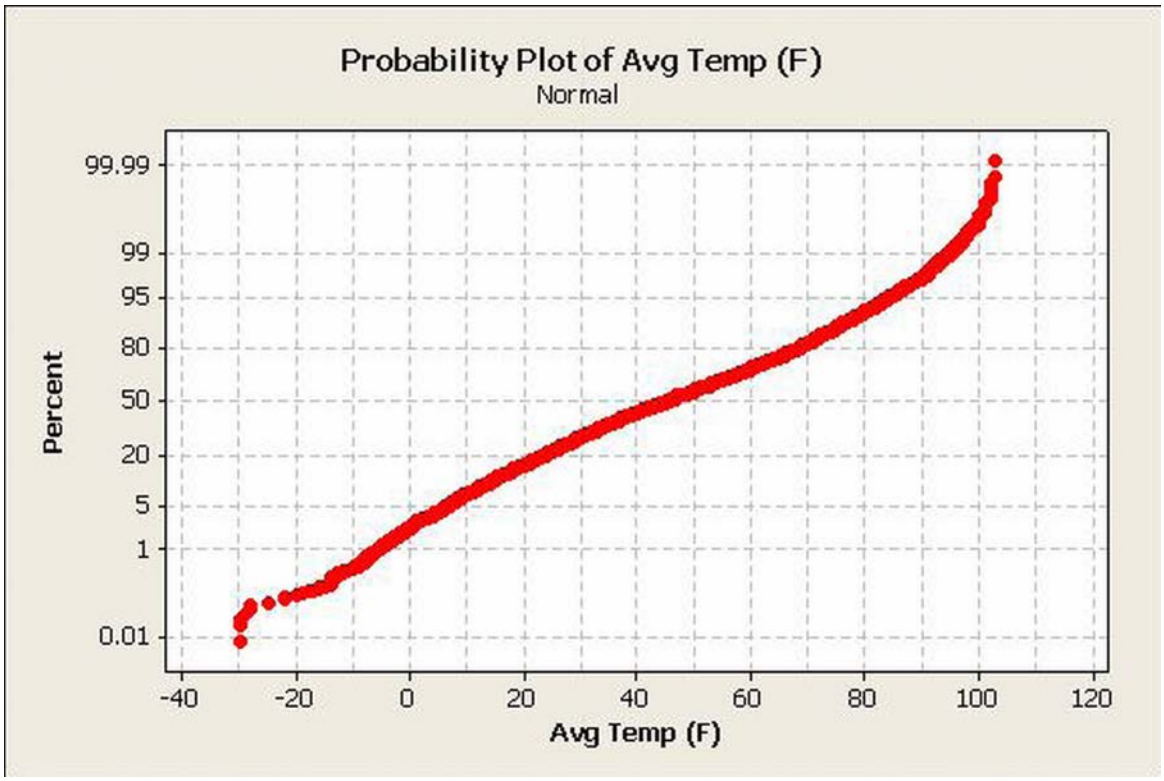
Source: SDSU, 2008

Figure 3.6-29: Average Temperature by Month from the Project Meteorological Site



Source: SDSU, 2008

Figure 3.6-30: Diurnal Average Temperature for the Project Meteorological Site by Season



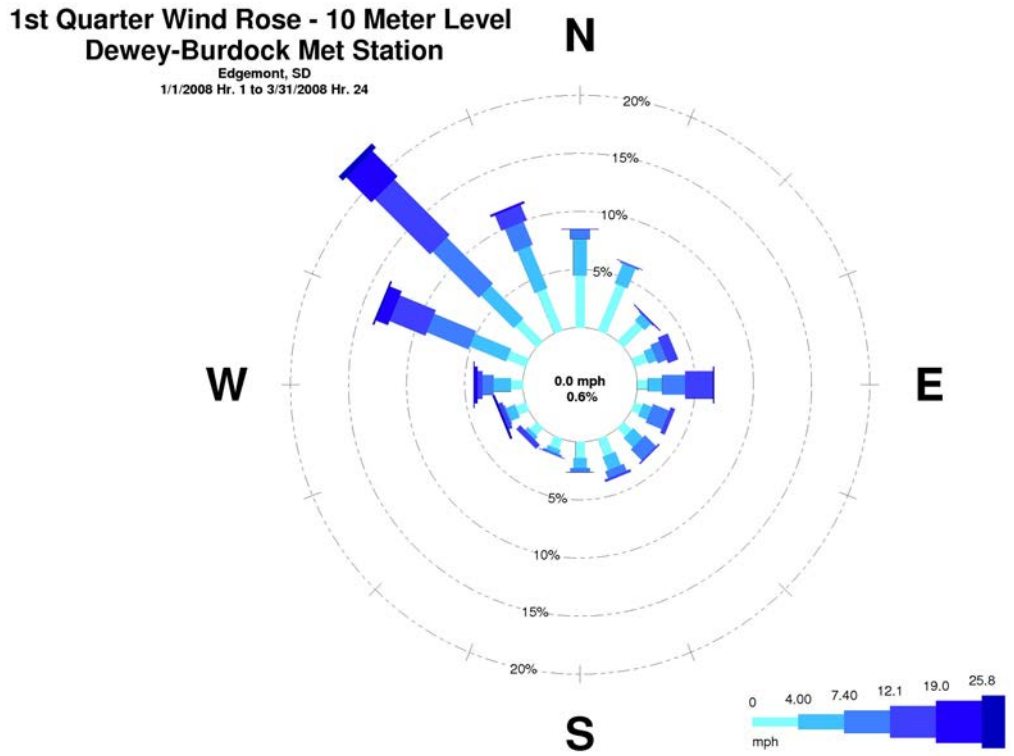
Source: SDSU, 2008

Figure 3.6-31: Probability Plot of Average Temperature from the Project Meteorological Site

Table 3.6-7: Normalized Frequency Distribution of Wind at the Project Meteorological Site

Frequency Distribution (Normalized)							
Wind Direction	**Wind Speed Classification (mph)**						
	1–3	**4–7**	**8–12**	**13–18**	**19–24**	**≥ 24**	**Total**
N	0.030713	0.024749	0.002587	0.001125	0.000337	0.000000	**0.059511**
NNE	0.027653	0.012374	0.001575	0.000450	0.000000	0.000112	**0.042165**
NE	0.016474	0.007087	0.004050	0.002025	0.000112	0.000337	**0.030086**
ENE	0.009649	0.011924	0.013612	0.011812	0.002025	0.001800	**0.050822**
E	0.009178	0.016424	0.028573	0.014174	0.001350	0.000562	**0.070262**
ESE	0.007531	0.014399	0.016312	0.008437	0.000787	0.000000	**0.047466**
SE	0.006825	0.015862	0.013837	0.002025	0.000225	0.000000	**0.038773**
SSE	0.011885	0.018224	0.008212	0.001237	0.000337	0.000000	**0.039896**
S	0.012120	0.013724	0.002025	0.000112	0.000000	0.000000	**0.027982**
SSW	0.012356	0.007087	0.002587	0.000337	0.000000	0.000000	**0.022368**
SW	0.008472	0.006750	0.002925	0.002137	0.000787	0.000112	**0.021184**
WSW	0.009414	0.010124	0.003600	0.002812	0.000900	0.000562	**0.027413**
W	0.009884	0.018449	0.006075	0.003262	0.001462	0.000112	**0.039245**
WNW	0.015650	0.031498	0.030486	0.018899	0.004162	0.000337	**0.101033**
NW	0.021299	0.035323	0.042298	0.042185	0.016762	0.002700	**0.160566**
NNW	0.028594	0.032623	0.012262	0.004837	0.001575	0.000337	**0.080229**
Subtotal	**0.237699**	**0.276621**	**0.191014**	**0.115868**	**0.030823**	**0.006975**	**0.859000**
Calms							**0.012200**
Missing/Incomplete							**0.128800**
Total							**1.000000**

Source: SDSU, 2008



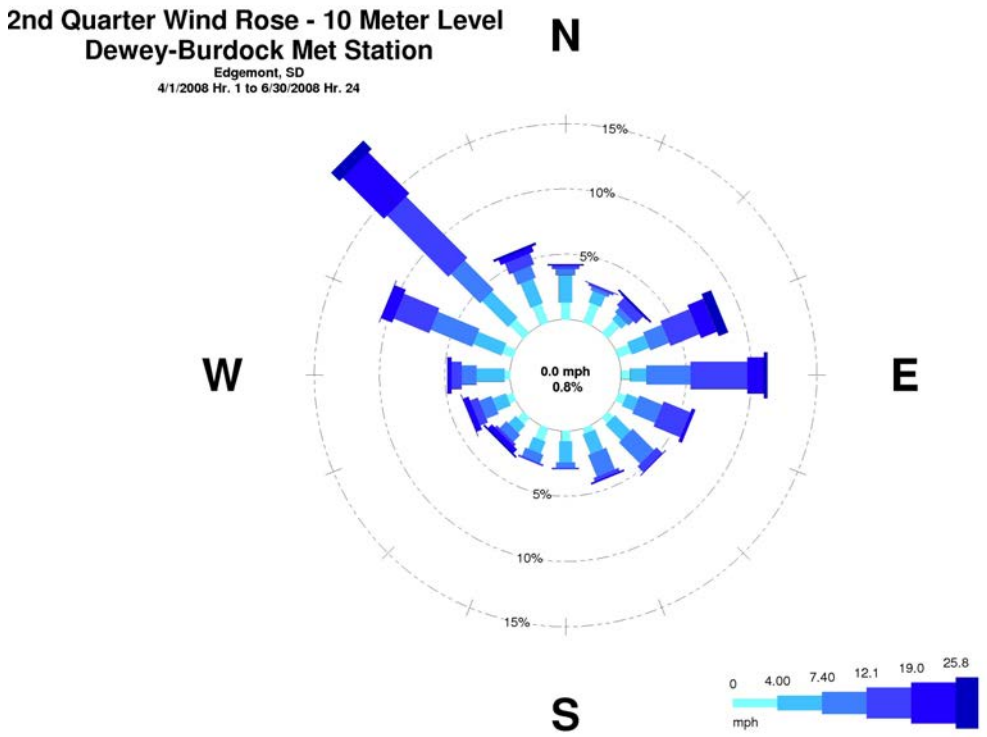
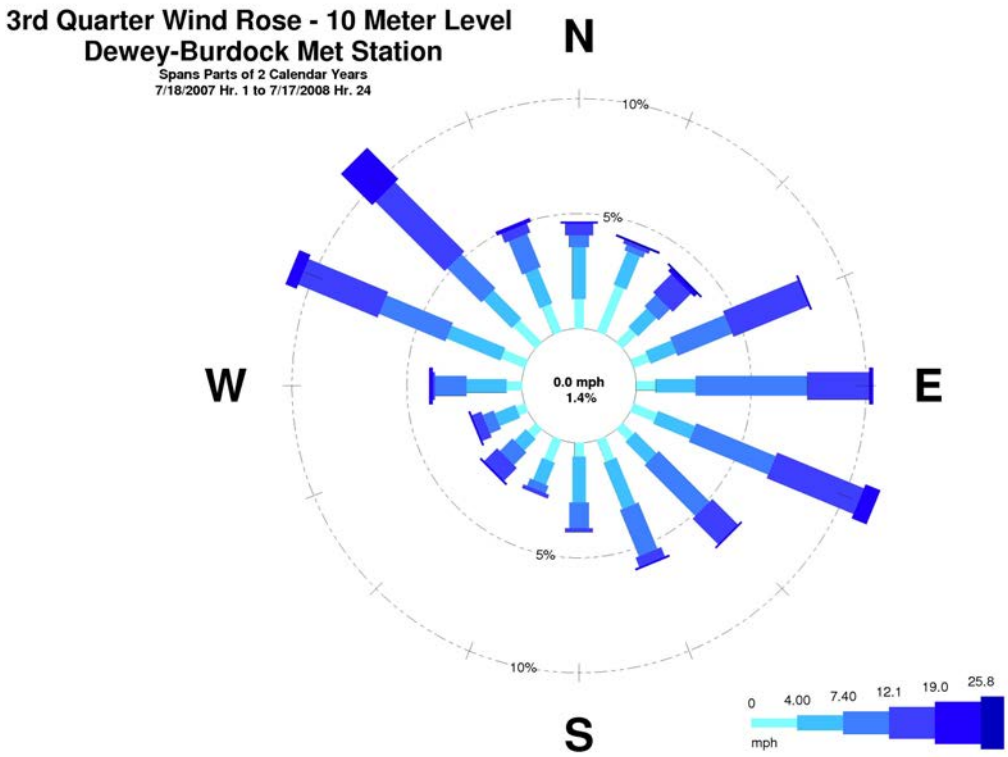


Figure 3.6-32: First and Second Quarter Wind Roses



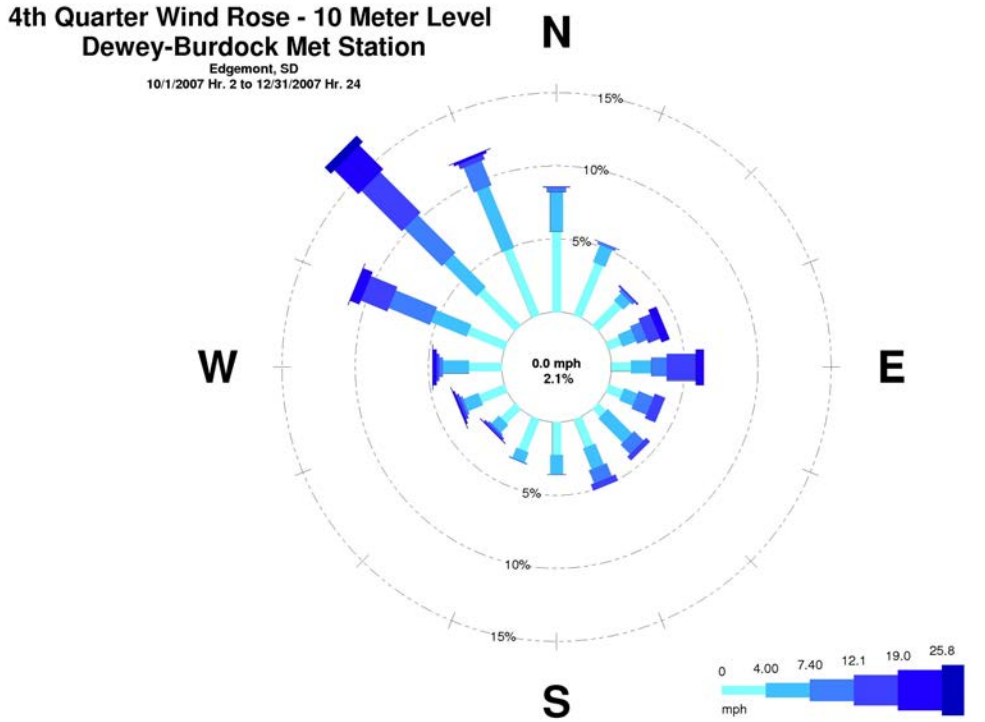


Figure 3.6-33: Third and Fourth Quarter Wind Roses

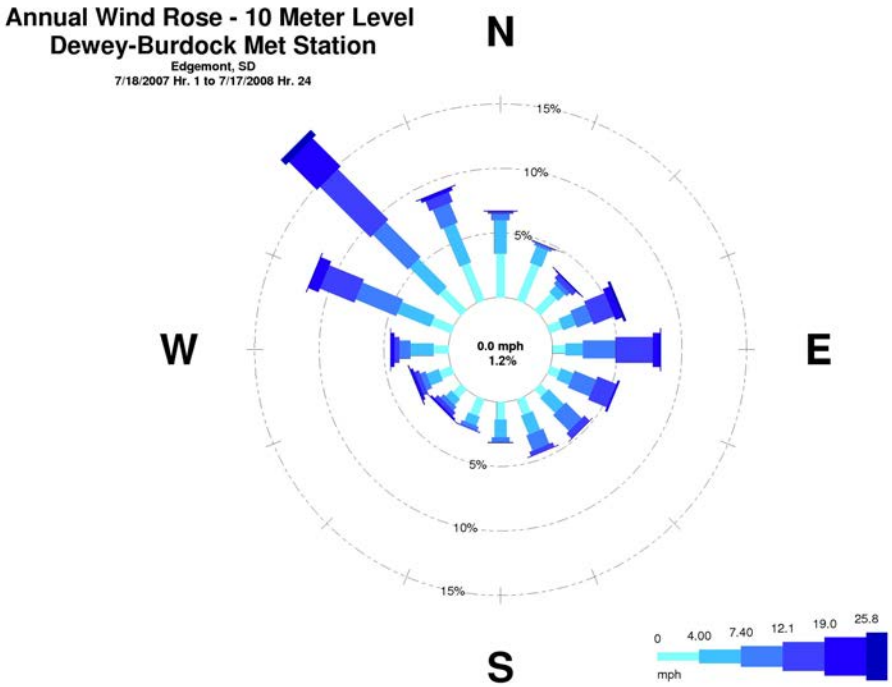


Figure 3.6-34: Annual Wind Rose

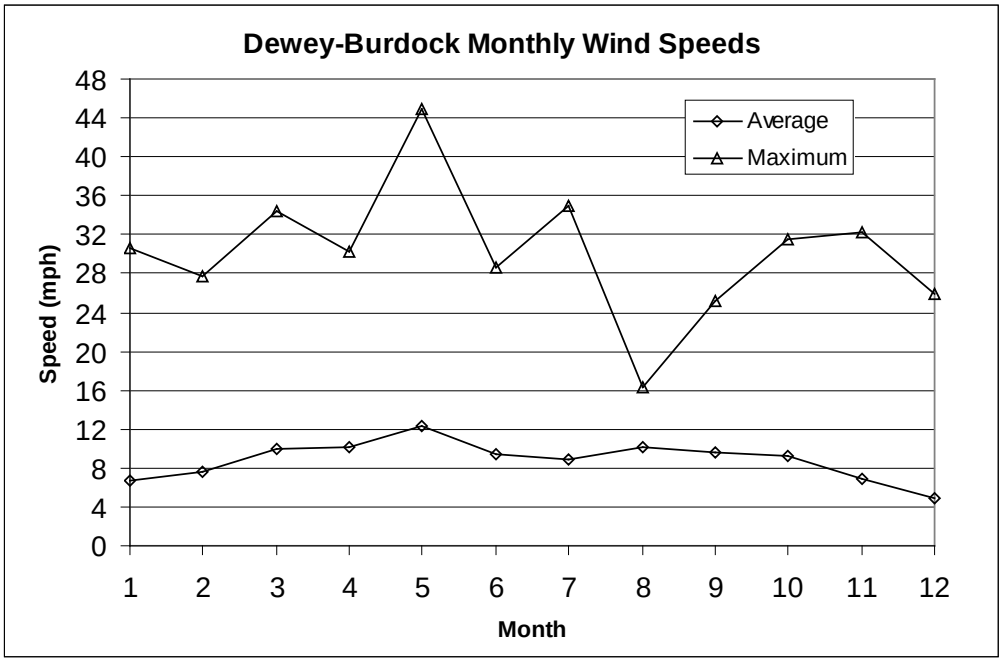


Figure 3.6-35: Dewey-Burdock Monthly Wind Speeds

3.6.1.2.3 Relative Humidity

As mentioned in previous sections, the relative humidity at the site is low. Mean values range from a low of 51 percent in the summer months to a high of 77 percent in the winter months. Relative humidity values varied greatly throughout the day, especially in the summer and spring months. On average, during the spring, summer, and fall months, relative humidity reached its maximum from 5 a.m. to 7 a.m. and then declined steadily until 4 p.m. to 5 p.m. when it began its evening ascent (Figure 3.6-36). During the winter months, the diurnal relative humidity range was much less because of less intense and shorter duration solar radiation.

3.6.1.2.4 Precipitation

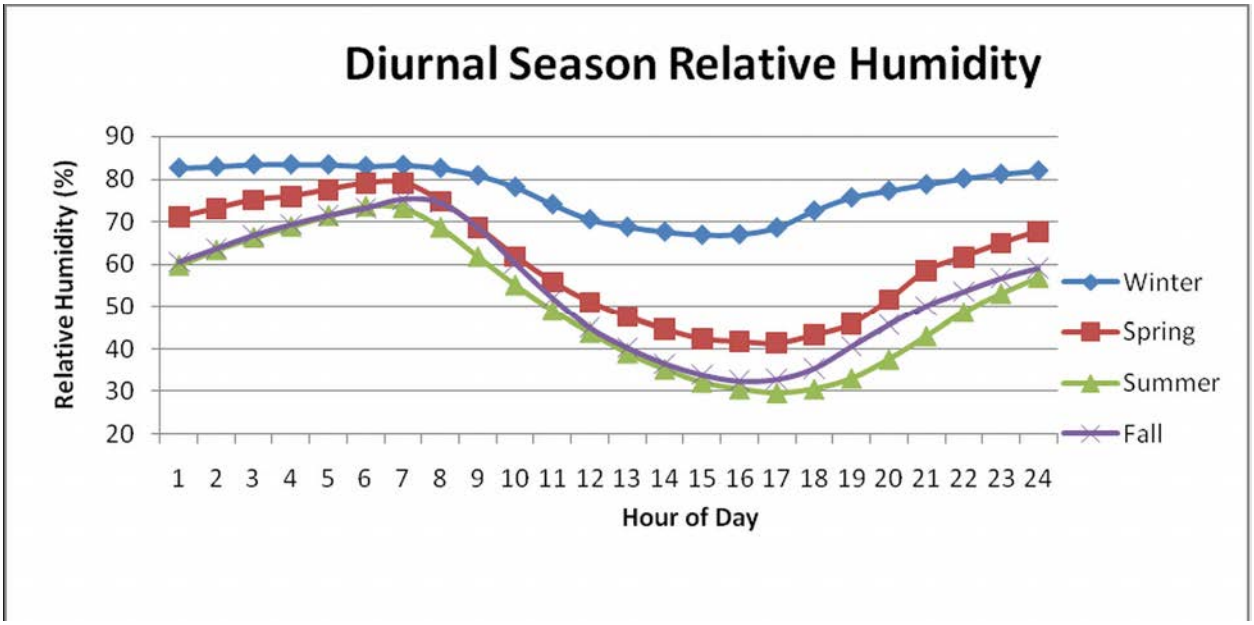
Data for this site were collected using a Vaisala VRG 101 all-weather precipitation gauge. The region received 12.42 inches of precipitation during the year of monitoring. Figure 3.6-37 displays the precipitation totals by month. The largest monthly precipitation total occurred in May (3.8 inches) and the least occurred in November (0.10 inch). The greatest daily precipitation total (1.29 inches) occurred on May 23, 2008. Also on May 23, 2008, the area received 0.71 inch of precipitation between the hours of 8 p.m. and 9 p.m., which was the most intense event of the sampled year.

3.6.1.2.5 Potential Evapotranspiration

The potential ET data were taken from July 18, 2007 to July 14, 2008. The ASCE Standardized Reference Evapotranspiration Equation for a tall reference crop was used to estimate daily ET. The weather parameters needed to estimate ET using this method are daily, maximum and minimum temperature, maximum and minimum relative humidity, total solar radiation, and average wind speed. Most ET occurs during the months of July, August, and September with an average monthly accumulation of 10.3 inches (Figure 3.6-38) because of the high temperatures and unstable weather. During the winter, low ET occurs because of low temperatures and low solar radiation. The average ET during the winter months is 1.5 inches.

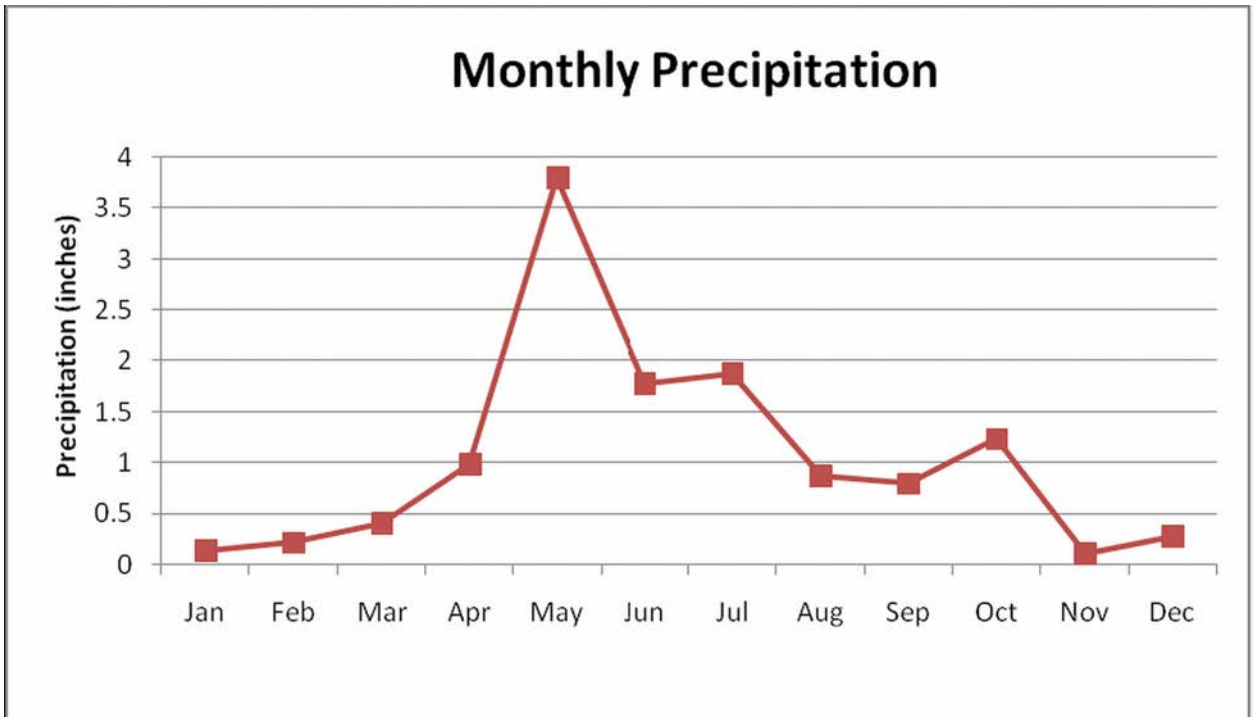
3.6.1.2.6 Upper Atmosphere Characterization

Mixing height is the height of the atmosphere above the ground that is well mixed due either to mechanical turbulence or convective turbulence. The air layer above this height is stable. Higher mixing heights are associated with greater dispersion, all other parameters being the same. Stable periods have much lower mixing heights and accompanying lapse rates allowing for less temperature variation. Unstable air leads to more dispersion, which leads to lower predicted impacts on ambient air quality. The default mixing height used by MILDOS-AREA is



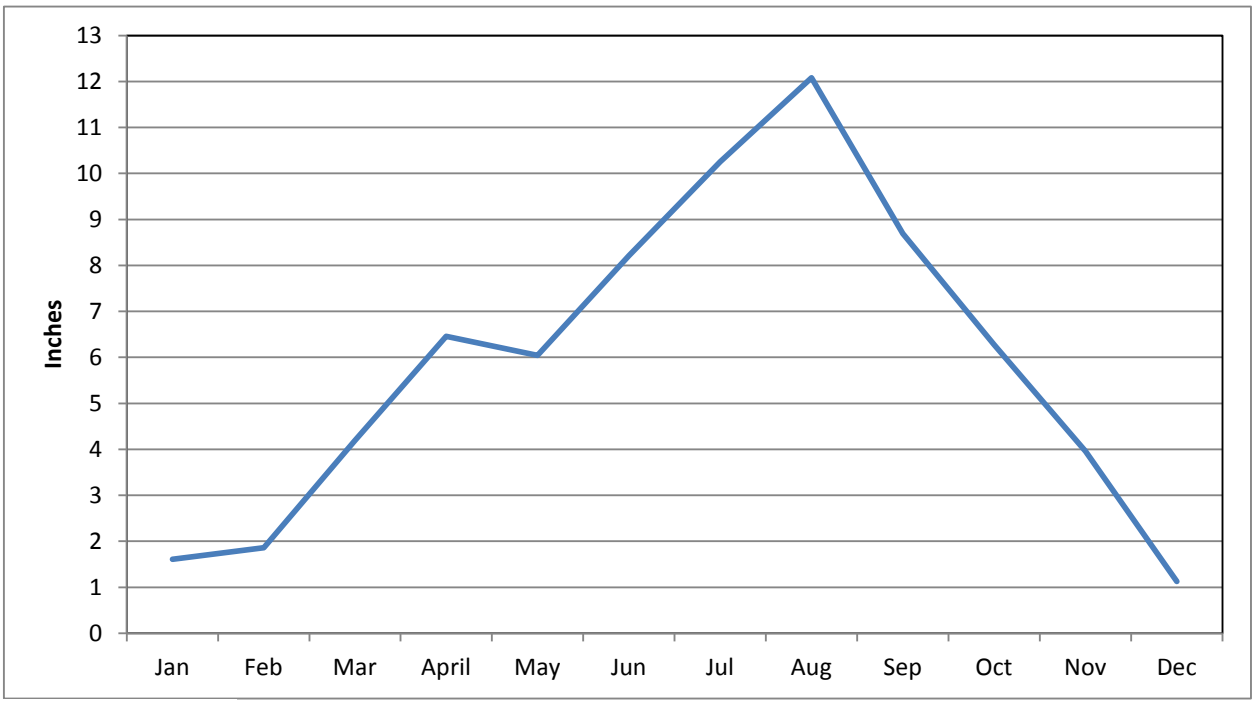
Source: SDSU, 2008

Figure 3.6-36: Diurnal Relative Humidity by Season from Project Meteorological Site



Source: SDSU, 2008

Figure 3.6-37: Monthly Precipitation from the Project Meteorological Site



Source: SDSU, 2008

Figure 3.6-38: Estimated Evapotranspiration Calculated Using Weather Data Collected at the Project Meteorological Site

100 meters, a very conservative value given that typical mixing heights exceed 1,000 meters. Table 3.6-8 provides the average mixing heights, computed from upper air and surface data, at the Rapid City Airport, which is the closest site to the permit area with upper air data.

For comparison purposes, average mixing heights were derived from the AERMOD calculations used for dispersion modeling, based on hourly data obtained from the NWS stations in Rapid City (upper air), Custer, and the local Edgemont station. The AERMOD calculation is based on a combination of mechanically and convectively driven boundary layer processes. The results of these calculations are provided on a quarterly basis in Table 3.6-9. The annual average mixing height is 1,110 meters, an order of magnitude higher than the default used for modeling potential radiological impacts.

3.6.2 Air Quality

Air particulate monitoring was conducted at the project for one year. Particulates were collected using high volume air samplers.

3.6.2.1 Methods

Eight Hi-Q Model HVP-4200AFC high volume air samplers were established within and surrounding the proposed permit area. The samplers operated continuously from August 2007 to August 2008 except for minor down time due to filter changes and short-term power outages. The locations of the air samplers are shown on Figure 3.6-39 and Plate 3.6-1.

The air particulate sampling locations were established in accordance with NRC regulatory guidance. The criteria used to establish air particulate sampling locations include the following factors:

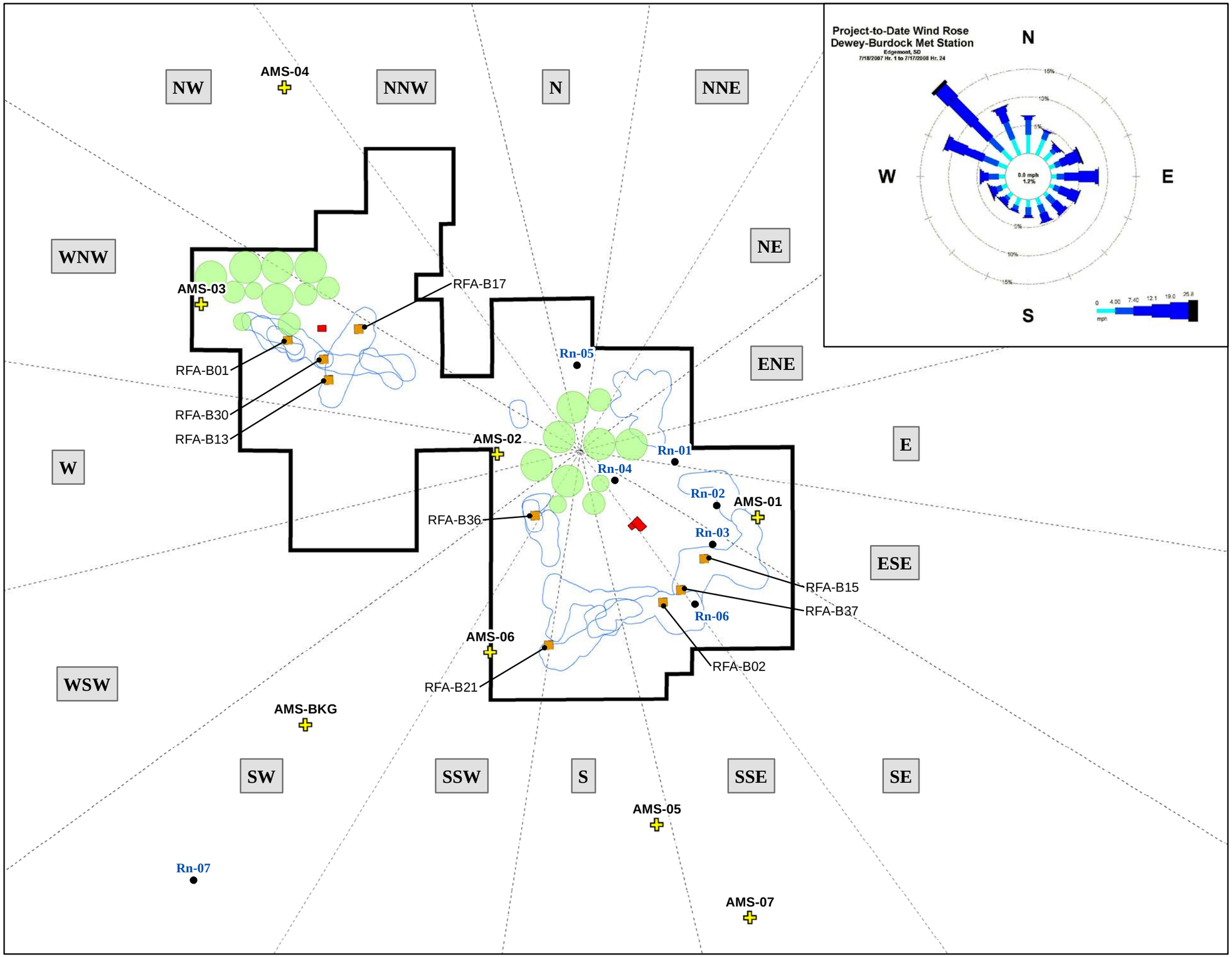
1) Average meteorological conditions such as wind speed, wind direction and atmospheric stability
2) Prevailing wind direction
3) Site boundaries nearest to proposed facility processing areas, land application areas, and well fields
4) Direction of nearest occupiable structure
5) Locations of estimated maximum concentrations of radioactive materials
6) Locations of existing features near or within the proposed permit boundary, but unrelated to proposed site activities, that may impact background radiological conditions (e.g., railroads and historical surface mines)
7) Location of nearest multiple resident area or town

Table 3.6-8: Rapid City Mixing Height Averages, 1984-1991

Averaging Period	Morning	Afternoon
Average Mixing Height (meters)	333	1,547

Table 3.6-9: Quarterly Mixing Height Averages

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Average Mixing Height (meters)	936	1,285	1,382	839



Legend

- Radon Track Etch Detector
- Land Application Area
- Air Monitoring Station
- Radon Flux Measurement
- Potential Well Field
- Permit Boundary
- Processing Plants

TLDs and radon track etch detectors located at each air monitoring station

Feet: 0, 2,500, 5,000, 10,000

Meters: 0, 1,000, 2,000, 3,000

N

Figure 3.6-39

Air Monitoring Station, Ambient Radon, and Radon Flux Measurement Locations

Dewey-Burdock Project

SIGNATURE OF PREPARER	
PREPARER	Richard Blubaugh
DATE	14-Sep-2012
FILE	AirMonRadonFlux.mxd

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Each high volume air sampler was equipped with an 8-in. by 10-in. 0.8 micron glass fiber filter paper. The air filters were collected approximately bi-weekly, prior to saturation, from each of the eight air samplers. Flow rate and total flow data were recorded at the same time. The samples were collected as follows:

- Period 1: August 13 to October 2, 2007
- Period 2: October 2, 2007 to January 4, 2008
- Period 3: January 4 to April 1, 2008
- Period 4: April 1 to July 9, 2008
- Period 5: July 9 to August 13, 2008

The air particulate samplers were equipped with air flow totalizers, which were recorded and reset during each filter change. Qualitative checks of air particulate sampler operation were also performed during each filter change. No anomalous flow volumes or conditions were observed.

The samples were composited and digested by the external independent analytical laboratory. The samples were analyzed for radium-226, thorium-230, natural uranium, and lead-210.

3.6.2.2 Sampling Results

In general and relative to one another (e.g., natural uranium to radium-226), the average concentrations of radionuclides were consistent at each location from period to period. The lowest average concentration was radium-226, followed by thorium-230, natural uranium, and lead-210. Average radium-226 concentrations were five orders of magnitude lower than lead-210 concentrations. The data are summarized in Table 3.6-10.

Site-wide, the data can be summarized as follows:

- Natural uranium concentrations ranged from $-8.1*10^{-18}$ to $1.5*10^{-14}$ µCi/ml and averaged $1.4*10^{-15}$ µCi/ml.
- Thorium-230 concentrations ranged from $-9.5*10^{-19}$ to $5.6*10^{-17}$ µCi/ml and averaged $1.2*10^{-17}$ µCi/ml.
- Radium-226 concentrations ranged from $-4.9*10^{-17}$ to $4.7*10^{-17}$ µCi/ml and averaged $1.7*10^{-18}$ µCi/ml.
- Lead-210 concentrations ranged from $7.0*10^{-18}$ to $4.3*10^{-17}$ µCi/ml and averaged $1.45*10^{-14}$ µCi/ml.

There are no clear patterns in the data, in terms of radionuclide concentrations, when evaluating them spatially or temporally. Natural uranium concentrations at each location were on the order

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Table 3.6-10: Summary of Radionuclide Concentrations in Air

Location	U-nat Concentration (µCi/ml)				Th-230 Concentration (µCi/ml)				Ra-226 Concentration (µCi/ml)				Pb-210 Concentration (µCi/ml)			
	Average	σ	Min	Max	Average	σ	Min	Max	Average	σ	Min	Max	Average	σ	Min	Max
AMS-01	1.4E-15	3.2E-15	-1.7E-17	7.1E-15	8.2E-18	6.4E-18	1.6E-18	1.7E-17	1.2E-17	3.0E-17	-3.1E-17	5.3E-17	2.3E-14	1.4E-17	9.1E-18	4.3E-17
AMS-02	1.4E-15	3.1E-15	-2.0E-17	7.0E-15	4.9E-18	6.5E-18	0.0E+00	1.6E-17	-1.4E-17	1.9E-17	-4.9E-17	-2.3E-18	1.3E-14	9.7E-18	7.0E-18	2.9E-17
AMS-03	1.0E-15	2.2E-15	-3.0E-17	5.0E-15	9.0E-18	7.2E-18	-1.5E-18	1.9E-17	-1.6E-18	9.3E-18	-1.4E-17	9.6E-18	1.1E-14	9.2E-18	8.9E-18	3.1E-17
AMS-04	1.0E-15	2.2E-15	-2.6E-17	5.0E-15	1.0E-17	9.8E-18	2.5E-18	2.7E-17	5.3E-18	2.7E-17	-2.8E-17	4.6E-17	1.3E-14	1.1E-17	8.3E-18	3.3E-17
AMS-05	1.2E-15	2.6E-15	0.0E+00	5.9E-15	2.4E-17	1.9E-17	4.7E-18	5.6E-17	9.6E-18	3.4E-17	-4.5E-17	4.7E-17	1.3E-14	1.0E-17	9.0E-18	3.4E-17
AMS-06	1.0E-15	2.3E-15	-1.4E-17	5.0E-15	9.9E-18	7.2E-18	1.5E-18	2.0E-17	-2.6E-18	2.3E-17	-3.9E-17	2.3E-17	1.4E-14	9.9E-18	7.4E-18	3.3E-17
AMS-07	3.1E-15	6.9E-15	-1.1E-17	1.5E-14	1.3E-17	5.7E-18	6.3E-18	2.0E-17	4.9E-18	1.7E-17	-1.3E-17	2.9E-17	1.6E-14	1.0E-17	7.5E-18	3.0E-17
AMS-BKG	1.1E-15	2.5E-15	-8.1E-18	5.7E-15	1.5E-17	1.4E-17	-7.8E-19	3.0E-17	-6.3E-19	1.1E-17	-1.7E-17	1.2E-17	1.3E-14	9.8E-18	8.0E-18	3.1E-17
Overall	1.4E-15		-3.0E-17	1.5E-14	1.2E-17		1.5E-18	5.6E-17	1.6E-18		-4.9E-17	5.3E-17	1.45E-14		7.0E-18	4.3E-17

of 10^{-17} µCi/ml over the course of monitoring. Thorium-230 concentrations fluctuated between the orders of 10^{-17} and 10^{-18} µCi/ml. Radium-226 concentrations fluctuated between the orders of 10^{-17} and 10^{-18} µCi/ml. Finally, lead-210 concentrations at each location were on the order of 10^{-15} µCi/ml over the course of monitoring.

3.6.2.3 Conclusions

With the exception of natural uranium, the values determined above are similar to U.S. background concentrations reported in the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) Report to the General Assembly, Sources and Effects of Ionizing Radiation, Annex B. The regional concentrations reported in this reference document are: uranium-238 ($2.4*10^{-17}$ to $1.4*10^{-16}$ µCi/ml), thorium-230 ($1.6*10^{-17}$ µCi/ml), radium-226 ($1.6*10^{-17}$ µCi/ml), and lead-210 ($2.7*10^{-15}$ to $2.7*10^{-14}$ µCi/ml).

3.7 Vegetation

A detailed vegetation study report is included in Appendix 3.7-A. The following information is provided as a summary of the information in the full report. Plate 3.7-1 was developed using the information presented in Appendix 3.7-A.

3.7.1 Methodology

All vegetation sampling procedures were designed according to previous experience with similar projects and in collaboration with SDGF&P. Refer to Appendix 3.7-A for the detailed vegetation study report, including the submitted methodology.

Vegetation sampling was conducted by BKS. Initial surveys were conducted during July 2007, with supplemental sampling performed to adjust to subsequent changes in the proposed permit boundary.

Mapping

Seven different plant communities were identified for the proposed permit area, i.e., Big Sagebrush Shrubland (BS), Greasewood Shrubland (GW), Ponderosa Pine Woodland (PP), Upland Grassland (UG), Cottonwood Gallery (CG), Silver Sagebrush Shrubland (SS), and Agricultural Land (AG), using 2001 color infrared (CIR) aerial photography, which was verified by field survey. The Agricultural Land was not sampled as it was actively being used for crop production. The Silver Sagebrush Shrubland will be described as an inclusion of the Greasewood Shrubland Community.

Transect Origin Selection

The transects were randomly located in the field within each sampled vegetation community. Each transect was at least 150 feet from the previous transect. Random numbers between 1 and 360 were generated to determine cover transect direction, and compasses were utilized to orient transects to the nearest 1/8 of 360 degrees in the field. Each sample site was marked with a hand-held Garmin global positioning system (GPS), and these points were later plotted on the final vegetation survey map (Plate 3.7-1).

Cover

A sample size of 37 50-meter point-intercept cover transects were sampled within the Ponderosa Pine Woodland and Greasewood Shrubland communities, while 27 samples were taken in the Big Sagebrush Shrubland, 26 samples in the Cottonwood Gallery and 30 samples in the Upland Grassland community for a total of 157 cover points in the proposed permit area.

In the vegetation communities, each 50-meter transect represented a single sample point. Percent cover measurements were taken from point-intercepts at 1-meter intervals along a 50-meter transect. Transects that exceeded the boundaries of the vegetation community being sampled were redirected back into its vegetation community at a 90 degree angle from the original transect direction at the point of intercept. In instances where a 90 degree angle of reflection did not place the transect within the sampled community, a 45 degree angle of reflection was used. Each point-intercept represents 2 percent towards cover measurements.

Percent cover measurements record “first-hit” point-intercepts by live foliar vegetation species, litter, rock, or bare ground. Multiple hits on vegetation were recorded, but used only for the purpose of constructing a plant species list for each plant community (Appendix 3.7-A).

Total Vegetation Cover

Vegetation cover data were recorded by species, using first hit data. All point intercepts of living vegetation and growth produced during the current growing season were counted toward total vegetation cover. Total vegetation cover measurements were expressed in absolute percentages for each sample point. Percent vegetation cover is the vertical projection of the general outline of plants to the ground surface. Cover summaries for each vegetation community within the proposed permit area are contained in Appendix 3.7-A.

Total Ground Cover

Total ground cover data was recorded by live vegetation, litter, or rock, minus bare ground. Litter includes all organic material that is dead including manure. Rock fragments were recorded when equal to or greater than two centimeters in size (i.e., sheet flow, minimum non-erodible particle size). Total ground cover measurements were expressed in absolute percentages for each sample point. Total ground cover equals the sum of cover values for percent vegetation, percent litter, and percent rock.

Shrub Density

These data were taken at the time of cover sampling to ensure adequate use of field time. Shrub density data were collected in conjunction with randomly selected cover transects, wherever possible. All shrubs, full, half, or sub, were counted within 50 centimeters on either side of the 50 meter cover transect (1 meter x 50 meter belt transect), yielding a 100 m^2 belt transect. Sample adequacy was not calculated for shrub density. The number of belt transects equaled the number of cover transects for a given vegetation type.

Tree Density

Data were collected at the time of cover sampling to ensure adequate use of field time. Tree density data were collected in the Ponderosa Pine Woodland vegetation community in conjunction with randomly selected cover transects, wherever possible. Tree density in this community was determined using the point-center quarter method. Trees within the Cottonwood Gallery or Riparian areas were directly counted on an aerial photograph. Within other vegetation communities, individual *Pinus ponderosa* (Ponderosa Pine) or other tree species found were directly counted for numbers. Sample adequacy was not calculated on the point-center quarter plots.

Species Composition

A list of plant species encountered during 2007 quantitative sampling is compiled in Appendix 3.7-A by vegetation community type for each of the vegetation communities. The species list includes plant species sampled in cover transects as well as plant species observed along the belt transect. Plant names in the Rocky Mountain Vascular Plants of Wyoming (Dorn, 2001) were utilized. Plant identification was confirmed by Robert Dorn, when necessary. Scientific nomenclature followed that in use at the Rocky Mountain Herbarium in Laramie, Wyoming, during 2007.

3.7.2 Vegetation Survey Results and Discussion

The permit area comprises five main vegetative communities: Big Sagebrush Shrubland, Greasewood Shrubland, Upland Grassland, Ponderosa Pine Woodland, and Cottonwood Gallery. Minor vegetation communities also include: Agricultural Land, Disturbed Areas, Existing Mine Pits, Silver Sagebrush Shrubland, Water, and Shale Outcrop. Refer to Table 3.7-1 for acreage of each vegetation community within the permit area. Plate 3.7-1 provides the vegetation map for Dewey-Burdock Project.

3.7.3 Species of State and Federal Interest

No threatened or endangered species were encountered within the permit area. The presence of the South Dakota-designated weed Canada thistle was present within the Cottonwood Gallery vegetation community. The presence of the Fall River County-designated weed field bindweed was present within the Greasewood Shrubland vegetation community.

3.8 Wetlands

A detailed wetland study report for the 2007 assessment is included in Appendix 3.8-A. Note that Section 3.8.3 describes updates in 2008 due to a change in the proposed permit area. The following information is provided as a summary of the information in the full report. Plate 3.8-1 was developed using the information presented in Appendix 3.8-A.

3.8.1 Methodology

BKS Environmental Associates, Inc. (BKS), of Gillette, Wyoming, completed the baseline wetland inventory fieldwork. The wetland surveys were conducted in accordance with the Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Region. All Waters of the U.S. (WoUS) and Other Waters of the U.S. (OWUS) were assessed during the surveys. The routine wetland delineation approach with onsite inspection was utilized, and the survey was conducted by pedestrian reconnaissance and review of existing maps of the permit area. Identification of potential wetlands was based on visual assessment of vegetation and hydrology indicators, as well as intrusive soil sampling to determine the presence of wetland criteria indicators. Wetland Determination Data Forms-Great Plains Region (DRAFT), were utilized for each observation point. Hydrology and soils were evaluated whenever a plant community type met hydrophytic vegetation parameters based on the Dominance Test and Prevalence Index (as defined by the Great Plains Regional Supplement), or whenever indicators suggested the potential presence of a seasonal wetland area under normal circumstances.

Table 3.7-1: Vegetation Mapping Unit Acreage within Proposed Permit Area

Map Unit	Acreage	% of Area
Sampled Vegetation Communities		
Big Sagebrush Shrubland	2,501.56	23.70
Greasewood Shrubland	2,190.45	20.75
Ponderosa Pine Woodland	2,183.76	20.69
Upland Grassland	2,187.56	20.72
Cottonwood Gallery	240.60	2.28
Described Vegetation Communities		
Agricultural Land	780.79	7.40
Disturbed	14.70	0.14
Existing Mine Pit	326.99	3.10
Silver Sagebrush Shrubland	119.49	1.13
Shale Outcrop	2.19	0.02
Water	8.94	0.08
TOTAL	**10,557.03**	**100.0**

Natural Resources Conservation Service (NRCS) soils mapping for Custer and Fall River counties, South Dakota (2007) and BKS soil mapping of the permit area were reviewed for general soils information.

Potential wetlands (WoUS) and OWUS were initially identified via review of area maps to include the following:

- 1977 USFWS National Wetland Inventory (NWI) mapping for the Dewey, Burdock and Twenty-one Quads
- Custer Quad Digital Elevation Model
- Burdock Quad Digital Elevation Model

Wetland indicator categories were identified for each dominant plant species noted through use of the National List of Vascular Plant Species that Occur in Wetlands, 1996 National Summary. Region 4 (North Plains) indicator categories were utilized for the permit area.

Field sample locations and resulting wetland boundaries were recorded with a hand-held Garmin GPS map 60Cx GPS unit in NAD 1983 UTM Zone 13.

3.8.2 Wetland Assessment Results and Discussion

The permit area generally occurs on uplands, with inclusions of two main drainages, Beaver Creek and Pass Creek, and several depressed areas. Beaver Creek and Pass Creek were evaluated using pedestrian reconnaissance, while the remaining small drainages were evaluated based on existing mapping. Wetlands were identified throughout the Beaver Creek drainage; however, Pass Creek only had wetlands present near an old open flowing well close to the project boundary. Wetlands were also identified in the majority of the old mine pits as well as depressed areas. The wetland classification along Beaver Creek was Riverine Lower Perennial Emergent (R2EM) WoUS, while that in Pass Creek and other small drainages was Palustrine Emergent (PEM) WoUS. The mine pits were primarily designated as Palustrine Unconsolidated Bottom (PUB) OWUS and depressions were typically PEM or PUB designations.

Beaver Creek had water present continuously in the drainage and wetland species near the banks. The upper banks were comprised mainly of *Artemisia tridentata* (big sagebrush), *Sarcobatus vermiculatus* (Greasewood), and *Elymus smithii* (Western wheatgrass). The wetland indicator status of these plants are UPL (upland), UPL, and FACU (facultative upland), respectively. The entire stretch of Beaver Creek within the permit area is designated as a R2EM wetland. Pass Creek was comprised of the Cottonwood Gallery vegetation community comprised mainly of

Bromus inermis (smooth brome), Western wheatgrass, and *Populus deltoides* (cottonwood trees). The wetland indicator statuses of these plants are UPL, FACU, and FAC (facultative), respectively.

There were several NWI 1977 previously mapped wetlands that were confirmed as non-wetland or not present during the 2007 field survey. The areas generally lacked hydrophytic vegetation, hydric soils, and hydrology. Most areas had geomorphic position but often lacked another secondary indicator. Datasheets were filled out to confirm no presence of these wetlands and can be found in Appendix 3.8-A.

There are seven historical open mine pits present within the permit area. Four of the mine pits were classified as non-wetland primarily due to lack of hydrophytic vegetation and/or hydrology presence. Two mine pits located in Section 1, T7S, R1E were classified as PUB wetlands. The only mine pit in Section 2 was classified as both a PEM and Open Water (OW). The PEM is located along the bank of the pit and OW throughout the rest of the pit. The mine pit in Section 34, T6S, R1E was classified as OW, and another small mine pit located at waypoint 92 in Section 1, T7S, R1E was classified as OW.

All the depressional areas identified as wetlands in 2007 were also previously identified during the 1977 NWI mapping. All of these wetlands are recommended to be non-jurisdictional based on the isolated nature of the wetlands. The wetlands were primarily classified as PEM, PEMC, PABJh, PUS, PUSA and PUB wetlands based primarily on the hydrology conditions of each waypoint.

Appendix 3.8-B includes a U.S. Army Corps of Engineers jurisdictional determination for some of the potential wetland sites within the permit area. Final determination of jurisdictional decision for all sites lies within the U.S. Army Corps of Engineers.

3.8.3 2008 Wetland Assessment Update

The following describes updates made in 2008 to the 2007 wetland assessment that occurred due to a change in the proposed permit area. The 2007 and 2008 boundaries are depicted in Appendix 3.8-A.

<u>Beaver Creek Update</u>

Beaver Creek is likely to have wetlands throughout the entire permit area as it is a major drainage and had a good flow of water when the surveys were conducted in 2007. The boundary

change took out 1.956 acres of R2EM wetlands along Beaver Creek in the NW1/4 of Section 31, T6S, R1E. The boundary change also added 4.81 acres of R2EM wetlands along Beaver Creek in the SE1/4 of Section 31, T6S, R1E and E1/2 of Section 5 and SW1/4 of Section 4, T7S R1E. The total acreage addition to the wetlands along Beaver Creek was 2.86 acres of R2EM.

Small PEM and PUB isolated wetlands may be found southwest of the Beaver Creek drainage in Section 5, T7S, R1E; however, accessibility to the area was not present to confirm. There are two depressions that can be seen on the map and based on the 2007 surveys the likelihood of either of the depressions being classified as a wetland is rare.

Pass Creek Update

In 2007, Pass Creek had 0.503 acre of PEM wetlands surveyed along its stretch; however due to the recent boundary change there are now only 0.05 acre of wetlands present on Pass Creek. The boundary change moved the boundary east of W22, and now excludes the three wetland points of W20, W21, and W22. The wetlands present on Pass Creek are primarily due to an old open flowing well on the other side of the road outside the permit boundary.

In 2007, Pass Creek was surveyed from the southern permit boundary to the old mine pit and no wetlands were identified except near the spring. No surveys were conducted on Pass Creek in 2008 as the map indicated that the area is likely dry.

Old Mine Pits

There were no changes in 2008 to the acreages identified in 2007 of old mine pits wetland occurrences.

Depressional Areas and Ponded Areas Identified as Wetlands

No changes were made in 2008 to the acreages on the 2007 depressional areas and ponded areas identified as wetlands. As noted above there may be some isolated PUB or PEM depressional areas southwest of Beaver Creek, but accessibility to the area was not present during the 2008 surveys. However, it is unlikely that the areas indicated contain wetlands as the 2007 surveys proved that many of the potential wetlands indicated on the map and NWI no longer existed.

3.9 Wildlife

A detailed wildlife study report is included in Appendix 3.9-A. The following information is provided as a summary of the information in the full report. Plate 3.9-1 was developed using the information presented in Appendix 3.9-A.

3.9.1 Methodology

Wildlife sampling was conducted by ICF Jones & Stokes (formerly Thunderbird Wildlife Consulting) of Gillette, Wyoming. Appendix 3.9-B contains a letter from SDGF&P approving ICF Jones & Stokes as the wildlife consultant. Background information on terrestrial vertebrate wildlife species and aquatic vertebrates and invertebrates in the vicinity of the permit area was obtained from several sources, including records from SDGF&P, BLM, USFWS, U.S. Forest Service (USFS), and the original Draft Environmental Statement (DES) prepared by TVA in 1979. Previous site-specific data for the permit area and surrounding perimeter were obtained from those same sources.

Current baseline wildlife information was collected from July 2007 through early August 2008 to meet agency requirements for one year of baseline data, and to accommodate changes to the permit area boundary during that period. The survey area included the entire permit area and a perimeter offset 1 mile from the permit area boundary for threatened and endangered (T&E) species, bald eagle winter roosts, all nesting raptors, upland game bird leks, and big game. Survey protocols and timing were developed collaboratively with SDGF&P to meet species-specific requirements. Surveys and documentation of occurrence conducted only in the permit area included other vertebrate species of concern tracked by the South Dakota Natural Heritage Program (SDNHP), as well as bats, small mammals, lagomorphs, prairie dog colonies, breeding birds, predators, and herptiles.

All surveys were conducted by qualified biologists using standard field equipment and appropriate field guides. Most terrestrial data were collected from vantage points during pedestrian or vehicular surveys to avoid disturbing wildlife; exceptions included breeding bird surveys and small mammal trapping. Raptor nests, prairie dog colonies, and other features or points of special interest were mapped in the field using a hand-held GPS receiver. Species were identified with the aid of field guides and other literature including, but not limited to, Robbins et al. (1966), Burt and Grossenheider (1976), Jones et al. (1983), Clark and Stromberg (1987), Peterson (1990), South Dakota Ornithological Union (1991), Baxter and Stone (1995), Stokes and Stokes (1996), and Kiesow (2006).

3.9.2 Wildlife Survey Results

Appendix 3.8-A lists all species that could potentially reside in the vicinity of the permit area or pass through during migration. Species actually observed in or adjacent to the permit area are noted. The appendix includes various tables listing sightings of targeted wildlife species,

including those tracked by SDNHP, recorded in the vicinity of the permit area from July 2007 through August 2008. Appendix 3.8-A also includes representative photographs of the permit area and wildlife species observed and resumes for the IFC Jones & Stokes staff who conducted the surveys and prepared the baseline report. Following is a brief summary of the wildlife survey results. Refer to Section 3.10 for aquatic resources survey results.

Habitat Mapping

A general description of the location, extent, and characteristics of each habitat is described in Appendix 3.8-A.

Big Game

Pronghorn (*Antilocapra americana*) and mule deer (*Odocoileus hemionus*) are the only two big game species that regularly occur in the survey area, and both are considered year-round residents. The pronghorn is the most common big game species in the survey area, though no species is prevalent. Elk (*Cervus elaphus*) and white-tailed deer (*Odocoileus virginianus*) are also present in the survey area, but only in small herds. The latter two species can also be seen in the survey area year-round, but may be more common during certain seasons.

Small Mammals

Four species of small mammals were captured in September 2007: the deer mouse (*Peromyscus maniculatus*), olive-backed pocket mouse (*Perognathus fasciatus*), western harvest mouse (*Reithrodontomys megalotis*), and northern grasshopper mouse (*Onychomys leucogaster*). The deer mouse was by far the most abundant small mammal captured during the baseline study, representing approximately 95 percent of the total, and was the only species trapped in all habitats. Each of the three other species captured accounted for less than 3 percent.

Lagomorphs

Two lagomorph species were observed within the survey area during spotlight surveys conducted in 2007: the white-tailed jackrabbit (*Lepus townsendii)* and cottontail (*Sylvilagus* spp.). Cottontail abundance was twice that of jackrabbits, though neither count was especially high. Results from lagomorph surveys conducted in northeast Wyoming annually since 1984, and periodic surveys in northwestern South Dakota in recent years, indicate that the regional lagomorph population recently experience a downward trend in its regular cyclic pattern. Although no data are available from the permit area prior to 2007, its proximity to other regional survey areas and the low counts recorded during the baseline survey period suggest the survey area lagomorph population was in a similar low cycle at that time. Declines in the Wyoming

population have been attributed to Tularemia, a disease known to infect lagomorph populations once they reach a certain threshold. It is possible that a similar disease event occurred recently in western South Dakota.

Other Mammals

A variety of small and medium-sized mammalian species have the potential to occur in the survey area, although not all were observed in the permit area itself during the baseline wildlife surveys. These potential species include a variety of common predators and furbearers such as the coyote (*Canis latrans*), red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), bobcat (*Lynx rufus*), badger (*Taxidea taxus*), beaver (*Castor canadensis*), and muskrat (*Ondatra zibethicus*). Numerous prey species, including rodents (e.g., mice, rats, voles, gophers, ground squirrels, chipmunks, prairie dogs, etc.), can also be found in the survey area. These species are cyclically common and widespread throughout the region, and are important food sources for raptors and other predators. Each of these prey species, with the exception of chipmunks and rats, were either directly observed during the field surveys, or were known to exist through burrow formation or scat. Observations of small mammals occurred most often near Beaver Creek and Pass Creek, in the northwestern and central portions of the survey area, respectively.

One black-tailed prairie dog colony overlaps the northwestern corner of the permit area, and two others are present in the southwestern portion of the one-mile perimeter. Portions of all three colonies were unoccupied during the baseline survey period. Local ranchers use shooting and other control methods to reduce and/or eradicate prairie dogs from private surface in the permit area and on surrounding lands. Other mammalian species such as the striped skunk (*Mephitis mephitis*), porcupine (*Erethizon dorsatum*), and various weasels (*Mustela* spp.*)* could inhabit the survey area, but no sightings or confirmed scat were recorded for those species during the baseline surveys. Infrequent, incidental bat sightings (species unknown) occurred during nocturnal amphibian surveys and spotlighting efforts conducted at targeted ponds in the permit area during the baseline period.

Game Birds

The wild turkey (*Meleagris gallopavo*) and mourning dove (*Zenaida Macroura*) were the only upland game bird species observed in the survey area during baseline inventories conducted from July 2007 to August 2008. Both species are relatively common and occur in a variety of woodland and open habitats in the permit area. No sage-grouse were observed during the entire year-long baseline survey period. Limited potential habitat for this species is present in the

general survey area, but only in small stands of sage surrounded by less suitable grasslands and pine breaks. Although sage-grouse were historically recorded in the general vicinity (TVA DES, 1979), no leks have been documented by agency biologists within 6 miles of the permit area in recent years.

Raptors

Raptor species observed during the baseline wildlife surveys included the bald eagle, red-tailed hawk (*Buteo jamaicensis*), golden eagle, northern harrier (*Circus cyaneus*), American kestrel (*Falco sparverius*), turkey vulture (*Cathartes aura*), Cooper's hawk (*Accipiter cooperii*), rough-legged hawk (*Buteo lagopus*), merlin (*Falco columbarius*), great horned owl, and long-eared owl (*Asio otus*). Other raptor species also could occur in the survey area, particularly as seasonal migrants, but were not seen during the 2007 and 2008 inventories. The bald eagle, red-tailed hawk, American kestrel, and northern harrier were the most commonly seen raptor species in the area. Raptor sightings for those species were recorded with regularity during all four seasons throughout the baseline survey period, though some of those species may leave the area under harsh winter conditions. Five confirmed, intact (i.e., material present) raptor nests and one potential nest site were located in the permit area and two additional nest sites (one confirmed and one potential) were recorded in the one-mile survey perimeter.

Breeding Birds

Thirty-four species were identified within the breeding bird transects during spring 2008. Two additional unknown species were logged during the surveys, with two other species recorded only while flying over the transects; those observations were not included in data analyses. The western meadowlark (*Sturnella neglecta*) was the most common species, followed by the mourning dove. The dove was the only species recorded in all six habitat types. The long-billed curlew (*Numenius americanus*) was the only observed species that is tracked by the SDNHP. Defensive behavior recorded during the transect surveys indicated that up to three pairs may have nested near the south-central edge of the permit area.

Reptiles

Lizards (species unknown) were often observed sunning themselves on rocks and on sandy soil in the summer months during all except the early morning hours. These sightings were widespread throughout the survey area, with observations increasing as the summer progressed and the days got hotter. The shed remains of a snakeskin were found in the north central portion

of the survey perimeter in early May 2007. The skin was at the base of a rock outcrop and looked as though it may have belonged to a bullsnake (*Pituophis cantenifer*).

3.9.3 Species of State and Federal Interest

The USFWS issued a block-clearance for ferrets throughout most of South Dakota in recent years, including the survey area in extreme southwestern Custer County and northwestern Custer County. No ferrets or evidence of their presence were observed during historical TVA surveys, or during the recent survey period.

The USFWS removed (delisted) the bald eagle from protection under the ESA in July 2007, and the ruling became effective that August. However, this species is still considered as a state-listed threatened species in South Dakota. In addition, bald eagles continue to be protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act, as well as any applicable state regulations. Bald eagles were repeatedly observed along Beaver Creek in the western portion of the permit area and perimeter during winter roost surveys conducted in late 2007 and early 2008.

Prior to initiating field surveys, biologists reviewed the list of rare, threatened, or endangered vertebrate species tracked by the SDNHP that could occur as permanent or seasonal residents on or within 1 mile of the permit area, based on each species' range and the habitats present in that area. Appendix 3.8-A includes a summary of vertebrate SDNHP species that were recorded in or within 1 mile of the permit area.

Seven vertebrate sensitive species or species of local concern other than the bald eagle were documented with the permit area during the baseline survey period: the long-billed curlew, great blue heron, golden eagle, Cooper's hawk, merlin, American white pelican, and long-eared owl. The long-eared owl and curlew are known or are suspected to have nested in the permit area, based on evidence (young present) or persistent defensive behavior, respectively. The remaining five species were observed perched in or flying over the permit area only once or twice each. These seven species of special interest are considered as secure populations within their respective overall ranges, though one or more could be less common in parts of a given range, especially in the periphery. Likewise, all seven are considered to be either rare and local throughout their statewide ranges, or locally abundant in restricted portions of those ranges. One other vertebrate species of concern was documented at least once in the one-mile perimeter: the Clark's nutcracker.

3.10 Aquatic Resources

The aquatic resources study was included as a portion of the complete wildlife study, included in Appendix 3.9-A. The following information is provided as a summary of the information in the full report.

3.10.1 Methodology

Because Beaver Creek is the only perennial stream in the permit area, and is the receiving water for drainage from the portions of the permit area identified for proposed ISR activities, it was the focus of aquatic habitat monitoring efforts conducted for this project. Some sampling was also conducted in the Cheyenne River downstream of the permit area to obtain additional site data. Baseline aquatics monitoring was conducted at sites that were previously established as water quality monitoring stations on Beaver Creek and the Cheyenne River. Using these sites allowed for comparisons with past and ongoing water quality records. One site on Beaver Creek was located upstream (BVC04) of the permit boundary and the other was downstream (BVC01). Fish sampling for species, abundance, and radiological testing was conducted at both Beaver Creek sites, and at one site on the Cheyenne River downstream of the Beaver Creek confluence (CHR05). Refer to Figure 3.5-12 and Plate 5.5-1 for the locations of these monitoring sites.

Habitat, invertebrate, and fish sampling was conducted during spring (April) and summer (July) conditions in 2008. This timing was selected to capture seasonal differences, including high and base flow conditions. However, the late spring and early summer of 2008 were unusually wet and, as a result, the flow during both seasonal events was similar.

The habitat description and invertebrate collection efforts followed the DENR protocol. Eleven cross-section transects were established at equidistant intervals from the downstream end of each sample site. The longitudinal distance of each survey reach was established as the distance equal to 30 average channel widths as determined by 10 preliminary width measurements.

Fish sampling was conducted according to SDGF&P guidelines by blocking and seining a 100-meter survey reach downstream of each sample site. Due to obstacles in the stream, it was not feasible to seine an entire reach in one sweep, so three separate sweeps were made at a given sample site and fish were collected on shore at three locations within each 100-meter reach. All fish captured were identified, counted, measured, and weighed. Individuals that were less than 100 millimeters in length were combined for a composite weight by species.

Numerous fish were collected for radiological testing during each of the spring and summer flow sampling events. The initial target at each sample site was six individual fish, preferably from six different species. Since many of the specimens collected in April 2008 contained no detectable uranium, up to five individuals of each of six species were collected in July 2008 (when available) and processed for radiology. Live fish were bagged, frozen, and kept frozen until they were analyzed by Energy Laboratories, Inc. for radionuclides that included uranium, thorium-230, radium-226, lead-210, and polonium-210. These radionuclides were selected in accordance with NRC regulatory guidance.

Benthic macro-invertebrates were sampled using DENR and EPA protocols. Samples were collected using a modified D-frame kick net, with sample sites located 1 meter downstream of each of the 11 cross-section transects at an assigned sampling point. Habitat conditions were also recorded at each sample site. Benthic samples were strained to cull the sample before sample preservation and packing. Samples were sorted, classified and counted in a private laboratory in Laramie, Wyoming.

3.10.2 Aquatic Survey Results

Amphibians and Aquatic Reptiles

Three aquatic or semi-aquatic amphibian species and one aquatic reptile were recorded during the 2007 and 2008 surveys conducted in the permit area: the boreal chorus frog (*Pseudacris triseriata*), Woodhouse's toad (*Bufo woodhousei*), great-plains toad (*B. cognatus*), and western painted turtle (*Chrysemys picta*). All four species were heard and/or seen in Beaver Creek as it flows through the western portion of the permit area or near stock reservoirs.

Benthic Invertebrates

The total number of invertebrates and the number of species were extremely low at both Beaver Creek sites. *Ephemeroptera* (mayflies) and *plecoptera* (stoneflies) were absent from both sites, indicating an impaired condition. Most taxa collected were moderately tolerant taxa. One individual of a sensitive taxa, *Lepidostoma*, and one individual of a highly tolerant taxa, *Culiciodes*, were collected at the downstream site (BVC01) in April. All other taxa collected are considered moderately tolerant.

Fish

A total of 12 fish species were collected from the three sampling locations. The fathead minnow (*Pimephales promelas*) was the most abundant species at both Beaver Creek sites during April and July 2008. The creek chub (*Semotilus atromaculatus*) was the most abundant species at the

Cheyenne River site in April, and the sand shiner (*Notropis stramineus*) was the most common fish caught there in July.

The only species that contained detectable levels of uranium in April was the channel catfish, but all of the fish collected in July contained uranium due, in large part, to increased sample sizes. Polonium-210, thorium-230 and radium-226 were detectable, but low in most samples. Lead-210 was only detected in one plains killifish (*Fundulus zebrinus*) collected in April at site BVC01.

3.10.3 Species of State and Federal Interest

The plains topminnow (*Fundulus sciadicus)* was the only aquatic species of concern documented in the survey area. It was captured during fisheries sampling efforts in the Cheyenne River in April 2008 and at the downstream sample site along Beaver Creek in July. Each of these sites is beyond the permit area. A northern river otter (*Lontra Canadensis)* carcass was discovered at the upstream fisheries sampling point (BVC04) on Beaver Creek in April 2008. The cause of death was not apparent, and the carcass was gone by the July 2008 sampling period. Otters are listed as a threatened species by the State of South Dakota, and are tracked by the SDNHP.

3.11 Cultural Resources

3.11.1 Methodology

A Level III Cultural Resources Evaluation was conducted in the permit area. Personnel from the Archeology Laboratory, Augustana College (Augustana), Sioux Falls, South Dakota, Conducted on-the-ground field investigations between April 17 and August 3, 2007.

Augustana documented 161 previously unrecorded archaeological sites and revisited 29 previously recorded sites during the current investigation. Expansion of site boundaries during the 2007 survey resulted in a number of previously recorded sites being combined into a single, larger site. Twenty-eight previously recorded sites were not relocated during the current investigation. Excepting a small foundation, the sites not relocated were previously documented as either prehistoric isolated finds or diffuse prehistoric artifact scatters.

3.11.2 Results and Discussion

The cultural resources evaluation is provided in Appendix 3.11-A. This appendix is being submitted as confidential information in accordance with SDCL 45-6B-19. The cover sheet for Appendix 3.11-A has been marked confidential. Following is a summary of the results of the cultural resources evaluation.

Approximately 87 percent of the total number of sites recorded are prehistoric. Historic sites comprise approximately 5 percent of total sites recorded, while multi-component (prehistoric/historic) sites comprise the remaining 8 percent.

The small number of Euro American sites documented was not unanticipated given the peripheral nature of the permit area in relation to the Black Hill proper. The disparity existing between the number of historic and prehistoric sites observed in the permit area is also not unexpected; however, the sheer volume of sites documented in the area is noteworthy. The land evaluated as part of the Level III cultural resources evaluation has an average site density of approximately one site per 8.1 acres. Even greater site densities were reported in 2000 during the investigation of immediately adjacent land parcels for the Dacotah Cement/BLM land exchange (Winham et al., 2001). This indicates that the permit area is not unique, in regard to the number of documented sites, and is typical of the periphery of the Black Hills.

The high density of sites observed in the permit area, specifically those of prehistoric affiliation, is both consistent with previous findings in the immediate vicinity (Winham et al., 2001) and strongly indicative of the intense degree to which this landscape was being exploited during prehistoric times. Data indicate a slight rise in the number of sites observed from earlier periods into the Middle Plains Archaic, and then a major increase into the Late Plains Archaic/Plains Woodland period before an equally significant drop-off into Late Prehistoric times. In general, this trend is largely consistent with the majority of available paleodemographic data from the region (Rom et al., 1996). Despite the high density of sites within the permit area, there is a lack of evidence indicative of extended or long-term settlement localities in the region. Though the reason behind this phenomenon remains unclear, the bulk of preliminary data from the current investigation appear to mirror this trend.

The landscape comprising the permit area is erosional in nature, leading to many sites being heavily deflated. The extend of the erosion processes is evidenced by the large number of sites recommended by Augustana as not eligible for listing on the National Register of Historic Places because of their location on deflated landforms. This equates to approximately half of the total number of identified sites in the permit area. Notable exceptions to these deflated localities include the valleys and terraces along Beaver and Pass Creeks, as well as many places within and adjacent to some of the more heavily wooded areas.

Nearly 200 hearths were identified within 24 separate sites areas during Augustana's investigation. These features varied considerably from one another in both size and form (and

likely function in many cases) and ranged from fully intact to completely eroded. Previous research in the nearby area has demonstrated a similar pervasiveness of such features in the archaeological record (Buechler, 1999; Lippincott 1983; Reher, 1981; Sundstrom, 1999; Winham et al., 2001), and specifically in relation to Plains Archaic-period site assemblages (Rom et al., 1996). Radiocarbon data obtained from a number of these hearths produced dates ranging from approximately 3,150-1,175 before present (B.P.) (UGa-4080 and Uga-4081), with the majority of these samples dating to Middle and Late Plains Archaic times (Reher, 1981).

3.11.3 Procedures to Avoid or Mitigate Potential Impacts

Powertech (USA) will administer a historic and cultural resources inventory before engaging in any development activity not previously assessed by NRC or any cooperating agency. Any disturbances to be associated with such development will be addressed in compliance with the National Historic Preservation Act (NHPA), the Archeological Resources Protection Act, and their implementing regulations. Any disturbances also will be addressed in compliance with Powertech (USA)'s Memorandum of Agreement (MOA) with the South Dakota State Archeologist and any future MOAs developed by Powertech (USA) or NRC under the NHPA. Powertech (USA) executed the MOA with the South Dakota State Archeologist in September 2008. The MOA, which is provided as Appendix 3.11-B, establishes procedures to avoid or mitigate potential effects on archaeological and historic sites pursuant to SDCL 45-6D-14 and 45-6B.

Powertech (USA) will immediately cease any work resulting in the discovery of previously unknown cultural artifacts to ensure that no unapproved disturbance occurs. Powertech (USA) will notify appropriate authorities per any license conditions and will not go forward without appropriate approvals from NRC or other agencies as appropriate. Any such artifacts will be inventoried and evaluated, and no further disturbance will occur until authorization to proceed has been received. Powertech (USA) recognizes that the NHPA environment is not static, but rather is ongoing up to and through final NRC license termination and LSM permit termination.

3.12 Noise

This section describes the background noise sources within the permit area. Existing noise sources within the permit area include county and local road traffic, livestock operations, crop production, the BNSF railroad, and wind. As described in Section 3.1.2, the predominant land use within the permit area is agricultural production related to grazing (rangeland). Other land

uses include hay production and recreation (primarily large game hunting). The nearest noise receptors are five residences within the permit area.

Due to the remoteness of the permit area, low population density of the surrounding area, and lack of noise generated from the primary land use of rangeland, existing noise levels are generally low. The majority of the existing ambient noise in the vicinity is generated from wind, the railroad, and traffic on county roads. Local residents use tractors, trailers, and pickup trucks when hauling livestock.

Noise standards and sound measurement equipment have been designed to account for the sensitivity of human hearing to different frequencies. The unit of measure used to represent sound pressure levels (decibels) using the A-weighted scale is a dBA (A-weighted decibel). It is a measure designed to simulate human hearing by placing less emphasis on lower frequency noise because the human ear does not perceive sounds at low frequency in the same manner as sounds at higher frequencies. Figure 3.12-1 and Tables 3.12-1 and 3.12-2 present noise levels associated with some commonly heard sounds. Table 3.12-1 presents typical noise levels from vehicles at a distance of 45 feet and speeds ranging from 50 to 75 mph. Assuming vehicles travel at 45 mph, the noise levels at 45 feet due to traffic generally should not exceed 79 dBA. The actual traffic noise levels at nearby residences would likely be much lower since residences are much more than 45 feet from county roads. The minimum distance between a residence and the primary county road in the permit area (S. Dewey Road is 3,700 feet). Noise levels from point sources decrease by about 6 dBA for each doubling of distance. Therefore, the maximum anticipated noise from a heavy truck traveling along the S. Dewey Road at a residence with the permit area is about 41 dBA.

The noise from the railroad is a result of the locomotive engine, wheel/rail interaction, and horn noise. Horn noise is a noise source at grade crossings where horns sounding are required by law for safety purposes. All these noises diminish with distance. The frequency of freight trains passing through the permit area on the BNSF railroad was reported by the local Edgemont Train Master to be 50 per day. The hourly rate is variable. The noise levels typically reported for a freight train traveling at approximately 50 mph on grade from a distance of 50 feet is approximately 80 dBA, with a range from about 55 to 90 dBA, depending on a number of factors, including condition and type of track, length of train, number of engines, condition of engines, speed, grade, etc. (Surface Transportation Board, CN-Control-EJ&E DEIS, Appendix L, 2008 and Surface Transportation Board, Alaska Railroad – Northern Rail Extension DEIS,

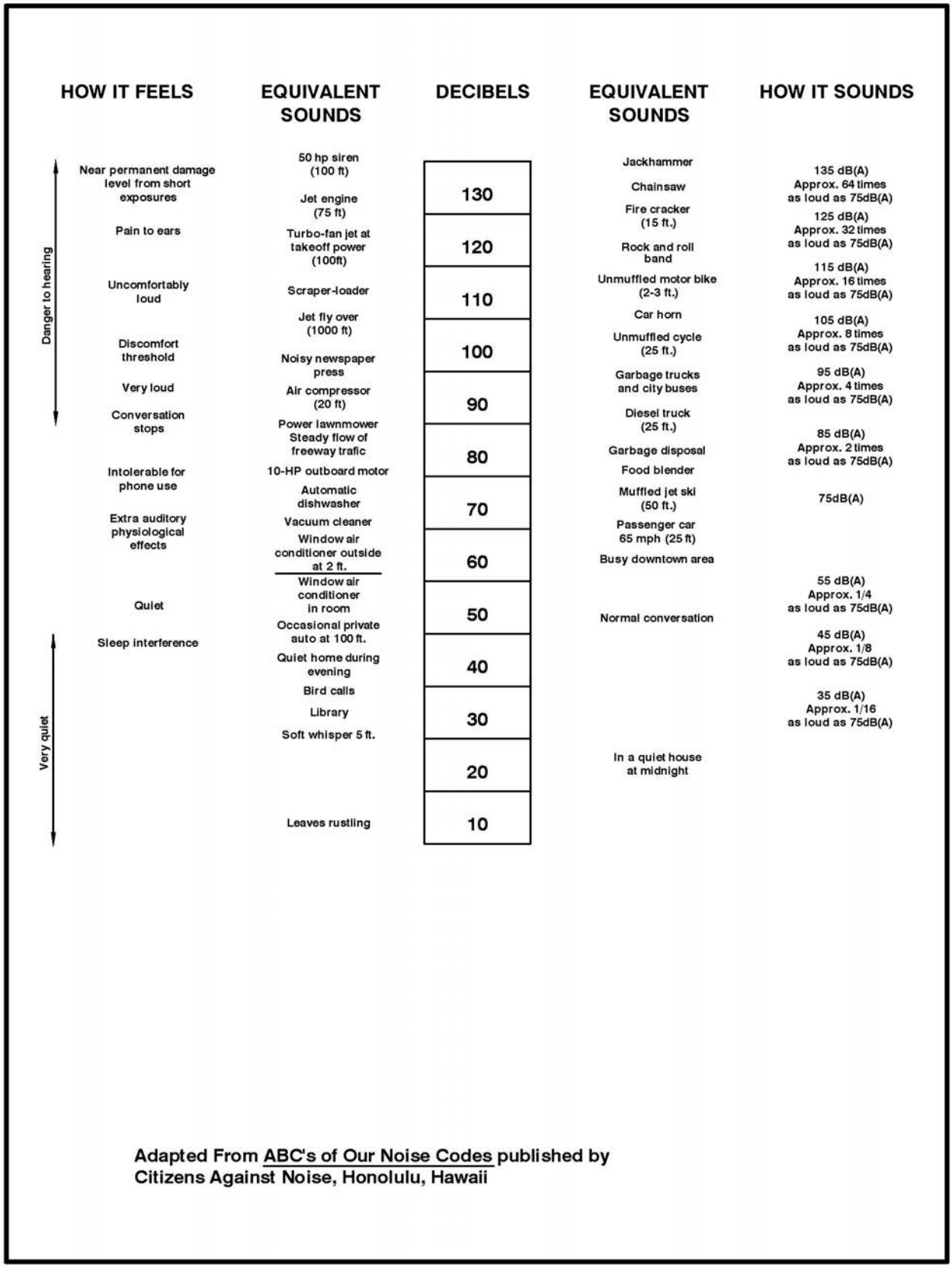


Figure 3.12-1: Relationship Between A-Scale Decibel Readings and Sounds of Daily Life

Table 3.12-1. Typical Vehicle Noise Levels

Speed (mph)	Noise Level at 45 ft (A-Weighted Decibels, dBA)		
	Automobiles	**Medium Trucks**	**Heavy Trucks**
45*	61	73	79
50	62	74	80
55	64	76	81
60	65	77	82
65	67	78	83
70	68	79	84

Notes: Automobiles: All vehicles with two axles and four wheels
Medium Trucks: All vehicles with two axles and six wheels
Heavy Trucks: All vehicles with three or more axles
*Noise levels for 45 mph were extrapolated

Source: DOT (1995)

Table 3.12-2: Comparative Examples of Noise Sources, Decibels and their Effects

Noise Source	Decibel Level	Decibel Effect
Jet take-off (at 25 meters)	150	Eardrum rupture
Aircraft carrier deck	140	
Military jet aircraft take-off from aircraft carrier with afterburner at 50 ft (130 dB).	130	
Thunderclap, chain saw. Oxygen torch (121 dB)	120	Painful, 32 times as loud as 70 dB.
Steel mill, suto horn at 1 meter. Turbo-fan aircraft at takeoff power at 200 ft (118 dB). Riveting machine (110 dB); live rock music (108 – 114 dB).	110	Average human pain threshold. 16 times as loud as 70 dB.
Jet take-off (at 305 meters), use of outboard motor, power lawn mower, motorcycle, farm tractor, jackhammer, garbage truck. Boeing 707 of DC-8 aircraft at one nautical mile (6080 ft) before landing (106 dB); jet flyover at 1000 feet (103 dB); Bell J-2A helicopter at 100 ft (100 dB).	100	8 times as loud as 70 dB. Serious damage possible in 8 hr exposure.
Boeing 737 or DC-9 aircraft at one nautical mile (6080 ft) before landing (97 dB); power mower (96 dB); motorcycle at 25 ft (90 dB). Newspaper press (97dB).	90	4 times as loud as 70 dB. Likely damage 8 hr exposure.
Garbage disposal, dishwasher, average factory, freight train (at 15 meters). Car wash at 20 ft (89 dB); propeller plane flyover at 1000 ft (88 dB); diesel truck 40 mph at 50 ft (84 dB); diesel train at 45 mph at 100 ft (83 dB). Food blender (88 dB); milling machine (85 dB); garbage disposal (80 dB).	80	2 times as loud as 70 dB. Possible damage in 8 hr exposure.
Passenger car at 65 mph at 25 ft (77 dB); freeway at 50 ft from pavement edge 10 a.m. (76 dB). Living room music (76 dB); radio or TV-audio, vacuum cleaner (70 dB).	70	Arbitrary base of comparison. Upper 70s are annoyingly loud to some people.
Conversation in restaurant, office, background music, air conditioning unit at 100 ft	60	Half as loud as 70 dB. Fairly quiet.
Quiet suburb, conversation at home. Large electrical transformers at 100 ft	50	One-fourth as loud as 70 dB.
Library, bird calls (44 dB); lowest limit of urban ambient sound	40	One-eighth as loud as 70 dB.
Quiet rural area	30	One-sixteenth as loud as 70 dB. Very quiet.
Whisper, rustling leaves	20	
Breathing	10	Barely audible

Table modified from http://www.wenet.net/~hpb/dblevels.html] on 2/2000.
SOURCES: Temple University Department of Civil/Environmental Engineering (www.temple.edu/departments/CETP/environ10.html), and Federal Agency Review of Selected Airport Noise Analysis Issues, Federal Interagency Committee on Noise (August 1992). Source of the information is attributed to Outdoor Noise and the Metropolitan Environment, M.C. Branch et al., Department of City Planning, City of Los Angeles, 1970.

Appendix J, 2008). A train's horn, dictated by the Federal Railroad Administration Train Horn Rule, is between 96 and 110 dBA for 15 to 20 seconds at railroad crossings.

Under the authority of the Noise Control Act of 1972, EPA identifies a 24-hour exposure level of 70 dBA as the level of environmental noise which will not cause any measureable hearing loss over a lifetime. A level of 55 dBA outdoors is identified as preventing activity interference and annoyance. People generally have a lower tolerance to noise at night when they are trying to sleep. Therefore 10 dBA is added to nighttime readings before an overall calculation of 24-hour equivalent sound level is made. Outdoor day-night sound levels in rural wilderness areas range from 20 dBA to 30 dBA (EPA, 1974). Given the moderately windy conditions in the permit area, the typical baseline noise levels are anticipated to range from 30 to 40 dBA, with higher levels present near the county road and BNSF railroad.

3.13 Visual Assessment

Visual and scenic resources consist of the visible natural (e.g., landforms and vegetation) and cultural components (e.g., roads and buildings) of the environment. Important visual resources can be landscapes that have unusual or intrinsic value, or areas with human or cultural influences that are valued for their visual or scenic setting. The BLM's Visual Resource Management (VRM) system is an attempt to assess and classify landscapes in order to properly manage their visual and scenic resources (BLM, 1984).

3.13.1 Methodology

In order to determine the VRM class of the landscape within the permit area and the surrounding 2-mile area, these areas were rated in accordance with BLM Manual 8400 – Visual Resource Management. The visual resource inventory classes are used to develop VRM classes. The following VRM classes are objectives that quantify the acceptable levels of disturbance for each class.

- Class I Objectives – To preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.
- Class II Objectives – To retain the existing character of the landscape. This level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.

- Class III Objectives – To partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.
- Class IV Objectives – To provide management activities which require major modifications of the existing character of the landscape. The level of change to the characteristic landscape can be high. These management activities may dominate the view and be the major focus of viewer's attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repeating the basic elements.

According to the scenic quality inventory conducted in June 2008, which rated scenic quality, sensitivity level, and distance zones, the area was classified as a VRM Class IV. The objective of this class is to provide management for activities that might require major modifications of the existing character of the landscape. The level of change permitted for this class can be high. Table 3.13-1 was used to determine the visual resource inventory class.

3.13.2 Visual Resource Management Rating

In order to determine the scenic quality rating of the permit area and the surrounding 2-mile area, a visual resource inventory was conducted in accordance with the BLM Handbook H-8410-1, Visual Resource Inventory (BLM, 1986). A visual resource inventory was conducted for each of the Scenic Quality Rating Units (SQRU) – areas that demonstrated similar physiographic characteristics – in the area.

Scenic Quality – Scenic quality is a measure of the visual appeal of a tract of land. In the visual resource inventory process, public lands are given an A, B, or C rating based on the apparent scenic quality, which is determined using seven key factors: landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications. These key factors are rated according to form, line, color, texture, scale and space on a comparative scale from zero to five taking into consideration similar features within the same physiographic province. The results of the inventory and the associated rating for each key factor are summarized in Table 3.13-2 and Table 3.13-3.

Sensitivity Level – Sensitivity levels are a measure of the public's concern for scenic quality. Public lands are assigned high, medium, or low sensitivity levels by considering the following factors: type of users, amount of use, public interest, adjacent land use, and special areas.

Table 3.13-1: BLM Visual Resource Inventory Classes

		Visual Sensitivity Levels						
		High			Medium			Low
Special Area		I	I	I	I	I	I	I
Scenic Quality	A	II	II	II	II	II	II	II
	B	II	III	III* IV*	III	IV	IV	IV
	C		IV	IV	IV	IV	IV	IV
		f/m	b	s/s	f/m	b	s/s	s/s
		Distance Zones						

Source: BLM (1986)
* If adjacent area is Class III or lower, assign Class III, if higher assign Class IV
f/m = foreground–middleground
b = background
ss = seldom seen

Table 3.13-2: Scenic Quality Inventory and Evaluation of the SQRU 001 for the Permit Area

Key Factor	Rating Criteria	Score
Landform	Flat to rolling plains with weathered plateaus in the background	3
Vegetation	Vegetation is dominated by several variety of grasses and shrubs with some wildflowers and cottonwood trees	3
Water	Water is present but not visible from the road and view points	0
Color	Soil is light brown to brown and vegetation is tan to light green and dark green	3
Adjacent Scenery	The area borders the forested Black Hills Uplift	1
Scarcity	Landscape is common for the region	1
Cultural Modifications	Existing modifications consist of a gravel road and railway and grazing activities	0
Total Score		11

Table 3.13-3: Scenic Quality Inventory and Evaluation of the SQRU 002 for the Permit Area

Key Factor	Rating Criteria	Score
Landform	Flat to rolling plains with hills covered by evergreen forests	3
Vegetation	Vegetation is dominated by several variety of grasses and shrubs with some wildflowers and cottonwood trees and evergreen forest	3
Water	Water is present but not visible from the road and view points	0
Color	Soil is light brown to brown and vegetation is tan to light green and dark green	3
Adjacent Scenery	The area borders the forested Black Hills Uplift	1
Scarcity	Landscape of the Black Hills Uplift is uncommon with the physiographic province of the Great Plains	3
Cultural Modifications	Existing modifications consist of a gravel road and railway and grazing activities	0
Total Score		13

Distance Zones – Distance zones categorize areas according to their visibility from travel routes or observation points. The three categories are foreground-middleground, background and seldom seen.

- Foreground-Middleground Zone – The area that can be seen from each travel route from a distance of 3 to 5 miles where management activities might be viewed in detail. The outer boundary of this distance zone is defined as the point where the texture and form of individual plants are no longer apparent in the landscape.
- Background – The area that can be seen from each travel route up to a distance of 15 miles and that extend beyond the foreground-middleground zone.
- Seldom Seen – The areas that are not visible within the foreground-middleground and background zones or areas beyond the background zones.

3.14 Baseline Radiologic Characteristics

Appendix 3.14-A provides baseline radiological data for surface soils (0-5 and 0-15 cm), subsurface soils to a depth of 1 meter, vegetation, locally grazed cattle, direct radiation, radon-222 in air, and radon-222 flux rates representative of the project property. The work was performed by Environmental Restoration Group (ERG) between August 2007 and July 2008.

4.0 SOCIOECONOMIC ASSESSMENT

A socioeconomic assessment was prepared in 2008 using 2000 Census data, population and demographic estimates from 2006, and revenue estimates from 2007. The results of the assessment are included in Appendix 4.0-A.

5.0 MINE PLAN

The regulation of ISR uranium extraction falls under the jurisdiction of several State and Federal agencies. Table 5.0-1 provides an overview of the agencies and their regulatory authority, and Table 5.0-2 describes the jurisdictional primacy for various media or environmental issues. The mine plan describes all aspects of facility design, construction, operation, and monitoring to demonstrate that potential environmental impacts will be minimized. Abbreviated discussions are provided for areas not specifically regulated by DENR (e.g., radiological effluent control systems), while much greater detail is provided for areas for which DENR has primary or joint jurisdictional primacy, including pond design, access roads, diversions, and sediment control. The designs for these aspects have been advanced beyond what has been submitted in previous license or permit applications. Table 5.0-3 provides the proposed regulatory primacy for the mine plan, including facility design, construction, operation, and monitoring.

5.1 General Mine Planning and Design

The Dewey-Burdock Project will implement a phased approach, consisting of a series of sequentially delineated and developed well fields, a satellite ion exchange (IX) facility (Satellite Facility) at the Dewey portion of the permit area and a central processing plant (CPP) and associated facilities to recover and process the final uranium product. Following is a description of the ore body geology, chemistry of ISR uranium extraction, and operational overview.

5.1.1 Overview of Operations

The Dewey-Burdock Project will implement *in situ* recovery (ISR) methods for uranium extraction using a Satellite Facility and associated well fields within the Dewey portion of the permit area and a CPP and associated well fields within the Burdock portion of the permit area. The CPP will be used to produce the final uranium product (yellowcake or U_3O_8).

Uranium will be recovered by injecting lixiviant fortified with oxygen and carbon dioxide (barren lixiviant) into injection wells and recovering the resulting solution (pregnant lixiviant) from production wells. The uranium will be recovered from solution in ion exchange (IX) vessels in the Satellite Facility or CPP. The CPP will include elution, precipitation, drying and packaging systems to recover the yellowcake. If it is determined that vanadium will be recovered, modifications to the facilities will be made to accommodate vanadium recovery, drying and packaging. Prior to making any modifications to recover vanadium, Powertech (USA) will provide DENR with descriptions of the updated processes and facilities.

Table 5.0-1: Uranium ISR Permitting in South Dakota

Agency	Pertinent Area of Regulatory Authority	Statutory Authority
NRC	Public health and safety, environmental protection; primary focus is radiation protection in all media and safeguarding materials and facilities for national security	Atomic Energy Act of 1954, as amended (Regs in CFR Title 10)
EPA	Water quality (UIC & NPDES), air quality (NAAQS & NESHAPS)	Environmental Protection Act, Safe Drinking Water Act, Clean Air Act, Clean Water Act (Regs in CFR Title 40)
BLM	Federal land and resource management (MOU with NRC)	Federal Land Policy and Management Act of 1976 (Regs in CFR Title 43)
DENR	Promote and encourage development of mineral resources, prevent the waste and spoilage of the land, ensure the health and safety of the public, provide for usable and productive post-mining land use; water rights; groundwater discharge permits; air quality permitting; NPDES permitting; public water supply system permitting.	Mined Land Reclamation Act; SDCL 45-6B (Regs in ARSD Title 74, primarily 74:29, 74:02, 74:03, 74:27, 74:28, 74:36 & 74:54)
DOT	Transportation of radiological and nonradiological materials	Federal-Aid Road Act of 1916 and the Federal Highway Act of 1921 (Regs in CFR Title 49)
OSHA	Occupational safety and health (MOU with NRC)	Occupational Safety & Health Act of 1970 (Regs in CFR Title 29)
ACHP & SD SHPO	Cultural & historic resource protection	National Historic Preservation Act (NHPA) (Regs in CFR Title 36)

Table 5.0-2: Regulatory Primacy

Media or Environmental Issue (from ISR GEIS, NRC, 2009)	Regulatory Agency (in order of perceived jurisdictional primacy)
Land Use	NRC, DENR, BLM
Transportation	NRC, DOT
Geology	NRC, EPA, BLM, DENR
Water Resources	NRC, DENR, EPA, BLM
Ecology	NRC, DENR, BLM
Meteorology, Climatology & Air Quality	NRC, EPA, DENR, BLM
Noise	NRC, OSHA, DENR, BLM
Historic and Cultural Resources	NRC, BLM, SHPO, DENR
Visual Resources	NRC, BLM, DENR
Socioeconomics	NRC, DENR, BLM
Public and Occupational Health	NRC, OSHA, BLM, EPA, DENR
Waste Management	NRC, DENR, BLM
Decontamination, Decommissioning, Reclamation	NRC, DENR, EPA, BLM
Accidents	NRC, OHSA, BLM, DOT, DENR
Environmental Justice	NRC, BLM, EPA
Cumulative Impacts	NRC, BLM, DENR, EPA
Monitoring	NRC, DENR, BLM
Financial Assurance	NRC, DENR, EPA, BLM

Notes:

1) NRC is the lead federal agency and is primarily responsible for licensing the construction, operation and closure of the ISR project. NRC is the primary enforcement regulator.
2) BLM is a cooperating agency with NRC for the NEPA review and is responsible for the issuance of an approved "Plan of Operations."
3) EPA has permitting authority for the UIC Class V and Class III permits dealing with underground injection of liquid wastes and lixiviant for the recovery of uranium. EPA also is attempting to require air quality permit for radon releases from impoundments.
4) DENR - Chief Engineer is responsible for issuing water rights. DENR – Water Quality is responsible for approving the Groundwater Discharge Plan and NPDES permit for releases to surface water. DENR - Minerals and Mining is responsible for issuing a permit to mine.
5) Considering the implications of the 2011 South Dakota Legislature's Senate Bill 158 that tolled the regulations promulgated for ISR operations, DENR regulations may not be duplicative of either NRC's or EPA's regulations that apply to ISR operations. However, since the authority to mine in South Dakota still resides with DENR and the contents of an acceptable application are still listed in SDCL 45-6B, Powertech (USA) suggests that complying with the application content requirements is necessary and appropriate, considering the intent of SB 158.

Table 5.0-3: Anticipated Regulatory Primacy for Facility Design, Construction, Operation and Monitoring

Mine Plan Section	Description	Regulatory Agency (in order of perceived jurisdictional primacy)
5.3.1	CPP equipment and chemical storage facilities	NRC, OSHA
5.3.2	Satellite Facility equipment and chemical storage facilities	NRC, OSHA
5.3.3.1	Well field design	NRC
5.3.3.2	Well construction and integrity testing	NRC, DENR, EPA
5.3.3.3	Pump testing	NRC
5.3.3.4	Well field hydrogeologic data packages	NRC, EPA
5.3.3.5	Well field operation	NRC, EPA
5.3.3.6	Approach to well field development with respect to partially saturated conditions	NRC
5.3.3.6	Approach to well field development with respect to historical mine workings	NRC
5.3.3.6	Approach to well field development with respect to alluvium	NRC
5.3.4	Ponds	NRC, DENR
5.3.5	Instrumentation	NRC
5.3.6	Backup power	NRC
5.3.7	Topsoil handling	DENR, NRC, BLM
5.3.8	Roads	DENR, BLM
5.3.9	Water management and erosion control	DENR, NRC, BLM
5.4.1	Waste management - AEA-regulated waste	NRC
5.4.2	Waste management - non-AEA-regulated waste	DENR, EPA, NRC
5.5.1	Well field monitoring	NRC, EPA
5.5.2	Operational groundwater monitoring	NRC, DENR
5.5.3	Operational surface water monitoring	NRC, DENR
5.5.4	Land application effluent monitoring	DENR, NRC
5.5.5	Flow and pressure monitoring	NRC, EPA
5.5.6	Soil sampling	NRC, DENR
5.5.7	Vegetation sampling	NRC, DENR
5.5.8	Livestock and fish sampling	NRC, DENR
5.5.9	Air monitoring	NRC, DENR
5.6	Potential Impacts and Mitigation	NRC, DENR, BLM
5.7	Operations	NRC
5.7.2.6	Reporting	NRC, DENR, EPA

Aquifer restoration, or groundwater restoration, will be completed following uranium recovery in each well field. During aquifer restoration, the groundwater in the well field will be restored in accordance with NRC requirements. The primary goal of aquifer restoration will be to restore the groundwater to baseline (background) quality or an EPA-established maximum contaminant level (MCL), whichever is higher.

The vast majority of water withdrawn from the production wells will be reinjected as part of the ISR process, such that the net withdrawal rate will be only a small fraction of the gross pumping rate. A small portion of the production and restoration streams will not be reinjected in order to maintain an inward hydraulic gradient within each well field. This is referred to as the production or restoration bleed. The production and restoration bleed will be disposed using one of the two wastewater disposal options.

The preferred wastewater disposal option is underground injection of treated liquid waste in Class V deep disposal wells (DDWs). In this disposal option wastewater will be treated to meet EPA non-hazardous waste requirements and injected into the Minnelusa and/or Deadwood formations in four to eight DDWs being permitted pursuant to the Safe Drinking Water Act through the EPA UIC Program. It is anticipated that all wastewater resulting from ISR operations will be disposed using this option if sufficient capacity is available in DDWs.

The alternate wastewater disposal option is land application. This option involves treatment in lined radium settling ponds followed by seasonal application of treated wastewater through center pivot sprinklers. Land application would be carried out under a groundwater discharge plan (GDP), which is currently being permitted through DENR. Depending on the availability and capacity of DDWs, Powertech (USA) may use land application in conjunction with DDWs or by itself.

Solid wastes such as pond sludge; soils contaminated by spills or leaks; spills of loaded or spent IX resin; filter sand or other process media; and parts, equipment, debris (e.g., pipe fittings and hardware) and PPE that cannot be decontaminated for unrestricted release are considered AEA-regulated wastes and will be disposed at an NRC or NRC agreement state-licensed facility in accordance with NRC license requirements.

Monitoring systems will be implemented to minimize potential impacts to the environment and public health. These include extensive groundwater monitoring, including establishing a perimeter monitor well ring around each well field and monitoring overlying and underlying

water-bearing intervals to identify any unintended movement of ISR solutions. It also includes instrumentation and control systems to rapidly detect any potential pipeline leaks or spills.

Section 6 describes the reclamation plan that will be implemented to restore groundwater, remove equipment, reclaim disturbed areas, and ensure that the permit area meets all postmining land uses following ISR activities.

5.1.2 Ore Body Geology

Uranium will be recovered from the Fall River Formation and Chilson Member of the Lakota Formation. Section 3.2 provides a detailed discussion on the regional geology, site geology, and ore mineralogy. The uranium mineralization targeted for ISR is found within fully saturated portions of the Fall River and Chilson, with overlying and underlying geologic confinement, making the project well suited for ISR uranium extraction. After LSM permit/NRC license issuance but prior to well field development, Powertech (USA) will conduct delineation drilling to fully characterize the geology of each well field (refer to Section 5.3.3.3).

5.1.3 Chemistry of Uranium ISR

The ISR process involves the oxidation and solubilization of uranium from its reduced state using a leaching solution (lixiviant). The lixiviant will consist of groundwater fortified with gaseous oxygen added to oxidize the solid-phase uranium to a soluble valence state and gaseous carbon dioxide added to form a complex with the soluble uranium ions so they remain in solution as they are transported through the ore body. As described in NRC guidance document NUREG-1569 (NRC, 2003), this lixiviant formulation will minimize potential groundwater quality impacts during uranium recovery and enable restoration goals to be achieved in a timely manner.

The chemistry of uranium oxidation and dissolution is described with the following equations:

Oxidation: UO_2 (solid) + ½O_2 (in solution) $\rightarrow$ UO_3 (at solid surface)

Dissolution: $UO_3 + 2\ HCO_3^- \rightarrow UO_2(CO_3)_2^{2-} + H_2O$

$UO_3 + CO_3^{2-} + 2HCO_3^- \rightarrow UO_2(CO_3)_3^{4-} + H_2O$

The principal uranyl carbonate ions formed as shown above are uranyl dicarbonate, $UO_2(CO_3)_2^{2-}$ [i.e., UDC], and uranyl tricarbonate, $UO_2(CO_3)_3^{4-}$ [i.e., UTC]. The relative abundance of each is a function of pH and total carbonate strength.

Once solubilized, the uranium-bearing groundwater will be pumped by submersible pumps in the production wells to the surface, where it will be ionically bonded onto IX resin. After the uranium is removed, the groundwater will be fortified with oxygen and carbon dioxide, recirculated and reinjected via the injection wells. When the IX resin is loaded with uranium, the loaded resin will be transferred to an elution (stripping) column, where the uranium will be eluted (stripped) from the resin using a saltwater solution. The resulting barren resin then will be recycled to recover more uranium. The saltwater eluate solution will be pumped to a precipitation process, where the uranium will be precipitated as a yellow, solid uranium oxide (yellowcake or U_3O_8). The precipitated uranium oxide then will be filtered, washed, dried and packaged in sealed containers for shipment for further processing to be used in the uranium fuel cycle. The chemistry of the IX process, elution, and precipitation is described in Section 5.3.1.1.

5.2 Schedule

Following the issuance of an NRC uranium recovery license, DENR LSM permit, and other relevant permits, it is anticipated that construction will commence on the first Burdock well field, CPP and ancillary facilities including storage ponds and land application pivots and/or deep disposal wells. It is anticipated that construction of the first Dewey well field and ancillary facilities will occur at the same time or follow shortly thereafter. Alternately, Powertech (USA) may develop either the Burdock or Dewey area well fields first, followed by the well fields in the other area. Uranium recovery operations within the permit area will continue for approximately 7 to 20 years during which additional well fields will be completed along the roll fronts at both the Dewey and Burdock portions of the permit area. Future exploration may occur within the permit area. Future exploration outside of the currently identified potential well field areas would be conducted under an exploration permit. With future exploration drilling, there is the potential of locating additional recoverable resources within the permit area, in which case Powertech (USA) would request an amendment to the LSM permit to accommodate additional potential well field areas. Following operation of each well field, aquifer restoration will restore groundwater quality. Following regulatory approval of successful aquifer restoration, each well field will be decommissioned, the procedures for which are described in Section 6. It is likely that the CPP will continue to operate for several years following decommissioning of the well fields. The CPP may continue to process uranium-loaded ion exchange resin from other ISR projects such as the nearby Powertech (USA) Aladdin and Dewey Terrace ISR projects planned in Wyoming, as well as possible tolling arrangements with other operators. The entire Dewey-Burdock Project then will be decommissioned and reclaimed in accordance with NRC, DENR, BLM and EPA

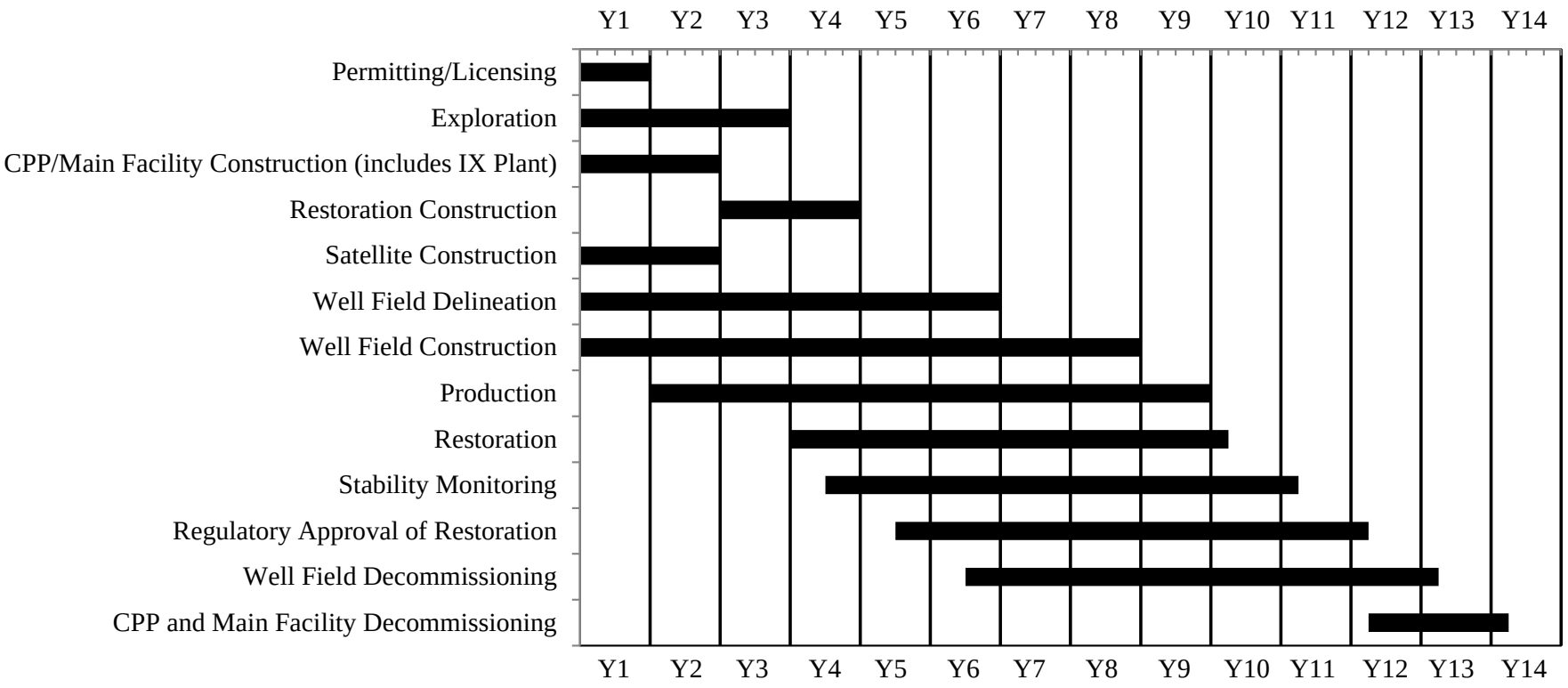


Figure 5.2-1: Projected Construction, Operation, Restoration and Decommissioning Schedule

requirements. The projected construction, operation, restoration and decommissioning schedule is provided in Figure 5.2-1.

5.3 Description of Facilities

Following is a description of the proposed facilities, including CPP and Satellite Facility processing equipment, well fields, wastewater disposal systems, ponds, roads, diversion channels, and sediment control features. Figures 5.3-1 and 5.3-2 depict the general locations of proposed facilities and potential initial well fields in the land application and deep disposal well liquid waste disposal options, respectively. Plates 5.3-1 and 5.3-2 depict the proposed facilities in each disposal option in greater detail and present the proposed affected area boundary. These plates also provide the contour basis for mining in accordance with SDCL 45-6B(6)(8)(a). The only significant change in the premining contours depicted on these plates will be the construction of ponds and diversion channels, the locations of which are depicted on these plates. Following is a narrative description of the premining contours in accordance with ARSD 74:29:02:04(2).

The premining topography within the proposed permit area is described in Section 3.5.2.1. The elevation ranges from approximately 3,600 to 3,900 feet, and the average slope is approximately 6 percent. Within the proposed affected area, the elevation ranges from approximately 3,590 feet near D-WF1 along Beaver Creek to approximately 3,930 feet at a spoil pile associated with the historical Darrow Mine. The slope within the proposed affected area ranges from nearly flat along the Beaver Creek and Pass Creek floodplains to vertical slopes in portions of the historical surface pits. The average slope in the proposed affected area is approximately 5 percent.

Near the proposed CPP and associated ponds, the premining elevation ranges from approximately 3,690 to 3,780 feet. The slope ranges from approximately 1 to 12 percent and averages approximately 5 percent. In the vicinity of the Satellite Facility and associated ponds, the elevation ranges from approximately 3,630 to 3,680 feet. The slope ranges from approximately 0 to 6 percent and averages approximately 2 percent.

Refer to Section 5.4.1.1.2 for a description of the slopes within the proposed land application areas. Plates 3.2-23 through 3.2-27 depict cross sections through the proposed land application areas.

Cross Sections AA-AA’ through HH-HH’, provided on Plates 5.3-15 and 5.3-16, depict cross sections through the processing facilities and ponds. These cross sections depict the premining

topography, postmining topography and the approximate finished ground topography during ISR operations. The postmining topography will approximate premining topography.

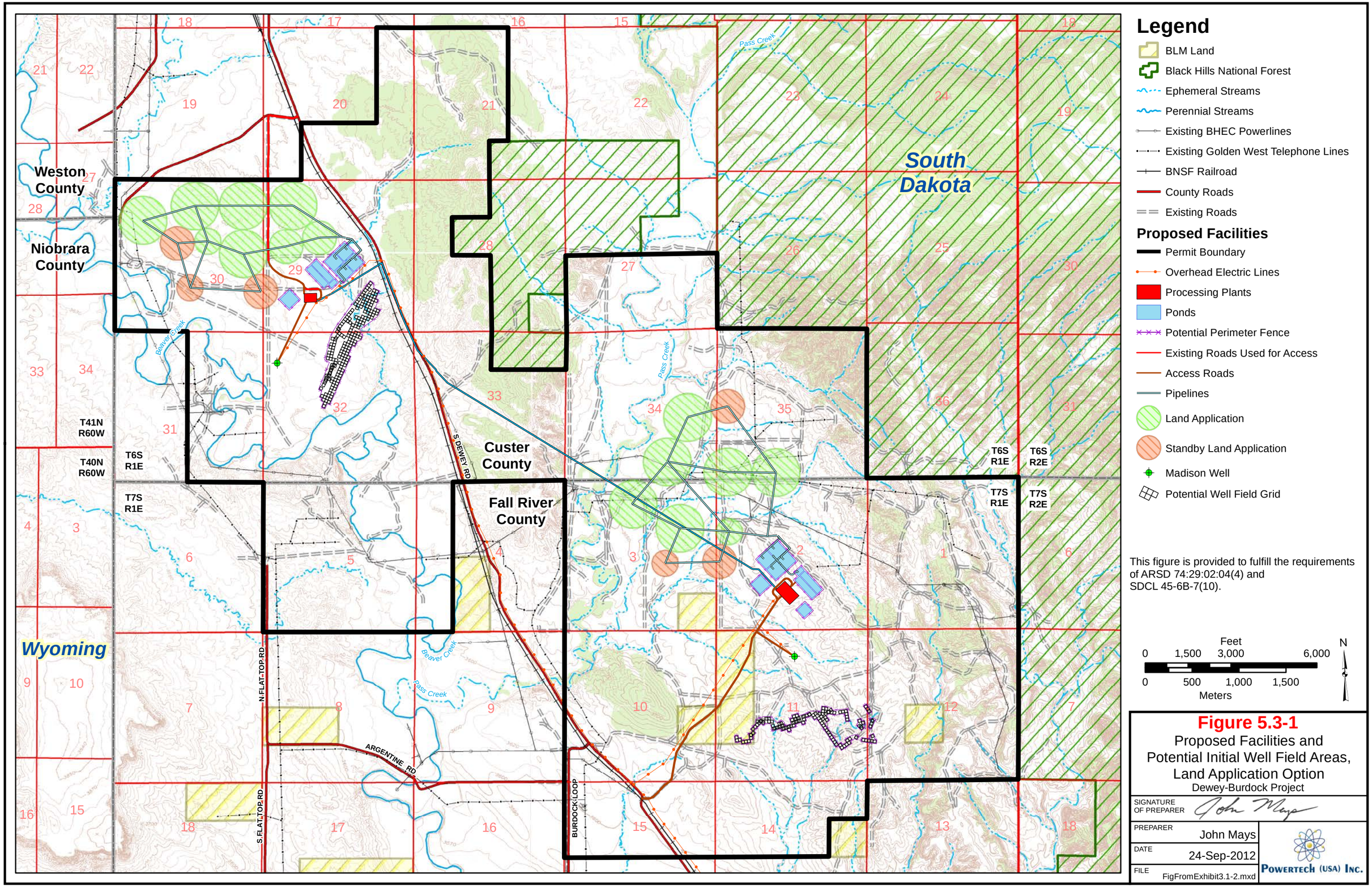
5.3.1 CPP Equipment and Chemical Storage Facilities

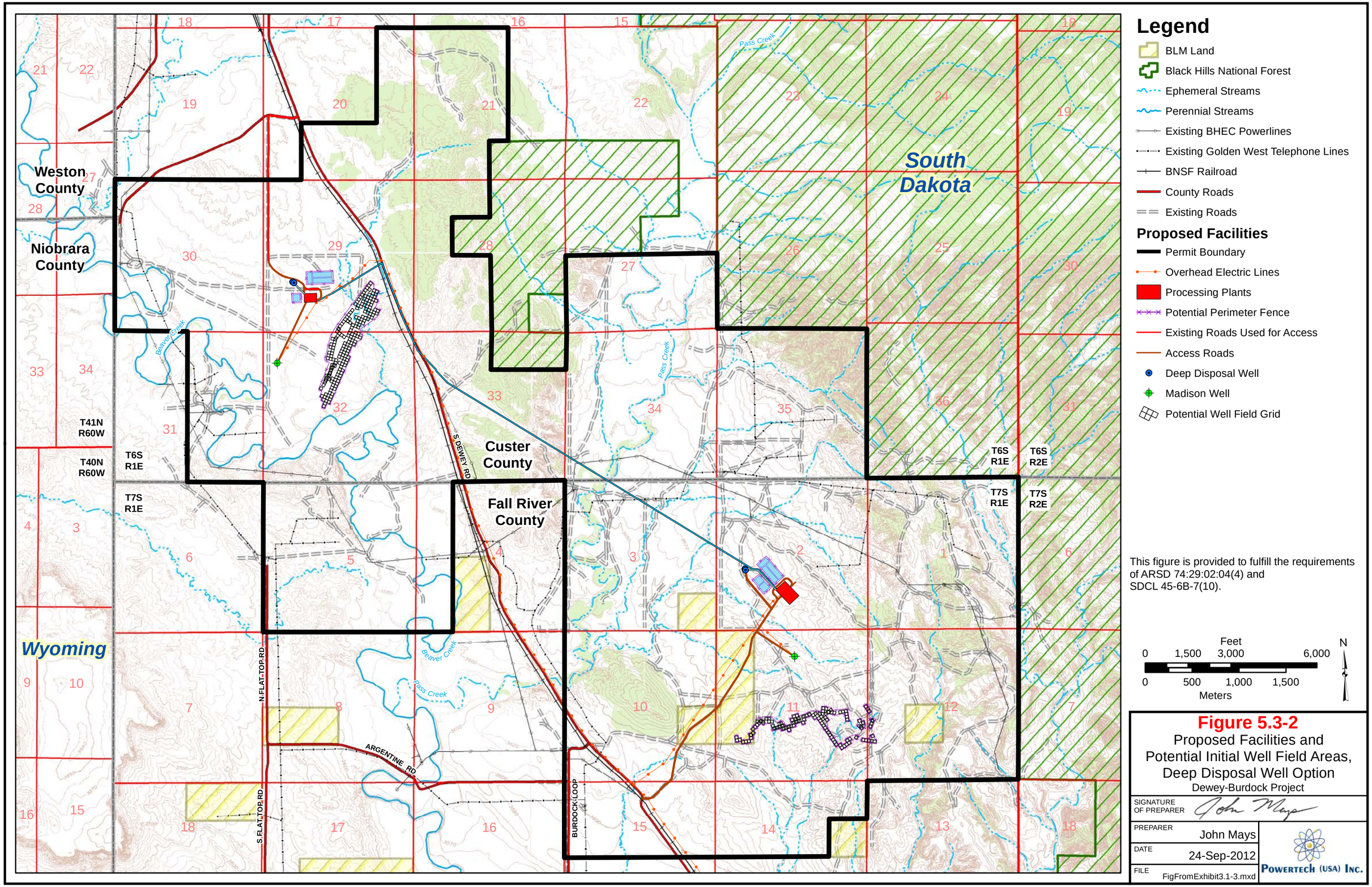
The CPP will be located in the Burdock portion of the permit area (Figures 5.3-1 and 5.3-2). Uranium recovery from the solution by IX, subsequent processing of the loaded IX resin to remove the uranium (elution), the precipitation of uranium, thickening of the uranium slurry, and the dewatering, drying, and packaging of solid uranium oxide (yellowcake) will be performed at the CPP.

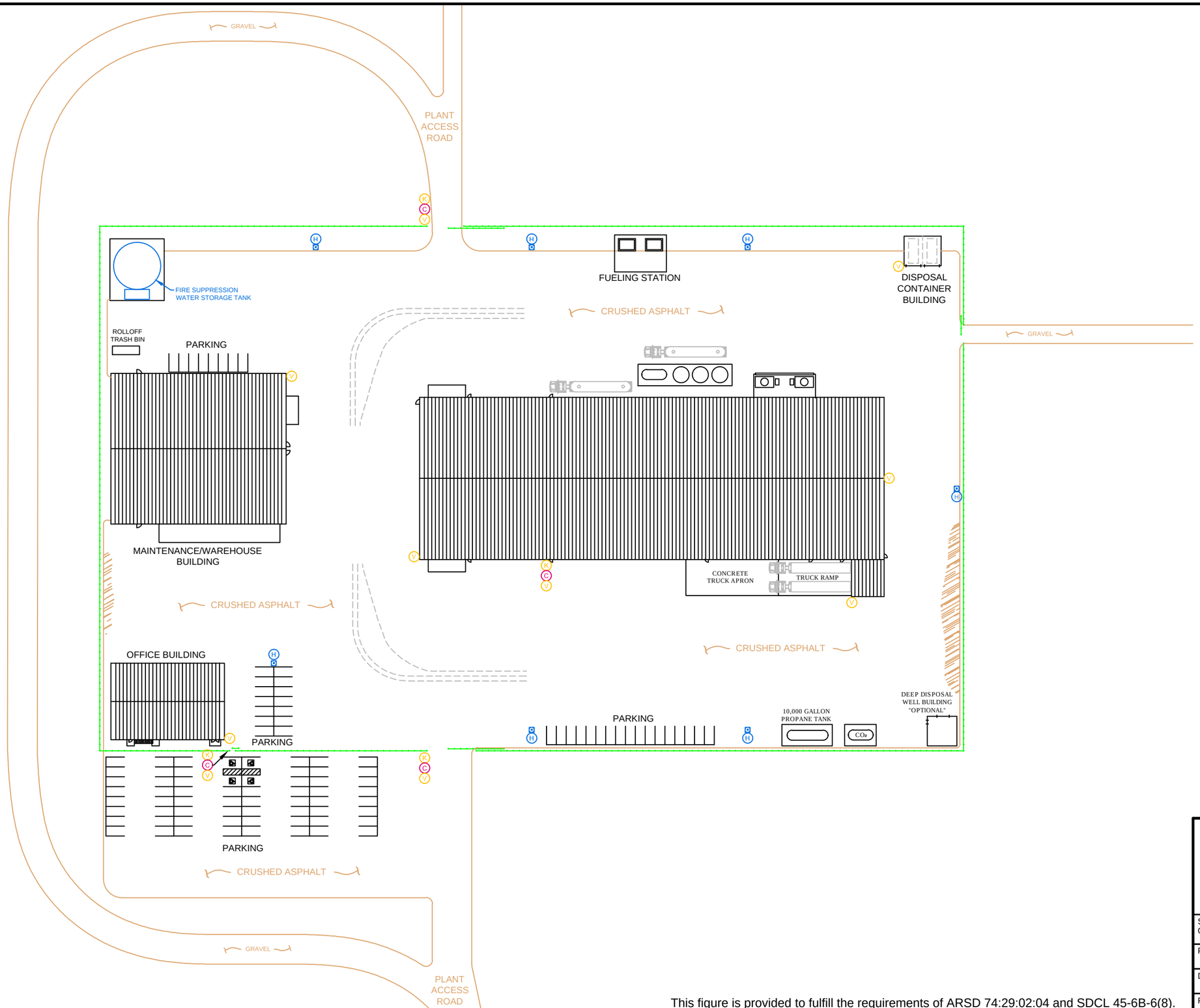
The site for the CPP has been designed to provide security and ease of access for operating purposes. The site is designed with ample areas for access by resin transfer trucks as well as truck transports for chemical delivery and shipment of product and byproduct materials. Figure 5.3-3 shows the site layout of the CPP, including the placement of an office building, a maintenance shop and the CPP building. Traffic routes and truck turning radii are indicated on this figure. The processing equipment within the CPP is regulated by the NRC, and the chemical storage facilities are regulated by OSHA and NRC. The following discussion is provided for informational purposes in this permit application and is a summary of the discussion provided in the NRC license application.

5.3.1.1 CPP Equipment

The processing facilities will be housed in a pre-engineered metal building. The equipment layout within the CPP building is shown in Figure 5.3-4. The CPP will include the following systems:


Legend
BLM Land
Black Hills National Forest
Ephemeral Streams
Perennial Streams
Existing BHEC Powerlines
Existing Golden West Telephone Lines
BNSF Railroad
County Roads
Existing Roads
Proposed Facilities
Permit Boundary
Overhead Electric Lines
Processing Plants
Ponds
Potential Perimeter Fence
Existing Roads Used for Access
Access Roads
Pipelines
Land Application
Standby Land Application
Madison Well
Potential Well Field Grid
This figure is provided to fulfill the requirements of ARSD 74:29:02:04(4) and SDCL 45-6B-7(10).
Feet
0 1,500 3,000 6,000
0 500 1,000 1,500
Meters
N
Weston County
Niobrara County
Custer County
Fall River County
South Dakota
Wyoming
T41N R60W
T40N R60W
T6S R1E
T7S R1E
T6S R2E
T7S R2E
S.DEWEY RD
N.FLAT-TOP.RD
S.FLAT-TOP.RD
ARGENTINE RD
BURDOCK LOOP
Pass Creek
Beaver Creek
Figure 5.3-1
Proposed Facilities and Potential Initial Well Field Areas, Land Application Option
Dewey-Burdock Project
SIGNATURE OF PREPARER
PREPARER John Mays
DATE 24-Sep-2012
FILE FigFromExhibit3.1-2.mxd
POWERTECH (USA) INC.


Legend
BLM Land
Black Hills National Forest
Ephemeral Streams
Perennial Streams
Existing BHEC Powerlines
Existing Golden West Telephone Lines
BNSF Railroad
County Roads
Existing Roads
Proposed Facilities
Permit Boundary
Overhead Electric Lines
Processing Plants
Potential Perimeter Fence
Existing Roads Used for Access
Access Roads
Deep Disposal Well
Madison Well
Potential Well Field Grid
This figure is provided to fulfill the requirements of ARSD 74:29:02:04(4) and SDCL 45-6B-7(10).
Feet
0 1,500 3,000 6,000
0 500 1,000 1,500
Meters
N
Weston County
Niobrara County
Custer County
Fall River County
South Dakota
Wyoming
T41N R60W
T40N R60W
T6S R1E
T7S R1E
T6S R2E
T7S R2E
S.DEWEY RD
N.FLAT.TOP.RD
S.FLAT.TOP.RD
ARGENTINE RD
BURDOCK LOOP
Pass Creek
Beaver Creek
Figure 5.3-2
Proposed Facilities and Potential Initial Well Field Areas, Deep Disposal Well Option
Dewey-Burdock Project
SIGNATURE OF PREPARER
PREPARER John Mays
DATE 24-Sep-2012
FILE FigFromExhibit3.1-3.mxd
POWERTECH (USA) INC.



Legend

- H — Fire Hydrant on Concrete Pad Surrounded by Pipe Bollards
- V — Video Surveillance Camera
- C — Call Box
- K — Key-card Reader
- Perimeter Fence
- Crushed Asphalt

N

Feet: 0 40 80 160

Meters: 0 10 20 40

Figure 5.3-3

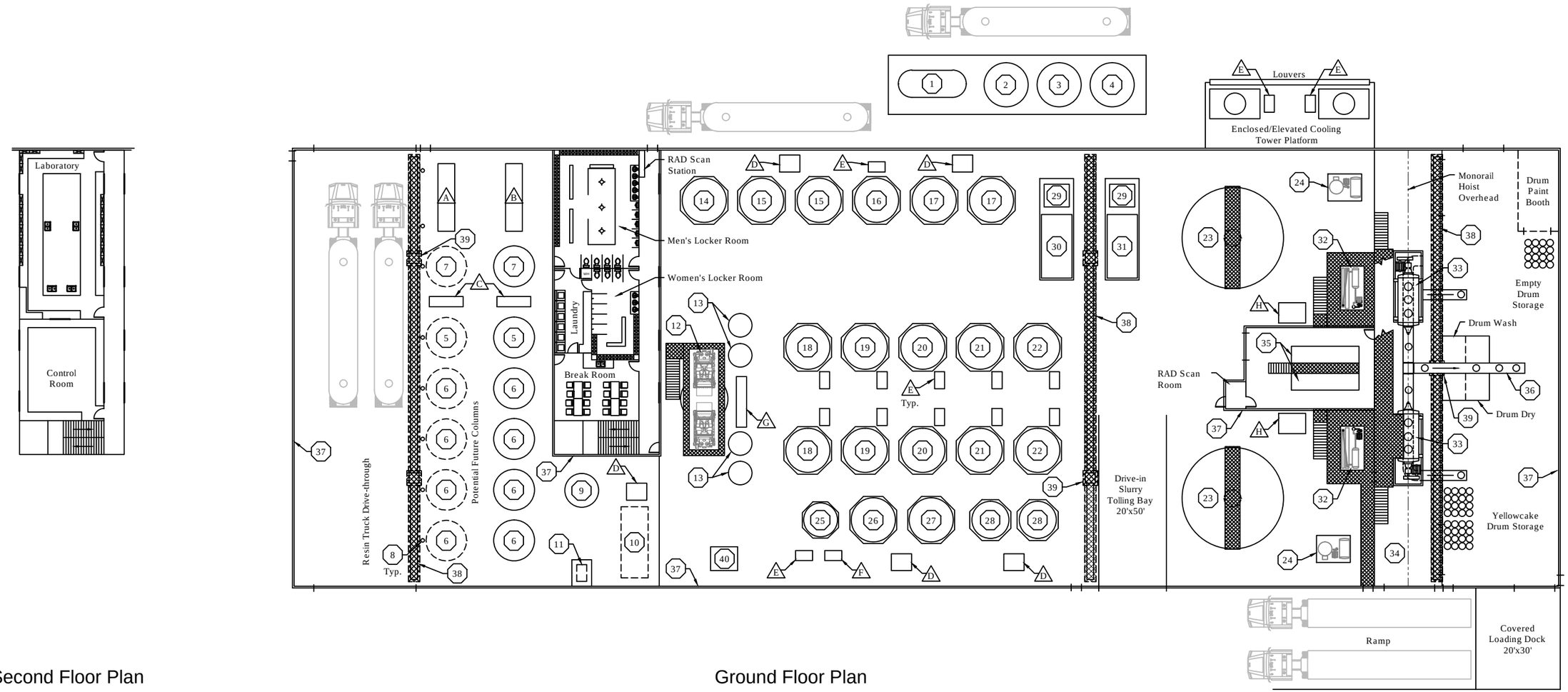
General Site Plan
Central Processing Plant

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	24-Sep-2012
FILE	CPP-SitePlan-New.dwg

POWERTECH (USA) INC.

This figure is provided to fulfill the requirements of ARSD 74:29:02:04 and SDCL 45-6B-6(8).



Second Floor Plan

Ground Floor Plan

Key Notes

1. CO_2
2. NaOH
3. H_2SO_4
4. H_2O_2
5. Reclamation IX Column 12'ø
6. Process IX Column 12'ø
7. Bleed IX Column 12'ø
8. Pipe Bollard Guard Post
9. Resin Transfer Water 10'ø
10. Resin Supersack Storage
11. Standby Generator in Sound Insulated Room
12. Shaker Screens with Shaker Overflow Collection Tank Below
13. Elution Column 7'ø
14. Reclamation Make-up Water 13'ø
15. NaCl 13'ø
16. Na_2CO_3 13'ø
17. Utility Water 13'ø
18. Fresh Eluant 13'ø
19. Lean Eluant 13'ø
20. Intermediate Eluant 13'ø
21. Rich Eluant 13'ø
22. Precipitation 13'ø
23. 30'ø Thickener, 5'ø Shear Tank Below
24. Hot Oil Boiler
25. Potable Water 10'ø
26. High TDS Wastewater Tank 13'ø
27. Low TDS Wastewater Tank 13'ø
28. Solids Removal Tank 11'ø
29. RO Pre-treatment
30. Recovery RO Unit
31. Restoration RO Unit
32. Elevated Condenser/Vacuum Pump Skid 7'x13'
33. Vacuum Dryer 8'x24'
34. Dryer Room 20'x130'
35. Filter Press and Transfer Pump 5'x20'
36. Drum Conveyor
37. 6" Curb Off All Walls, Typ.
38. 2'-0" Trench Drain, Typ.
39. 3'-0" Sump, Typ.
40. Barium Chloride Storage

Housekeeping Pads

- A. 5'x20' - PC Booster Pumps
- B. 5'x20' - IC Booster Pumps
- C. 3'x10' - Pump
- D. 6'x5' - Pump
- E. 3'x5' - Pump
- F. 3'x5' - Disinfectant
- G. 3'x15' - Pump
- H. 6'x8' - Pump

Feet: 0 15 30 60
Meters: 0 5 10 20

Figure 5.3-4

Central Processing Plant Detail

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	18-Sep-2012
FILE	CPP-Floorplan.dwg

POWERTECH (USA) INC.

This figure is provided to fulfill the requirements of ARSD 74:29:02:04 and SDCL 45-6B-6(8).

- Recovery – ion exchange (IX)
- Resin transfer
- Elution
- Precipitation
- Drying and packaging
- Restoration
- Chemical storage and feeding
- Utility water
- Wastewater
- Drum storage and decontamination area
- Byproduct storage

Based on preliminary design and site geotechnical evaluations, the project CPP will be located within Section 2, T7S, R1E. Chemical storage also will be located within this area. The plant location is shown on Figures 5.3-1 and 5.3-2.

The CPP will serve production from Dewey-Burdock ISR operations, and possibly resin from other potential Powertech (USA) satellite projects in the area. In addition, depending on market conditions and regional demand for yellowcake processing, the CPP may be used for tolling arrangements with other ISR operations licensed under a different operator.

The following subsections present a brief description of each recovery and processing system and the equipment components comprising each system. An overall process flow diagram is presented in Figure 5.3-5.

5.3.1.1.1 Recovery

Recovery of the uranium from the uranium bearing or pregnant lixiviant solution will be accomplished via an ion exchange process. The pregnant lixiviant from the well field will be pumped through IX vessels containing uranium-specific IX resin beads. As the lixiviant flows through the resin beds, the complexed uranium molecules attach themselves to the beads of resin, displacing chloride or bicarbonate ions as shown below:

$$2RCl + UO_2(CO_3)_2^{2-} \rightarrow R_2UO_2(CO_3)_2 + 2Cl^-$$

$$2RHCO_3 + UO_2(CO_3)_2^{2-} \rightarrow R_2UO_2(CO_3)_2 + 2HCO_3^-$$

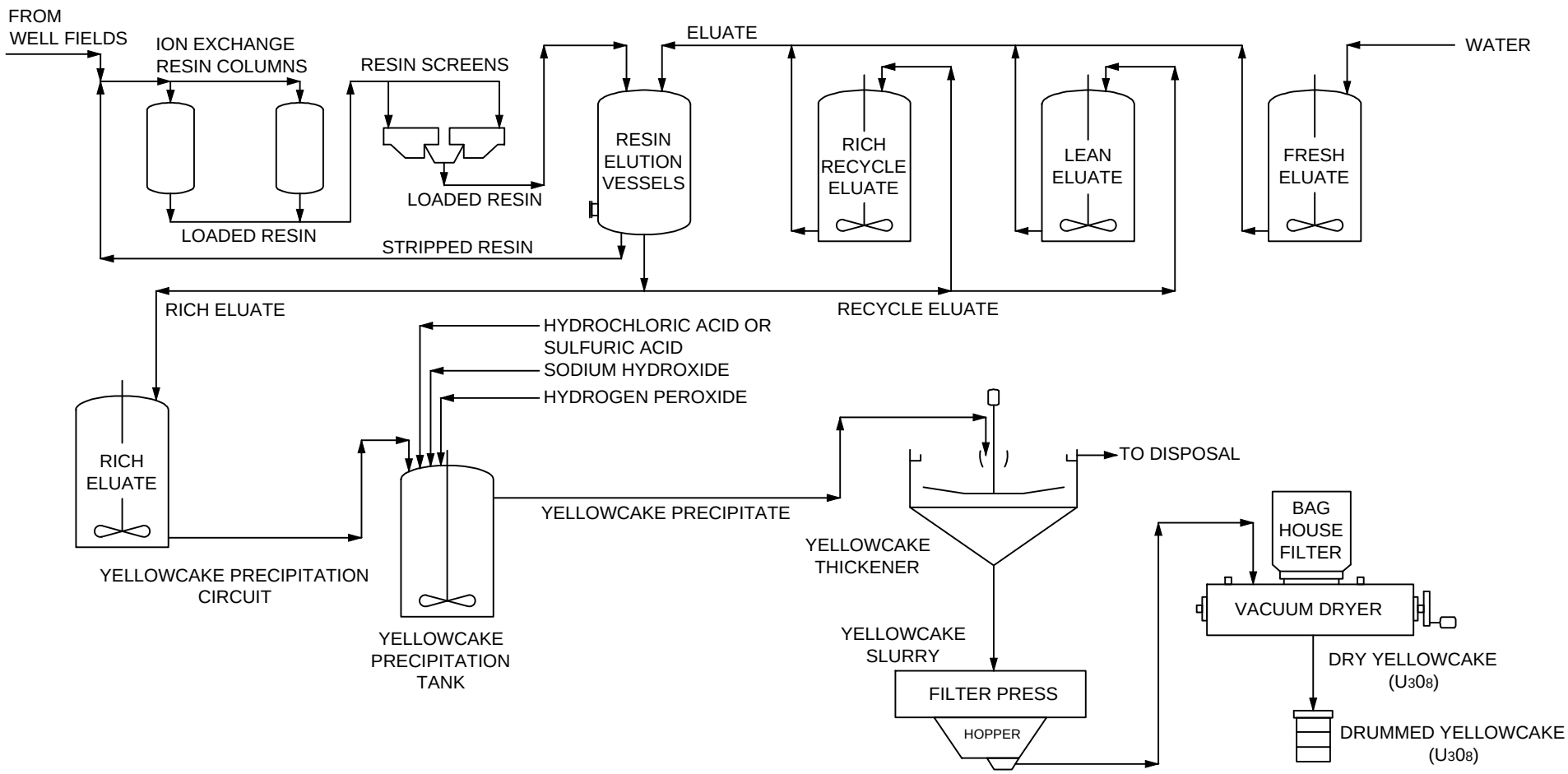


Figure 5.3-5

Process Flow Diagram

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	16-Sep-2012
FILE	PFD.dwg

POWERTECH (USA) INC.

This figure is provided to fulfill the requirements of ARSD 74:29:02:04 and SDCL 45-6B-6(8).

Each resin bead has a finite number of sites where the uranium complex can attach. When most of the available sites in the resin bed are occupied by uranyl dicarbonate (UDC) or uranyl tricarbonate (UTC) ions, the resin will be considered to be "loaded" and will be ready for processing.

The IX vessels will be designed to operate in downflow mode, which will help ensure that radon-222 captured in the well field stays in solution and is not released. Each IX vessel will contain approximately 500 ft^3 of resin. The IX vessels will be arranged in multiples of two vessels in series. The lixiviant will be passed through the primary or lead vessel, where most of the resin loading will occur. The lixiviant will then pass through the secondary or lag vessel where the solution will be "polished" by removing any remaining dissolved uranium. When the lead vessel becomes loaded, it will be taken off line and flow of lixiviant will be routed to the secondary vessel, which will become the lead vessel. The resin in the off-line vessel will be removed and regenerated resin will be returned to the vessel. The resin that was removed will be transferred to the elution and regeneration process in the CPP.

After passing through the IX vessels, the barren lixiviant will be returned to the well field where oxygen and carbon dioxide will be added prior to reinjection. A sidestream referred to as the production bleed will be removed from the barren lixiviant and routed to the wastewater disposal system or the production bleed reverse osmosis (RO) system (if deep disposal wells are used). Refer to Section 5.4.1.1 for a discussion of the two options for liquid waste disposal.

The recovery equipment includes the recovery IX vessels, the production bleed RO system (deep disposal well option only), and the recovery and injection composite booster pumps.

5.3.1.1.2 Resin Transfer

Resin will be transferred out of IX vessels at the CPP to the elution circuit, where it will be regenerated by contacting it with concentrated salt solutions. The concentrated salt solution will displace the UDC and UTC and replace them with chloride or bicarbonate ions. The regenerated resin will be then transferred back to IX vessels.

At the CPP, resin transfer will be accomplished by pumping water into the top of the IX vessel with the bottom discharge valve open. This will force the resin to flow out of the vessel into the transfer pipe. The resin and water will be pumped via the transfer piping to one of two elevated shaker screens. The shaker screens will be inclined, vibrating screens which will separate transfer water, loaded resin, and waste into separate streams. The transfer water will pass

through the screens and flow by gravity into a collection tank which feeds the resin transfer pumps. The loaded resin will drop into one of four elution columns to be regenerated. The oversized or undersized solid waste from the shaker screens will consist of broken resin beads, silt and sand from the wells, and scale removed from the resin, and will collect in a hopper to be periodically removed and drummed for disposal as 11e.(2) byproduct material.

Following elution of the resin, the transfer process will be reversed. Water will be pumped into the top of the elution column with the bottom discharge valve open. This will force the resin out of the column and into the resin transfer piping. The resin and water will be pumped back to the IX vessel.

Equipment associated with the resin transfer system includes two shaker screens, a shaker screen water tank, a resin transfer water tank, and a resin transfer pump.

5.3.1.1.3 Elution

The elution process will remove the UDC and UTC from the resin and restore the resin to its chloride form to allow it to be put back into service to remove uranium from pregnant lixiviant. This process is represented by the following equations (similar reactions for bicarbonate loading also will occur but are not shown):

$$R_2UO_2(CO_3)_2 + 2C1^- \rightarrow 2RCl + UO_2(CO_3)_2^{2-}$$

$$R_4UO_2(CO_3)_3 + 4Cl^- \rightarrow 4RCl + UO_2(CO_3)_3^{4-}$$

Elution will be a four-stage process that will take place in an elution column and involve contacting the loaded resin with batches of eluant solution containing approximately 10 percent by weight sodium chloride and 2 percent by weight sodium carbonate. Each elution stage will strip the resin of additional uranium complex and further restore the exchange capacity of the resin. Following the final elution stage, more than 95 percent of the uranyl carbonate complexes will have been removed from the resin.

Elution system equipment will include four elution columns, eight elution tanks, and elution pumps.

5.3.1.1.4 Precipitation

The precipitation process will break the uranyl carbonate complexes, precipitate the uranium as uranium peroxide, and settle the precipitated solids from the eluant solution. The precipitation

process will include a series of chemical addition steps, each causing a specific change in the rich eluate solution.

Prior to beginning the precipitation process, a pump will transfer the rich eluate from the rich eluate tank to the precipitation tank. The precipitation tank contents will be mixed via an agitator. The first stage of chemical addition will be to add sulfuric or hydrochloric acid to bring the pH down to a range of approximately 2-3 pH units. This change in pH will cause the uranyl carbonate complexes to break, liberating carbon dioxide, which will be vented from the tank, as illustrated in the following chemical reaction.

$$UO_2(CO_3)_3^{4-} + 6H^+ \rightarrow UO_2^{2+} + 3CO_2\uparrow + 3H_2O$$

Following completion of CO_2 evolution, sodium hydroxide will be added to raise the pH of the solution to between 4 and 5 pH units. When the pH has stabilized, hydrogen peroxide (H_2O_2) will be added to the solution to form insoluble uranium peroxide (UO_4) as shown below. Following addition of H_2O_2, the agitator speed will be slowed down to promote crystal growth.

$$UO_2^{2+} + H_2O_2 + 2H_2O \rightarrow UO_4 \bullet 2H_2O + 2H^+$$

After a precipitation period of up to 8 hours, sodium hydroxide will be added to raise the pH to approximately 7, and the contents of the precipitation tank will be pumped into the thickener.

Precipitation system equipment will include precipitation tanks, transfer pumps, a pressure filtration system (filter press), and thickeners.

5.3.1.1.5 Drying and Packaging

The uranium peroxide filter cake will be dried in a rotary vacuum dryer under low temperature (approximately 250°F). Angled paddles attached to a central shaft in the dryer will agitate the filter cake to promote even drying. The dryers will be heated with a thermal fluid that will be circulated through the dryer shell and the rotating central shaft. The thermal fluid will be heated by an electric heater with a pump for circulating the thermal fluid through the shell and central shaft of the dryer.

The vapor pulled from the dryer by the vacuum pump will be filtered through a baghouse filter located on the top of the dryer to remove particles down to approximately 1 micron in size. The vapor exiting the baghouse will be cooled using a condenser to remove water vapor and remaining small particles. Liquid ring vacuum pumps will provide the vacuum source. The

water collected from the condenser will be pumped to the solids removal tank in the wastewater system.

Two rotary vacuum dryers, baghouses, and packaging equipment will be housed in a separate room in the CPP. The vacuum pump and condenser system for each dryer, and the thermal fluid heaters and pumps will be located in the main CPP area to provide access for operation and maintenance. The vacuum pumps will discharge to the dryer room. Air in the dryer and packaging room will be monitored routinely for airborne dust. A dedicated air handler equipped with HEPA filters will ventilate the dryer and packaging room and will provide an additional level of control for particulate emissions. NRC guidance in NUREG-1910 (NRC, 2009) describes how the system of treating gases emanating from the dryer chamber with bag house filters and water condenser is designed to capture virtually all particles from the vapor stream leaving the dryer. Furthermore, NUREG-1569 (NRC, 2003) states, "When a vacuum dryer is used for yellowcake, then dust emissions from drying may also be assumed to be negligible."

The major components of the system include the vacuum dryers, baghouses, vacuum pump and condenser systems, thermal fluid heaters, and the packaging system.

5.3.1.1.6 Restoration

The restoration system is designed to extract, store, and distribute makeup water for aquifer restoration of well fields. The restoration system may also incorporate an RO system to remove TDS from extracted water and return low TDS permeate to the restoration system. Reject from the RO system, if utilized, will be routed to a high TDS wastewater system.

Restoration system equipment will include a restoration water tank, a restoration makeup water pump, and a restoration RO system, if used.

5.3.1.2 Chemical Storage and Feeding Systems

The ISR process requires chemical storage and feeding systems to store and dose chemicals at various stages in the extraction, processing, and waste treatment processes. The chemicals to be utilized in uranium processing at the project are listed in Table 5.3-1. The potential for any of these chemicals to impact radiological safety is variable in likelihood and consequence. Chemicals that have the potential to impact radiological safety include hydrochloric acid, sulfuric acid, hydrogen peroxide, and sodium hydroxide. Oxygen, because of its ability to support combustion, also requires special handling. In all instances, process controls and preventative safety measures minimize the risk of increased radiological exposure or release.

Table 5.3-1: Process-related Chemicals and Quantities Stored On-site

Burdock CPP and Well Fields					
Chemical Name	**No. Tanks**	**Unit Storage Capacity**	**Units**	**Usage Rate ton/yr**	**Hazard Classification**
Sodium chloride (NaCl)	2	20,000	gal	2,250	Non-flammable
Sodium carbonate (Na_2CO_3) i.e., soda ash	1	20,000	gal	450	Non-flammable
Hydrochloric acid (HCl 32%) or sulfuric acid (H_2SO_4 93%)	1	7,000	gal	487	Toxic, reactive, corrosive
Sodium hydroxide (NaOH 50%)	1	7,000	gal	446	Toxic, reactive, corrosive
Hydrogen peroxide (H_2O_2 50%)	1	7,000	gal	177	Oxidizer, irritant, corrosive
Oxygen (O_2, liquid)	1	11,000	gal	979	Cryogenic, oxidizer
Carbon dioxide (CO_2)	1	6,000	gal	245	Asphyxiant, freezing hazard
Barium chloride ($BaCl_2$)	1	275	50-kg sacks	7	Toxic, non-flammable
Dewey Satellite Facility and Well Fields					
Oxygen (O_2, liquid)	1	11,000	gal	653	Cryogenic, oxidizer
Carbon dioxide	1	6,000	gal	163	Asphyxiant, freezing hazard
Barium chloride	1	138	50-kg sacks	7	Toxic, non-flammable

Each chemical storage and feeding system will be designed to safely store and accurately deliver process chemicals to the process delivery points. All chemical storage tanks will be clearly labeled to identify contents. Design criteria for chemical storage and feeding systems include applicable regulations of the International Building Code (IBC), National Fire Protection Association (NFPA), Compressed Gas Association (CGA), Occupational Safety and Health Administration (OSHA), Resource Conservation and Recovery Act (RCRA), and the Department of Homeland Security (DHS). Designing, constructing, and maintaining chemical storage facilities in accordance with applicable regulations will help ensure the safety of Powertech (USA) employees and members of the public, both with regard to the specific chemicals and with regard to the potential release of radioactive materials in the event of an accident.

Any negative impact to radiological safety from use of these chemicals would be due to accidents, improper use, or human error. Nevertheless, these chemicals would only indirectly cause a radiological hazard as they do not contain radiological materials themselves.

Figure 5.3-4 shows the storage locations of all chemicals used in the CPP. Oxygen will be stored as cryogenic liquid in tanks located in the well field areas. Oxygen storage tanks will be located near but at a safe distance from header houses as required by NFPA and OSHA standards.

At the CPP, the chemicals include sulfuric and/or hydrochloric acid, hydrogen peroxide, sodium hydroxide, sodium carbonate, and sodium chloride. Of these, only hydrogen peroxide presents a fire hazard if it comes in contact with combustible materials. Most of these chemicals are corrosive and reactive. Areas within the CPP and chemical storage areas will be provided with secondary containment consisting of concrete curbs around the floor perimeters. Curbs also will divide areas to prevent mixing of incompatible fluids in the event of a leak or spill. Concrete floors, secondary containment, and sumps in areas where corrosive fluids could be spilled will be coated with corrosion-resistant materials as recommended by the manufacturer. All slurry piping will use materials that are abrasion and corrosion resistant and solution piping will be appropriately corrosion resistant. Tanks holding process solutions will be constructed appropriate to the conditions as recommended by the manufacturers.

5.3.1.2.1 Sodium Chloride Storage

Sodium chloride will be used to make up fresh eluant and will be stored in tanks as a saturated solution (approximately 26 percent by weight) in equilibrium with a bed of crystals in each storage tank. Dry sodium chloride will be delivered by truck and will be blown into the storage tanks using air pressure.

5.3.1.2.2 Sodium Carbonate Storage

Sodium carbonate will be used to make up fresh eluant and will be stored in tanks as a saturated solution in equilibrium with a bed of crystals in the storage tank. Sodium carbonate solution must be kept above 140°F to prevent precipitation in the tank and piping. This will be accomplished by heating the water added to the tank, and continuously circulating liquid from the tank through a heat exchanger. An electric heater will be used to heat a thermal fluid to heat the exchanger. Dry sodium carbonate will be delivered by truck and will be blown into the storage tanks using air pressure.

5.3.1.2.3 Acid Storage and Feeding System

Sulfuric acid and/or hydrochloric acid will be used in the precipitation circuit of the CPP to break down the uranium carbonate complexes. The hazards associated with use and storage of acid include corrosiveness, toxicity to tissue, and reactivity with other chemicals at the project such as sodium carbonate and water. Acid storage tanks will be isolated from the above listed chemicals to reduce the risk of reactions. The acid storage and feeding system will include a storage tank and delivery pump. The storage tank will be located outside of the CPP building in a lined concrete secondary containment basin designed to contain 110 percent of tank volume plus a 25-year, 24-hour storm event. This secondary containment basin will be separate from the containment basins for other chemical systems.

5.3.1.2.4 Sodium Hydroxide Storage and Feeding System

The sodium hydroxide system will include a storage tank and delivery pump. The storage tank will be located outside of the CPP building in a concrete secondary containment basin designed to contain 110 percent of tank volume plus a 25-year, 24-hour storm event. This secondary containment basin will be separate from the containment basins for other chemical systems. The sodium hydroxide feed pump will be located inside the building, directly adjacent to the storage tank. Sodium hydroxide will be purchased as aqueous caustic soda, and will be pumped directly into the storage tank from the supplier's tanker trucks.

5.3.1.2.5 Hydrogen Peroxide Storage and Feeding System

The hydrogen peroxide system will include a storage tank and delivery pump. The storage tank will be located outside of the CPP building in a concrete secondary containment basin designed to contain 110 percent of tank volume plus a 25-year, 24-hour storm event. This secondary containment basin will be separate from the containment basins for other chemical systems. Hydrogen peroxide is a strong oxidizer, can be very reactive and is easily decomposable. Its hazardous decomposition products include oxygen, heat, and steam.

The hydrogen peroxide feed pump will be located inside the building, directly adjacent to the storage tank.

5.3.1.2.6 Oxygen Storage and Feeding System

Liquid oxygen will be present within the well fields. The primary hazard associated with oxygen is fire since it is a strong oxidizer in the presence of combustible materials. To reduce the risk of an accident that could potentially affect other processes or storage facilities and radiological safety, oxygen will be stored near the well fields, so that in the event of an accidental release the gas would disperse and not cause a fire hazard to project equipment or infrastructure. Where above-ground oxygen storage or conveyance facilities exist, barriers will be used to prevent impacts from mobile equipment. Oxygen conveyance pipelines will be surveyed and marked with tracer wire to make them locatable by field personnel during excavation activities. A fire within a header house, where the oxygen is metered into separate injection lines, could damage equipment and instrumentation within the header house but would be unlikely to result in a spill of injection or recovery fluids. If a spill of lixiviant were to occur, well field personnel will have been trained in emergency procedures for responding to well field spills containing radiological materials. Oxygen will be stored in storage vessels designed, fabricated, tested, and inspected in accordance with the ASME Boiler and Pressure Vessel Code. Oxygen storage vessels will be equipped with safety relief devices and will be located at least 25 feet from buildings or as required by applicable NFPA and OSHA standards. Oxygen will be delivered and stored as a cryogenic liquid and then conveyed to the injection point (either upstream of the injection manifold within the header house or at each well head) as a gas through piping made from appropriate materials. Oxygen storage and delivery systems will be designed and fabricated in accordance with NFPA 55 and OSHA standards for the installation of bulk oxygen systems on industrial premises (29 CFR § 1910.104). To reduce the risk of an accident which could potentially affect other processes or storage facilities and radiological safety, oxygen will be stored a sufficient distance from other infrastructure and storage areas. Facilities used to store oxygen will conform to standards detailed in NFPA 55. Typically, oxygen storage and dispensing systems will be leased from the bulk oxygen vendor. Conveyance systems for oxygen will be clean of oil and grease because these substances will burn violently if ignited in the presence of oxygen. The proper pressure relief devices, component isolation and barriers also will be employed. Cleaning of equipment used for delivering and storing oxygen will be done in accordance with CGA G4.1. The design and installation of the oxygen piping system will be done according to the requirements of CGA G4.4. Powertech (USA) will develop procedures that implement emergency response instructions for a spill or fire involving oxygen systems.

5.3.1.2.7 Carbon Dioxide Storage and Feeding System

The carbon dioxide storage and feeding system will be used to dissolve carbon dioxide into the pregnant lixiviant to improve recovery of uranium in the IX vessel. This system will be a vendor supplied packaged system including cryogenic tank, vaporizer, pressure gauges, and pressure relief devices.

5.3.1.2.8 Barium Chloride Storage and Feeding System

The barium chloride storage and feeding system includes a storage tank, agitator, and chemical metering pump. This system will be designed to dissolve solid barium chloride in water to make up the solution for feeding into the low TDS wastewater for radium precipitation. Barium chloride will be stored as palletized sacks.

5.3.1.2.9 Byproduct Storage

Prior to transportation to a licensed disposal facility, 11e.(2) byproduct material will be stored in designated storage buildings (also referred to as "byproduct storage buildings"), one located at the CPP site and one located at the Satellite Facility site. These buildings will consist of a concrete slab with a containment curb surrounding the perimeter. Storage of byproduct material will be within "roll-off" containers (bins) which are both liquid tight and fully enclosed. As each storage building will accommodate two 20 cubic yard bins, the volume of byproduct material could accumulate to 30 to 40 cubic yards at each of the two storage locations prior to transport. There will be two bays in each storage building, each accessed by an overhead roll-up door and allowing exchange of containers necessary for transport to a licensed 11e.(2) disposal site. The concrete slabs will be designed to allow external decontamination of the roll-off bins prior to transport.

The byproduct storage buildings will allow for control of byproduct materials and specific segregation of these wastes from other non-11e.(2) wastes. Typically these wastes are expected to consist of contaminated used equipment parts, personal protective equipment, and wastes from cleanup of spills or other housekeeping activities. Other waste not in contact with the uranium production process will be disposed of in regular dumpsters situated at a separate location.

Containment of these byproduct wastes within a designated, fully enclosed building will allow for proper control of the materials, monitoring, and necessary restricted access. These measures will ensure best possible control of 11e.(2) solid and liquid wastes to minimize any potential exposures or contamination.

5.3.1.3 Utility Water

The utility water system will be used to extract, store, and distribute water for consumptive process uses. Water will be extracted from wells drilled in a suitable formation in the vicinity of the CPP.

The utility water system equipment will include the utility water tank and utility water pumps.

5.3.1.4 Potable Water

Powertech (USA) will permit a public water supply system for the Dewey-Burdock Project that is anticipated to include a public water supply well, a disinfection system, a treated water storage tank, and a pressure distribution system. The public water supply system will be permitted through the DENR Drinking Water Program.

5.3.1.5 Process Wastewater

The process wastewater system will be designed to receive, treat, and discharge wastewater generated at various stages of the process. The wastewater system will be divided into two main categories of wastewater: high TDS wastewater and low TDS wastewater. High TDS wastewater consists of waste eluant brine from the CPP and the reject streams from process bleed or restoration RO systems if these systems are in use. Low TDS water sources include process bleed and extracted restoration water that have not been concentrated by RO.

High TDS wastewater will flow by gravity from the solids removal tank to the high TDS wastewater tank. This wastewater then will be pumped to the liquid waste disposal system.

Low TDS wastewater will be collected in the low TDS wastewater tank and then pumped to a radium precipitation tank where barium chloride will be added to co-precipitate barium and radium sulfates. Treated wastewater will flow from the radium precipitation tank to the radium settling ponds for removal of the precipitate by settling.

Wastewater system equipment inside the CPP will include the solids removal tank, the high TDS wastewater tank, the low TDS wastewater tank, the wastewater pumps, the radium precipitation tank and agitator. Refer to Section 5.4.1.1 for a discussion of liquid waste disposal system equipment.

5.3.1.6 Domestic Wastewater

Domestic waste (septic waste) will be disposed in on-site wastewater disposal systems constructed at the CPP and Satellite Facility. Domestic wastewater disposal systems will be designed to meet applicable DENR and Fall River County or Custer County regulations and will

be permitted through DENR and/or Fall River or Custer County. Domestic wastewater systems are anticipated to include septic tanks and drainfields and may include dosing tanks and pressure dosing systems for liquid effluent.

5.3.1.7 HVAC System

The heating, ventilating and air conditioning (HVAC) system in the CPP will be designed to provide routine heating, cooling and required air changes in occupied areas, as well as mitigate the potential for human exposure to radionuclides. The primary exposure concerns will be radon gas and uranium oxide dust or particulates.

The general HVAC system for the CPP will be designed both for controlling the temperature in the CPP and for preventing the buildup of fugitive radon emissions by ensuring a minimum number of air changes.

Radon gas is a decay product of uranium and will be mobilized and dissolved into the pregnant lixiviant during ISR uranium extraction. The potential for radon emissions from the process arises when the pressurized flow from the production wells and booster pumps is exposed to atmospheric pressure. The two process systems with the potential for radon emissions are the IX vessels via the air/vacuum relief valves and the shaker screens where the loaded resin and resin transfer water will be pumped onto an open screen at atmospheric pressure.

The shaker screens each will have a dedicated vent hood directly overhead. The vent hoods will be connected to an exhaust fan designed to create sufficient air flow and velocity to minimize the concentration of radon in the vicinity of the shaker screens. The exhaust fans will discharge the air through a vent in the roof of the building. The vent will be located away from air intakes for the building.

Systems that have the potential to emit dust particles containing uranium include the filter presses, the dryers, and the drum filling stations.

The filter presses will be installed in a dedicated filtration room, and the vacuum dryers will be installed in a dedicated dryer room. These two rooms will be serviced with dedicated HVAC equipment that includes particulate filtration to minimize the potential for personnel exposure within the rooms and to prevent the emission of particles.

5.3.2 Satellite Facility

A Satellite Facility will be located in the Dewey portion of the permit area as shown on Figures 5.3-1 and 5.3-2. The Satellite Facility will be located in Section 29, T6S, R1E. It will include IX

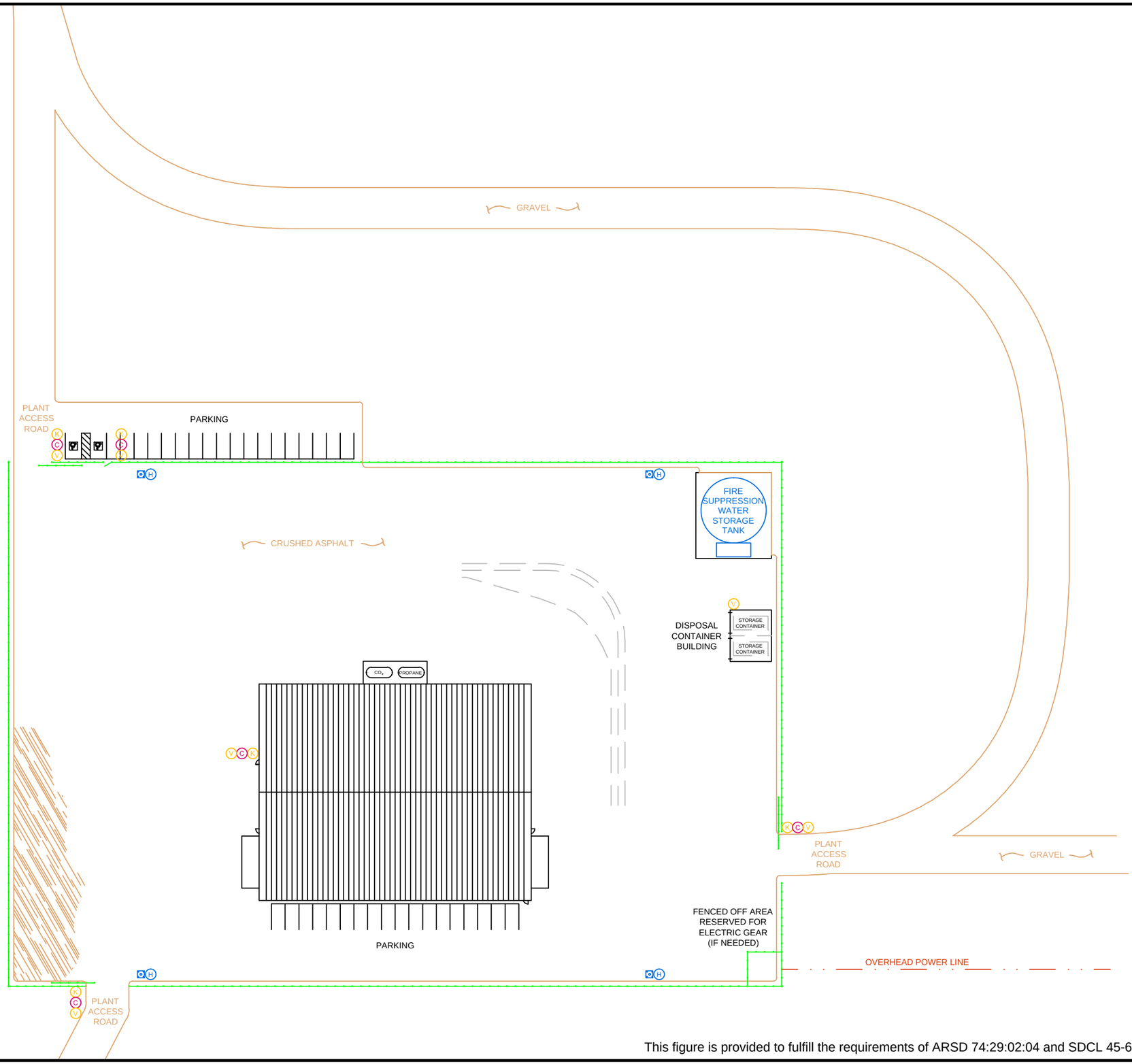
equipment to recover uranium and aquifer restoration equipment for well fields in the Dewey portion of the permit area. Uranium-loaded IX resin will be trucked from the Satellite Facility to the CPP for elution, precipitation, drying and packaging. As with the CPP site, the site for the Satellite Facility has been designed to provide security and ease of access for operating purposes. The site is designed with ample areas for access by resin transfer trucks as well as truck transports for chemical delivery. Figure 5.3-6 shows the site layout of the Satellite Facility.

Powertech (USA) proposes to install up to eight underground pipelines between the CPP and the Satellite Facility to transport the various fluids present during ISR operations. Conduits for electronic communication and control purposes also may be installed between the CPP and the Satellite Facility. The fluids that may be transported include, but are not limited to: barren and pregnant lixiviant, restoration water, RO reject brines, wastewater resulting from well drilling and maintenance operations, and supply water from the Madison Limestone or other aquifers. All infrastructure associated with ISR activities will be located within the permit boundary.

5.3.2.1 Satellite Facility Equipment

Figure 5.3-7 presents the detailed layout of the Satellite Facility. The Satellite Facility will house uranium recovery equipment (IX vessels) and aquifer restoration equipment. Uranium will be recovered using pressurized, downflow IX vessels as described for the CPP in Section 5.3.1.1.1. Loaded resin will be transferred from the IX vessels to a tanker truck that enters the building. Each tanker truck will have one or more compartments with sloped bottoms and screened bottom outlet nozzles. Resin transfer will be accomplished through resin transfer piping and hoses that connect the IX vessels to the tanker truck. With the connections made and transfer valves opened, resin transfer water will be pumped into the top of the IX vessel with the bottom discharge valve of the vessel open. This will force the resin to flow out of the vessel and into the tanker truck. Water and resin will enter the tanker, and water will exit the tanker through a screened outlet port and be returned to the resin transfer water tank. The resin, which cannot pass the screen, will remain in the tanker truck. When the resin has been flushed from the vessel and piping, the excess transfer water will be drained from the truck, the valves controlling the transfer will be closed and the hoses disconnected from the truck.

The truck then will transport the resin to the CPP where the truck will be connected via hoses to the resin transfer water headers. To transfer resin out of the tanker truck, water will be introduced to the tanker truck from the resin transfer water tank, and water and resin will flow out of the tanker truck to the elevated shaker screens described in Section 5.3.1.1.2. Following elution of the resin, the transfer process will be reversed. When the tanker truck returns to the



Legend

- H — Fire Hydrant on Concrete Pad Surrounded by Pipe Bollards
- V — Video Surveillance Camera
- C — Call Box
- K — Key-card Reader
- Perimeter Fence
- Crushed Asphalt

N

Feet: 0, 30, 60, 120
Meters: 0, 10, 20, 40

Figure 5.3-6

General Site Plan
Satellite Facility

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	24-Sep-2012
FILE	SPP-SitePlan-New.dwg

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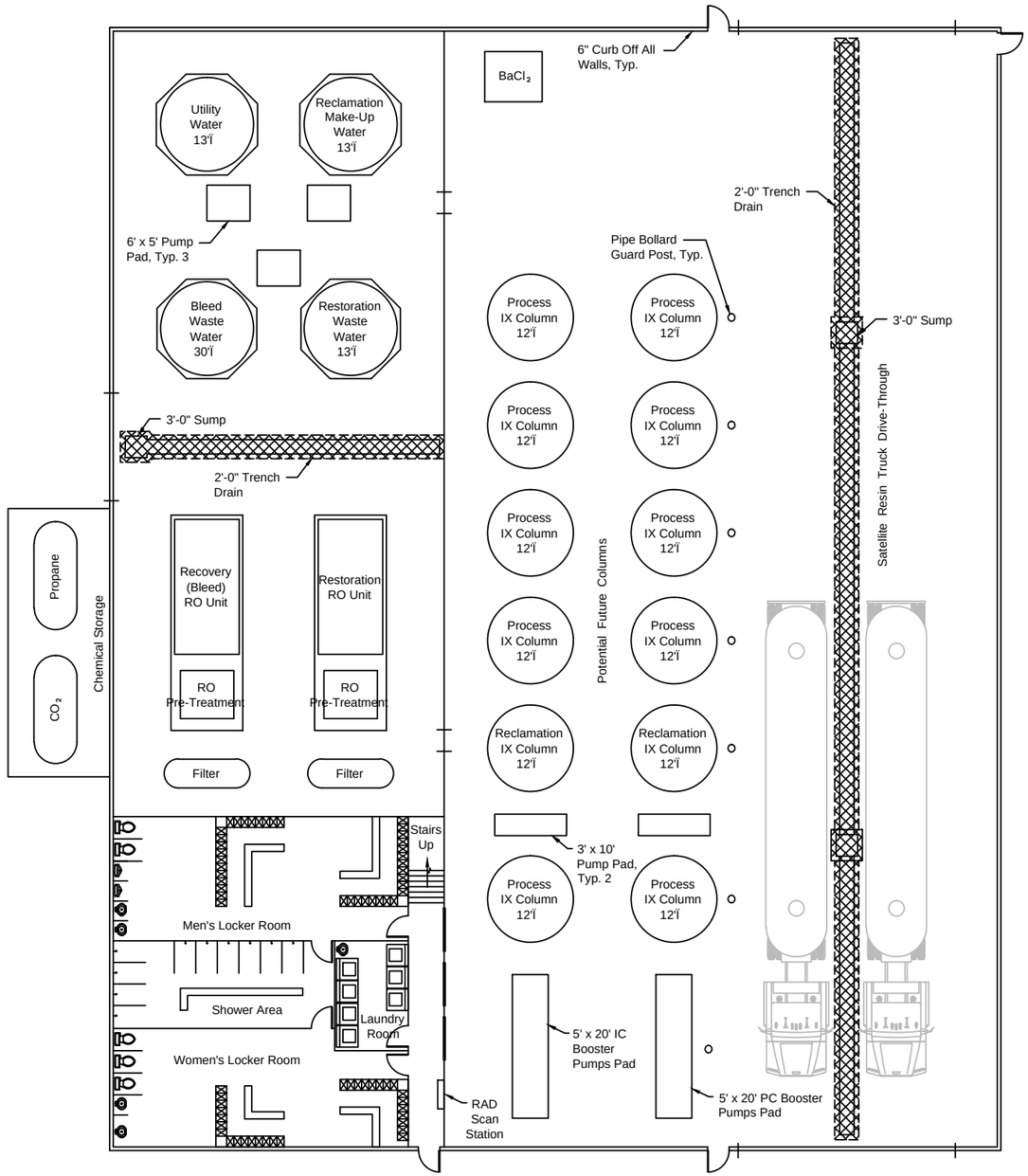
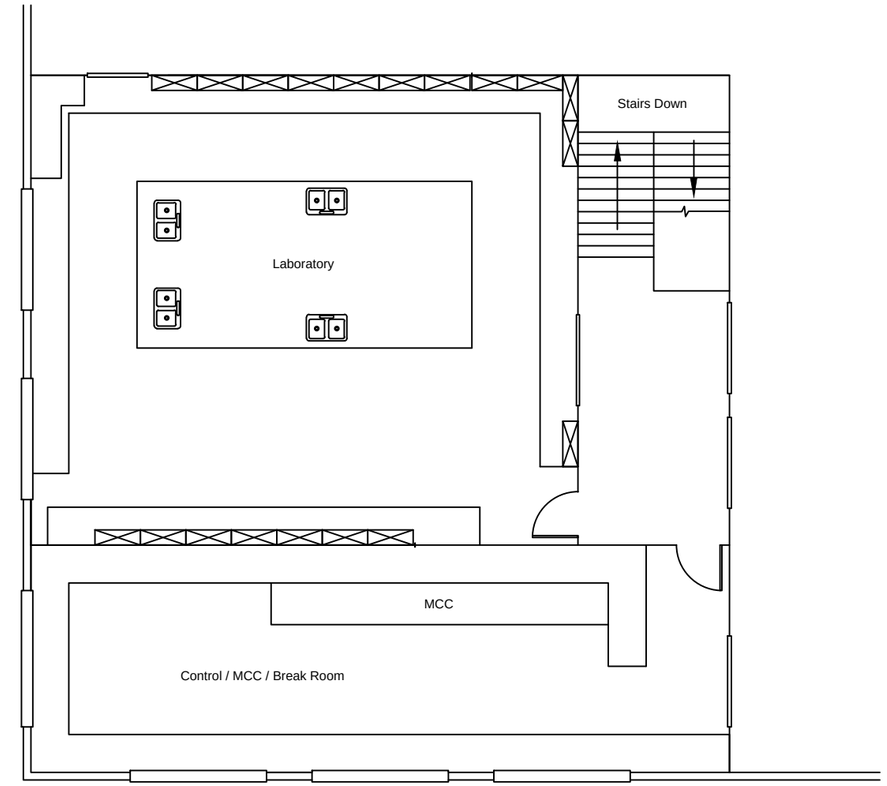
This figure is provided to fulfill the requirements of ARSD 74:29:02:04 and SDCL 45-6B-6(8).



Ground Floor Plan

Feet 0 10 20 40

0 5 10 Meters



Second Floor Plan

Feet 0 5 10 20

0 2 4 6 Meters

N

This figure is provided to fulfill the requirements of ARSD 74:29:02:04 and SDCL 45-6B-6(8).

Figure 5.3-7

Satellite Facility Plant Detail

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	24-Sep-2012
FILE	SPP-Floorplan.dwg

POWERTECH (USA) INC.

Satellite Facility, the regenerated resin will be transferred back into the IX vessel using the same methods.

Restoration system equipment will include a restoration water tank, a restoration makeup water pump, and a restoration RO system, if used.

The Satellite Facility HVAC system will be designed to provide routine heating, cooling and required air changes in occupied areas, as well as mitigate the potential for human exposure to radionuclides.

Chemical storage at the Satellite Facility will be limited to carbon dioxide used to enhance uranium recovery in IX vessels and to fortify barren lixiviant, barium chloride used for radium precipitation, and small quantities of laboratory reagents. Laboratory waste will be disposed with the liquid process waste and not in the domestic wastewater system. A byproduct storage building will be located in a separate building as described in Section 5.3.1.2.9. The Satellite Facility also will include a utility water system, potable water system, domestic wastewater disposal system, and process wastewater system, including ponds and either a deep disposal well system or land application system (refer to Section 5.4.1.1).

5.3.3 Well Fields

This section describes the well field design, construction, and methods of operation. Well fields will be developed using a phased approach, in which each well field will be delineated, designed, constructed, operated, restored, and decommissioned.

5.3.3.1 Well Field Design

Each ISR well field will consist of a series of injection and production wells completed within the target mineralization zone. Prior to design and layout of the wells, the ore bodies will be delineated with exploration holes. These holes will be geologically and geophysically logged. Before drilling, each injection and production well will be assigned lateral coordinates, a ground surface elevation, depth to top of screened interval, and length of screened interval.

5.3.3.1.1 Injection and Production Wells

For all injection and production wells, the top of the screened interval will be at or below the base of the confining unit overlying the mineralized zone. The screened interval will be completed only across the targeted ore zone.

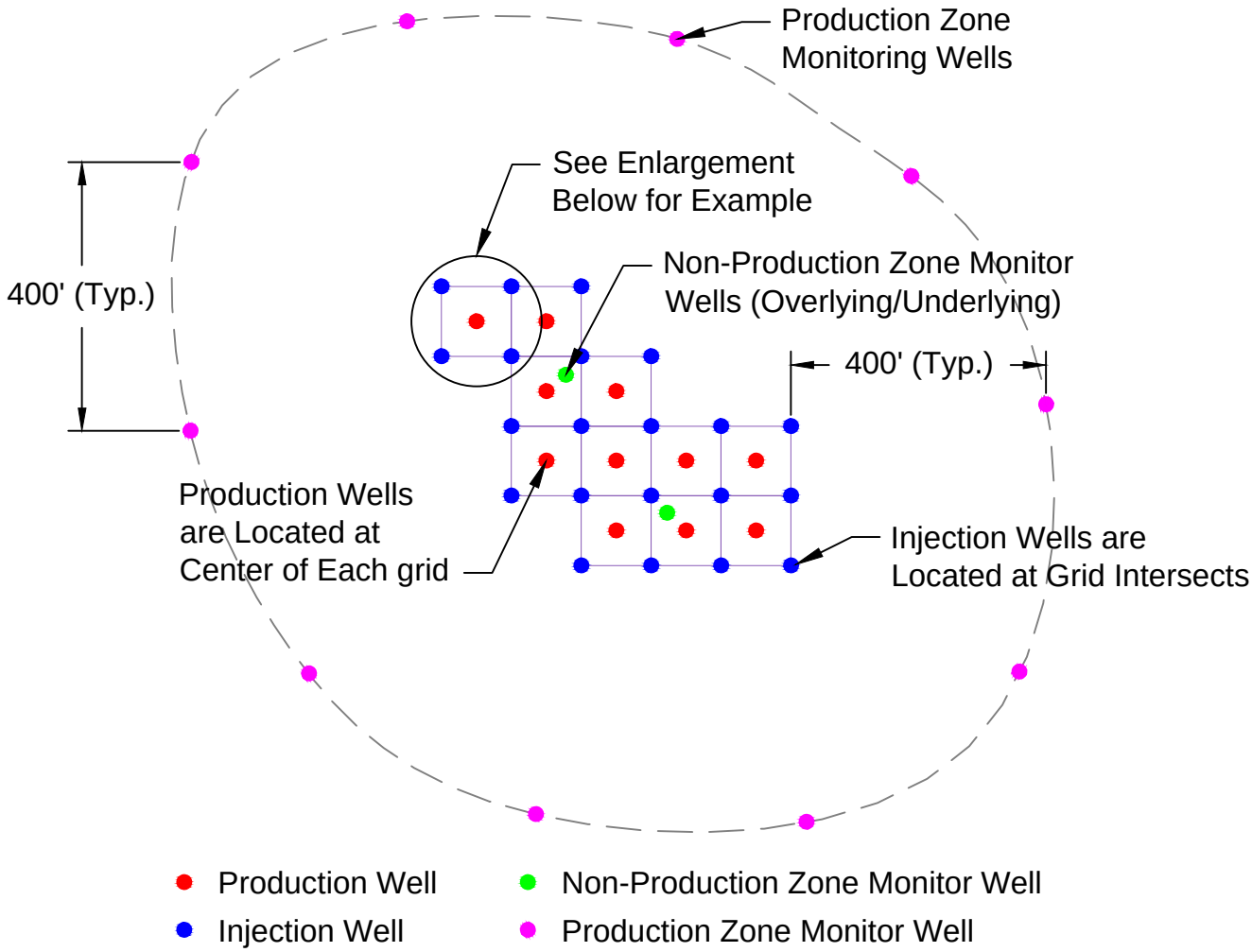
A typical (100 x 100 ft grid) well field layout is illustrated on Plate 5.3-3. This typical layout is based on the lateral distribution and grade of one of the uranium deposits within the permit area.

The well patterns may differ from well field to well field, but a typical pattern will consist of five wells, with one well in the center and four wells surrounding it oriented in four corners of a square measuring between 50 and 150 feet on a side. Typically, a production well will be located in the center of the pattern, and the four corner wells will be injection wells. Figure 5.3-8 depicts a typical 5-spot well field pattern. The pattern dimensions will be modified as needed to fit the characteristics of each ore body. Other well field designs may be considered and evaluated in the well field hydrogeologic data packages (refer to Section 5.3.3.4).

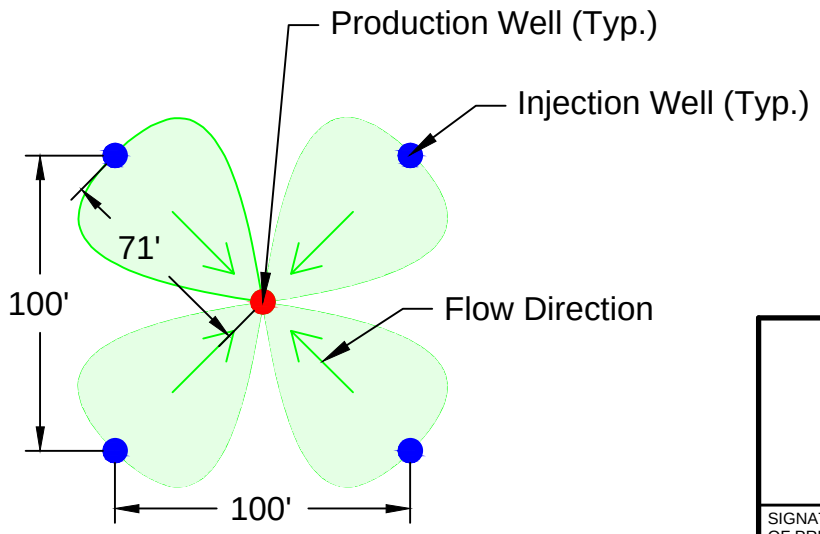
All injection and production wells will be completed for use as either injection or production wells, so that flow patterns can be changed as needed to recover uranium and restore groundwater quality in the most efficient manner.

Figure 5.3-9 depicts the project ore bodies proposed for uranium recovery and shows all lower Fall River ore bodies in blue (Fall River ore depth ranges from approximately 200 to 600 feet), all ore bodies within the upper Chilson Member of the Lakota Formation in green and middle/lower Chilson ore bodies in red (Chilson ore depth ranges from approximately 200 to 800 feet). No well fields will be located within 1,600 feet of the permit boundary in order to establish an operational buffer between the well fields and the permit boundary. In addition, no well fields are proposed for partially saturated or unsaturated Fall River ore bodies in the eastern portion of the permit area. All well fields and perimeter monitor wells will be located within the permit boundary.

Production and injection wells will be connected to a header house, as shown on Plate 5.3-4. Well head connection details for injection and production wells are illustrated on Figures 5.3-10 and 5.3-11, respectively. Typically, one header house will service up to 20 production wells and 80 injection wells. Piping between the wells and header house will consist of high density polyethylene (HDPE) pipe with heat-welded joints, buried at least 5 feet below grade. The piping will be designed to withstand an operating pressures of 150 psig. The piping will terminate at the header house where it will be connected to manifolds equipped with control valves, flow meters, check valves, pressure sensors, oxygen and carbon dioxide feed systems (injection only), and programmable logic controllers. Electrical power to the header houses will be delivered via overhead power lines and via buried cable. Electrical power to individual wells will be delivered via buried cable from the header house.



TYPICAL FIVE SPOT GRID PATTERN



Modified from Power Resources

This figure is provided to fulfill the requirements of ARSD 74:29:02:04 and SDCL 45-6B-6(8).

Figure 5.3-8

Typical 5-Spot
Well Field Pattern

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	16-Sep-2012
FILE	FiveSpotPattern.dwg

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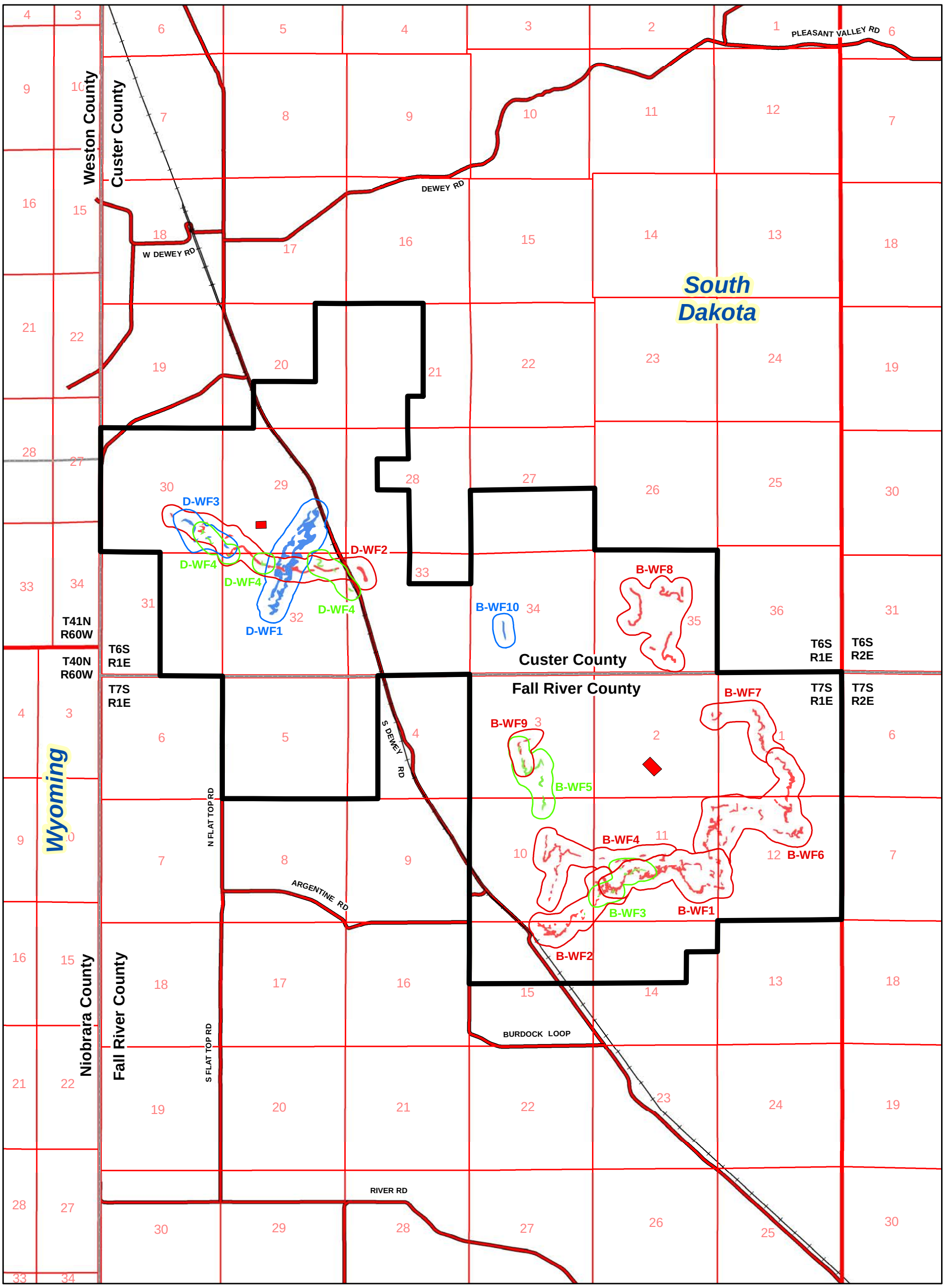

This figure is provided to fulfill the requirements of ARSD 74:29:02:04 and SDCL 45-6B-6(8).

Feet: 0, 2,000, 4,000, 8,000
Meters: 0, 1,000, 2,000

Legend

- Permit Boundary
- Processing Plants
- BNSF Railroad
- County Roads

Potential Well Field Areas
- Lower Fall River
- Upper Chilson
- Middle/Lower Chilson

Ore Bodies
- Lower Fall River
- Upper Chilson
- Middle/Lower Chilson

N

Figure 5.3-9

Potential Well Field Areas

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	09-Nov-2012
FILE	WF-PotentialConfig.mxd

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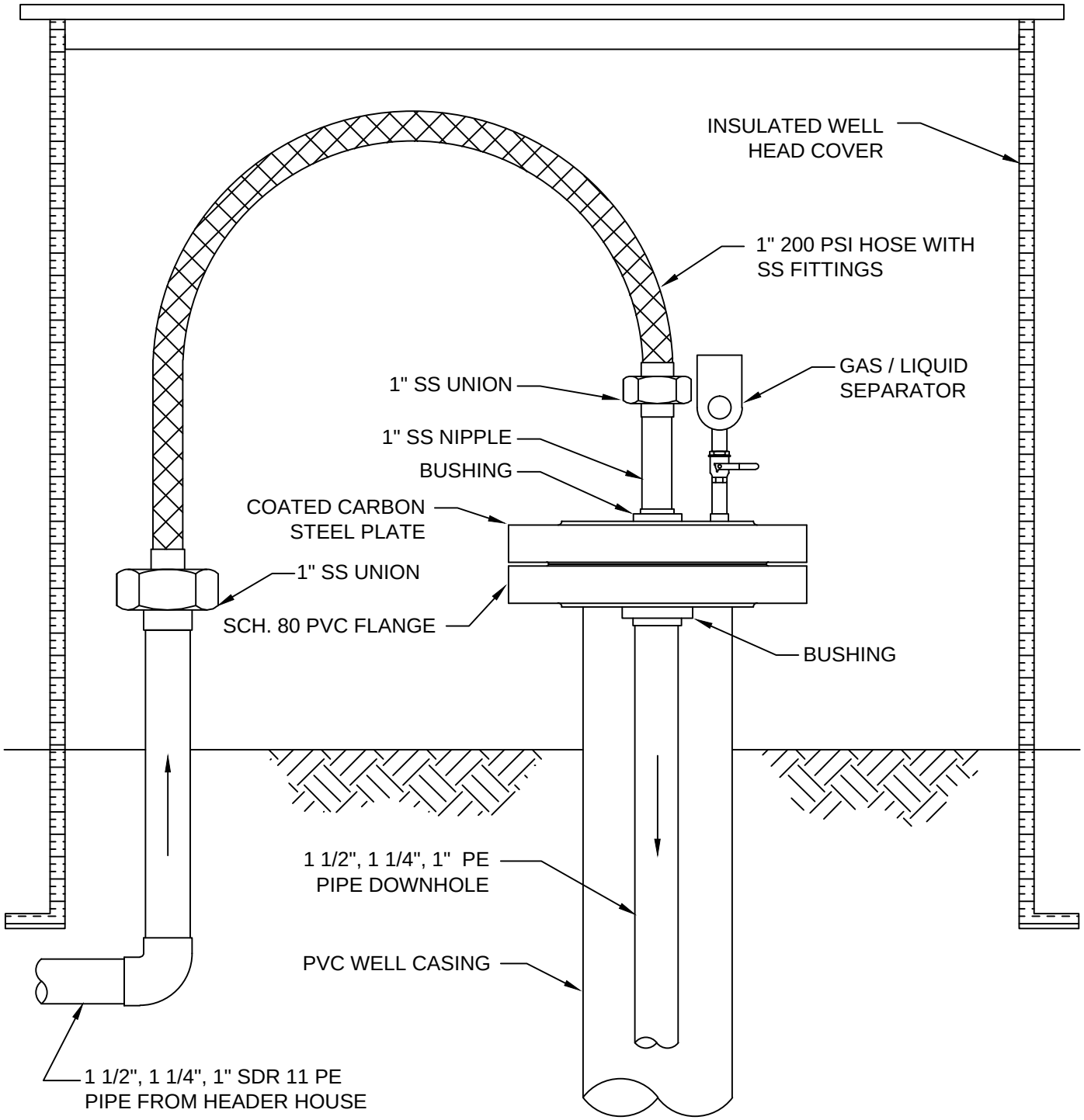

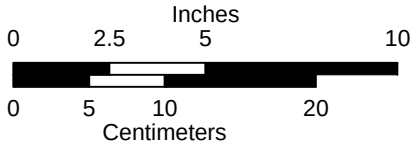

Figure 5.3-10

Typical Injection Wellhead

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	16-Sep-2012
FILE	Wells-InjWellhead.dwg

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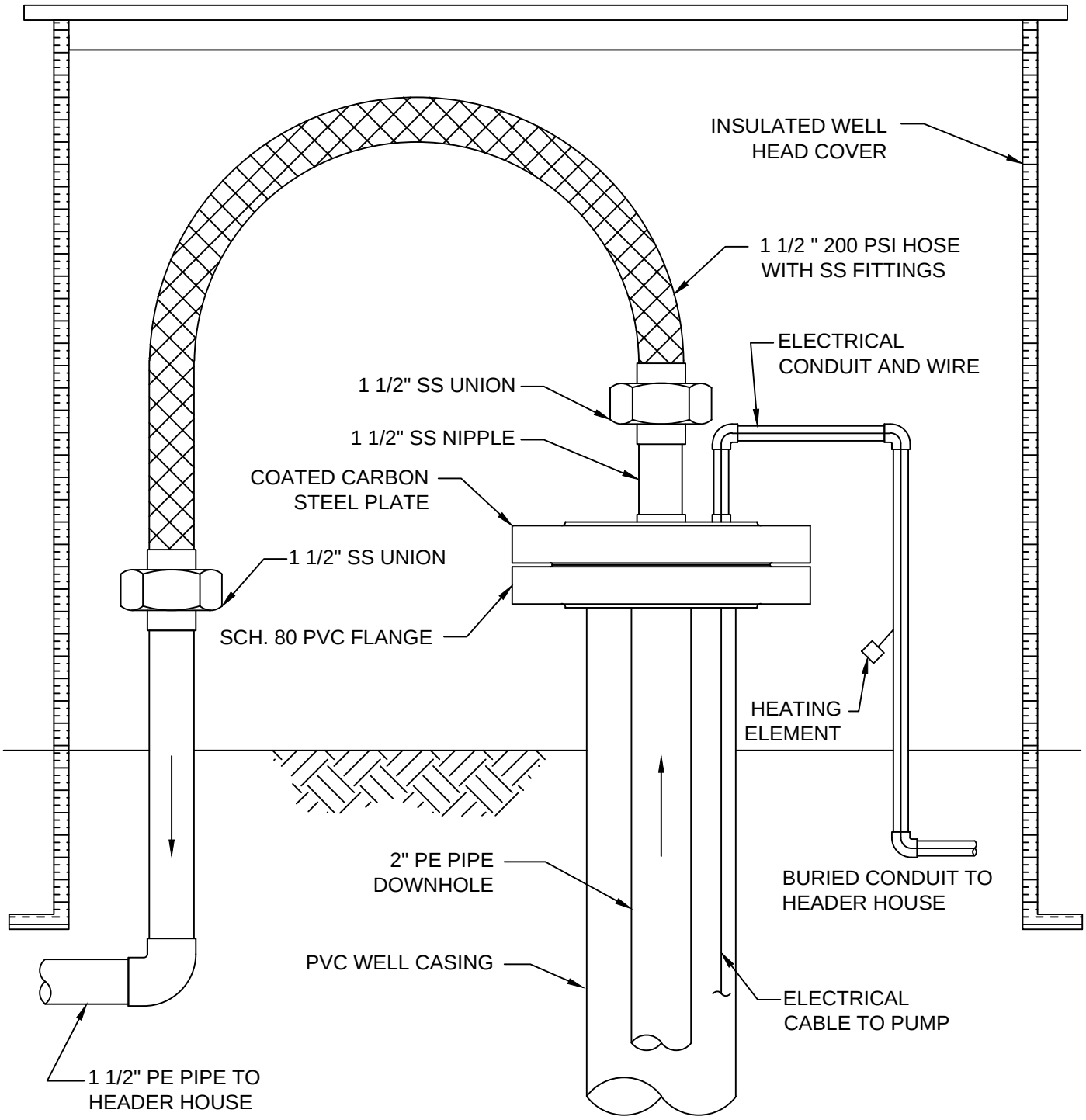

Inches
0 2.5 5 10
0 5 10 20
Centimeters

Figure 5.3-11

Typical Production Wellhead

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	16-Sep-2012
FILE	Wells-ProdWellhead.dwg

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This figure is provided to fulfill the requirements of ARSD 74:29:02:04 and SDCL 45-6B-6(8).

As a well field expands, additional header houses will be constructed. They will be connected to one another via buried piping that is sized to accommodate the necessary injection and production flow rates and pressures. In turn, header pipes from entire well fields will be connected to either the Satellite Facility or CPP. A piping detail that shows the connection between the main header piping and laterals to header houses is shown on Plate 5.3-4.

5.3.3.1.2 Monitor Wells

Monitor wells will be installed in and around each well field to detect the potential migration of ISR solutions away from the target production zone. Perimeter monitor wells will be completed in the production zone around the perimeter of each well field. Non-production zone monitor wells will be completed within each well field in the overlying and underlying aquifers.

5.3.3.1.2.1 Perimeter Monitor Wells

Perimeter monitor wells will be positioned around the perimeter of each well field as illustrated on Plate 5.3-3 and Figure 5.3-8. The perimeter monitor well "ring" serves two purposes: 1) to monitor any horizontal migration of fluid outside of the production zone, and 2) to determine baseline water quality data and characterize the area outside the production pattern area.

Perimeter monitor wells will be located no farther than 400 feet from the well field patterns. They will be evenly spaced with a maximum spacing of either 400 feet or the spacing that will ensure a 70 degree angle between adjacent perimeter monitor wells and the nearest injection well. This maximum distance is based on and consistent with standard monitoring practices at operating ISR facilities. It also is supported by site-specific data and evaluation through numerical groundwater modeling. The numerical groundwater modeling report presented in Appendix 6.2-A demonstrates that the maximum perimeter monitor ring spacing of 400 feet is adequate to detect an excursion and that an excursion can be controlled.

Perimeter wells will be screened across the entire thickness of the production zone, which will be determined following completion of delineation drilling for each well field. In cases where a localized confining unit is present between stacked ore bodies within one of the primary geologic units (Fall River or Chilson), the monitoring approach may be modified such that perimeter monitor wells are screened only within the portion of the hydrogeologic unit in which the ore body is located. In all cases, the screens will fully penetrate the hydrogeologic unit to be monitored, i.e., spanning the entire interval between the overlying and underlying confining beds. As described in Section 3.2.2, the Fuson Shale is pervasive throughout the permit area and forms a confining unit between the Fall River and Chilson. No monitor well will be screened

across the Fuson Shale. Prior to initiating ISR operations in each well field, pre-operational pumping tests will be conducted to confirm that the perimeter monitor wells are hydraulically connected to the production zone. Additional information is found in Section 5.3.3.3.

5.3.3.1.2.2 Non-Production Zone Monitor Wells

Depending on site-specific conditions, non-production zone monitor wells may consist of two types of monitor wells, termed overlying and underlying. The overlying and underlying monitor wells will be used to obtain baseline water quality data and used in the development of compliance limits for the overlying and underlying zones that will be used to determine if vertical migration of lixiviant is occurring. The screened zone for the overlying and underlying monitor wells will be determined from electric logs by qualified geologists or hydrogeologists. Each of the non-production zone monitor well types is described below.

Overlying Monitor Wells

The overlying monitor wells will be designed to provide monitoring of any upward movement of ISR solutions that may occur from the production zone and to guard against potential leakage from production and injection well casing into any overlying aquifer. The term “overlying aquifer” refers to any hydrogeologic unit(s) above the production zone and separated by a confining layer. The terms “overlying aquifer” and “overlying hydrogeologic unit” are used interchangeably when describing well field design and operations.

All overlying hydrogeologic units will be monitored. Monitor wells completed in the first overlying hydrogeologic unit will be designated with the prefix MO and will have a density of at least one well per 4 acres of well field pattern area. Monitor wells completed in subsequent overlying hydrogeologic units will be designated with prefixes MO2, MO3, etc. and will have a density of at least one well per 8 acres of well field pattern area.

Underlying Monitor Wells

The underlying monitor wells will be designed to provide monitoring of any downward movement of ISR solutions from the production zone. Monitor wells completed in the first underlying hydrogeologic unit will be named with the prefix MU and will have a density of one well per 4 acres of pattern area. Only the first underlying hydrogeologic unit will be monitored, unless the production zone is the lowermost hydrogeologic unit above the Morrison Formation, in which case the Unkpapa Sandstone will be the underlying aquifer. Excursion monitoring will not occur in the Unkpapa Sandstone. The justification for not performing excursion monitoring is as follows:

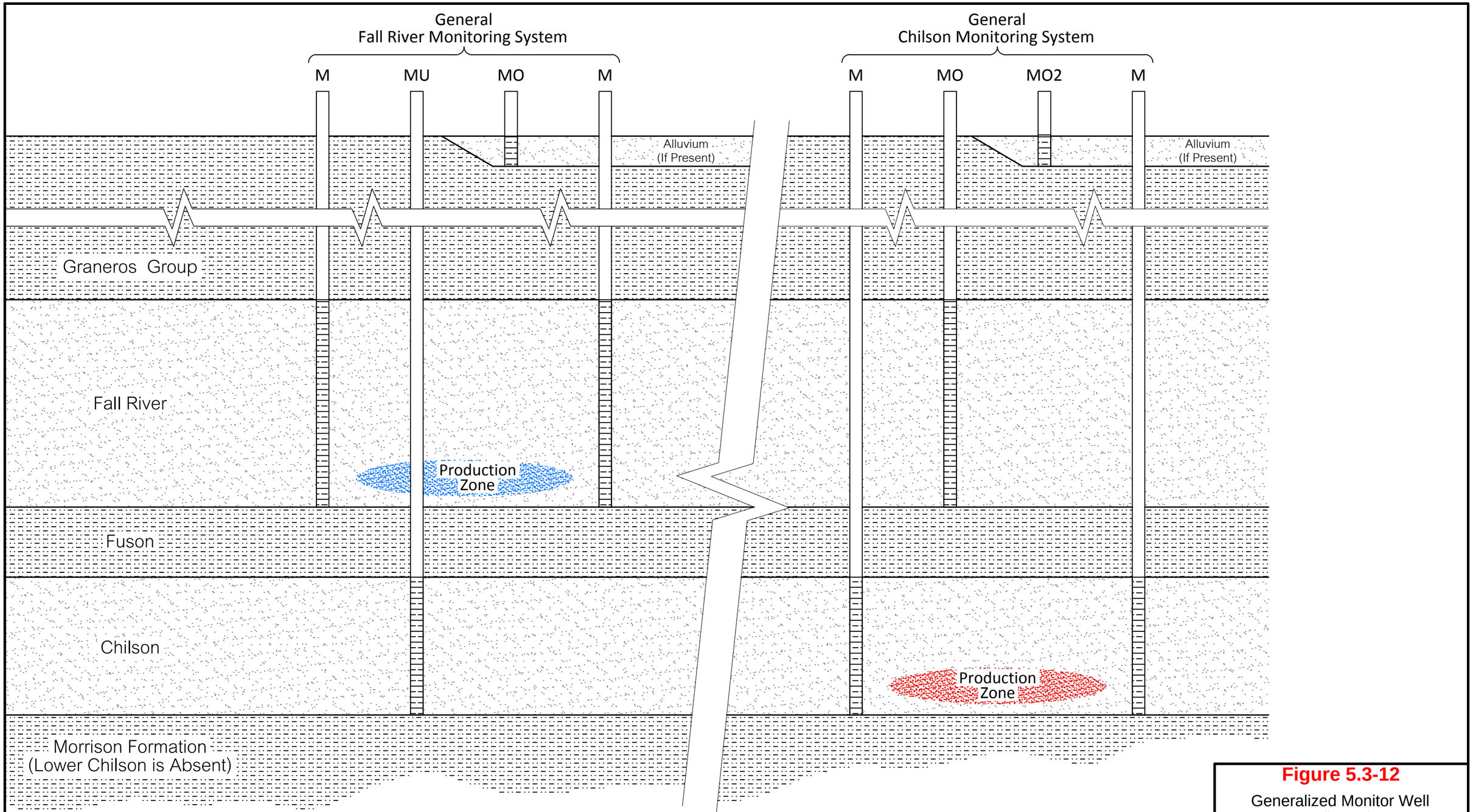
1) The Unkpapa Sandstone shows substantially higher potentiometric head than the Fall River and Chilson throughout the permit area. During ISR operations, the potentiometric head will be reduced (creating a cone of depression) in the Chilson and Fall River due to a net withdrawal (production flow greater than injection flow) in order to maintain well field bleed. Flow into the Unkpapa from production zones in the Fall River and Chilson operating at a substantially lower potentiometric head would be impossible.
2) The Morrison Formation is prevalent across the entire permit area, with a thickness ranging from 60 to 140 feet, and will act as an aquitard to prevent flow between the Unkpapa and the Fall River and Chilson. This was demonstrated by the pumping tests conducted by Powertech (USA), where no response occurred in the Unkpapa during pumping of either the Fall River or Chilson.
3) The Unkpapa is a low-yield aquifer determined by a recent water supply well installation by Powertech (USA). Water samples from the Unkpapa can no longer be obtained from well 704 because this well was cemented off in the Unkpapa in 2009 and perforated in the Chilson due to low yield from the Unkpapa.
4) NRC guidance in NUREG/CR-6733 (NRC, 2001) allows that, "Where confining layers are shown to be very thick and of negligible permeability, requirements for vertical excursion monitoring can be relaxed or eliminated."

5.3.3.1.2.3 Monitor Well Layout

The generalized monitoring scheme is depicted in Figure 5.3-12. This approach will be used when there are no substantial confining layers between ore bodies within the Fall River or Chilson.

Local confining units within the Fall River or Chilson generally are anticipated to be utilized in the monitoring scheme. The presence or absence of these will be confirmed with delineation drilling and mapped in more detail in the process of developing each well field hydrogeologic data package (refer to Section 5.3.3.4). Figures 5.3-13 and 5.3-14 depict the conceptual monitoring schemes for the initial Burdock and Dewey well fields, respectively. Following is a brief summary of the conceptual monitor well layouts. Note that additional monitor wells may be installed as needed.

For Burdock Well Field 1 (Figure 5.3-13), the anticipated production zone is the Lower Chilson. Since the production zone is anticipated to be in the lowermost hydrogeologic unit above the Morrison Formation, no monitoring would occur in the underlying hydrogeologic unit (Unkpapa). Refer to the previous section for additional explanation. Monitor wells would be installed in the first overlying hydrogeologic unit (Middle Chilson) with a minimum density of



Production Zone Legend

- Fall River
- Chilson

M - Monitor Ring in Production Sand
MU - Monitor Underlying Sand
MO - Monitor Overlying Sand (1 per 4 acres)
MO2 - Monitor Overlying Sand (1 per 8 acres)

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(7).

Figure 5.3-12

Generalized Monitor Well Configuration

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	16-Sep-2012
FILE	MonWell-GenConf.dwg

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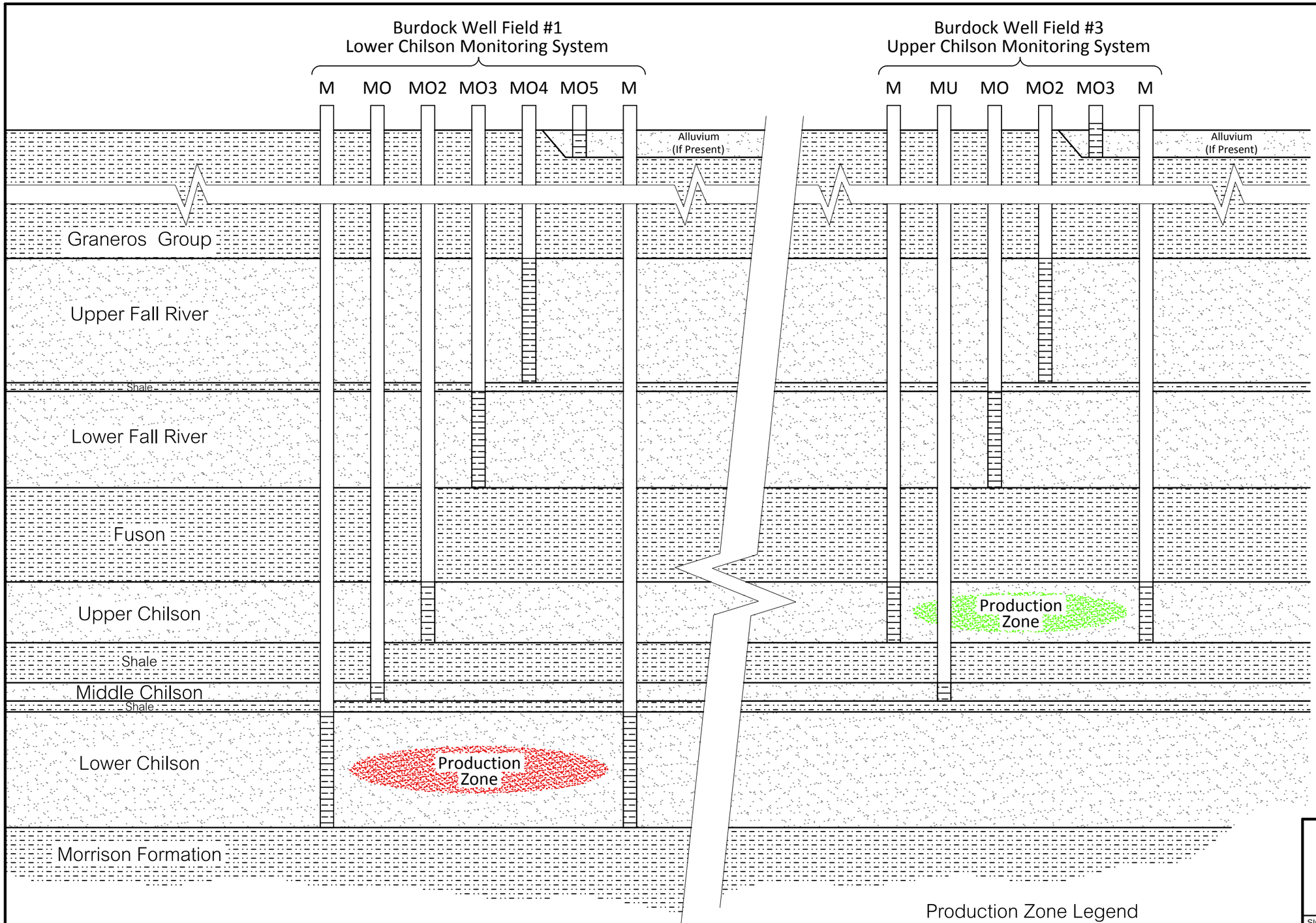

M - Monitor Ring in Production Sand
MU - Monitor Underlying Sand
MO - Monitor Overlying Sand (1 per 4 acres)
MO2, MO3, MO4, MO5 - Monitor Overlying Sand (1 per 8 acres)

Production Zone Legend
Upper Chilson
Lower Chilson

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(7).

Figure 5.3-13

Anticipated Burdock Monitor Well Configuration

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	16-Sep-2012
FILE	MonWell-BurdConf.dwg

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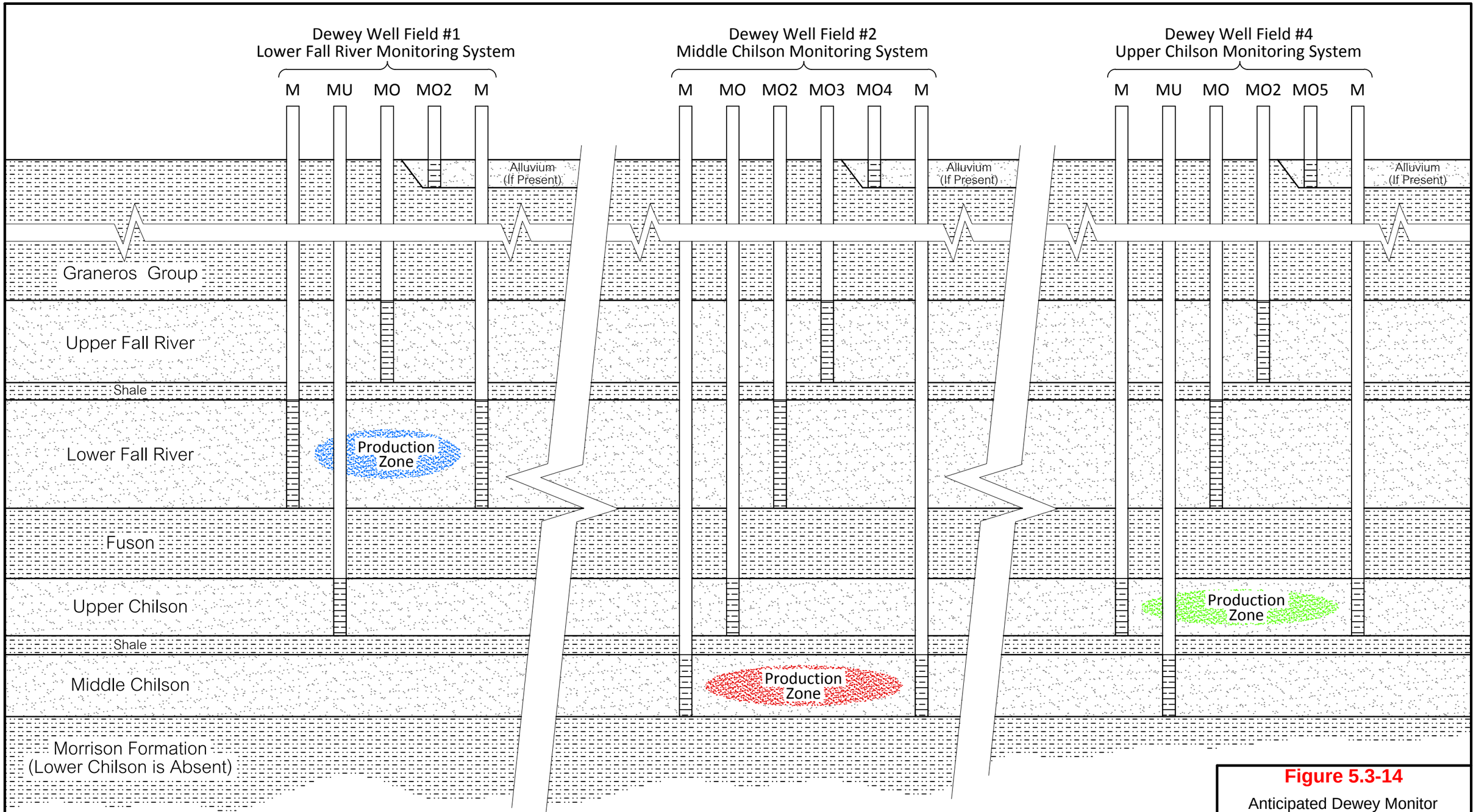

Production Zone Legend

- Lower Fall River
- Upper Chilson
- Middle Chilson

M - Monitor Ring in Production Sand
MU - Monitor Underlying Sand
MO - Monitor Overlying Sand (1 per 4 acres)
MO2, MO3, MO4, MO5, MO6 - Monitor Overlying Sand (1 per 8 acres)

This figure is provided to fulfill the requirements of ARSD 74:29:02:11(7).

Figure 5.3-14

Anticipated Dewey Monitor Well Configuration

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	16-Sep-2012
FILE	MonWell-DeweyConf.dwg

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one well per 4 acres. Monitor wells would be installed in all other overlying hydrogeologic units with a minimum density of one well per 8 acres. This includes the Upper Chilson, Lower and Upper Fall River, and alluvium (where present).

For Burdock Well Field 3 (Figure 5.3-13), the anticipated production zone is the Upper Chilson. In this case the immediately overlying hydrogeologic unit would be the Lower Fall River Formation and would be monitored at a minimum density of one well per 4 acres. Other overlying hydrogeologic units would be monitored at a minimum density of one well per 8 acres, including the Upper Fall River and alluvium (where present). The first underlying hydrogeologic unit would be the Middle Chilson and would be monitored at a minimum density of one well per 4 acres.

For Dewey Well Field 1 (Figure 5.3-14), the anticipated production zone is the Lower Fall River. In this case overlying hydrogeologic units would only include the Upper Fall River and alluvium (where present). The first underlying hydrogeologic unit would be the Upper Chilson. Similar conventions are shown for Dewey Well Fields 2 and 4.

5.3.3.2 Well Construction and Integrity Testing

Well construction materials, methods, development, and integrity testing are described in the following subsections. All injection and production wells will be completed in accordance with South Dakota Well Construction Standards in ARSD 74:02:04 and EPA Standards for Class III UIC wells.

5.3.3.2.1 Well Construction Materials

Well casing material typically will be thermoplastic such as polyvinyl chloride (PVC) with at least SDR 17 wall thickness. The wells typically will be 4.5 to 6-inch nominal diameter and will meet or exceed the specifications of ASTM Standard F480 and NSF Standard 14. In order to provide an adequate annular seal, the drill hole diameter will be at least 2 inches larger than the outside diameter of the well casing.

The annulus will be pressure-grouted and sealed with neat cement grout composed of sulfate-resistant Portland cement in accordance with South Dakota well construction standards. Water used to make the cement grout will not contain oil or other organic material. Cement grout could contain adequate bentonite to maintain the cement in suspension in accordance with Halliburton cement tables.

Casing will be joined using methods recommended by the casing manufacturer. PVC casing joints approximately 20 feet apart will be joined mechanically (with a watertight O-ring seal and a high strength nylon spline) to ensure watertight joints above the perforations or screens. Casings and annular material will be routinely inspected and maintained throughout the operating life of the wells.

5.3.3.2.2 Well Construction Methods

Typical production and injection well installation will begin by drilling a pilot bore hole through the ore zone to obtain a measurement of the uranium grade and thickness. The ore depth is anticipated to range from 200 to 800 feet. Typical monitor well construction will begin with drilling a pilot bore hole through the target completion zone. For all wells, the pilot bore hole will be geologically and geophysically logged. After logging, the pilot bore hole will be reamed to the appropriate diameter to the top of the target completion zone. A continuous string of PVC casing will be placed into the reamed borehole. Casing centralizers will be installed as appropriate. With the casing in place a cement/bentonite grout will be pumped into the casing. The grout will circulate out the bottom of the casing and up the casing annulus to the ground surface. The volume of grout necessary to cement the annulus will be calculated from the bore hole diameter of the casing with sufficient additional allowance to achieve grout returning to surface. Grout remaining inside the well casing may be displaced by water or heavy drill mud to minimize the column of the grout plug remaining inside the casing. Care will be taken to assure that a grout plug remains inside the casing at completion. The casing and grout then will be allowed to set undisturbed for a minimum of 24 hours. When the grout has set, if the annular seal observed from the ground surface has settled below the ground surface, additional grout will be placed into the annular space to bring the grout seal to the ground surface. Figure 5.3-15 depicts the typical well construction schematic.

After the 24-hour (minimum) setup period, a drill rig will be mobilized to finish well construction by drilling through the grout plug and through the target completion zone to the specified total well depth. The open bore hole then will be underreamed to a larger diameter. The following discussion represents the anticipated typical well construction methods. The actual methods may vary.

A well screen assembly (if used) will be lowered through the casing into the open hole. The top of the well screen assembly will be positioned inside the well casing and centralized and sealed inside the casing using K packers. With the drill pipe attached to the well screen, a 1-inch diameter tremie pipe will be inserted through drill pipe and screen and through the sand trap

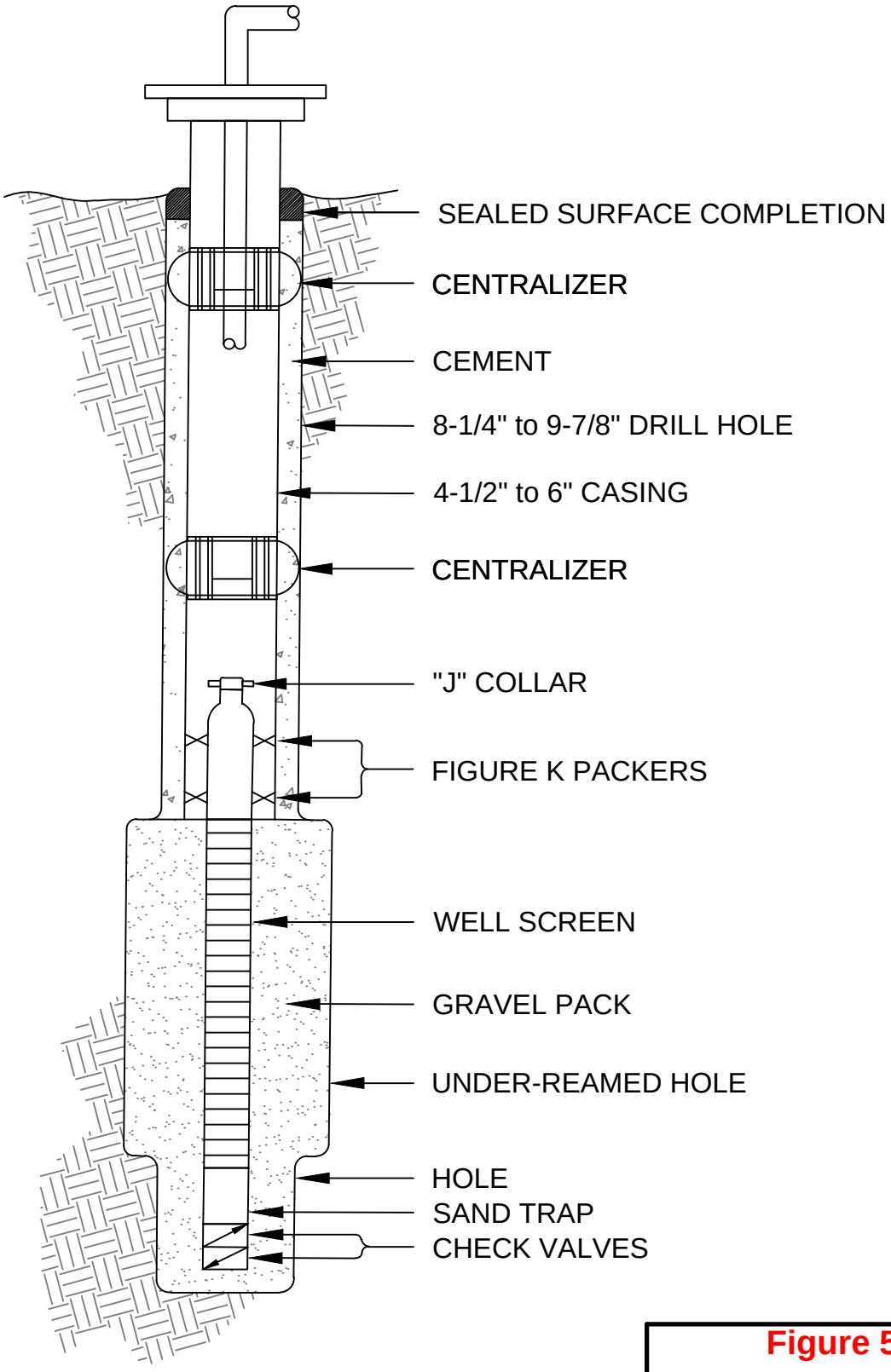

Figure 5.3-15

Typical Well Construction

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	16-Sep-2012
FILE	Wells-TypConstruction.dwg

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This figure is provided to fulfill the requirements of ARSD 74:29:02:04 and SDCL 45-6B-6(8).

check valves at the bottom of well screen assembly. Filter sand (if used), composed of well-rounded silica sand sized to optimize hydraulic communication between the target zone and well screen, then will be placed between the well screen and the formation. The volume of sand introduced will be calculated such that it fills the annular space. The sand will not extend upward beyond the K packers due to packer design. A well completion report then will be prepared for each well.

5.3.3.2.3 Geophysical Logging

Ore grade gamma log, self potential and single point resistivity electric logs will be run in the pilot holes prior to reaming the hole to final diameter to run casing. These logs will determine the location and grade of uranium and the sand and clay unit depths to properly plan each pattern.

5.3.3.2.4 Well Development

The primary goals of well development will be to allow formation water to enter the well screen, flush out drilling fluids, and remove the finer clays and silts to maximize flow from the formation through the well screen. This process is necessary to allow representative samples of groundwater to be collected, if applicable, and to ensure efficient injection and production operations. Wells will be developed immediately after construction using air lifting, swabbing, pumping or other accepted development techniques which will remove water and drilling fluids from the casing and borehole walls along the screened interval. Prior to obtaining baseline samples from monitor wells, additional well development will be conducted to ensure that representative formation water is sampled. The water will be pumped sufficiently to show stabilization of pH and conductivity values prior to sampling to demonstrate that development activities have been effective.

5.3.3.2.5 Mechanical Integrity Testing

All injection, production, and monitor wells will be field tested to demonstrate the mechanical integrity of the well casing. The mechanical integrity testing (MIT) will be performed using pressure-packer tests. The bottom of the casing will be sealed with a plug, downhole inflatable packer, or other suitable device. The casing will be filled with water and the top of the casing will be sealed with a threaded cap, mechanical seal or downhole inflatable packer. The well casing then will be pressurized with water or air and monitored with a calibrated pressure gauge.

Internal casing pressure will be increased to 125 percent of the maximum operating pressure of the well field, 125 percent of the maximum operating pressure rating of the well casing (which is always less than the maximum pressure rating of the pipe), or 90 percent of the formation

fracture pressure (calculated according to EPA-approved methods), whichever is less. A well must maintain 90 percent of this pressure for a minimum of 10 minutes to pass the test.

If there are obvious leaks, or the pressure drops by more than 10 percent during the 10-minute period, the seals and fittings on the packer system will be checked and/or reset and another test will be conducted. If the pressure drops less than 10 percent the well casing will have demonstrated acceptable mechanical integrity.

If a well casing does not meet the MIT criteria, the well will be removed from service. The casing may be repaired and the well re-tested, or the well may be plugged and abandoned. Well plugging procedures are described in Section 6.3.3. If a repaired well passes MIT, it will be employed in its intended service following demonstration that the well meets MIT criteria. If an acceptable test cannot be demonstrated following repairs, the well will be plugged and abandoned.

In addition to the integrity testing after well construction, MIT will be conducted on any well following any repair where a downhole drill bit or under-reaming tool is used. Any well with evidence of subsurface damage will require a new MIT prior to the well being returned to service. MIT also will be repeated once every 5 years for all active wells.

MIT documentation will include the well designation, test date, test duration, beginning and ending pressures, and the signature of the individual responsible for conducting the test. Results of the MIT will be maintained on-site and will be available for inspection by regulatory agencies.

5.3.3.3 Pump Testing

The following pump testing procedures will be used to establish that the production and injection wells are hydraulically connected to the perimeter production zone monitor wells, that the production and injection wells are hydraulically isolated from non-production zone vertical monitor wells, and to detect potentially improperly plugged wells or exploration holes. Pump testing results will be included in the well field hydrogeologic data packages described in Section 5.3.3.4.

Pump Testing Design

An extensive pump test program will be designed and implemented prior to operation of each well field to evaluate the hydrogeology and assess the ability to operate the well field. Prior to pump testing several important well field development steps will be completed:

1) Delineation drilling at spacing sufficient to finalize well field design. As standard procedure, all delineation holes will be plugged and abandoned after drilling.
2) Detailed mapping of the ore bodies targeted for ISR operations and the lithology of overlying and underlying sand units and aquitards.
3) Revision of the conceptual geology and hydrogeology including definition of aquitards and sand units to be produced or monitored.
4) Design of the production and injection wells including well locations and screened intervals.
5) Design of the monitor well system based on production and injection well locations and refined conceptual geology and hydrogeology.
6) Specification of all monitor well locations and screened intervals.
7) Installation of all monitor wells and production wells to be used during pump testing.
8) Plugging and abandoning all water supply wells within ¼ mile of the well field or that have been determined through preliminary evaluation to be potentially impacted by ISR operations or to impact ISR operations.

Pump Testing Procedures

Appropriate wells as needed for characterization and regulatory purposes will be monitored during the pumping test, including but not necessarily limited to the following wells:

1) Pumping wells,
2) Monitor wells within the production zone,
3) Perimeter production zone monitor wells,
4) Monitor wells in the immediately overlying non-production zone sand unit,
5) Monitor wells in each subsequently overlying non-production zone sand unit,
6) Monitor wells in the alluvium, if present,
7) Monitor wells in the immediately underlying non-production zone sand unit, if the production zone does not occur immediately above the Morrison,
8) Any additional wells installed for investigating other hydrogeologic features, and
9) Any other wells within proximity to the well field that have been identified as having the potential to impact or be impacted by ISR operations.

In general, the monitoring system wells will be monitored using downhole data logging pressure transducers, which will be corrected for variations in barometric pressure. Some manual measurements with electronic meters also may be made.

Prior to testing, static potentiometric water levels will be measured in every well in the monitoring system. Where a sufficient number of data points exist, these data will be used to map the pre-operational potentiometric surface for each unit including alluvium, where present. Because of the high density of wells and artesian conditions at the site, any leakage across aquitards due to improperly plugged boreholes or wells typically will become apparent while preparing potentiometric surface maps. Water samples will be collected from selected monitor wells and analyzed for baseline parameters. The water quality will be evaluated to identify any potential areas of leakage across aquitards due to improperly plugged boreholes or wells.

Pump testing will involve inducing stress on the production zone sand unit by operating pumping wells. The goal of the test will be to demonstrate suitable conditions for ISR operations. This will be done by causing drawdown in the production zone extending to all perimeter monitor wells, creating a cone of depression across the well field area to test the confinement between the production zone and the overlying and underlying sand units and alluvium, if present, and addressing potential leakage through confining units via improperly sealed or unplugged exploration boreholes, or associated with naturally occurring geologic features. The presence or lack of response in vertical monitor wells will be used for evaluation of confinement between these units and for identification of leakage due to anomalies such as improperly plugged boreholes. If leakage is present, the relative responses in the overlying, underlying, and/or alluvial monitor wells will indicate the proximity and direction toward the source of leakage.

If saturated alluvium is present within the well field, alluvial monitor wells will be installed and monitored above the production zone and within an appropriate distance from the well field. The water level in the alluvium will be measured prior to testing and monitored during pump testing. If there are anomalous conditions that cause communication between the production zone and alluvium such as an improperly plugged borehole, these conditions will be identified through responses in the alluvial monitor wells.

The pumping test duration will be sufficient to create a suitable response in the perimeter monitor wells, typically a minimum drawdown of 1 foot. If hydrogeologic conditions dictate, less response may be adequate to show a direct cause and effect from pumping.

The flow rate of the pumping test will be based on well capacity and design requirements. More than one pumping well may be required to create drawdown in all perimeter monitor wells.

Measurements during pump testing will include instantaneous and totalized flow, periodic pressure transducer measurements, barometric pressure, and time. A step rate test will be performed initially. There will be an initial stabilization phase with no flow, a stress period of constant flow, and a recovery period with no flow.

Pump Test Evaluation

Evaluation of pump test data will address the following:

1) Demonstration of hydraulic connection between the production and injection wells and all perimeter monitor wells and across the production zone.
2) Verification of the geologic conceptual model for the well field.
3) Evaluation of the vertical confinement and hydraulic isolation between the production zone and overlying and underlying units.
4) Calculation of the hydraulic conductivity, storativity, and transmissivity of the production zone sand unit.
5) Evaluation of anisotropy within the production zone sand unit.

5.3.3.4 Well Field Hydrogeologic Data Packages

Pump testing data and results will be included in the well field hydrogeologic data packages, which will be prepared in accordance with NRC license requirements. Upon completion of field data collection and laboratory analysis, the well field hydrogeologic data packages will be assembled and submitted for review by the Safety and Environmental Review Panel (SERP) for evaluation. The SERP is described in Section 5.7.2.3. The SERP evaluation will determine whether the results of the hydrologic testing and the planned ISR operations are consistent with standard operating procedures and technical requirements stated in the NRC license. The evaluation will include review of the potential impacts to human health and the environment. Relevant portions also will be included in injection authorization data packages, which will be submitted to EPA for review and verification. If anomalous conditions are present, the SERP evaluation indicates potential to impact human health or the environment, or to meet NRC license requirements, the well field hydrogeologic data package will be submitted to NRC. The well field hydrogeologic data package and written SERP evaluation will be maintained at the site and available for regulatory agency review.

Each well field hydrogeologic data package will contain the following:

1) A description of the proposed well field (location, extent, etc.).

2) Map(s) showing the proposed production and injection well patterns and locations of all monitor wells.
3) Geologic cross sections and cross section location maps.
4) Isopach maps of the production zone sand and overlying and underlying confining units.
5) Discussion of how pump testing was performed, including well completion reports.
6) Discussion of the results and conclusions of the pump testing, including pump testing raw data, drawdown match curves, potentiometric surface maps, water level graphs, drawdown maps and, when appropriate, directional transmissivity data and graphs.
7) Sufficient information to show that wells in the monitor well ring are in adequate communication with the production patterns.
8) Baseline water quality information including proposed upper control limits (UCLs) for monitor wells and target restoration goals (TRGs).
9) Any other information pertinent to the proposed well field area tested will be included and discussed.

In addition to the well field hydrogeologic data packages, Powertech (USA) will prepare and submit injection authorization data packages to EPA for each well field. The injection authorization data packages will contain much of the information described previously for well field hydrogeologic data packages, including well field designs, pump testing results, calculated formation fracture pressure for each header house and the designated maximum injection pressure for each header house.

5.3.3.5 Well Field Operation

Refer to Section 5.1.3 for an overview of well field operations. The following sections describe key operating provisions in greater detail, including hydraulic well field control, injection pressure, and the water balance.

5.3.3.5.1 Hydraulic Well Field Control

Powertech (USA) will maintain hydraulic control of each well field from the first injection of lixiviant through the end of aquifer restoration. During uranium recovery, the groundwater removal rate in each well field will exceed the lixiviant injection rate, creating a cone of depression within each well field. During aquifer restoration, the groundwater removal rate in each well field will exceed the injection rate of permeate and clean makeup water from the Madison Limestone or another suitable formation. If there are any delays between uranium recovery and aquifer restoration, production wells will continue to be operated as needed to

maintain water levels within the perimeter monitor rings below baseline water levels. This activity may be intermittent or continuous.

Verification of hydraulic control will be performed through water level measurements in perimeter monitor wells. Water levels will be measured using pressure transducers or manual electronic meters and recorded at a frequency appropriate to confirm hydraulic well field control.

5.3.3.5.1.1 Flare Control

Flaring (movement of lixiviant outside of the well field pattern area) will be limited by maintaining hydraulically balanced well fields and adequate bleed during uranium recovery and aquifer restoration. The financial assurance calculations for aquifer restoration that are reviewed and approved by NRC will account for flare. Powertech (USA) has provided a flare estimate in Appendix 6.7-A that is justified by numerical groundwater modeling and is comparable to values that have been approved recently by NRC for other ISR facilities.

5.3.3.5.2 Injection Pressure

The maximum injection pressure for ISR injection wells will be regulated by both EPA UIC permit condition and NRC license condition. Class III UIC regulations in 40 CFR § 144.28(f)(g)(i) limit the injection pressure in ISR injection wells to a level below the formation fracture pressure. Similarly, NRC guidance in NUREG-1569 (NRC, 2003) requires demonstration that down-hole injection pressure will be maintained below the formation fracture pressure. Powertech (USA) will maintain the injection pressure of ISR injection wells below the formation fracture pressure as required by EPA permit and NRC license conditions.

Powertech (USA) will specify the maximum injection pressure for each header house. The designated maximum pressure will be posted near the injection trunk line gauge used to monitor injection pressure. The maximum injection pressure will be calculated as the lowest value of the following:

- The lowest value of maximum allowable wellhead pressure for all injection wells connected to the header house based on fracture pressure calculations using methodology approved by EPA in the Class III UIC permit.
- The manufacturer-specified maximum operating pressure for the well casing.
- The manufacturer-specified maximum operating pressure of the injection piping and fittings.

The anticipated range of injection pressure, measured at each header house, is 20 to 150 psig.

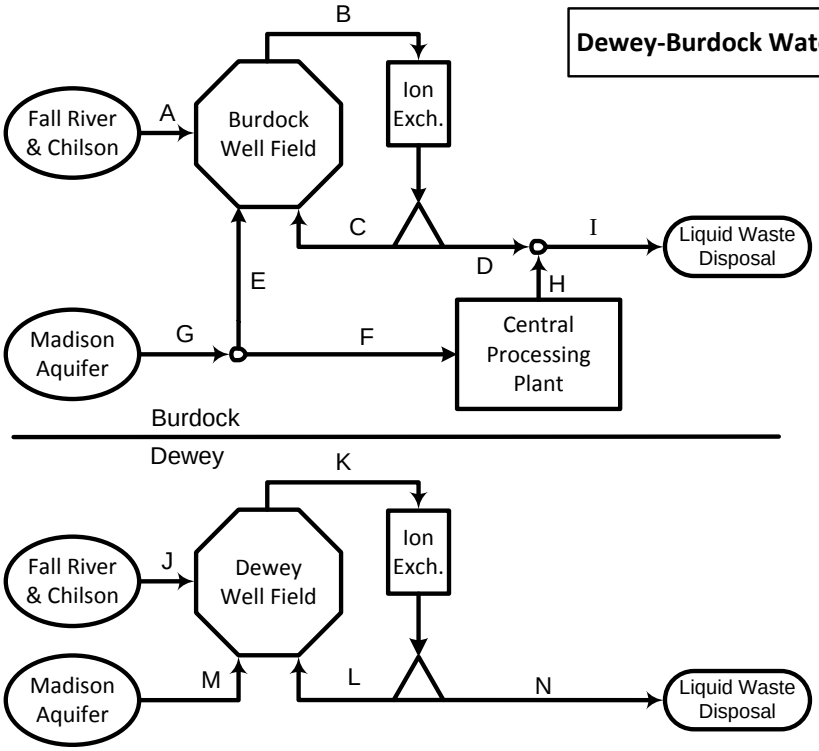
5.3.3.5.3 Water Balance

Typical water balances during uranium recovery and aquifer restoration are presented in Figure 5.3-16. The figure depicts typical flow rates during the uranium recovery and aquifer restoration phases. Table 5.3-2 shows the typical design flow rates during concurrent uranium recovery and aquifer restoration. Detailed descriptions of the water balances for the Dewey-Burdock Project are provided below along with a discussion of liquid waste disposal capacities.

5.3.3.5.3.1 Uranium Recovery Water Balance

During uranium recovery without concurrent aquifer restoration, the flow rates will be the same for either wastewater disposal option. The typical production bleed will be approximately 0.875%. The typical well field production will be approximately 4,800 gpm (Stream B) from Burdock well fields and 3,200 gpm (Stream K) from Dewey wells fields. Note that these are typical flow rates provided to illustrate the water balance when the Dewey and Burdock well fields are operating simultaneously. An important value is the sum of Streams B and K, which represents the typical project-wide production flow rate. The maximum project-wide gross pumping rate from producing well fields is anticipated to be 8,000 gpm (Streams B plus K). This will be limited by NRC license conditions. Although the NRC license application currently requests a maximum gross pumping rate of 4,000 gpm, Powertech (USA) anticipates submitting an amendment application to NRC to increase the maximum allowable gross pumping rate in order to provide operational flexibility. It is important to note that the net withdrawal from the Inyan Kara typically will be only 0.875% of this amount, or the amount of the typical production bleed. Multiplying the typical production bleed rate by the maximum anticipated gross pumping rate of 8,000 gpm yields typical production bleed flow rates of 42 gpm (Stream A) at Burdock and 28 gpm (Stream J) at Dewey. This demonstrates that the vast majority of water pumped from the production zone will be reinjected, such that the net withdrawal rate will be only a small fraction of the gross pumping rate.

Wastewater resulting from uranium recovery operations at the Dewey area will consist almost entirely of production bleed. At the Burdock area, wastewater also will include process solutions (such as resin transfer water and brine generated from the elution and precipitation circuits), affected well development water, laboratory wastewater, laundry water, and plant wash down water. Wastewater flow rates, which are represented by Streams I and N, will typically be approximately 54 gpm and 28 gpm, respectively. As described in Section 5.4.1.1.3, all wastewater associated with ISR operations will be treated prior to disposal via deep disposal wells and/or land application.



Stream ID	Description
A	Burdock Aquifer Bleed
B	Burdock Extraction Composite
C	Burdock Reinjection
D	Burdock Well Field Bleed
E	Burdock Madison Make-up
F	Burdock Fresh Brine Make-up
G	Burdock Madison, Total
H	Burdock CPP Brine
I	Burdock Liquid Waste
J	Dewey Aquifer Bleed
K	Dewey Extraction Composite
L	Dewey Reinjection
M	Dewey Madison Make-up
N	Dewey Liquid Waste

Water Balance Flow Rates (gpm)											
Operation Phase	Aquifer Bleed Option	Disposal Option	Burdock								
			Stream ID								
			A	B	C	D	E	F	G	H	I
Recovery	0.875%	DDW	42	4800	4758	42	0	12	12	12	54
		LA	42	4800	4758	42	0	12	12	12	54
Restoration	Without Groundwater Sweep	DDW	2.5	250	175	75	73	0	73	0	75
		LA	2.5	250	0	250	248	0	248	0	250
	With Groundwater Sweep	DDW	42	250	175	75	33	0	33	0	75
		LA	42	250	0	250	208	0	208	0	250

Water Balance Flow Rates (gpm)							
Operation Phase	Aquifer Bleed Option	Disposal Option	Dewey				
			Stream ID				
			J	K	L	M	N
Recovery	0.875%	DDW	28	3200	3172	0	28
		LA	28	3200	3172	0	28
Restoration	Without Groundwater Sweep	DDW	2.5	250	175	73	75
		LA	2.5	250	0	248	250
	With Groundwater Sweep	DDW	42	250	175	33	75
		LA	42	250	0	208	250

Figure 5.3-16: Typical Project-wide Flow Rates during Uranium Recovery and Aquifer Restoration

Table 5.3-2: Typical Project-wide Flow Rates during Concurrent Uranium Recovery and Aquifer Restoration

Typical Project-wide Flow Rates		Wastewater Disposal Option			
		Deep Disposal Well		Land Application	
Restoration Option		Without Groundwater Sweep	With Groundwater Sweep	Without Groundwater Sweep	With Groundwater Sweep
Fall River & Chilson	gpm	75	154	75	154
Madison Limestone	gpm	158	78	508	428
Wastewater Disposal	gpm	232	232	582	582

5.3.3.5.3.2 Aquifer Restoration Water Balance

Powertech (USA) proposes two options for disposal of wastewater associated with ISR operations at the Dewey-Burdock Project: (1) injection of treated wastewater in non-hazardous Class V DDWs, and/or (2) land application of treated wastewater using center pivots (refer to Section 5.4.1.1). The disposal option selected will determine the method of aquifer restoration used. RO treatment with permeate injection will be used in the DDW option, and groundwater sweep with injection of clean makeup water from the Madison Limestone or another suitable formation will be used in the land application option. The aquifer restoration methods are described in detail in Section 6.2. Both disposal options are included in the water balance to illustrate the different wastewater disposal flow rates in each option. In the DDW option, the groundwater withdrawn during aquifer restoration will be treated by RO. The concentrated brine solution will be disposed in the DDWs, while the permeate will be reinjected along with makeup water from the Madison Limestone or another suitable formation into the well fields. This will reduce the overall wastewater flow rate. Flow rates will be higher if land application is used, because the entire restoration stream will be disposed in the land application system.

Although a 1% or less restoration bleed will be adequate to maintain hydraulic control of well fields undergoing active aquifer restoration, additional bleed may be recovered to enhance aquifer restoration through a process known as groundwater sweep. As described in Section 6.2.2.3, Powertech (USA) may withdraw up to one pore volume of water through groundwater sweep over the course of aquifer restoration. This will result in an average restoration bleed of approximately 17%. The wastewater disposal systems have been designed to accommodate both options, and both options are depicted in the water balance.

The typical restoration extraction flow rate from the Dewey and Burdock well fields will be approximately 250 gpm each for a total of 500 gpm. The total project-wide restoration extraction flow rate will be approximately 500 gpm, while the specific contribution from the Dewey and Burdock well fields will vary. If groundwater sweep is not used, approximately 2.5 gpm less will be injected than is recovered. For the DDW option, RO treatment of the restoration solution typically will result in 175 gpm of permeate returning to each of the Dewey and Burdock well fields (Stream C for Burdock and Stream L for Dewey) and 75 gpm of wastewater being routed to the DDWs (Stream I for Burdock and Stream N for Dewey). If land application is used for wastewater disposal, all 250 gpm of the restoration extraction solution will be sent to the land application systems. In this case clean makeup water from the Madison Limestone or another suitable formation will be injected instead of permeate. Regardless of the disposal option, the

balance of water required to maintain the restoration bleed of 1% will be supplied from the Madison Limestone or another suitable formation.

If groundwater sweep of one pore volume is used, overall restoration bleed will average approximately 17%, resulting in 42 gpm being removed from the ore zone aquifer under both disposal options. Similar to the aquifer restoration option without groundwater sweep, the resulting wastewater disposal flow rates typically will be 75 gpm for the DDW option and 250 gpm for the land application option.

Note that Streams F and H, which represent the flows from the Madison to the CPP and from the CPP to wastewater disposal, are typically zero during aquifer restoration without concurrent uranium recovery. While there will be times during this phase when wastewater will be generated from the CPP, they will be infrequent due to the small number of resin transfers and elution and precipitation cycles during this phase. During this phase the water supply needs for the CPP will be nearly zero in the typical water balance.

5.3.3.5.3.3 Concurrent Uranium Recovery and Aquifer Restoration Water Balance

A typical water balance for concurrent uranium recovery and aquifer restoration is shown in Table 5.3-2. The table shows the typical combined flow from the Fall River Formation and Chilson Member and the flow from the Madison. It also shows the typical wastewater disposal flow rates under the different restoration options. The typical values for Fall River and Chilson flow rates were obtained by adding the Streams A and J in Figure 5.3-16 for both uranium recovery and aquifer restoration. The typical Madison Formation makeup water flow rate was obtained by adding Streams G and M in Figure 5.3-16 for uranium recovery and aquifer restoration. The wastewater disposal flow rate was obtained by adding the Streams I and N in Figure 5.3-16 for uranium recovery and aquifer restoration. The typical wastewater flow rates during concurrent uranium recovery and aquifer restoration will be approximately 232 gpm for the DDW option and 582 gpm for the land application option.

5.3.3.5.3.4 Wastewater Disposal Capacity

The wastewater disposal capacity is described in Section 5.4.1.1. In the DDW option, the wastewater disposal capacity will be up to 300 gpm. This is about 30 percent more than the maximum anticipated wastewater flow rate in the DDW option (232 gpm during concurrent uranium recovery and aquifer restoration as shown in Table 5.3-2).

In the land application option, the wastewater disposal capacity will be at least 620 gpm on an annual average basis (accounting for zero discharge during the time of year when land application will not be used). This is approximately 7 percent greater capacity than the maximum shown in Table 5.3-2 (582 gpm during concurrent uranium recovery with aquifer restoration, groundwater sweep option). In addition, significant surplus capacity will be provided with standby center pivots in each land application area. Refer to Section 5.4.1.1 and the GDP.

5.3.3.6 Approach to Well Field Development with Respect to Partially Saturated Conditions

Refer to Section 3.4.2.2.4 for a description of partially saturated conditions. The only instance where hydrologically unconfined (partially saturated) conditions exist within an area proposed for ISR operations occurs in the eastern portion of the permit area. Powertech (USA) does not intend to conduct ISR operations in the Fall River sands in the eastern portion of the permit area where the Fall River is partially saturated (i.e., hydraulically unconfined). Powertech (USA) is, however, proposing to conduct ISR operations in the underlying Chilson at these locations. The Chilson is physically and hydraulically isolated from the Fall River by the Fuson Shale. Although the Chilson is not fully saturated near the eastern edge of the permit area, the mineralization occurs near the base of the formation. As a result, any ISR operations will occur within the portion of the Chilson where confining layers and sufficient head above the ore body will provide ample means to control ISR solutions.

Geologic Cross Section B-B' (Plate 3.2-14) shows the potentiometric surfaces as well as the interbedded shales and siltstones within the Fall River and Chilson. The cross section depicts the location of the mineralization in the Chilson in relation to the Chilson potentiometric surface. Near the eastern portion of the permit area the potentiometric surface is nearly 100 feet higher than the mineralization. Locally occurring shale units may serve to further confine the mineralization within the Chilson. As such, Powertech (USA) does not anticipate that ISR operations will occur where there is less than 50 feet of potentiometric head over the ore body.

After license/permit issuance but prior to well field development, delineation drilling and well field pumping tests will be conducted to fully characterize the existing geologic and hydrogeologic conditions and to confirm sufficient head is available to perform normal ISR operations. As an integral component of the characterization activities, a detailed evaluation will be made, based on actual site conditions, regarding the application of ISR under partially saturated conditions should it be necessary. Partially saturated conditions, if encountered, would

be similar in many respects to what has been licensed at other ISR projects (e.g., Moore Ranch in Wyoming) and would be addressed similarly with modeling.

5.3.3.7 Approach to Well Field Development with Respect to Historical Mine Workings

As described in Section 3.2.5.2 the former Darrow and Triangle open-pit mines and associated underground workings in the eastern portion of the permit area extracted ore from the Fall River Formation. There are no underground mines within the permit area that are not associated with, adjacent to, or extensions of the open pits, all of which are within the Upper Fall River Formation. These open-pit mines and underground workings did not penetrate the underlying Fuson Shale, which physically and hydraulically separates the Fall River from the underlying Chilson Member of the Lakota Formation across the entire permit area.

Powertech (USA) will not conduct ISR operations in ore bodies in the Fall River in the vicinity of the Darrow and Triangle pits. Powertech (USA) proposes to conduct ISR operations within the Chilson in this area. Because of the physical and hydraulic separation of the Chilson from the overlying Fall River Formation, ISR operations in the Chilson will not affect the Fall River or create or enhance migration of constituents of concern from the surface (open-pit) or underground mines.

Figure 3.2-8 shows the spatial relationship between the potential ISR well fields and the historical mine areas. An examination of this figure shows that proposed Burdock Well Field 7 (B-WF7) underlies portions of the historical Darrow mine area. The targeted production zone for B-WF7 is the Lower Chilson. Figure 3.2-12 illustrates the stratigraphic separation of this Lower Chilson sand unit from the historical mining operations in sands of the Fall River Formation. The gamma activity shown within the Lower Chilson sand on the type log is representative of the proposed uranium recovery horizon in B-WF7. This interval is over 200 feet below the base of the Fall River Formation and is separated by 40 feet of the Fuson Shale confining unit, as well as two interbedded shale intervals within the Chilson Member – one 12 feet thick and the other 23 feet thick.

As also shown on Figure 3.2-8, potential Burdock Well Field 8 (B-WF8) is below and horizontally adjacent to the surface expression of an area of past mining disturbance in Section 35, T6S, R1E. Excavation in this area was underway when the Edgemont mill was closed. This operation was on land owned by the Spencer family, and Donald Spencer (2011) related that all mining operations ceased before reaching the ore horizon. The pit was backfilled and reclaimed. Powertech (USA)'s targeted uranium recovery horizon for B-WF8 is the Lower

Chilson. This unit is at least 200 feet beneath the base of the Fuson Shale and is well below the historical mining disturbance in the Fall River Formation.

Powertech (USA) also will install and sample operational monitor wells in the Fall River, Chilson, and alluvium between the surface (open-pit) mines and well field areas. For additional information, refer to Section 5.5.2.3.

5.3.3.8 Approach to Well Field Development with Respect to Alluvium

This section summarizes Powertech (USA)'s approach to well field development in areas of Beaver Creek and Pass Creek alluvium, including alluvial characterization, pump testing, and operational monitoring. This section consolidates information presented elsewhere in the application and includes references to the applicable sections.

Alluvial Characterization

Powertech (USA) completed an alluvial drilling program in 2011 to characterize the thickness, extents, and saturated thickness (if water was present) of the alluvium along Beaver Creek and Pass Creek. Alluvial characteristics will be further evaluated during well field delineation drilling described in Section 5.3.3.3.

Pump Testing

As described in Section 5.3.3.3, an extensive pump testing program will be designed and implemented prior to operation of each well field to evaluate the hydrogeology and assess the ability to operate the well field. Monitor wells will be completed in the alluvium, if present.

Operational Monitoring

Section 5.3.3.1.2.2 describes how alluvium will be treated as an overlying hydrogeologic unit and monitored appropriately during operational groundwater monitoring. Powertech (USA) also will monitor potential changes in alluvial water quality throughout the permit area through the monitoring network described in Section 5.5.2.3.

5.3.4 Ponds

5.3.4.1 Pond Design

Lined ponds will be used to temporarily store liquid waste generated at the Satellite Facility and CPP. The pond lining systems will vary according to pond use. Ponds containing untreated liquid waste or ponds used in the treatment process (e.g., radium settling ponds) will be provided with two geosynthetic liners, a clay liner, and a leak detection system. Ponds containing treated water

will be provided with a single geosynthetic liner underlain by a clay liner. The pond capacity will vary according to the liquid waste disposal option. Greater capacity is required for the land application option, since liquid waste will be stored during times of year when the land application systems are not operated.

The pond design for both liquid waste disposal options is summarized below. Appendix 5.3-A provides detailed pond design information, and Appendix 5.3-B contains pond construction specifications, testing and QA/QC procedures. Section 5.3.4.2 provides detailed descriptions of pond sizing calculations.

Land Application Option

The land application disposal option will include the following ponds:

- **Two (2) Radium Settling Ponds** - one near each land application area (Dewey and Burdock). Each pond will have an operating capacity of 39.4 acre-feet. Radium settling ponds for the land application disposal option were designed such that a single pond has sufficient capacity for radium removal of the entire project-wide wastewater stream at the maximum expected production bleed of 3% while maintaining a minimum retention time of 14.1 days.
- **Two (2) Spare Ponds** - one at each area. Each pond will have an operating capacity of 39.4 acre-feet. The spare ponds will be designed with the same dimensions and liner system as the radium settling ponds so that they can be used as either spare radium settling ponds or spare central plant ponds.
- **Two (2) Outlet Ponds** - one at each area. Each pond will have an operating capacity of 4.9 acre-feet. The outlet ponds will be designed to temporarily store treated water from the radium settling ponds and provide extra capacity for the radium settling ponds during large precipitation events.
- **Eight (8) Storage Ponds** - four at each area. Each pond will have an operating capacity of 63.8 acre-feet. The storage ponds will be used to store treated water during the winter months when no liquid waste disposal by land application systems is available. The total storage required at each area was obtained using the SPAW model, which is discussed in more detail in Appendix 5.3-A and the GDP.
- **Two (2) Spare Storage Ponds** - one at each area. Each pond will have an operating capacity of 63.8 acre-feet. The spare storage ponds will be designed with the same dimensions and liner system as the storage ponds so that they can be used in the event of an upset condition.
- **One (1) Central Plant Pond** - located at the CPP, with an operating capacity of 36.2 acre-feet. The storage capacity design for the central plant pond allows for over 18 months of CPP liquid waste storage, which will be required during initial uranium

recovery operations when no groundwater sweep water is available to blend with CPP liquid waste.

Deep Disposal Well Option

The DDW liquid waste disposal option will include the following ponds:

- **Two (2) Radium Settling Ponds** - one at each area. Each pond will have an operating capacity of 15.9 acre-feet. Radium settling ponds for the DDW option were designed such that a single pond has sufficient capacity for radium removal of the entire project-wide liquid waste stream at the maximum expected production bleed of 3% while maintaining a minimum retention time of 12.7 days.
- **Two (2) Spare Ponds** - one at each area. Each pond will have an operating capacity of 15.9 acre-feet. The spare ponds will be designed with the same dimensions and liner system as the radium settling ponds so that they can be used as either spare radium settling ponds or spare central plant ponds.
- **Two (2) Outlet Ponds** - one at each area. Each pond will have an operating capacity of 5.1 acre-feet. The outlet ponds will be designed to temporarily store treated water from the radium settling ponds and provide extra capacity for the radium settling ponds during large precipitation events.
- **Two (2) Surge Ponds** - one at each area. Each pond will have an operating capacity of 8.4 acre-feet. The surge ponds will provide surge capacity for treated liquid waste flowing out of the radium settling ponds. They have been sized to accommodate 7 days of water production.
- **One (1) Central Plant Pond** - located at the CPP, with an operating capacity of 15.9 acre-feet.

In the event that both deep disposal wells and land application are used, the pond capacity will be in between the two sizes discussed above.

All ponds have been designed to accommodate the design flows of liquid waste plus the precipitation from the 100-year, 24-hour precipitation event, while maintaining 3 feet of freeboard.

Seismic stability analyses for the pond designs are discussed in Sections 3.11.4 and 3.11.5 of the Dewey-Burdock Pond Design Report (Appendix 5.3-A), which concludes, “The factors of safety indicate that the inner and outer slopes are stable under static and maximum credible earthquake seismic loading conditions.”

5.3.4.2 Pond Sizing and Sludge Accumulation

The capacity of all of the ponds for each liquid waste disposal option is summarized in Section 5.3.4.1. Following is more detailed discussion on the sizing calculations for the radium settling ponds, storage ponds, and central plant pond.

Radium Settling Ponds

In either liquid waste disposal option, the liquid waste will be treated for radium removal through co-precipitation with barium sulfate in the radium settling ponds. Barium chloride will be added to the liquid waste from the Satellite Facility and low-TDS liquid waste from the CPP, and the resulting solution will be discharged into the radium settling ponds, where the radium will co-precipitate with barium sulfate.

The radium settling ponds have been sized to provide adequate settling time even after 20 years of operation, during which time barium sulfate sludge will accumulate in the ponds. The calculated resulting retention time after 20 years is estimated to be at least 15 days for either liquid waste disposal option. As stated in the Pond Design Report (Appendix 5.3-A), "a literature survey of radium settling ponds has indicated that typical retention times range from 8 to 14 days." Therefore, radium settling ponds at the Dewey-Burdock Project will have adequate retention times even after 20 years of service. In addition, the Satellite Facility and CPP each will have a spare pond suitable for use as a settling pond if the primary ponds need to be temporarily removed from service for sludge removal or repair.

Storage Ponds

Appendix 5.3-A and the GDP describe how the SPAW (Soil-Plant-Atmosphere-Water) model was used to estimate the water budget for the storage ponds. The model results show that the total required irrigation storage pond volume having a 1-percent exceedance probability is 216 acre-feet at both the Dewey and Burdock sites. An additional 31 acre-feet of active capacity was added to the ponds at each site, for a total primary storage capacity of 247 acre-feet. This additional capacity acts as contingency storage for days at the beginning of the irrigation season when weather conditions may limit land application. In addition, a spare storage pond will be provided with 61.8 acre-feet usable capacity. The total available capacity is therefore about 43 percent greater than the capacity required for a 1-percent exceedance probability. The surplus capacity will allow the land application season to be reduced by at least 2 months if needed (e.g., during an abnormally wet year or late spring).

Central Plant Pond

The purpose of the central plant pond is to temporarily store wastewater originating from the CPP during uranium recovery and aquifer restoration operations until the CPP wastewater can be blended with other sources of wastewater and treated to meet discharge standards.

The CPP wastewater stream will consist of process solutions (such as resin transfer water and brine generated from the elution and precipitation circuits), and also may contain laboratory wastewater, laundry water, plant washdown water, plant sump water, and other minor sources of liquid waste excluding domestic sewage. The CPP wastewater will be blended with well field production bleed and aquifer restoration bleed prior to final treatment to applicable standards for removal of uranium and other radionuclides.

A summary of the central plant pond size and storage capacity under each disposal option is presented in Table 5.3-3. The central plant pond has been designed to accommodate the CPP wastewater design flow plus direct precipitation from the 100-year, 24-hour storm event, while maintaining 3 feet of freeboard. As shown in Table 5.3-3, the central plant pond capacity will depend on the wastewater disposal option. The active wastewater storage capacity, excluding freeboard and reserve capacity for precipitation, will be 15.2 ac-ft for the DDW option, which is sufficient storage for approximately 287 days at the typical CPP wastewater production rate of 12 gpm. The central plant pond active wastewater storage capacity for the land application disposal option will be 35.0 ac-ft. This capacity will allow storage of up to 660 days of CPP wastewater production at 12 gpm. The central plant pond capacity allows for adequate storage for CPP wastewater during the initial project startup period when uranium recovery is occurring, but before aquifer restoration activities have started. During this time, CPP wastewater will need to be stored for approximately 18 months until groundwater sweep water is available for blending with the CPP wastewater. In addition, the larger capacity will also provide more flexibility for blending the wastewaters during normal operation. This will be necessary because the land application disposal option will be more sensitive to higher dissolved solids concentrations. A larger central plant pond also will allow for additional excess storage during the winter months when no land application will occur.

The flow rate of the CPP wastewater from the central plant pond to the radium settling pond will be adjusted according to the concentration of dissolved solids in the CPP wastewater stream. When well field bleed has relatively lower concentrations of dissolved solids, for example when restoration is near completion in a particular well field, the percentage of CPP wastewater in the disposal stream can be higher, or when well field bleed has a relatively higher concentration of

Table 5.3-3: Central Plant Pond Size and Capacity

Parameters	Units	Deep Disposal Well Option	Land Application Option
Central Plant Pond Total Capacity	ac-ft	15.9	36.2
100-year Precipitation Volume	ac-ft	0.7	1.2
Central Plant Pond Wastewater Storage Capacity	ac-ft	15.2	35.0
CPP Wastewater Flow Rate	gpm	12	12
Wastewater Storage Capacity in Time of Operation[1]	yr	0.79	1.81
	d	287	660

[1] During uranium recovery and concurrent uranium recovery and aquifer restoration. Refer to the water balance presented in Section 5.3.3.5.3.

dissolved solids (e.g., near the end of uranium recovery in a particular well field), the percentage of CPP wastewater in the disposal stream can be lower. Powertech (USA) also may choose to treat the high TDS wastewater from the CPP prior to discharge to the central plant pond or further treatment and discharge to the radium settling ponds.

5.3.4.3 Pond Leak Detection

The radium settling ponds, spare ponds, and central plant pond designs include a dual geosynthetic and clay liner system with a leak detection system (refer to Section 3.6 in Appendix 5.3-A). The primary liner and secondary liner will be separated by a geonet, which will provide a physical separation and allow fluid flow between the two liners. A minimum grade of 2 percent will be maintained across the bottom of the ponds toward a leak detection sump. Any leakage from the primary liner will be contained by the secondary liner and collected in the leak detection sump. The sump will be routinely monitored for the presence of fluid as described in Section 5.3.4.5. This leak detection sump will be monitored through a pipe installed within the impoundment wall. This pipe will allow a submersible pump to be installed within the sump for the purpose of monitoring and/or removal of fluid should a leak occur.

Detection within the leak detection sump will initiate measures to take the pond out of use, remove its contents to another pond, and initiate an investigation into the cause of, and ultimately the repair of, the condition creating the leak. The ponds are designed to be completely emptied with the use of a submersible pump.

5.3.4.4 Pond Construction

Detailed construction specifications, testing, and QA/QC procedures for the ponds are provided in Appendix 5.3-B. The following is a summary of the construction specifications and testing and inspection program for pond construction. In the following specifications “engineer” refers to a professional engineer licensed in South Dakota.

Construction specifications include the following:

i) Clearing, grubbing and stripping: The natural ground surface shall be cleared and stripped and/or grubbed of all organic and objectionable materials. The limits of stripping shall generally be 10.0 feet outside of the work activity areas.

ii) Excavation and fill placement: Excavation shall be to the lines and grades shown on the pond drawings. Excavations shall not exceed a vertical tolerance of plus or minus 0.1 foot, and a horizontal tolerance of 0.5 foot. Fill and backfill shall be placed within a vertical tolerance of plus or minus 0.1 foot, and a horizontal tolerance of 0.5 foot, unless otherwise approved by the Engineer. All precautions necessary to preserve, in an

undisturbed condition, all areas outside the lines and grades shown on the drawings, will be taken. Fill will be constructed in near horizontal layers with each layer being completed over the full length and breadth of the zone before placement of subsequent layers. Each zone will be constructed with materials meeting the specified requirements, and shall be free from lenses, pockets and layers of materials, which are substantially different in gradation from the surrounding material in the same zone. All over-sized material shall be removed from the fill material either prior to being placed, or after it is dumped and spread but prior to compaction. The Engineer will conduct testing, as discussed below, to establish suitability of all fill materials used. No fill material shall be placed until the Engineer has inspected and approved the foundation or in-place lift.

iii) Rolling: Compaction of each layer of fill shall proceed in a systematic, orderly and continuous manner that has been approved by the Engineer, to ensure that each layer receives the compaction specified. Compaction equipment shall be routed parallel to the embankment axis or the long axis of the fill zone, and overlap between roll patterns shall be a minimum of 12 inches. The rolling pattern for compaction of all zone boundaries or construction joints shall be such that the full number of passes required in one of the adjacent zones, or on one side of the construction joint, extends completely across the boundary or joint. Compaction equipment shall be of the types and sizes specified in Section 4.6 of Appendix 5.3-A.

iv) Compaction and moisture control: All material, after placing, spreading and leveling to the appropriate layer thickness shall be uniformly compacted in accordance with the requirements for each type of fill as indicated in Table 5.3-4.

v) Finishing: Finished grades shall slope uniformly between given spot and contour elevations. All grades shall provide for natural runoff of water without low spots or pockets.

Testing and Inspection Program

Inspection of earthwork will involve testing and visual examination of all materials being used for construction to establish compliance with the material requirements, moisture conditioning, spreading procedures, layer thicknesses, and compaction requirements. To ensure that satisfactory quality control is maintained and that the design objectives are achieved, specific testing requirements will be implemented for all materials placed within the Work area. Tests to be carried out will be divided into two categories; control tests and record tests. Control tests will be used to verify whether the materials comply with the specifications prior to placement. Record tests will be used during placement and after completion of the work to assess whether the work and materials meet the requirements of the specifications.

Control tests will include: i) particle size distribution for fill materials, soil liner, filter sand and riprap; ii) moisture content of fill materials and the soil liner; iii) Modified Proctor compaction tests (ASTM D1557) of fill materials and the soil liner: iv) Atterberg limits of fill materials and

Table 5.3-4: Compaction Requirements

Material	Compaction Specifications	Moisture Content
Prepared Subgrade	92% of Maximum Dry Density by ASTM D1557	+/- 3% of Optimum
Random Fill	92% of Maximum Dry Density by ASTM D1557	+/- 3% of Optimum
Soil Liner	92% of Maximum Dry Density by ASTM D1557	0 to +5% of Optimum

soil liner; v) and other tests of fill materials taken from borrow areas and on the fill, as necessary to assess whether the fill material is in compliance with the technical specifications.

The record tests will include: i) particle size distribution for fill materials, soil liner and filter sand; ii) field density test on fill materials and the soil liner; iii) moisture content of the fill materials and soil liner; iv) laboratory compaction and particle size distribution of materials recovered from select field density test locations; v) in-situ laboratory permeability tests on fill materials and the soil liner; vi) Atterberg limit tests on fill materials and the soil liner; vii) other tests on fill compacted in place as necessary to assess whether the compacted fill is in full compliance with the technical specifications.

Testing Frequencies

Geotechnical tests will be conducted to establish compliance of the work with the technical specifications. Standard procedures will be used for all tests. Tables 5.3-5 through 5.3-10 (also provided in Appendix 5.3-B) show the test methods and frequency of testing for various materials.

5.3.4.5 Pond Inspection

An inspection program will be implemented for all ponds. A detailed checklist will be developed and followed to document the observations of each significant geotechnical, structural, and hydraulic feature, including control equipment. Inspections will be conducted by trained personnel who are knowledgeable of the pond construction and safety features. Inspections will be documented and the reports retained on site for reference and inspection by regulatory authorities. Inspections will include but are not limited to the following:

- Daily inspections of the liner, liner slopes, and other earthwork features
- Daily inspections of pond freeboard to ensure adequate containment capacity is available for the 100-year, 24-hour storm
- Daily checks for water accumulation in leak detection systems
- Monthly inspection of the functionality of leak detection systems
- Quarterly inspections of embankment settlement and slope stability; unscheduled inspections will be performed after occurrence of significant earthquakes, tornadoes, intense local rainfall, or other unusual events

If these inspections reveal any damage or defects that could result in leakage, this information will be reported to the NRC within 24 hours as required by the NRC license. Appropriate repairs will be implemented as soon as possible.

Table 5.3-5: Test Methods

Test Designation[(1),(2)]	Type of Test	Test Methods (ASTM)
C1, R1	Atterberg Limits	D4318
R2a C2, R2b	Nuclear Method Moisture Content Laboratory Moisture Content	D6938 D2216
C3, R3	Particle Size Distribution	D422[(3)]
C4, R4	Laboratory Compaction	D1557
R5a R5b R5c	Nuclear Method Field Density Sand Cone Field Density Water Replacement Field Density	D6938 D1556 D5030
C6, R6	Laboratory Permeability Test	D5084
C7, R7	Riprap Particle Size Distribution	Pebble Count

Notes:

1. C- Denotes Control Tests
2. R- Denotes Record Tests
3. Hydrometer tests down to the 2-micron size will be carried out as directed by the Engineer but will generally not be required. All samples are to be wash graded over a #200 sieve.

Table 5.3-6: Test Frequency- Prepared Subgrade

Test Designation	Type of Test	Frequency (1 per)
R1	Atterberg Limits	2,000 yd^2
C2, R2a, R2b	Moisture Content	1,000 yd^2
C3, R3	Particle Size Distribution	2,000 yd^2
C4, R4	Laboratory Compaction	2,000 yd^2
R5a	Nuclear Density	1,000 yd^2
R5b	Sand Cone Density	5,000 yd^2

Table 5.3-7: Test Frequency- Random Fill

Test Designation	Type of Test	Frequency (1 per)
R1	Atterberg Limits	5,000 yd^3
C2, R2a, R2b	Moisture Content	2,500 yd^3
C3, R3	Particle Size Distribution	5,000 yd^3
C4, R4	Laboratory Compaction (Modified Proctor)	5,000 yd^3
R5a	Nuclear Density	1,000 yd^3
R5b	Sand Cone Density	10,000 yd^3
C6, R6	Laboratory Permeability Test	5,000 yd^3

Table 5.3-8: Test Frequency - Soil Liner

Test Designation	Type of Test	Frequency (1 per)
R1	Atterberg Limits	1,000 yd^3
C2, R2a, R2b	Moisture Content	500 yd^3
C3, R3	Particle Size Distribution	1,000 yd^3
C4a, R4a	Laboratory Compaction	1,000 yd^3
R5a	Nuclear Density	1,000 yd^3
R5b	Sand Cone Density	2,500 yd^3
C6, R6	Laboratory Permeability Test	1,000 yd^3

Table 5.3-9: Test Frequency - Filter Sand

Test Designation	Type of Test	Frequency (1 per)
C3, R3	Particle Size Distribution	250 yd^3

Table 5.3-10: Test Frequency - Riprap

Test Designation	Type of Test	Frequency (1 per)
C7, R7	Riprap Particle Size Distribution	1,000 yd^3

If significant water is found in the leak detection system, the water in the standpipes will be sampled immediately for indicator parameters to confirm that the water in the detection system is from the pond. The indicator parameters will be chloride and conductivity. If the analysis confirms a leak, a secondary sample shall be collected and analyzed within 24 hours. Upon confirmation of a leak by the second analysis, the pond will be taken out of service until repairs can be completed. The leak will be reported to the NRC within 24 hours of the confirmation. A pond removed from service because of a confirmed leak will be dewatered by transferring the contents to a spare pond. Regardless of the disposal option used at the project, the Dewey and Burdock areas each will have a spare pond of identical capacity, construction, and dimensions as the primary radium settling ponds. At the Burdock area, the spare pond also may serve as a spare for the central plant pond.

5.3.5 Instrumentation and Emergency Shutdown

Powertech (USA) will install automated control and data recording systems at the Satellite Facility and CPP which will provide centralized monitoring and control of the process variables including the flow rate and pressure of production, injection, and waste streams. The systems will include alarms and automatic shutoffs to detect and control a potential release or spill.

Pressure and flow sensors will be installed, for the purpose of leak detection, on the main trunklines that connect the CPP and Satellite Facility to the well fields. In addition, the flow rate of each production and injection well will be measured automatically. Measurements will be collected and transmitted to both the CPP and Satellite Facility control systems. Should pressures or flows fluctuate outside of normal operating ranges, alarms will provide immediate warning to operators which will result in a timely response and appropriate corrective action.

Both external and internal shutdown controls will be installed at each header house to provide for operator safety and spill control. The external and internal shutdown controls will be designed for automatic and remote shutdown of each header house. In the event of a header house shutdown, an alarm will occur and the flows of all injection and production wells in that header house will be stopped automatically. The alarm will activate a blinking light on the outside of the header house and will cause an alarm signal to be sent to the CPP and Satellite Facility control rooms.

An external header house shutdown will activate an electrical disconnect switch located on the outside of the header house or at the transformer pole which will shut down all electrical power to the header house. This will mitigate potential electrical hazards while de-energizing the header

house and operating equipment. The production pumps will be de-energized which will result in flow stopping from all production wells. A control valve that will close when de-energized will be used on the injection header, which will stop the flow to all injection wells.

Internal shutdown controls will not involve de-energization of the header house but will result in the same alarm condition and shutdown of flow to all production and injection wells feeding the header house.

Each header house also will include a sump equipped with a water level sensor so that if a leak occurs, and the water level approaches a preset level, the sensors will cause an automatic shutdown of the header house. A pressure switch will be installed on the injection header to ensure that fluid pressures do not exceed the maximum designated pressure of the injection wells served by that header house (refer to Section 5.3.3.5.2). If the injection pressure reaches the maximum set value in the pressure switch, an automatic header house shutdown will occur.

If an excursion or pipeline leak were to occur, procedures will be in place to address and correct it. Well field operators will conduct daily visual inspections of well field facilities, including header houses and all visible pipes, connections, and fittings. Operating flow rates and pressures of all injection wells, production wells, and associated buried piping systems also will be monitored and recorded on a daily basis. The CPP and Satellite Facility control rooms both will receive the pressure and flow data transmitted from the well fields, trunklines, and header houses. This information will provide the plant operators access to instantaneous data on well field operating conditions, enabling them to respond appropriately to unexpected or upset conditions, and allow them to direct well field operators to specific locations where immediate attention is needed.

A detailed description of the deep disposal wells operation and control is included in Section 2.K, “Injection Procedures,” of Appendix 3.4-A, which includes the Class V UIC permit application. The automated control system on the Class V deep disposal wells will include control switches to alert the operator if certain operating conditions are encountered. A high injection pressure switch (set below the permitted maximum) and a low annulus differential pressure switch (set above the permitted minimum) will shut off injection pump power and will alert the operator so that the well can be fully isolated and secured. The alarm will sound in the central control room of the CPP and/or Satellite Facility, whichever is nearer. In the event that any of the set points are exceeded, injection operations will cease immediately until the problem

is identified and corrected. The system then will be manually restarted by an operator when operating parameter compliance is verified.

5.3.6 Backup Power

Loss of power to the project site will cause production wells to stop operating, resulting in shutdown of all production and injection flows. This condition avoids flow imbalance within the well fields, but a well field bleed would not be maintained during the power failure. The time span for the aquifer to recover from operational drawdown back to its natural groundwater gradient is much longer than the duration of a typical power outage. Since ISR solutions would not begin to travel to the monitoring ring until the cone of depression caused by the bleed had recovered and groundwater had returned to its natural gradient, excursions are very unlikely within the short time period of a typical power outage.

Power outages in the permit area would not likely last more than a few days or weeks under most conceivable scenarios. Powertech (USA) will use generators onsite and may also contract for temporary generators to operate well field pumps sufficiently to maintain a cone of depression within the well field if unforeseen power outages occur with expected duration of more than a few weeks. Backup generators will be installed to maintain continuous instrumentation, monitoring and alarms in the CPP, Satellite Facility, and well fields. Backup power also will be provided for lights and emergency exits.

5.3.7 Topsoil and Spoil Handling

Topsoil will be salvaged from building sites, permanent storage areas, primary and secondary access roads, ponds and chemical storage areas prior to construction in accordance with SDCL 45-6B-7(11). Typical earth moving equipment such as rubber tired scrapers and front-end loaders will be used for topsoil stripping. Trees, large rocks, and other waste materials which may hinder redistribution of topsoil will be separated from the topsoil before stockpiling.

Plates 5.3-1 and 5.3-2 show the proposed locations of topsoil and spoil stockpiles for the processing facilities and ponds in the land application and deep disposal well option, respectively. Topsoil and spoil stockpile locations for the well fields will be designated during final well field design, and Plates 5.3-1 and 5.3-2 will be updated accordingly. Topsoil and spoil stockpiles will be located in a manner to facilitate reclamation by placing the piles near the locations where they will be used. Topsoil and spoil piles associated with the CPP, Satellite Facility and associated ponds will be placed near the processing facilities. Topsoil and spoil piles

for the access roads and well fields will be placed near the roads and well fields to minimize the haul distance.

The estimated topsoil stockpile volumes for the processing facilities and ponds are 100,000 to 200,000 cubic yards in the Burdock area and 50,000 to 100,000 cubic yards in the Dewey area. In the initial Burdock well field, the anticipated topsoil salvage depth is estimated to range from 0 to 3 feet and average approximately 1.0 foot (from the baseline soil survey in Appendix 5.3-A). In the initial Dewey well field, the anticipated topsoil salvage depth is estimated to range from 0 to 1.67 feet and average approximately 0.15 foot. The total anticipated topsoil stripping area over the life of the Dewey-Burdock Project is estimated to be approximately 250 acres in the deep disposal well option and 440 acres in the land application option. The maximum area of construction disturbance and associated topsoil stripping at any one time will be approximately 100 acres in the deep disposal well option and 300 acres in the land application option.

Salvaged topsoil will be stored in designated topsoil stockpiles in accordance with SDCL 45-6B-40. These stockpiles will be located such that losses from wind erosion are minimized. Additionally, topsoil stockpiles will not be located in any drainage channels or other locations subject to flooding. Berms will be constructed around the perimeter of stockpiles and the stockpiles will be seeded with the approved seed mix to help minimize erosion. Additionally, all topsoil piles will be identified with highly visible signs.

During excavations of mud pits associated with exploration drilling and delineation drilling activities, topsoil will be separated from the subsoil with a backhoe. First the topsoil will be removed and placed at a separate location and then the subsoil will be removed and deposited next to the mud pit. Usually within 30 days of the initial excavation, use of the mud pit will be complete, the subsoil will be redeposited in the mud pit followed by replacing topsoil. During the construction of well fields and pipeline ditch construction, topsoil and subsoil will be temporarily accumulated near the excavation during construction, then redistributed after construction activities are complete. The temporary stockpiles will be marked in the field, constructed to minimize wind erosion, and placed outside of drainages.

In only limited instances will more material be excavated (spoil) than is required for facility construction. This will include pond and diversion channel construction. Spoil will be handled in accordance with ARSD 74:29:07:14 requirements. Spoil will be stockpiled separately from topsoil stockpiles and identified with highly visible signs. The footprint of the spoil stockpiles will have the topsoil stripped prior to placement of the spoil. The spoil stockpiles will be located

such that losses from wind and water erosion are minimized and will not be located in drainage channels. Berms will be constructed around the perimeter of the spoil stockpiles.

Spoil material is not anticipated to be acid forming, toxic, or a source of water pollution. The baseline soil sampling results in Appendix 3.3-A show that only in limited instances were the pH levels within sampled soil profiles deemed unsuitable as a plant growth medium according to the guideline used for comparison. If any spoil material is suspected of being acid forming, toxic, or capable of causing water pollution, Powertech (USA) will sample the material and have it analyzed for pH and other parameters deemed necessary by DENR. If the material is determined to have potential to cause water pollution, Powertech (USA) will prepare a plan for mitigating the condition in accordance with ARSD 74:29:07:14(3) and (4). Potential mitigation measures include disposing the spoil material in an appropriately permitted landfill and using suitable spoil material excavated from another area as a replacement during backfill. Since it is not anticipated that spoil material will be acid forming, toxic, or a source of water pollution, only minimal changes in the postmining topography are expected due to disposing unsuitable spoil material.

5.3.8 Roads

Roads in the permit area are classified as existing county roads, existing private roads, primary access roads, secondary access roads, and light-use roads (tertiary access roads). The roads are depicted on Plate 5.3-5. Construction of roads within the permit area will conform to ARSD 74:29:07:12.

Existing County and Private Roads

South Dewey Road (County Road 6463) is located within the permit boundary as shown on Plate 5.3-5. The maintenance of this existing road will remain the responsibility of Fall River County and Custer County. Powertech (USA) will work with both counties to help pay for maintenance costs and dust control of affected county roads.

Powertech (USA) will use existing private roads within the permit area to the maximum extent possible to minimize disturbance due to access road construction.

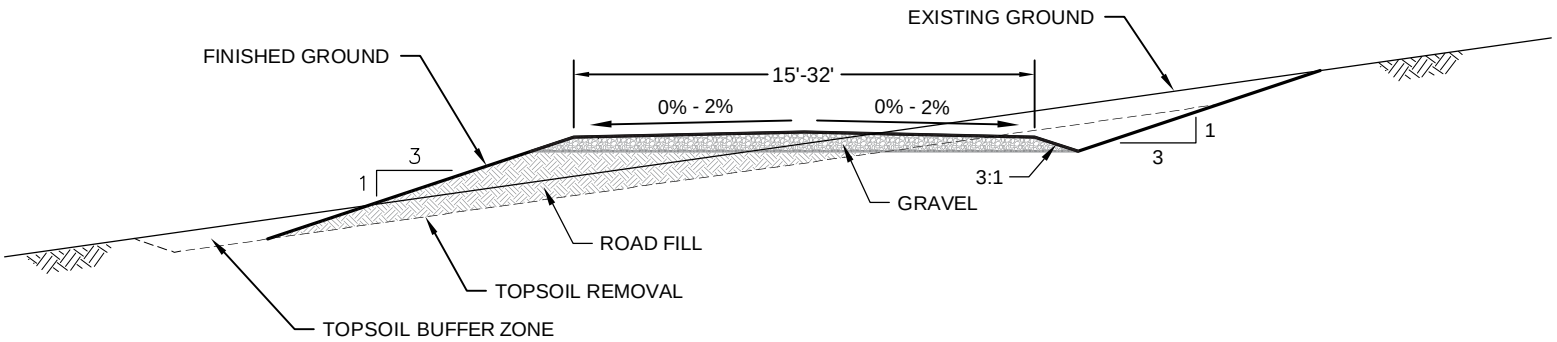
Primary Access Roads

The CPP and Satellite Facility each will be accessed by one primary access road from South Dewey Road, as shown on Plate 5.3-5. The typical cross section for the access roads is presented in Figure 5.3-17.

Topsoil will be salvaged from the roadbed area prior to construction. Topsoil will be placed in designated stockpiles near the access roads. Topsoil handling is described in the previous section. Topsoil will be redistributed on the roadbed when the road is removed and reclaimed as described in Section 6.4.3.3. To the extent possible, existing private roads will be upgraded and used for primary access roads. If existing private roads require upgrades, topsoil will be removed and stockpiled. Roads will be upgraded to the typical access road standards as presented in Figure 5.3-17.

Access road side slopes and disturbed areas will be seeded with the approved seed mixture. The surfacing of the roads will be gravel. Road surfaces, ditching, and cross drainage will provide adequate drainage. Crossing of major drainages will include the installation of culverts, which are shown on Plate 5.3-5. Culverts will be sized and constructed to avoid plugging, collapsing and minimizing erosion at the inlet and outlet of the culverts. The table on Plate 5.3-5 provides a summary of the preliminary culvert sizing for the primary and secondary access roads. The well field designs are preliminary, and the access road alignments and culverts sizes and locations are subject to change. Powertech (USA) will coordinate revisions with DENR during final design of each well field. Primary access road culverts will be designed to convey the discharge from a 10-year, 24-hour precipitation event.

Maintenance of all access roads will be performed routinely and will include grading, gravel replacement, and dust control as needed.



This figure is provided to fulfill the requirements of ARSD 74:29:07:12.

Road Type	Top Width (ft)
Primary Access Road	28 - 32
Secondary Access Road	15 - 24

Figure 5.3-17

Typical Access Road Cross Section

Dewey-Burdock Project

SIGNATURE OF PREPARER	Dale E. Brown
PREPARER	Dale Brown
DATE	26-Sep-2012
FILE	ACCESS_TYP.DWG

POWERTECH (USA) INC.

Secondary Access Roads

Secondary access roads will be used for the transportation of personnel and equipment within the permit area. Parking areas and roads near the CPP and Satellite Facility and laydown areas also are classified as secondary access roads. Secondary access roads are shown on Plate 5.3-5.

Secondary access road construction, topsoil handling, drainage and surfacing will be the same as the primary access road. The travel width of secondary access roads will be narrower as shown in Figure 5.3-17 due to the lower traffic demands compared to primary access road. Secondary access road culverts will be designed to convey at a minimum the discharge from a 2-year, 6-hour precipitation event.

Light-Use Roads (Tertiary Access Roads)

These roads are essentially non-constructed, two-track trails. Existing ranch or private roads established by previous landowners will be used to the extent possible. The primary use of these roads will be to access monitoring sites using light trucks or other passenger vehicles. The locations of these roads are shown on Plate 5.3-5.

Light-use roads will be maintained as necessary to minimize erosion. Crossing of major drainages will be kept at a minimum and such crossings will be dry weather only crossings.

5.3.9 Water Management and Erosion Control

Pursuant to ARSD 74:28:02:11, a sediment control plan will be implemented during and after ISR operations to reduce soil loss within the permit area. Ditches, diversions, sediment traps/ponds, culverts, and other best management practices (BMPs) will be used to control surface water flow within the permit boundary. Plates 5.3-6 through 5.3-8 show the plan for water control. See Appendix 5.3-B for details on diversions in and around the facility areas.

Powertech (USA) has evaluated flood inundation boundaries and will construct facilities outside of these boundaries to avoid potential impacts to facilities from flooding and potential impacts to Beaver Creek and Pass Creek in the event of any potential spills or leaks. Where possible, facilities will be located outside of the 100-year flood inundation boundaries. Pipelines will be buried below the frost line and will not be subject to flooding. Pipeline valve stations will be located outside of the 100-year flood inundation boundaries. Facilities which must be located within flood inundation boundaries will be protected from flood damage by the use of straw bales, collector ditches, and/or berms. If it is necessary to place a well head within a flood inundation boundary, diversions or erosion control structures will be constructed to divert flow and protect the well head. The well head also will be sealed to withstand brief periods of

submergence. Figures 5.3-10 and 5.3-11 show that all ISR wells and monitor wells will be sealed.

Estimates of peak flood discharges and water levels produced by floods on Pass Creek, Beaver Creek and local small drainages are provided in Section 3.5.2.3 and Appendix 3.5-A. Plate 3.5-1 depicts the modeled flood inundation areas for all surface water features during the 100-year, 24-hour storm event in relation to proposed facilities and infrastructure. As described in Appendix 3.5-A, HEC-HMS models were used to calculate peak discharges, and HEC-RAS models were used to compute water-surface profiles and inundated areas for the respective runoff events.

Any disturbance to the prevailing hydrologic balance of the affected land and of the surrounding area and to the quality and quantity of water in surface water systems both during and after ISR operations and during reclamation will be minimized in accordance with SDCL 45-6B-41. No diversions will be constructed on perennial stream channels, and only relatively minor quantities of surface runoff will be captured in sediment ponds. Therefore, little or no impacts to the surface water hydrologic balance will occur. Surface water quality will be protected through erosion control BMPs and sediment control measures described below. Section 5.6.5 describes mitigation measures to protect surface and groundwater from potential leaks or spills.

5.3.9.1 Diversion Channels

Following is a description of the diversion channels that will be constructed within the permit area for the processing facilities and ephemeral stream channels.

Diversion channel designs for the processing facilities in the DDW option are provided on Plates 5.3-13 and 5.3-14. These supersede the diversion channel designs for the processing facilities in the DDW option in Appendix 5.3-B. In accordance with ARSD 74:29:07:09(6), the diversions around the CPP, Satellite Facility and associated radium settling ponds and central plant pond have been designed for the 6-hour PMP event. Diversions were not designed for the PMP event around the storage ponds or spare storage ponds, since these ponds are not part of uranium processing and will store only treated water. In the land application option, no diversions will be required around the processing facilities, radium settling ponds or central plant pond due to the small drainage area above these facilities.

With the exception of Beaver Creek, all stream channels within the permit area are ephemeral. Pass Creek above the permit area could be considered intermittent, but it is ephemeral within the permit area since there is no groundwater component and flows only occur in response to

precipitation or snowmelt events. No diversions are planned on Beaver Creek or Pass Creek, and no diversions are planned on perennial or intermittent streams.

Plates 5.3-6 and 5.3-7 provide the locations of planned ephemeral stream channels within the permit area. The designs for the diversions associated with the initial well fields and land application areas are presented on Plates 5.3-9 through 5.3-11. Diversion designs for future well fields, if needed, will be provided to DENR for review and verification prior to construction.

Diversions of ephemeral channels will be designed to maintain channel velocities equal to or less than 5 feet per second for the discharge from a 2-year, 6-hour precipitation event and have the ability to contain the discharge from a 100-year, 24-hour precipitation event.

Interim revegetation will be performed on the bottoms and side slopes of all diversions to reduce erosion. In instances where the diversion channel velocity during the design storm exceeds 5 feet per second, other erosion control measures will be implemented such as geosynthetic liners, geosynthetic filter media, or riprap. Diversions will be constructed with 3:1 or shallower side slopes to reduce the risk of slope failure, promote interim revegetation, and allow safe passage for humans, wildlife and livestock. Diversion bottom elevations will tie to undisturbed upstream and downstream channel elevations to eliminate increased erosion potential. Diversions will not discharge onto topsoil or spoil stockpiles or other unconsolidated material such as newly reclaimed areas. Culvert or bridge crossings over the diversions are not planned. If it becomes necessary to cross a diversion in the future, Powertech will submit design drawings to DENR for review and approval prior to construction.

5.3.9.2 Erosion Control

Powertech (USA) will minimize erosion of disturbed, reclaimed and native areas through proper land management and farming techniques. Typically, following ground disturbance, areas will be prepared and seeded as soon as possible to reduce the possibility of erosion. Also, erosion control measures will be used to reduce overland flow velocity, reduce runoff volume or trap sediment. Examples include rip-rap, vegetative sediment filters, check dams, mulches, cover crops, and other measures. Plates 5.3-6 through 5.3-8 show the sediment control measures that will be used in the permit area.

5.3.9.3 Sediment Control Plan

The greatest potential for erosion and sedimentation will occur during the construction and decommissioning phases of the project. To mitigate soil loss Powertech (USA) will minimize the surface disturbance to soil and vegetation by using existing roads where possible, limiting secondary and tertiary road widths, and locating access roads adjacent to utility corridors. Powertech (USA) also will limit the sediment mobility by reseeding disturbed areas as soon as possible. Sediment control structures will be most critical while the well field is being constructed and immediately after redistributing topsoil.

Plates 5.3-6 through 5.3-8 show the sediment control measures that will be implemented in the permit area. These include sediment ponds, traps, and other Alternative Sediment Control Measures (ASCMs). Areas that will use silt fence have not been shown on the sediment control maps. Silt fence typically will be used at the toes of disturbed slopes to trap sediment caused by sheet flow. ASCMs will be used in drainages below projected disturbance to capture sediment. Several sediment control ponds also are planned to service larger drainage areas. Sediment pond designs for the first two well fields are provided on Plates 5.3-12 and 5.3-13. Other sediment pond designs will be completed following delineation of future well fields and will be provided to DENR for review and verification prior to construction.

To select the type of sediment control structure, a breakdown of drainage basin acreage was developed to provide general guidance. The following sediment control structures were designated for corresponding drainage basin sizes:

- Silt fence – sheet flow
- Straw bale check dam – 0 to 5 acres
- Reinforced silt fence – 5 to 10 acres
- Incised sediment trap – 10 to 20 acres
- Sediment fence check dam – 20 to 30 acres
- Single fence rock check dam – 30 to 40 acres
- Loose rock check dam – 40 to 50 acres
- Wire-bound rock check dam – 50 to 60 acres
- Sediment pond – 60 acres and greater

The design criteria for sediment ponds and ASCM structures will vary depending upon the length of time that the structure will be required. The proposed design event for sediment control structures associated with well field construction is the 5-year, 24-hour precipitation

event. This is justified on the basis that typical well field construction is anticipated to be approximately 2 years per well field, during which time topsoil will be redistributed and revegetated as portions of the well field are completed. The runoff volume for the precipitation event will be calculated using the NRCS triangular hydrograph method. Any number of computerized models (HEC-HMS TRIHYDRO, SEDCAD, TR-20, etc.) may be used to conduct the hydrologic analysis. Ponds also will be sized to contain 2 years of sediment accumulation. Sediment volumes will be calculated using the revised soil loss equation (Renard et al., 1990). For structures in areas that will be disturbed for more than 5 years, the design criteria will be the capacity for the runoff from a 10-year, 24-hour precipitation event and 3 years of sediment accumulation.

Throughout the life of the project, Powertech (USA) will identify potential sources of pollution and determine BMPs to be used, including erosion and sediment controls (e.g., silt fence, straw bale check dams, etc.) and operational controls (e.g., housekeeping, signage, etc.).

Quarterly inspections of sediment ponds will be conducted by trained personnel who are knowledgeable of pond construction and safety features. A detailed checklist will be developed and followed to document the pond structural and erosional condition. Inspections will be documented and the reports retained on site for reference and inspection by regulatory agencies.

5.4 Waste Management

This section describes the types, quantities and management of wastes associated with the Dewey-Burdock Project. Liquid and solid wastes are divided into two general categories: Atomic Energy Act (AEA)-regulated waste and non-AEA-regulated waste. AEA-regulated waste includes liquids and solids meeting the definition of "byproduct material" in 10 CFR § 40.4: "The tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content." This is also referred to as "11e.(2) byproduct material." All other waste is classified as non-AEA-regulated waste.

5.4.1 AEA-Regulated Waste

5.4.1.1 Wastewater Associated with ISR Operations

This section describes the disposal methods for wastewater associated with ISR operations from the Dewey-Burdock Project. Wastewater associated with ISR operations includes the production bleed, groundwater generated during aquifer restoration, process solutions (such as resin transfer water and brine generated from the elution and precipitation circuits), affected well development

water, laboratory wastewater, laundry water, plant wash down water, and decontamination/decommissioning solutions from surface facilities.

Powertech (USA) proposes two options for the disposal of wastewater associated with ISR operations. The preferred disposal option is underground injection of treated liquid waste in non-hazardous Class V DDWs. In this disposal option, wastewater will be treated to meet EPA non-hazardous waste requirements and injected into the Minnelusa and/or Deadwood formations in four to eight DDWs permitted pursuant to the SDWA through the EPA UIC Program. It is anticipated that all wastewater will be disposed using this option if sufficient capacity is available in DDWs. Additional details about the design of the DDWs are provided below.

The alternate wastewater disposal option is land application. This option involves treatment in lined radium settling ponds followed by seasonal application of treated wastewater through center pivot sprinklers. Land application will be carried out under a GDP permitted through DENR. Depending on the availability and capacity of DDWs, Powertech (USA) may use land application in conjunction with DDWs or by itself. An overview of the land application system design and operation is provided below.

Both wastewater disposal options involve the use of lined ponds, which are described in Section 5.3.4.

5.4.1.1.1 Deep Disposal Wells

Powertech (USA) submitted a Class V UIC permit application (Appendix 3.4-A) to EPA Region 8 in March 2010 for authorization to install and operate DDWs within the permit area. DDWs will target the Pennsylvanian and Permian-age Minnelusa Formation and the Cambrian-age Deadwood Formation. The targeted injection interval in the Minnelusa Formation ranges from 1,615 to 2,540 feet below ground surface (bgs), and the targeted injection interval in the Deadwood Formation ranges from 3,095 to 3,530 feet bgs.

Powertech (USA) has requested an Area Permit authorizing the installation and operation of four to eight DDWs within the permit area. The number of wells required will depend on well capacity. Powertech (USA) has requested authorization to inject up to 300 gpm total in a maximum of eight wells. Proposed locations for the first four wells are provided in Figure 5.3-2. The initial four DDWs are proposed at two sites, one near the Satellite Facility and one near the CPP. Two disposal wells are proposed at each site with one well targeting the Minnelusa Formation and one targeting the Deadwood Formation. Based on the anticipated porosity,

thickness, lateral extent, and permeability of the receiving formations, the capacity of each Class V DDW is expected to range from 50 to 75 gpm.

Prior to Class V DDW disposal, wastewater will be treated as necessary to comply with non-hazardous Class V UIC requirements. Treatment methods are described in Section 5.4.1.1.3. Surface facilities near the CPP and Satellite Facility related to wastewater disposal in the DDW option will include radium settling ponds, outlet and surge ponds, a central plant pond located at the CPP, and surface facilities required for DDW operation such as pretreatment facilities, screens/filters, and high pressure pumps for DDWs. Proposed facilities for the deep disposal option are depicted on Figure 5.3-2.

In the DDW option, RO treatment with permeate injection will be the primary method of aquifer restoration. Groundwater withdrawn during aquifer restoration will be treated using RO, and the resulting brine will be treated and disposed with other treated wastewater in DDWs. The water balance is presented in Section 5.3.3.5.3.

5.4.1.1.2 Land Application Systems

In the land application option, land application will occur at two areas, one near the Satellite Facility, and one near the CPP. Land application systems have been designed to apply water at agronomic rates that prevent runoff and limit the potential for deep percolation beneath the land application areas. Hydrologic modeling presented in the GDP demonstrates that groundwater is not expected to be impacted by the proposed land application systems. Nevertheless, Powertech (USA) will establish perimeter of operational pollution (POP) zones in the alluvial groundwater systems with alluvial compliance monitor wells to ensure protection of waters of the State of South Dakota. The proposed land application systems are separated from bedrock aquifers by some 25 to 500 feet of Graneros Group shales, which will eliminate any potential to impact bedrock aquifers.

Each land application system will consist of irrigation center pivots, associated pumps and piping, and catchment areas. Catchment areas will be designed to capture precipitation and runoff from land application areas up to the 100-year, 24-hour precipitation event. Associated facilities include radium settling ponds and storage ponds. Wastewater will be treated to remove radionuclides in lined radium settling ponds. Treated water will be stored temporarily in lined storage ponds and then seasonally applied to the land application areas through center pivots. Powertech (USA) anticipates that land application will typically occur during late March through October, but it could occur during other times of the year weather permitting. Adequate capacity in the storage ponds will provide storage during the months when land application will not be

used (typically November through early March). Additional design information for the land application systems is presented in the GDP. Figure 5.3-1 depicts the proposed facilities in the land application option.

Each of the two land application systems will have up to 315 acres of irrigated area and an additional 65 acres of center pivots on standby. Each of the two land application systems is designed for an average annual application rate of 310 gpm and an instantaneous application rate of 297 to 653 gpm.

In the land application option, groundwater withdrawn during aquifer restoration will not be treated with RO. Instead, the aquifer restoration water will be disposed directly in land application systems following treatment to remove uranium and radium. The water balance for the land application option is presented in Section 5.3.3.5.3.

Following is a summary of how the proposed land application systems satisfy specific site evaluation and compatibility criteria in ARSD 74:29:05:16.

Potential Impacts to Wildlife Grazing in Land Application Areas (ARSD 74:29:05:16(1))

Potential impacts to wildlife grazing in the land application areas will be minimized through treating the land application effluent prior to application, monitoring vegetation within land application areas, and evaluating the monitoring results annually to detect potential increasing trends in constituent concentrations. As a condition of the GDP, the land application water quality will be required to meet effluent limits established by DENR that are protective of groundwater quality. Section 5.4.1.1.4.1 describes the anticipated land application water quality. Trace metal concentrations are anticipated to be at or below ARSD 74:54:01:04 human health standards. Radionuclide concentrations will be below 10 CFR Part 20, Appendix B, Table 2, Column 2 effluent limits for release of radionuclides to the environment. The suitability of land application vegetation to wildlife grazing will be verified through annual vegetation monitoring in the land application areas. Section 5.5.6.2 describe how vegetation in the land application areas will be sampled each year. Section 5.5.6.2 describes how this information will be evaluated annually and the results reported to DENR to determine whether there is any risk to wildlife.

Compatibility with Site Geology ((ARSD 74:29:05:16(2))

The site geology is well suited to land application. The depth to alluvial groundwater, where encountered, is greater than the maximum anticipated infiltration depth of the land application water. The Graneros Group shales will prevent the land application water from reaching bedrock

aquifers. The thickness of the Graneros Group is approximately 500 to 550 feet beneath the proposed Dewey land application area and approximately 25 to 250 feet beneath the proposed Burdock land application area. Refer to Cross Sections 3.2-23 through 3.2-27, which depict the thickness of the Graneros within the proposed land application areas.

Compatibility of Slopes with Land Application Systems (ARSD 74:29:05:16(5))

In the proposed Dewey land application area, the average slope is approximately 3.5 percent. The maximum slope is between 15 and 25 percent in a small area (approximately 5 acres) at the northern edge of one proposed land application area (refer to page 5.3-B-42 in Appendix 5.3-B). In the proposed Burdock land application area, the average slope is approximately 2 percent. Only about 2 acres of the proposed Burdock land application area has a slope greater than 15 percent (refer to page 5.3-B-43 in Appendix B). These slopes will be compatible with center pivot irrigation.

During final design of the land application systems and catchment areas, Powertech (USA) will evaluate any areas with slopes greater than 15 percent to determine whether they can be avoided or whether they require mitigation. The evaluation will consider the maximum manufacturer-recommended slope based on the center pivot climbing capability and ground clearance requirements. It also will consider whether regrading will be necessary to reduce the potential for runoff and erosion. It is currently anticipated that approximately 5 acres in the proposed Dewey land application area and 2 acres in the proposed Burdock land application area will be regraded to a maximum slope of 15 percent unless these areas are avoided during final design.

Potential for Erosion (ARSD 74:29:05:16(6))

The potential for erosion within the land application areas will be minimized through siting land application areas in relatively flat terrain, maintaining vegetation, optimizing the irrigation rate to avoid runoff, using low-impact sprinkler heads, and capturing any runoff in catchment areas. The average slopes in the proposed land application areas are 2 to 3.5 percent. Small areas with slopes greater than 15 percent are anticipated to be regraded to minimize the potential for erosion and to meet the maximum manufacturer-recommended slopes for the center pivots. Relatively flat slopes along with maintenance of the land application areas in a vegetated state will limit the potential for erosion. The land application water will be applied at an agronomic rate to prevent runoff into the catchment areas. Should runoff from precipitation or snowmelt occur, the runoff and sediment will be captured in the catchment areas and will not reach perennial or ephemeral stream channels.

Daily inspections of the land application areas and catchment berms during operation of the land application systems will determine whether there are any unplanned effects such as erosion.

Distance to Flowing Streams (ARSD 74:29:05:16(7))

Beaver Creek is the only flowing stream within the proposed permit area. The minimum distance from a proposed Dewey land application area to Beaver Creek is approximately 280 feet. The minimum distance from a proposed Burdock land application area to Beaver Creek is approximately 1.1 miles.

Potential Impacts to Adjacent Land Uses (ARSD 74:29:05:16(8))

Land uses adjacent to the proposed land application areas includes livestock grazing on rangeland and recreational use (primarily hunting) on private lands. No effects from land application on adjacent land uses are anticipated due to the operation of land application systems to minimize overspray and due to Powertech (USA)'s commitment to limit hunting within the proposed permit area. Section 3.1.2 describes how Powertech (USA) will work with BLM, SDGF&P and private landowners to limit hunting within the proposed permit area to the extent practicable.

Consideration of Weather Conditions (ARSD 74:29:05:16(9))

Prior to operation of the land application systems, Powertech (USA) will develop a standard operating procedure (SOP) for land application system operation that will include provisions to minimize overspray outside of the center pivot areas. The SOP will include using the results of meteorological monitoring (wind speed, wind direction and temperature) to modify operating parameters. It will include maximum wind speed/wind direction combinations for land application system operation. The SOP also will address precipitation thresholds to avoid land application during heavy or prolonged precipitation events. Temperature thresholds also will be included to avoid land application when water cannot infiltrate due to frozen ground.

5.4.1.1.3 Wastewater Treatment

Prior to discharge to the storage ponds, Powertech (USA) will treat all wastewater associated with ISR operations to meet the requirements of 10 CFR 20, Appendix B, Table 2, Column 2, which are the established limits for discharge of radionuclides to the environment and include limits for natural uranium, radium-226, lead-210 and thorium-230 (see Table 5.4-1). Powertech (USA) anticipates that the GDP will include effluent limits established according to ARSD 74:54:01:04 groundwater standards and ambient alluvial water quality. Treatment will be accomplished by ion exchange for uranium removal followed by radium removal through co-

precipitation with barium sulfate in radium settling ponds. It is not anticipated that thorium-230, lead-210 or other radionuclides will be present at concentrations above the limits. If concentrations in the storage ponds are above the release limits, the effluent will be treated as necessary to satisfy the GDP limits.

5.4.1.1.4 Treated Wastewater Quality

The types of wastewater that will be disposed in the DDWs or land application systems include production bleed, groundwater generated during aquifer restoration, affected groundwater generated during well development, and liquid process waste such as resin transfer water and the brine generated during uranium processing. Of these, the largest contributors will be the production bleed and groundwater generated during aquifer restoration.

Table 5.4-2 presents the estimated end-of-production water quality in the ISR well fields. This represents the untreated water quality extracted from the ore zone at the end of uranium recovery and at the beginning of aquifer restoration. This table represents the worst-case water quality

Table 5.4-1: Anticipated NRC Effluent Limits for DDWs or Land Application

Radionuclide	Anticipated Effluent Limits		Analytical Method
	µCi/ml	pCi/L	
Lead-210	1E-8	10	E903.0
Radium-226	6E-8	60	E908.0
Uranium-natural	3E-7	300	E907.0
Thorium-230	1E-7	100	E905.0

Source: 10 CFR 20, Appendix B, Table 2, Column 2

Table 5.4-2: SAR, ESP and RSC Calculations for Dewey and Burdock End-of-Production Groundwater Quality

	Dewey					Burdock				
Constituent	**(mg/L)**	**(meq/L)**	**ESP**	**RSC**	**SAR**	**(mg/L)**	**(meq/L)**	**ESP**	**RSC**	**SAR**
CO_3	0.5	0.02				0.50	0.02			
HCO_3	25	0.41				25.00	0.41			
Cl	1,300	36.67				1,300	36.67			
SO_4	1,000	20.82				1,800	37.48			
Na	270	11.74				190	8.26			
Ca	730	36.43				970	48.40			
Mg	120	9.87	2.29	-45.87	2.44	220	18.09	0.85	-66.07	1.43
K	20	0.51				10	0.26			
Total Ion Bal.		0.54					0.29			
SAR (measured)	4.9					2.8				
pH (s.u.)	6.5-7.5					6.5-7.5				
TDS (mg/L)	4,500					4,500				
Spec. Cond. (µS/cm)	5,000					5,000				
As	0.01					0.01				
V	<10					6				

Notes: SAR = sodium adsorption ratio
ESP = exchangeable sodium percentage
RSC = residual sodium carbonate

encountered in the well fields, and it was used to estimate the range of concentrations of the treated effluent proposed for land application after accounting for treatment and blending.

5.4.1.1.4.1 Land Application Water Quality

The typical water quality during land application will be better than that shown in Table 5.4-2, since the water quality will be continually improving during aquifer restoration. Table 5.4-3 presents the anticipated land application water quality. The upper values shown in this table represent the estimated worst-case water quality to be land applied. The typical land application water quality will be better than the upper values, since multiple well fields typically will be in various stages of production and aquifer restoration at one time, with water quality gradually degrading toward the worst case during production and gradually improving to approximately baseline water quality during restoration. In addition, Madison water may be used at any time to improve the land application water quality.

It is anticipated that trace metal concentrations will be at or below ARSD 74:54:01:04 human health standards. In addition, the effluent concentration limits will be met for the release of radionuclides to the environment as defined in 10 CFR Part 20, Appendix B, Table 2, Column 2. This will be accomplished through treating the water as described previously.

The values shown in Tables 5.4-2 and 5.4-3 were estimated by Powertech (USA) based on results of laboratory-scale leach tests conducted on ore samples from the project sandstones, as well as from historical end-of-production water quality data from other ISR facilities in Wyoming and Nebraska, with adjustments as necessary to account for planned post-production water treatment(s).

The primary source of land application water, production and restoration bleed, will result from multiple well fields undergoing differing phases of production and restoration. During production, the concentrations of dissolved constituents in each well field will gradually increase from the baseline quality to the post-production quality estimated in Table 5.4-2. During restoration, the water quality will be returned to approximately baseline water quality. The water from multiple well fields will be combined in the storage ponds, where increasing concentrations from producing well fields will be offset by decreasing concentrations from well fields undergoing restoration. This, combined with adequate pond capacity, will ensure that the land application water has relatively consistent water quality throughout the project duration. Additional information is found in the GDP.

Table 5.4-3: Estimated Land Application Water Quality

Analyte	Units	Land Application Water Estimate
Physical Properties		
pH	s.u.	6.5 - 7.5
Total dissolved solids (TDS)	mg/L	1,000 - 5,000
Electrical conductivity	umhos/cm	1,500 - 6,000
Common Elements and Ions		
Bicarbonate	mg/L	50 - 300
Calcium	mg/L	200 - 1,000
Carbonate	mg/L	<1
Chloride	mg/L	300 - 1300
Magnesium	mg/L	50 - 300
Potassium	mg/L	10
Sodium	mg/L	100 - 500
Sulfate	mg/L	500 - 2,000
Sodium adsorption ratio (SAR)	unitless	2 - 6
Minor Ions and Trace Elements		
Arsenic	mg/L	0.01
Barium	mg/L	0.4
Cadmium	mg/L	0.3
Chromium	mg/L	0.4
Copper	mg/L	0.3
Iron	mg/L	0.2
Molybdenum	mg/L	<0.1
Nickel	mg/L	0.3
Selenium	mg/L	<0.2
Vanadium	mg/L	<10
Radiological Parameters		
Lead-210	pCi/L	<10
Radium-226	pCi/L	<60
Thorium-230	pCi/L	<100
U-natural	pCi/L	<300

Note: Estimates of land application water quality were based on the results of laboratory scale leach tests conducted on ore samples from the Dewey (Fall River) and Burdock (Chilson) sites, as well as from historical end-of-production water quality data from other ISR sites in Wyoming and Nebraska, with adjustments as necessary to account for planned post-production water treatments.

5.4.1.1.4.2 Deep Disposal Well Water Quality

Table 5.4-4 shows the estimated water quality of various liquid waste streams for the Highland ISR Facility. The wastewater from the Dewey-Burdock Project is expected to fall within the broad ranges of concentrations shown in the table because both the Dewey-Burdock Project and Highland ISR Facility will use virtually identical processes and chemistry during ISR operations. The column labeled "Restoration Wastes" is expected to be representative of the quality of the production bleed and the restoration composite streams at the Dewey- Burdock Project prior to treatment. For the DDW liquid waste disposal option, the restoration composite will be treated with RO and the resulting brine will be combined with other liquid waste (e.g., production bleed, process solutions, etc.) in the lined ponds prior to disposal in the DDWs. In the DDW liquid waste disposal option, the water quality of the composite liquid waste stream will resemble the first four columns in Table 5.4-4 depending on the specific contribution from each of the liquid waste sources, except that the liquid waste will be treated to remove uranium, radium-226 and gross alpha.

5.4.1.2 Solid 11.e(2) Byproduct Material

Solid 11e.(2) byproduct material will include spent resins and process sludges, including pond sludges; spent sand, disposable filters, or other process media; solid waste such as spent resin from shaker screens; contaminated personal protective equipment; rags or other wastes from cleanup of spills or other housekeeping activities; and, potentially, small amounts of contaminated soil from leaks and/or spills. Additional solid 11e.(2) byproduct material will include contaminated piping and equipment as result of use and/or contact with process streams. Contaminated equipment will be generated primarily during decommissioning. Some contaminated equipment will be decontaminated and released as non-11e.(2) byproduct material in accordance with NRC license conditions.

Solid 11e.(2) byproduct material will be accumulated temporarily at designated on-site locations pending further evaluation and/or shipment offsite. Pond sludge will be accumulated temporarily in the lined ponds until it is removed during decommissioning. Other solid 11e.(2) byproduct material will be accumulated temporarily in byproduct storage buildings as described in Section 5.3.1.2.9. 11e.(2) byproduct material storage areas will be in designated restricted access areas to minimize any potential exposure or contamination.

Table 5.4-4: Estimated Process Wastewater Quality

Estimated Flow Rates and Constituents in Liquid Waste Streams for the Highland In-Situ Leach Facility*					
	Water Softener Brine	**Resin Rinse**	**Elution Bleed**	**Yellowcake Wash Water**	**Restoration Wastes**
Flow Rate, gal/min	1	<3	3	7	450
As, ppm					0.1–0.3
Ca, ppm	3,000–5,000				
Cl, ppm	15,000–20,000	10,000–15,000	12,000–15,000	4,000–6,000	
CO_3, ppm		500–800			300–600
HCO_3, ppm		600–900			400–700
Mg, ppm	1,000–2,000				
Na, ppm	10,000–15,000	6,000–11,000	6,000–8,000	3,000–4,000	380–720
NH_4, ppm			640–180		
Se, ppm					0.05–0.15
Ra-226, pCi/L	<5	100–200	100–300	20–50	50–100
SO_4, ppm					100–200
Th-230, pCi/L	<5	50–100	10–30	10–20	50–150
U, ppm	<1	1–3	5–10	3–5	<1
Gross Alpha, pCi/L					2,000–3,000
Gross Beta, pCi/L					2,500–3,500
*NRC. NUREG–0489, "Final Environmental Statement Related to Operation of Highland Uranium"					

Source: NUREG-1910, Table 2.7-3 (NRC 2009)

5.4.2 Non-AEA-Regulated Waste

The Dewey-Burdock Project will generate small quantities of non-radioactive, solid and liquid waste as described below. These wastes will be managed in compliance with EPA, DENR, and county regulations addressing solid waste, hazardous waste, used oil, and non-AEA-regulated liquid waste such as domestic waste and stormwater runoff. These wastes also will be managed in accordance with NRC license requirements.

5.4.2.1 Solid Waste

Solid waste will include construction debris, office trash, uncontaminated equipment and parts, and decontaminated material and equipment. It will be accumulated in dumpsters and transported to an appropriately permitted solid waste disposal or recycling facility permitted by South Dakota or another state.

5.4.2.2 Hazardous Waste and Used Oil

The potential exists for any industrial facility to generate hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Hazardous waste may include hydraulic fluid, cleaners, solvents, degreasers, and used batteries. On the basis of the processes and materials to be used on the project, it is likely that this project will be classified as a Conditionally Exempt Small Quantity Generator (CESQG), defined as a generator that generates less than 100 kg of hazardous waste in a calendar month and that complies with all applicable hazardous waste program requirements. In the event that Powertech (USA) is not classified as a CESQG, Powertech (USA) will obtain the appropriate approvals or permits. Hazardous waste and used oil (including used oil filters and oily rags) will be accumulated in designated hazardous waste and used oil storage areas and transported and disposed in an appropriately permitted disposal or recycling facility permitted by South Dakota or another state.

5.4.2.3 Liquid Waste

Liquid waste not classified as AEA-regulated waste will include domestic (septic) waste and stormwater runoff. Management of each of these liquid waste streams is described below.

5.4.2.3.1 Domestic (Septic) Waste

Domestic waste will be disposed in on-site wastewater disposal systems constructed at the CPP and Satellite Facility. Domestic wastewater disposal systems will be designed to meet applicable DENR and Fall River County or Custer County regulations and will be permitted through DENR and/or Fall River or Custer County.

5.4.2.3.2 Stormwater Runoff

Stormwater runoff will be managed through construction and industrial NPDES permits obtained through DENR. Facility drainage will be designed to route stormwater runoff either away from or around the plants, ancillary buildings, parking areas, and chemical storage areas. The design of the project facilities, combined with engineering and procedural controls contained in a Stormwater Pollution Prevention Plan (SWPPP), will ensure that stormwater runoff is not a potential source of pollution. Section 5.3.9 provides more detail regarding the stormwater management plan.

5.4.3 Waste Minimization

Waste will be minimized during all project phases to minimize potential exposure to hazardous and radiological emissions from waste, minimize disposal costs, and minimize potential impacts from waste management activities such as from transporting waste to appropriately permitted disposal facilities. Waste minimization measures may include but will not be limited to:

- Limit production and restoration bleed to the minimum amount needed to ensure hydraulic well field control;
- Recycle wastewater to reduce the amount of water needed for facilities and the amount of wastewater that requires disposal;
- Use decontamination techniques that reduce waste generation;
- Institute preventative maintenance and inventory management programs to minimize waste from breakdowns and overstocking;
- Recycle materials where appropriate;
- Encourage the reuse of materials and the use of recycled materials;
- Avoid using hazardous materials when possible; and
- Salvage extra materials and use them for other construction activities or for regrading activities.

5.5 Monitoring

This section describes the monitoring programs associated with the Dewey-Burdock Project. Extensive monitoring programs will be implemented to detect any potential impacts to human health or the environment in accordance with the requirements of the NRC license, LSM permit, GDP, EPA Class III and V UIC permits, and other relevant permits. These include well field, groundwater, surface water, land application effluent, flow/pressure, soil, vegetation, livestock/fish, air, and meteorological monitoring programs.

5.5.1 Well Field Monitoring

Following is a description of the ISR well field monitoring that will be conducted in accordance with NRC license and EPA Class III UIC permit requirements. This includes baseline groundwater monitoring to establish the ambient water quality and target restoration goals for each well field, excursion monitoring to detect any potential migration of ISR solutions away from the production zone, groundwater restoration monitoring, injection fluid monitoring, and well field leak detection monitoring.

5.5.1.1 Well Field Production Zone Baseline Groundwater Monitoring

Production zone baseline water quality and target restoration goals (TRGs) will be established according to NRC license requirements. Prior to uranium ISR, a subset of wells within each well field to be utilized as production wells will be identified for baseline water quality sampling. The sample density is anticipated to be one well per 4 acres of well field pattern area or six wells, whichever is greater, except that fewer than six wells may be used for well fields smaller than 6 acres. The expected sample frequency is four sample events spaced at least 14 days apart, with samples analyzed for the constituents listed in Table 6.2-1. Baseline water quality and TRGs will be established according to statistical methods approved by NRC.

5.5.1.2 Excursion Monitoring Program

The excursion monitoring program will be conducted in accordance with NRC license requirements to detect the potential horizontal or vertical movement of ISR solutions away from the production zone. The monitor well design is described in Section 5.3.3.1.2 and includes perimeter monitor wells completed in the production zone around the perimeter of each well field and non-production zone monitor wells completed in the overlying and underlying hydrogeologic units. The following sections describe how Powertech (USA) will establish baseline water quality and upper control limits (UCLs) for each monitoring zone and perform the excursion monitoring program throughout uranium extraction and aquifer restoration. Corrective actions to control and correct excursions are described in Section 5.6.3.2.

5.5.1.2.1 Establishing UCLs

Powertech (USA) will establish baseline water quality in the perimeter wells and non-production zone monitor wells according to NRC license requirements. Baseline water quality will be calculated based on the analysis of multiple samples from each monitor well. Baseline water quality will be used to establish UCLs as a function of the average baseline water quality and the variability in each parameter according to statistical methods approved by NRC.

UCLs will be established for constituents that provide early indication of a potential excursion. The anticipated excursion indicators include chloride, conductivity and total alkalinity. These are commonly used excursion indicators that are highly mobile in groundwater and not influenced significantly by pH changes or oxidation-reduction reactions.

5.5.1.2.2 Excursion Sampling

Excursion sampling will occur in accordance with NRC license requirements. The sampling frequency will be twice monthly during uranium recovery operations and once every 60 days during aquifer restoration. As previously described, the anticipated excursion indicators include chloride, conductivity and total alkalinity. Water levels will be recorded during excursion sampling events.

Water levels will be measured using downhole pressure transducers or manual electronic meters. These measurements will alert operators to any significant change in the water levels within the monitor wells to provide an early warning of a potential excursion. Operators may then follow standard operating procedures to make adjustments to well field production and/or injection flow rates to avoid an excursion due to any unbalanced flow condition in a well field. Water level readings will be recorded at a minimum frequency of twice monthly from production zone monitor wells and monitor wells installed in the overlying and underlying hydrogeologic units.

5.5.1.2.3 Excursion Confirmation

An excursion will be deemed to have occurred if two or more excursion indicators in any monitor well exceed their UCLs. A verification sample will be taken within 48 hours after results of the first analyses are received. If the results of the verification sampling are not complete within 30 days of the initial sampling event, then the excursion will be considered confirmed for the purpose of meeting the reporting requirements described below. If the excursion is not confirmed by the verification sample, a third sample will be taken within 48 hours after the second set of sampling data are received. If neither the second nor the third sample confirms the excursion by two indicators exceeding their UCLs, the first sample will be considered to have been in error, and the well will be removed from excursion status. If either the second or third sample exhibits two or more indicators above their UCLs, an excursion will be confirmed, the well will be placed on confirmed excursion status, and corrective action will be initiated. Corrective actions are described in the Section 5.6.3.2.

5.5.1.3 Groundwater Restoration Monitoring

During all phases of groundwater restoration, including active restoration and stability monitoring, excursion monitoring will continue in accordance with NRC license conditions. The following additional monitoring associated with groundwater restoration will be conducted in accordance with NRC license requirements.

5.5.1.3.1 Monitoring during Active Restoration

Powertech (USA) will monitor the progress of aquifer restoration by sampling ore zone monitor wells in each well field at a frequency sufficient to determine the success of aquifer restoration, optimize the efficiency of aquifer restoration, and determine if any areas need additional attention. The results of active restoration monitoring will be used to evaluate potential areas of flare or hot spots. If potential flare or hot spots are identified, appropriate corrective measures will be taken such as adjusting the flow in the area, changing wells from injection to production, or adjusting the restoration bleed in a specific area.

5.5.1.3.2 Restoration Stability Monitoring

A groundwater stability monitoring period will be implemented to show that the restoration goal has been adequately maintained. The stability monitoring period proposed in the NRC license application includes 12 months with quarterly sampling (at least 5 sample events, including 1 at the beginning of the stability monitoring period and following each of the following 4 quarters). The sample results will be analyzed using statistical methods approved by the NRC to evaluate stability.

If a constituent does not meet the stability criteria, Powertech (USA) will take appropriate action considering the constituent and the status of the restored groundwater system. Potential actions may include extending the stability period or returning the well field to a previous phase of active restoration to resolve the issue.

If the analytical results from the stability period continue to meet the TRGs and meet the stability criteria, then Powertech (USA) will submit supporting documentation to the NRC showing that the restoration parameters have remained at or below the restoration standards and requesting that the well field be declared restored.

5.5.1.4 ISR Solution Monitoring

Powertech (USA) will install automated control and data recording systems at the Satellite Facility and the CPP that will provide centralized monitoring and control of the process variables

including the flow rate and pressure of the injection and production stream in each header house. In addition, the flow rate of each injection and production well will be measured automatically. Pressure gauges installed at each injection wellhead or in the injection manifold also will be manually recorded at least daily.

The volumetric flow rate of oxygen and carbon dioxide will be measured at the point of injection into the barren lixiviant using calibrated gas flow meters. The flow meters will be routinely calibrated according to manufacturer recommendations.

The injection fluid in each operating well field will be sampled in accordance with EPA Class III permit requirements. Samples will be collected from the injection manifold, individual injection flow lines, or the injection well heads following the appropriate quality assurance/quality control (QA/QC) procedures. The anticipated sampling frequency is monthly. Samples will be submitted to an EPA-certified laboratory and analyzed for parameters required by the Class III UIC permit. These are anticipated to include pH, TDS, specific conductance, total alkalinity, chloride, sulfate, and select dissolved metals and radionuclides.

5.5.1.5 Well Field Leak Detection Monitoring

Leak detection will be performed by daily visual inspection of all aboveground pipe, connections, and fittings by field personnel during their daily site visits.

5.5.2 Operational Groundwater Monitoring Program

The operational groundwater monitoring program will be conducted in accordance with NRC license requirements and will be used to detect potential changes in groundwater quality in and around the permit area as a result of the Dewey-Burdock Project. The operational monitoring program is designed to provide a comprehensive evaluation of water supply wells in and around the permit area. Wells to be included in the operational monitoring program include domestic wells, stock wells, irrigation wells, and additional monitor wells in the alluvium, Fall River, Chilson and Unkpapa.

Prior to operations all domestic, stock, and irrigation wells within 2 km of the potential perimeter monitor well rings will be sampled to establish baseline water quality. These will be monitored quarterly for one year prior to operation (including monitoring already completed). All samples will be analyzed for constituents listed in Table 6.2-1.

5.5.2.1 Domestic Wells

Prior to operations, all domestic wells within the permit area will be removed from private use, or, at a minimum, from drinking water use. Depending on the well construction, location and screen interval, Powertech (USA) may continue to use the well for monitoring or plug and abandon the well. From the onset of ISR operations until groundwater restoration is approved by NRC, Powertech (USA) will monitor all domestic wells within 2 km of the perimeter monitor well rings. Samples will be collected annually and analyzed for the constituents listed in Table 6.2-1.

5.5.2.2 Irrigation Wells

From the onset of ISR operations until groundwater restoration is approved by NRC, Powertech (USA) will monitor all irrigation wells within 2 km of the perimeter monitor well rings. Samples will be collected annually and analyzed for the parameters in Table 6.2-1.

5.5.2.3 Stock Wells

During the design of each well field, all nearby stock wells will be evaluated for the potential to be adversely affected by ISR operations or to adversely affect ISR operations. At a minimum, all stock wells within ¼ mile of well fields will be removed from private use prior to operation of nearby well fields. Depending on the well construction, location and screen interval, Powertech (USA) may continue to use the well for monitoring or plug and abandon the well. During operation, Powertech (USA) will monitor all stock wells within the permit area. Samples will be collected quarterly and analyzed for water level and the three excursion indicators of chloride, total alkalinity, and conductivity.

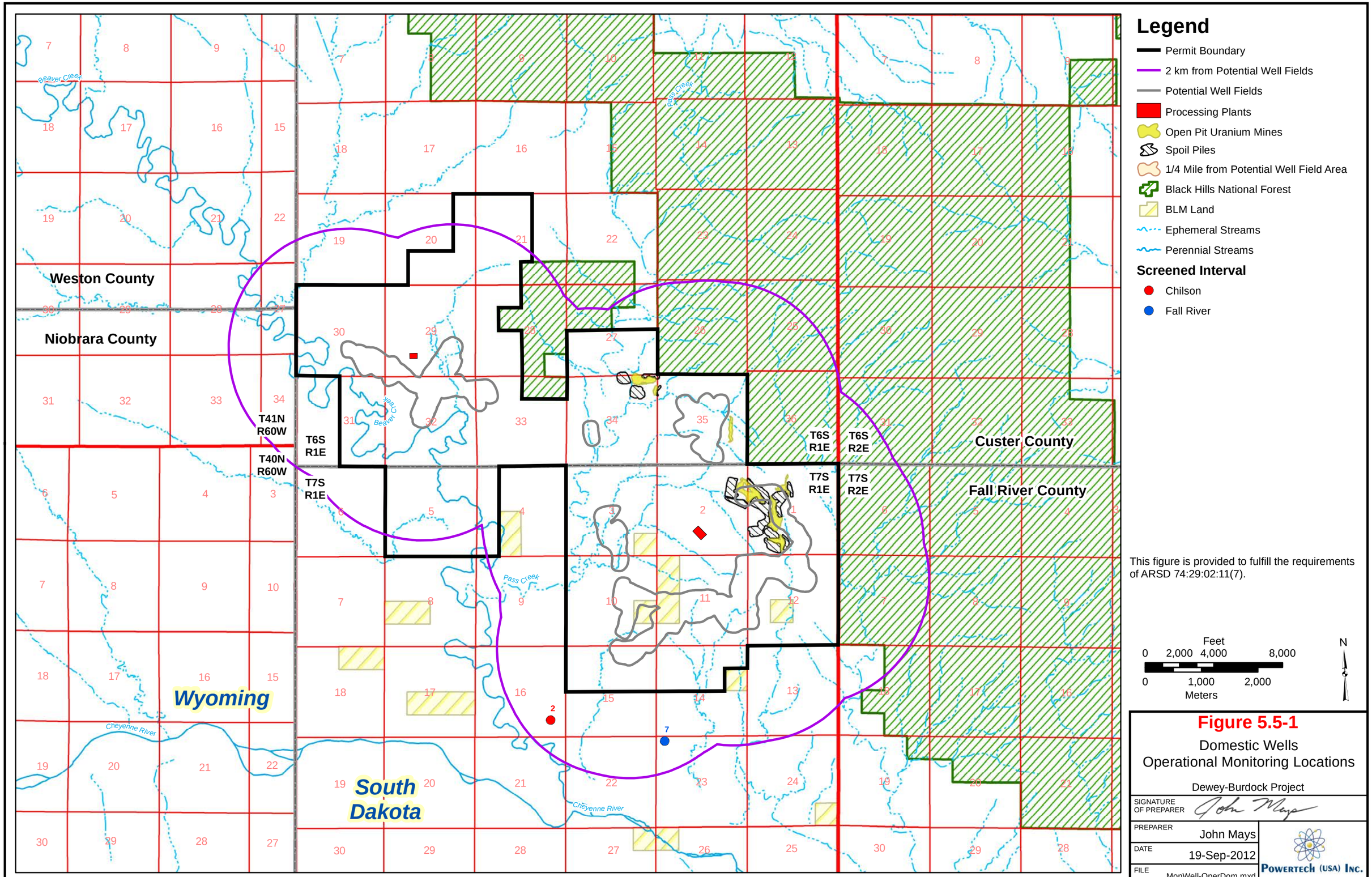
5.5.2.4 Monitor Wells

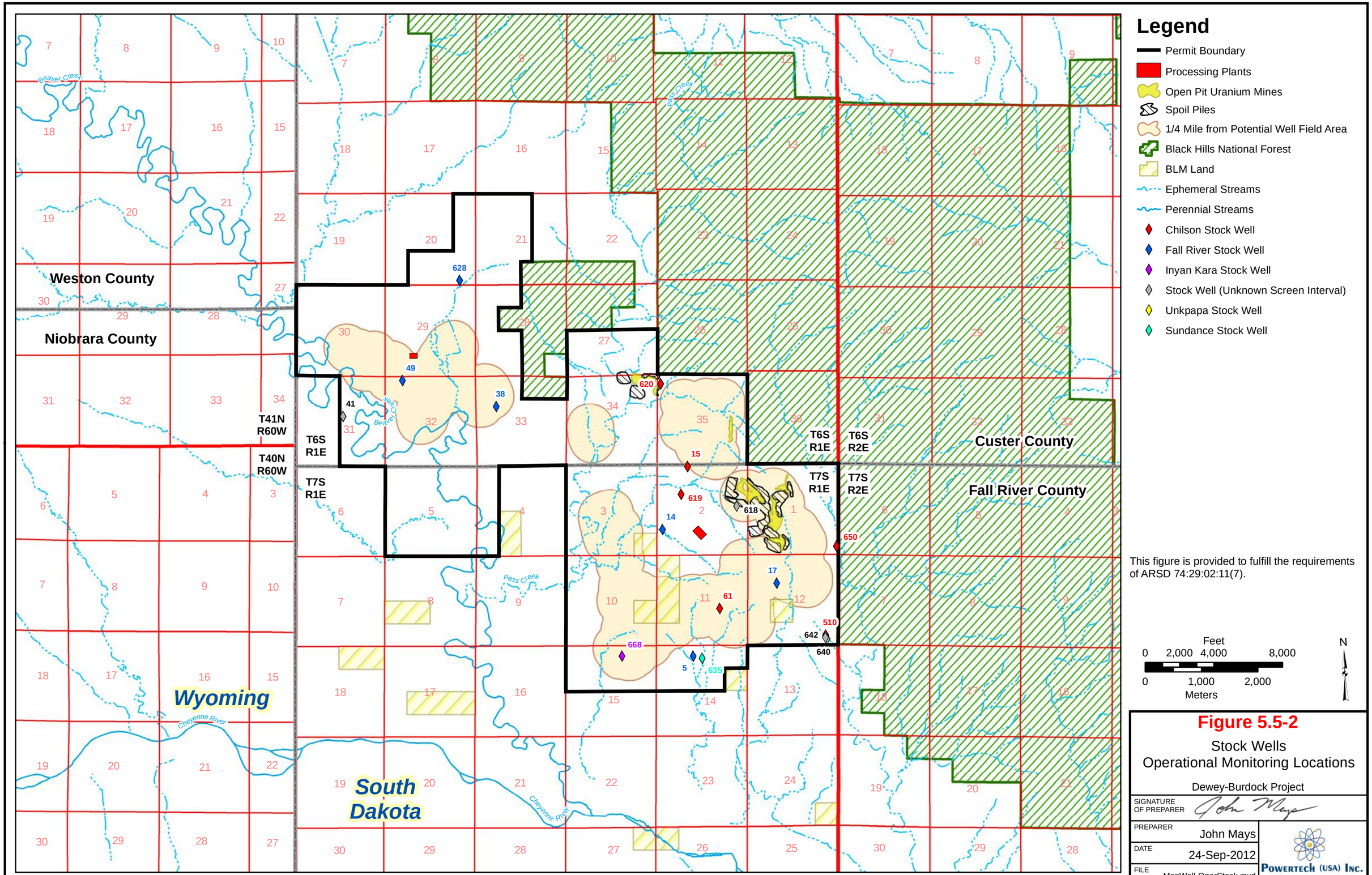
Per NRC license requirements, Powertech (USA) will monitor wells located hydrologically upgradient and downgradient of ISR operations as part of the operational groundwater monitoring program. A list of the monitor wells included in the operational monitoring program is provided in Table 5.5-1. Monitor wells included in the operational monitoring program are depicted on Figures 5.5-1 through 5.5-6 and include domestic wells, stock wells, and wells completed in the alluvium, Fall River, Chilson, and Unkpapa. Currently there are no irrigation wells within 2 km of the potential perimeter monitor well rings. The monitor wells will be monitored quarterly from the onset of ISR operations through NRC approval of groundwater restoration and analyzed for constituents listed in Table 6.2-1.

Table 5.5-1: Monitor Wells Included in Operational Monitoring Program

Well ID	Qtr-Qtr	Section	Township	Range	Relative Position
Alluvium					
676	SESW	34	6S	1E	Downgradient of land application
677	SWSW	27	6S	1E	Downgradient
678	SWNE	4	7S	1E	Downgradient
679	NESW	9	7S	1E	Upgradient
707	SWNE	34	6S	1E	Downgradient of Triangle Pit
708	SESW	3	7S	1E	Downgradient of land application
709	SENW	15	7S	1E	Downgradient of well field
TBD	NWNW	20	6S	1E	Upgradient
TBD	NENE	31	6S	1E	Downgradient of well field
TBD	NWSE	32	6S	1E	Downgradient of well field
TBD	NWNW	20	6S	1E	Downgradient of land application
Fall River					
631	SWSW	23	6S	1E	Upgradient
681	NWNE	32	6S	1E	Production zone
688	NESW	11	7S	1E	Overlying production zone
694	NWNW	15	7S	1E	Upgradient
695	SESE	32	6S	1E	Downgradient
698	SENW	2	7S	1E	Downgradient
706	NENE	21	6S	1E	Upgradient
TBD	SWNE	34	6S	1E	Downgradient of Triangle Pit
TBD	NWSE	2	7S	1E	Downgradient of Darrow Pit
Chilson					
43	SWSE	34	6S	1E	Downgradient of Triangle Pit
680	NESW	11	7S	1E	Production zone
689	NENW	32	6S	1E	Production zone
696	NWNW	15	7S	1E	Downgradient
697	SESE	32	6S	1E	Downgradient
705	NENE	21	6S	1E	Upgradient
3026	SESE	12	7S	1E	Upgradient
TBD	SWSE	2	7S	1E	Downgradient of Darrow Pit
Unkpapa					
690	NESW	11	7S	1E	
693	NENW	32	6S	1E	
703	SWSE	1	7S	1E	

TBD – To be determined; well not yet installed.


Legend
Permit Boundary
2 km from Potential Well Fields
Potential Well Fields
Processing Plants
Open Pit Uranium Mines
Spoil Piles
1/4 Mile from Potential Well Field Area
Black Hills National Forest
BLM Land
Ephemeral Streams
Perennial Streams
Screened Interval
Chilson
Fall River
Weston County
Niobrara County
Custer County
Fall River County
Wyoming
South Dakota
T41N R60W
T40N R60W
T6S R1E
T7S R1E
T6S R2E
T7S R2E
Beaver Creek
Pass Creek
Cheyenne River
2
7
This figure is provided to fulfill the requirements of ARSD 74:29:02:11(7).
Feet
0 2,000 4,000 8,000
0 1,000 2,000
Meters
N
Figure 5.5-1
Domestic Wells
Operational Monitoring Locations
Dewey-Burdock Project
SIGNATURE OF PREPARER
PREPARER John Mays
DATE 19-Sep-2012
FILE MonWell-OperDom.mxd
POWERTECH (USA) INC.



This figure is provided to fulfill the requirements of ARSD 74:29:02:11(7).

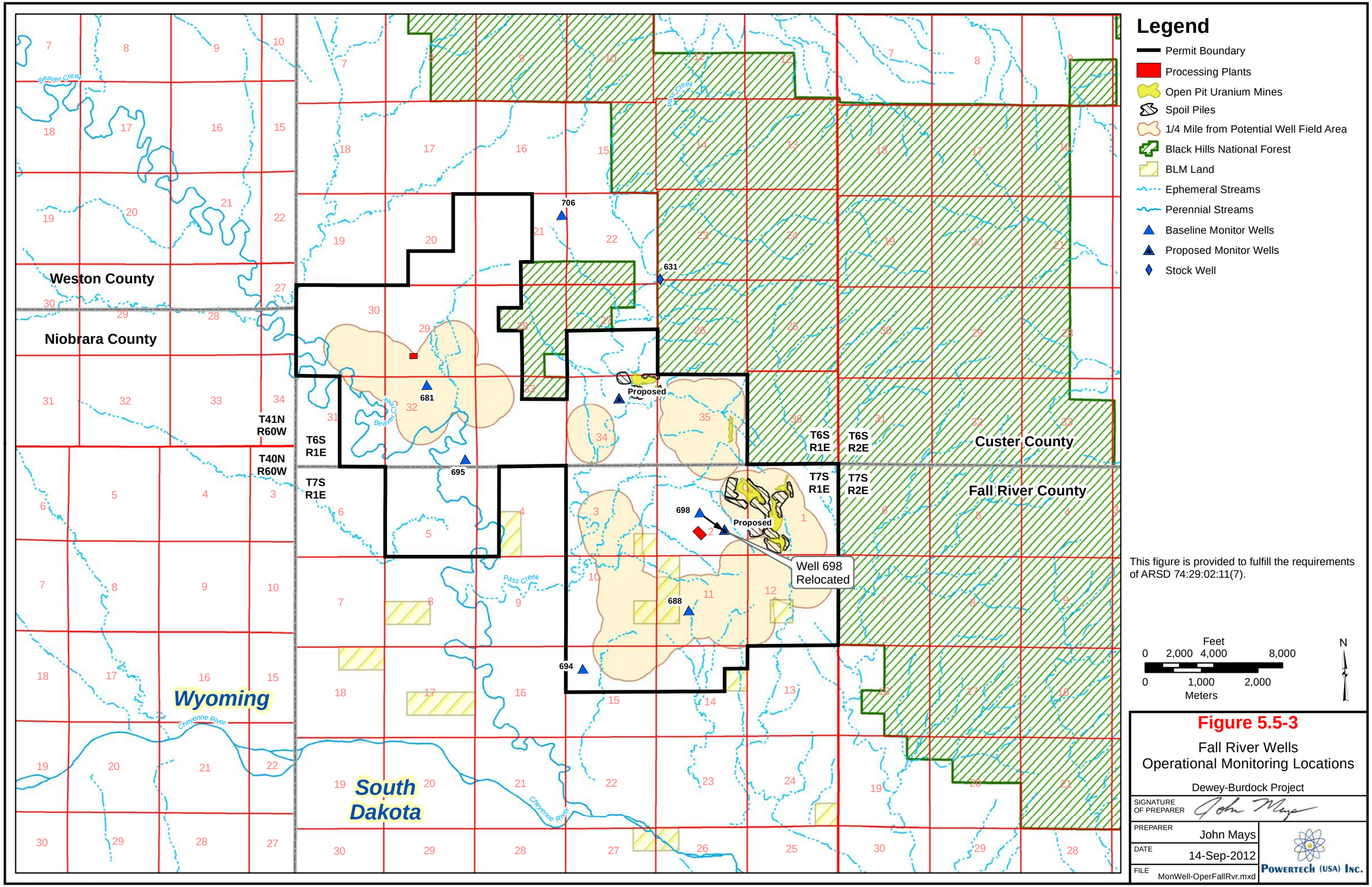
Figure 5.5-2

Stock Wells
Operational Monitoring Locations

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	24-Sep-2012
FILE	MonWell-OperStock.mxd

POWERTECH (USA) INC.



This figure is provided to fulfill the requirements of ARSD 74:29:02:11(7).

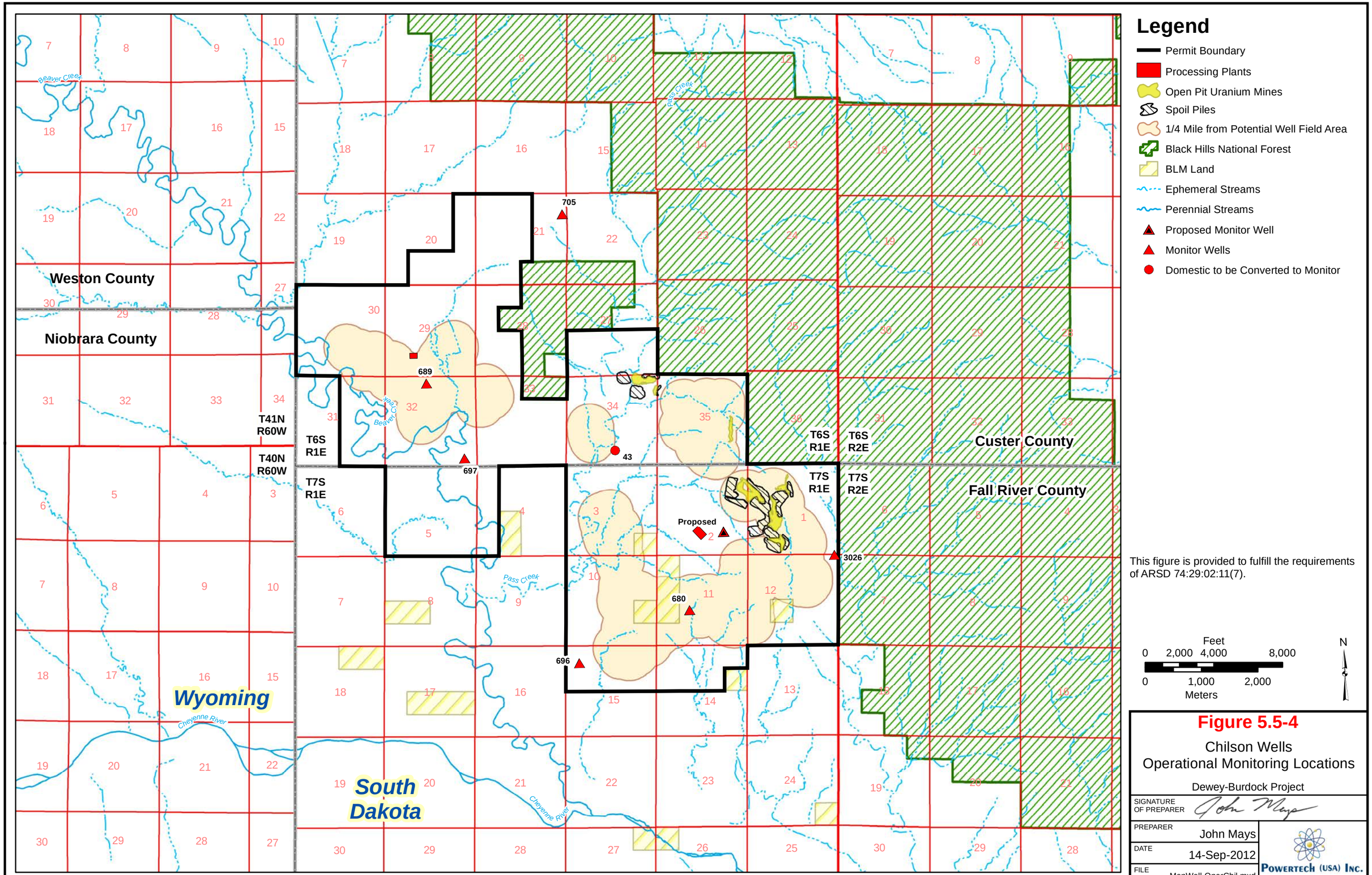
Figure 5.5-3

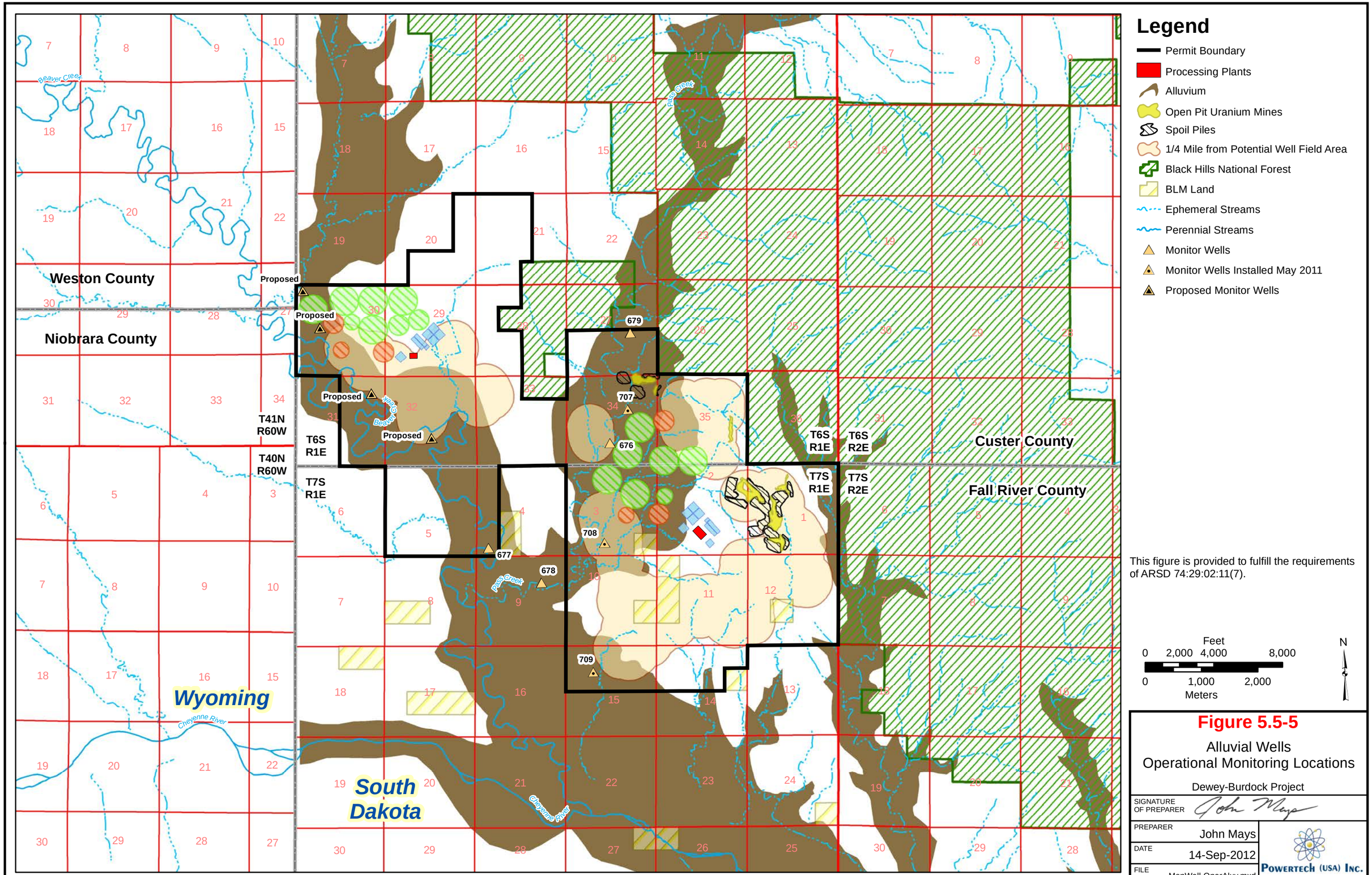
Fall River Wells
Operational Monitoring Locations

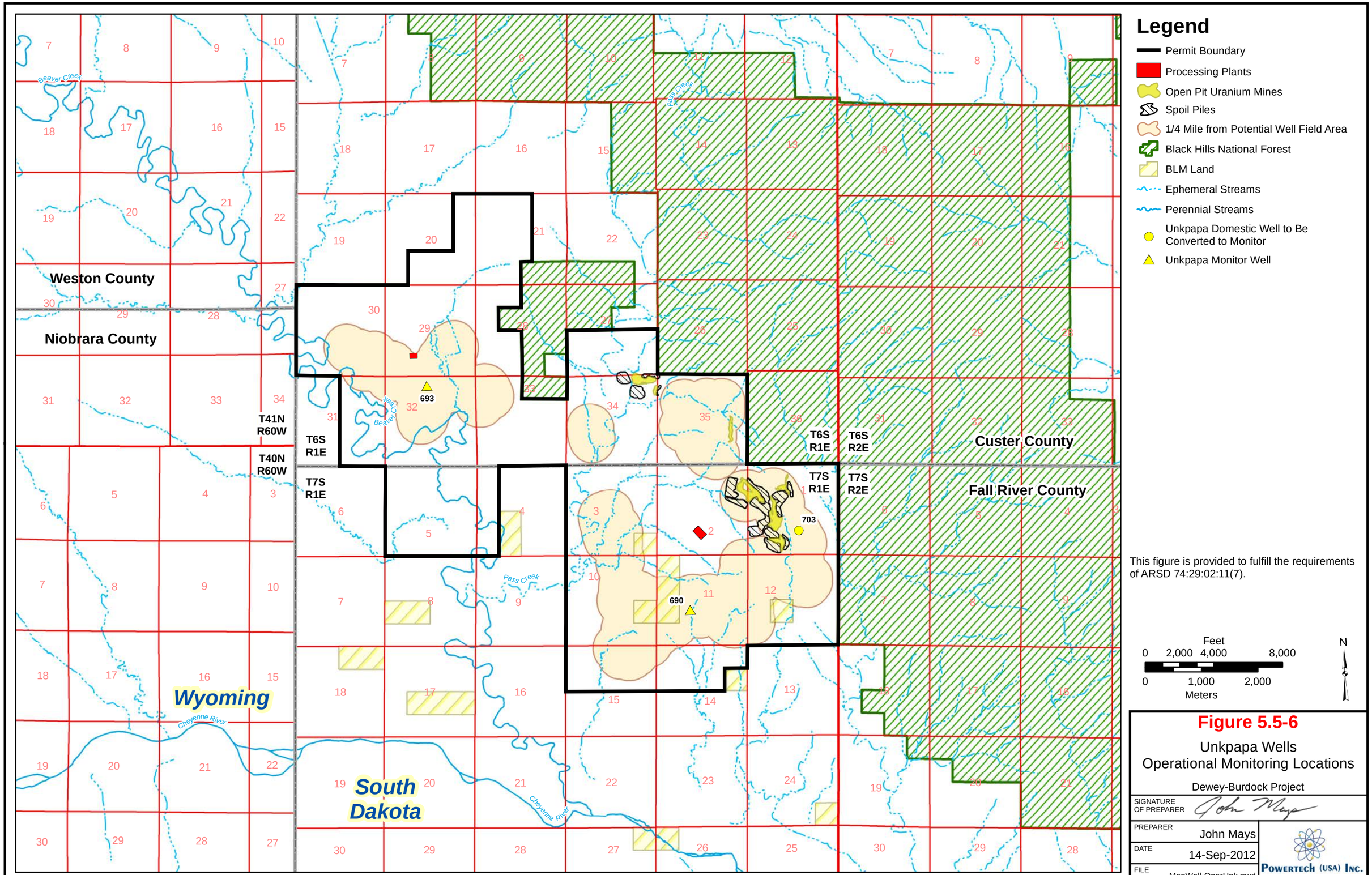
Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	14-Sep-2012
FILE	MonWell-OperFallRvr.mxd

POWERTECH (USA) INC.


Legend
Permit Boundary
Processing Plants
Open Pit Uranium Mines
Spoil Piles
1/4 Mile from Potential Well Field Area
Black Hills National Forest
BLM Land
Ephemeral Streams
Perennial Streams
Proposed Monitor Well
Monitor Wells
Domestic to be Converted to Monitor
Weston County
Niobrara County
Custer County
Fall River County
Wyoming
South Dakota
T41N R60W
T40N R60W
T6S R1E
T7S R1E
T6S R2E
T7S R2E
Beaver Creek
Pass Creek
Cheyenne River
705
689
697
43
Proposed
3026
680
696
This figure is provided to fulfill the requirements of ARSD 74:29:02:11(7).
Feet
0 2,000 4,000 8,000
0 1,000 2,000
Meters
N
Figure 5.5-4
Chilson Wells
Operational Monitoring Locations
Dewey-Burdock Project
SIGNATURE OF PREPARER
PREPARER John Mays
DATE 14-Sep-2012
FILE MonWell-OperChil.mxd
POWERTECH (USA) INC.


Legend
Permit Boundary
Processing Plants
Alluvium
Open Pit Uranium Mines
Spoil Piles
1/4 Mile from Potential Well Field Area
Black Hills National Forest
BLM Land
Ephemeral Streams
Perennial Streams
Monitor Wells
Monitor Wells Installed May 2011
Proposed Monitor Wells
Weston County
Niobrara County
Custer County
Fall River County
Wyoming
South Dakota
T41N R60W
T40N R60W
T6S R1E
T6S R2E
T7S R1E
T7S R2E
Proposed
679
707
676
677
678
708
709
Beaver Creek
Pass Creek
Cheyenne River
This figure is provided to fulfill the requirements of ARSD 74:29:02:11(7).
Feet
0 2,000 4,000 8,000
0 1,000 2,000
Meters
N
Figure 5.5-5
Alluvial Wells
Operational Monitoring Locations
Dewey-Burdock Project
SIGNATURE OF PREPARER
PREPARER John Mays
DATE 14-Sep-2012
FILE MonWell-OperAluv.mxd
POWERTECH (USA) INC.



This figure is provided to fulfill the requirements of ARSD 74:29:02:11(7).

Figure 5.5-6

Unkpapa Wells
Operational Monitoring Locations

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	14-Sep-2012
FILE	MonWell-OperUnk.mxd

POWERTECH (USA) INC.

In addition, Powertech (USA) will monitor additional alluvial monitor wells within and downgradient of the land application systems if land application is used. These wells will be monitored as required by the GDP, and the well locations are provided in the GDP.

Monitoring conducted as part of the operational monitoring program will be conditional upon landowner access and suitable conditions allowing proper collection of a sample. If access is not available during the time of monitoring, a second attempt will be made to collect a sample during the monitoring period. If a well cannot be accessed continually, Powertech (USA) will establish an alternate monitoring location or remove the well from the operational groundwater monitoring program.

5.5.2.5 Sampling Methods

Groundwater sampling methods will be the same as the methods utilized for baseline characterization. Static water level will be measured before sample collection when access is available. Measurement techniques will include pressure transducers, a portable electronic water level meter, or an ultrasonic water level sensor. For flowing artesian wells, the shut-in pressure will be measured, where access is available, using a 15 or 30 psi NIST pressure gauge. Prior to measuring the pressure, the well will be shut in and the pressure allowed to stabilize before recording the hydrostatic pressure.

Three casing volumes will be purged prior to sample collection where possible, except that flowing artesian wells will be assumed to contain representative formation water without purging. In all cases, field parameters will be measured and recorded and samples will not be collected until field pH, conductivity and temperature have stabilized. The criterion used to assess stability will be three consecutive measurements of each of the field parameters with values for each parameter within 10%.

All groundwater samples will be collected in clean sample containers and field preserved, where required. The sample containers will be kept cool (less than 4°C) until delivery to the contract laboratory.

5.5.2.6 Reporting

Powertech (USA) will provide DENR with the results of all operational groundwater monitoring, including domestic wells, stock wells, irrigation wells, and monitor wells. These will be provided in the annual environmental monitoring report described in Section 5.7.2.6.

5.5.3 Operational Surface Water Monitoring Program

During ISR operations, 24 impoundments and 10 stream sampling sites, depicted on Plate 5.5-1, will be monitored as part of the operational monitoring program. Impoundments within and surrounding the permit area were evaluated based on location in relation to ISR operations (i.e., downgradient of proposed well fields, CPP, etc.). Table 5.5-2 lists all of the impoundments identified during the baseline surveys. The table lists all of the impoundments and identifies which impoundments are located downgradient (i.e., potentially subject to surface runoff) from ISR operations. The table also denotes the 24 impoundments included in the operational monitoring program and provides justification for impoundments not included. All 24 impoundments identified for operational monitoring will be visited on a quarterly basis throughout construction and operation. In addition, Powertech (USA) will visit all 24 of the impoundments included in the operational monitoring program four times (including pre-operational samples already collected) prior to operations to satisfy NRC pre-operational monitoring requirements. Water samples will be collected, when available, and analyzed for constituents listed in Table 6.2-1.

The previous stream sampling sites described in Section 3.5.3.1 were evaluated against NRC regulatory guidance (NRC, 1980a) to establish an operational monitoring program. Four sites (BVC01, BVC04, PSC01, and PSC02) used for baseline monitoring will be replaced with operational monitoring sites that better meet NRC guidance as follows:

- BVC11 will be located where Beaver Creek exits the permit area. This monitoring location will replace BVC01, which was approximately 2 stream miles farther downstream, below the confluence with Pass Creek.

- BVC14 will be located where Beaver Creek enters the permit area. This monitoring location will replace BVC04, which was approximately 12 stream miles upstream from the permit area.

- PSC11 will be located where Pass Creek exits the permit area. This monitoring location will replace PSC01, which was approximately 2 stream miles upstream from the PSC11 location, within the permit area.

- PSC12 will be located where Pass Creek enters the permit area. This monitoring location will replace PSC02, which was about 2 stream miles upstream from the permit area

A total of 10 stream sampling sites will be included in the operational monitoring program. In addition to the four new sites described above, Powertech (USA) will establish two additional

Table 5.5-2: Impoundments Included in the Operational Monitoring Program

Site	Type/Name	Down-Gradient of ISR Operations*	Included in Operational Monitoring Program	Justification for Not Including in Operational Monitoring Program
Sub01	Stock Pond	No		Not downgradient and outside of permit area
Sub02	Triangle Mine Pit	No	**Yes**	
Sub03	Mine Dam	Yes	**Yes**	
Sub04	Stock Pond	Yes	**Yes**	
Sub05	Mine Dam	Yes	**Yes**	
Sub06	Darrow Mine Pit Northwest	Yes	**Yes**	
Sub07	Stock Dam	Yes	**Yes**	
Sub08	Stock Pond	Yes	**Yes**	
Sub09	Stock Pond	Yes	**Yes**	
Sub10	Stock Pond	Yes	**Yes**	
Sub11	Stock Pond	Yes	**Yes**	
Sub20	Stock Pond	Yes	**Yes**	
Sub21	Stock Pond	Yes	**Yes**	
Sub22	Stock Pond	Yes	**Yes**	
Sub23	Stock Pond	No		Not an impoundment, but an infrequent, small pool of water due to inadequate stormwater control at county road crossing
Sub24	Stock Pond	No		Outside of permit area; not located in a permit area drainage
Sub25	Stock Pond	No		Outside of permit area; not downgradient
Sub26	Stock Pond	No		Outside of permit area; not downgradient
Sub27	Stock Pond	Yes		Outside of permit area; downstream of Sub28
Sub28	Stock Pond	Yes		Outside of permit area; downstream of Sub08 and Sub09 with no proposed ISR operations between Sub08 or Sub09 and Sub28
Sub29	Stock Pond	Yes	**Yes**	
Sub30	Stock Pond	Yes	**Yes**	
Sub31	Stock Pond	Yes	**Yes**	
Sub32	Stock Pond	Yes	**Yes**	
Sub33	Stock Pond	Yes	**Yes**	
Sub34	Stock Pond	Yes	**Yes**	
Sub35	Stock Pond	Yes	**Yes**	
Sub36	Stock Pond	Yes	**Yes**	

Table 5.5-2: Impoundments Included in the Operational Monitoring Program (Cont'd)

Site	Type/Name	Down-Gradient of ISR Operations*	Included in Operational Monitoring Program	Justification for Not Including in the Operational Monitoring Program
Sub37	Stock Pond	Yes		Downstream of Sub36
Sub38	Stock Pond	No		Outside of permit area; not downgradient
Sub39	Stock Pond	No		Not downgradient
Sub40	Darrow Mine Pit Southeast	Yes	**Yes**	
Sub41	Stock Pond	Yes		Only downgradient of potential perimeter monitor wells
Sub42	Stock Pond	No		Not downgradient
Sub43	Stock Pond	No		Not downgradient
Sub44	Stock Pond	No		
Sub45	Stock Pond	No		Outside of permit area; not downgradient
Sub46	Stock Pond	No		Outside of permit area; not downgradient
Sub47	Stock Pond	No		Outside of permit area; not downgradient
Sub48	Stock Pond	No		Outside of permit area; not downgradient
Sub49	Darrow Mine Pit	Yes	**Yes**	
Sub50	Darrow Mine Pit	Yes	**Yes**	
Sub51	Stock Pond	No		Outside of permit area; not downgradient
Sub52	Stock Pond	No		Outside of permit area; not downgradient
Sub53	Stock Pond	No		Outside of permit area; not downgradient
Sub54	Stock Pond	No		Outside of permit area; not downgradient

* Potentially subject to surface runoff from Satellite Facility, CPP, ponds, potential land application areas, pipelines, or potential well field areas.

sites on unnamed tributaries in the southeast portion of the permit area. Details for each of the operational stream sampling sites are provided in Table 5.5-3.

Prior to ISR operations, Powertech (USA) will sample each site monthly (including samples already collected) for 12 consecutive months in accordance with NRC license requirements. Grab samples will be collected from sites BVC11, BVC14, CHR01, and CHR05. Passive samplers will be installed at the remaining sites to collect samples during ephemeral flow events. Water samples will be analyzed for constituents listed in Table 6.2-1.

5.5.3.1 Sampling Methods and Parameters

Impoundments will be sampled by collecting grab samples. Prior to sampling, the sampler will conduct a visual survey of the impoundment to identify an appropriate sample location. This will include an area free of ice or floating debris and with sufficient water depth to permit sample collection without disturbing sediments. If necessary, a clean, long-handled dip sampler will be used. Typically the sample location will be near the impoundment embankment where the water is deepest. Grab samples will be collected in clean sample containers provided by the contract laboratory. Water will be obtained by filling the containers from the top 10 cm (4 in) of the water column. Samples will be field-preserved where required. The sample containers will be kept cool (less than 4°C) until delivery to the contract laboratory. In the event that a sample cannot be collected from an impoundment during the quarterly visit, the reason will be stated on a field sheet.

Streams will be sampled by grab sampling or with automatic samplers. Perennial stream sampling locations include those on Beaver Creek and the Cheyenne River. These will be sampled by collecting grab samples as described above. Passive samplers (single-stage samplers) will be installed at all other stream sampling sites from April through October. These will collect samples automatically when the flow rate in the channel reaches a field-adjustable minimum depth threshold. Following the runoff event the water will be manually transferred from the temporary sample container to clean sample bottles and submitted to the contract laboratory for analysis.

Representative water of that collected in the grab samples will be analyzed in the field for pH, conductivity and temperature. Impoundment and stream samples will be analyzed for the parameters presented in Table 5.5-4, which has been prepared according to NRC regulatory guidance to monitor potential impacts to surface water from uranium ISR facilities.

Table 5.5-3: Operational Stream Sampling Locations

Site ID	Name	Sample Type	Location in NAD 27, South Dakota State Plane South (feet)	
			Northing	Easting
BVC11	Beaver Creek Downstream	Grab	433,638	1,022,546
BVC14	Beaver Creek Upstream	Grab	446,829	1,012,976
CHR01	Cheyenne River Upstream	Grab	423,009	1,016,699
CHR05	Cheyenne River Downstream	Grab	405,925	1,047,227
PSC11	Pass Creek Downstream	Passive sampler	431,452	1,028,064
PSC12	Pass Creek Upstream	Passive sampler	446,470	1,031,222
BEN01	Bennett Canyon	Passive sampler	416,196	1,047,473
UNT01	Unnamed Tributary	Passive sampler	422,482	1,039,166
UNT02	Unnamed Tributary	Passive sampler	424,478	1,035,236
UNT03	Unnamed Tributary	Passive sampler	425,438	1,029,910

Table 5.5-4: Operational Surface Water Monitoring Parameter List and Analytical Methods

Parameter	Units	Analytical Method
pH	pH units	A4500-H B
Total dissolved solids (TDS)	mg/L	A2540 C
Total suspended solids (TSS)	mg/L	A2540 D
Hardness, total as $CaCO_3$	mg/L	A2340 B
Chloride	mg/L	A4500-Cl B; E300.0
Sulfate	mg/L	A4500-SO4 E; E300.0
Arsenic, dissolved	mg/L	E200.8
Cadmium, dissolved	mg/L	E200.8
Chromium, dissolved	mg/L	E200.8
Selenium, dissolved	mg/L	E200.8, A3114 B
Uranium, dissolved	mg/L	E200.8
Uranium, suspended	mg/L	E200.8
Ra-226, dissolved	pCi/L	E903.0
Ra-226, suspended	pCi/L	E903.0
Th-230, dissolved	pCi/L	E907.0
Th-230, suspended	pCi/L	E907.0
Pb-210, dissolved	pCi/L	E909.0M
Pb-210, suspended	pCi/L	E909.0M
Po-210, dissolved	pCi/L	RMO-3008
Po-210, suspended	pCi/L	RMO-3008

5.5.3.2 Reporting

Powertech (USA) will provide DENR with the results of all operational surface water monitoring, including impoundment and stream sampling results. These will be provided in the annual environmental monitoring report described in Section 5.7.2.6.

5.5.4 Land Application Effluent Monitoring

The following describes the effluent water quality monitoring program that will be implemented if land application is used as a wastewater disposal option. Land application system reporting also is described.

5.5.4.1 Monitoring Frequency and Parameters

Powertech (USA) will collect and analyze effluent water quality samples using a progressive sampling schedule that includes volume-based grab samples in accordance with ARSD 74:29:05:15 and time-based grab samples designed to detect any changes in the land application water quality. ARSD 74:29:05:15 specifies the following sampling requirements: "Sampling of solution to be applied to the land shall consist of not less than one grab sample per 100,000 gallons of solution. If less than 100,000 gallons is to be applied to land, at least one grab sample must be taken and analyzed for the required parameters. Each grab sample must be of sufficient volume so the sample can be split. Each split of the sample must be of a volume sufficient to allow for analysis for all operational monitoring parameters. At every fifth sampling, one split sample of each five consecutive grab samples shall be preserved and analyzed for the required monitoring parameters." To meet these requirements, Powertech (USA) proposes to collect a grab sample of the water pumped from the storage ponds to the land application systems at a frequency of at least one sample per 100,000 gallons. This will be accomplished by manually filling the sample containers or installing an automated grab sampler. At every fifth sampling, five consecutive grab samples will be composited and analyzed for the parameters shown in Table 5.5-5.

Justification for a relatively small list of sample parameters for the volume-based grab sampling is based on the large storage capacity available in the storage ponds at each land application site. Based on an anticipated land application rate of 297 to 653 gpm, grab samples representing each 100,000 gallons of effluent will be collected every 2.6 to 5.6 hours, and composite samples representing each 500,000 gallons of effluent will be collected every 12.8 to 28.1 hours. By comparison, the available storage capacity at each site will be 247.2 ac-ft, which is equal to 86 to 188 days of water storage at the typical pumping rates of 297 to 653 gpm, respectively. Changes

Table 5.5-5: Volume-Based Effluent Water Quality Sampling Parameter List

Constituent	Units	Analytical Method
Field pH	s.u.	Field
Laboratory pH	s.u.	A4500-H B
Field conductivity	umhos/cm	Field
Conductivity @ 25°C	umhos/cm	A2510 B

in water quality in the storage ponds will occur very slowly, since the storage capacity far exceeds the pumping rate and since changes in well field water quality will occur slowly. The primary source of land application water, production and restoration bleed, will result from multiple well fields undergoing differing phases of uranium recovery and aquifer restoration. This water will be combined in the storage ponds, where increasing concentrations in water quality constituents from well fields undergoing production will tend to be offset by decreasing concentrations in water quality constituents from well fields undergoing aquifer restoration.

In addition to the volume-based effluent sampling, Powertech (USA) will collect grab samples monthly during operation of each land application system and have them analyzed for the parameters listed in Table 6.2-1. In addition to the parameters in Table 6.2-1, monthly effluent samples will be analyzed for compliance with the anticipated NRC effluent limits listed in Table 5.4-1. These anticipated NRC effluent limits are the 10 CFR Part 20, Appendix B, Table 2, Column 2 established limits for discharge of radionuclides to the environment.

Prior to operation of the land application systems each year, Powertech (USA) will sample the storage ponds and have the samples analyzed for the parameters in Table 6.2-1.

5.5.4.2 Land Application System Reporting

Powertech (USA) will establish and maintain records and prepare and submit reports for land application system operation in accordance with the requirements of ARSD 74:29:05. Refer to Section 5.7.2.6 for a description of land application system reporting, including written notice to implement land application and a written report following each land application cycle, which is defined as the last land application operational period during each calendar year. Additional reporting will be done in accordance with DENR requirements in the approved GDP.

5.5.5 Pond Monitoring

Section 5.3.4.5 describes the monitoring and inspection program that will be implemented to document pond conditions, including inspections of liners, liner slopes and other earthwork features; measurement of pond freeboard to ensure that adequate containment capacity is available; monitoring for water accumulation in leak detection systems; and routine inspections of leak detection system functionality, embankment settlement, and slope stability.

5.5.6 Soil Sampling

5.5.6.1 Land Application Systems

If land application is used to dispose treated wastewater, soil sampling will occur as described in the GDP. Baseline soil samples will be collected prior to operation of each land application system. During operation, soil samples will be collected each year from each land application pivot that was active during that year. Soil samples also will be collected from each catchment area each year.

Potential impacts will be mitigated by monitoring soil concentrations during operations and implementing a contingency plan if concentrations approach trigger values. The proposed trigger values for arsenic and selenium are the average baseline concentrations plus 2 standard deviations. In addition, Powertech (USA) will monitor additional constituents listed in Table 6.4-1 of the GDP. Powertech (USA) will analyze the annual monitoring results and propose additional trigger values if increasing trends are observed. This analysis will be completed annually and provided in the written report submitted to DENR each year that is described in Section 5.7.2.6.

5.5.6.2 General Permit Area Soil Sampling

During operation, Powertech (USA) will collect and analyze soil samples from the air particulate monitoring locations as required by the NRC license. The anticipated sample requirements include sampling surface soils (0-5 cm) annually from each air particulate monitoring location once per year and having the samples analyzed for natural uranium, radium-226, and lead-210. This sampling will provide detection of potential aerial deposition of radionuclides from the Dewey-Burdock Project.

In addition, as described in Section 6, Powertech (USA) will conduct radiological surveys during decommissioning to identify areas for cleanup operations. A pre-reclamation survey will be used to identify cleanup areas, and a post-reclamation survey will be used to ensure that radium and other radionuclides do not exceed NRC standards. The radiological surveys will use gamma-ray detectors that are calibrated to soil radium-226 concentrations.

5.5.6.3 Vegetable Garden Soil Sampling

In accordance with NRC license conditions, Powertech (USA) will sample vegetable garden soil within 2 miles (3.3 km) of the permit area prior to operations. Plant-to-soil concentration factors will be then be used to estimate the levels of radionuclide concentrations in locally grown

vegetables. Powertech (USA) anticipates modifying the NRC monitoring program to exclude vegetable garden soil sampling if the pre-operational sample results along with modeling potential radiological impacts demonstrate no significant exposure pathway from vegetable gardens to potential human receptors.

5.5.7 Vegetation Sampling

5.5.7.1 Land Application Systems

If land application is used to dispose treated wastewater, vegetation sampling will occur as described in the GDP. Vegetation samples will be collected annually from the land application areas. Vegetation samples also will be collected from each catchment area each year. Powertech (USA) will monitor for the potential buildup of metals, metalloids, and radionuclides in irrigated vegetation. The vegetation sampling parameters are listed in Table 6.5-1 of the GDP application. Metals and metalloids to be monitored include natural uranium, selenium and arsenic. Prior to operation, Powertech (USA) will develop trigger values for arsenic and selenium based on the preoperational concentrations and the variability in each parameter. Should routine operational monitoring indicate an increasing trend in constituent concentrations with potential to approach trigger values, a contingency plan will be implemented as described in Section 8.4 of the GDP application. The proposed trigger values will be provided to DENR for review and approval prior to initiating land application. The results of annual monitoring and evaluation of potential increasing trends will be provided in the written report submitted to DENR each year that is described in Section 5.7.2.6.

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5.5.7.2 General Permit Area Vegetation Sampling

During operation, Powertech (USA) will collect and analyze vegetation samples from the air particulate monitoring locations as required by the NRC license. The anticipated sample requirements include sampling vegetation annually from each air particulate monitoring location once per year and having the samples analyzed for radium-226 and lead-210. The air particulate monitoring locations are located in areas having the highest predicted airborne radionuclide concentrations due to operation of the Dewey-Burdock Project.

In addition, Powertech (USA) will sample general grazing vegetation during the first year of operations in accordance with NRC license conditions. Powertech (USA) anticipates modifying the NRC monitoring program to exclude vegetation or forage sampling after the first year of operations if the initial monitoring results demonstrate that there is no ingestion pathway from grazing animals to potential human receptors. This will not impact vegetation sampling described in 5.5.7.1.

5.5.8 Livestock and Fish Sampling

In accordance with NRC license conditions, Powertech (USA) will collect livestock samples during the first year of operations for comparison to baseline. The anticipated sample requirements include collecting tissue samples at the time of slaughter of cattle, pigs and other livestock grazing within the permit area and analyzing samples for natural uranium, radium-226, lead-210, polonium-210 and thorium-230. Powertech (USA) anticipates modifying the NRC monitoring program to exclude livestock sampling after the first year of operations if the initial monitoring results demonstrate that there is no ingestion pathway from grazing animals to potential human receptors.

Powertech (USA) will collect samples of fish species with the potential for human consumption in accordance with NRC license conditions. The anticipated sample requirements include semiannual sampling of species with the potential for human consumption (green sunfish and channel catfish) if present in water bodies potentially affected by contamination.

5.5.9 Air Monitoring

Powertech (USA) will conduct an airborne radiation monitoring program at the Dewey-Burdock Project in accordance with NRC license conditions. The airborne radiation monitoring program will be designed to detect potential worker doses from radon and radionuclide particulates. It will include measurement of radon decay products and radionuclide particulates in the facilities and at effluent release points (e.g., vents).

Powertech (USA) also will conduct an airborne effluent and environmental monitoring program in accordance with NRC license conditions. The anticipated sampling requirements include continuously operating air monitoring stations located around the permit boundary. Filters from air particulate samplers operating continuously will be analyzed quarterly for natural uranium, thorium-230, radium-226, and lead-210. Radon gas will be measured monthly using passive track-etch detectors at each air monitoring station.

5.5.10 Meteorological Monitoring

The meteorological station at the site will continue to be operated by SDSU, or Powertech (USA) may install and operate a new meteorological station. A meteorological station within the permit area will be operated in accordance with NRC license requirements.

5.6 Potential Impacts and Mitigation

5.6.1 Land Use

5.6.1.1 Potential Land Use Impacts

Rangeland and agricultural cropland are the primary land uses within the permit area and the surrounding area. A portion of the land within the permit area will be temporarily converted from its previous use as rangeland and cropland to ISR use on a progressive, phased basis during construction and operation of ISR well fields, processing facilities, and associated infrastructure. However, most of the permit area will be undisturbed, and surface operations (e.g., wells and processing facilities) will affect only a small portion of it. Section 5.3.7 describes the total anticipated disturbance (topsoil stripping) area over the life of the project.

The land likely will experience an increase in human activity also contributing to land disturbance. The disturbance associated with drilling, pipeline installation, and facility construction will be limited and temporary as vegetation will be re-established through concurrent reclamation. The construction of access roads will be minimized to the extent possible by using and upgrading existing roads.

Operation of the project facilities will restrict the use of a portion of the land as rangeland and cropland for the duration of operations. This includes fenced well field areas, facility areas, and land application areas. This temporary change in land use will last until these areas are reclaimed and released for unrestricted use. Given the relatively small size of the impacted areas, the exclusion of grazing from well field and facility areas over the course of the project is

expected to have minimal impact on local livestock production. Following reclamation, the permit area will be returned to the approved postmining land uses.

Recreational use, which is limited primarily to large game hunting, also will be temporarily impacted within the permit boundary. Hunting is currently open to the public on approximately 5,700 acres. Approximately 240 acres of federal land are managed by the BLM. SDGF&P leases around 3,000 acres annually of privately owned land and currently designates this acreage as walk-in hunting areas (refer to Section 3.1.2). Due to safety concerns, Powertech (USA) will work with BLM, SDGF&P and private landowners to limit hunting within the permit area to the extent practicable.

5.6.1.2 Mitigation of Potential Land Use Impacts

The following procedures will be used to minimize the potential impacts to land use.

- Disturbance will be limited to only what is necessary for operations; this will be done by using existing access roads as practicable and combining access road and utility corridors.
- Development of Quality Assurance/Quality Control (QA/QC) plan to monitor the effectiveness of mitigation methods.
- Restrict normal vehicular traffic to designated roads and keep required traffic in other areas of the well field to a minimum.
- Use Class V deep disposal wells to the extent practicable for disposal of liquid wastes to mitigate potential land use impacts from land application systems.
- Conduct site ISR reclamation in interim steps to minimize potential land use environmental impacts. Sequential well field development will minimize land area impacted at any one time.
- Ponds will be reclaimed and re-vegetated and the land released for postmining uses.
- After groundwater restoration is completed, each well field and associated pipelines and facilities will be decommissioned. This includes plugging and abandoning all wells in accordance with DENR requirements. As areas are restored, they will be backfilled, contoured, and smoothed to blend with the natural terrain in accordance with the surface reclamation plan.
- All processing facilities will be decontaminated and removed unless they are to be used for other future activities as agreed in writing by the surface owner.
- Prior to completion of reclamation, landowners will be contacted and given the option to retain the roads for their private use or have the roads reclaimed by Powertech (USA). If the roads are deemed beneficial to others (i.e., hunters, ranchers and residents) and the

landowner agrees, the roads will not be reclaimed. Only roads related to ISR operations will be reclaimed.

5.6.2 Soils

5.6.2.1 Potential Soil Impacts

The two main drainage basins in the permit area have different soil types. The soil mapping unit descriptions are in Section 3.3. The Beaver Creek basin soils are composed of Haverson loam, with 0-2 percent slopes throughout the drainage. The Pass Creek basin soils are composed of Barnum silt loam in the south half of the drainage and Barnum-Winetti complex, with 0-6 percent slopes. The historical mine pits also were classified as Barnum silt loam and Barnum-Winetti complex.

Potential soil impacts to disturbed areas include:

- Compaction
- Loss of productivity
- Loss of soil
- Salinity
- Soil contamination

These impacts could potentially occur via:

- Clearing vegetation
- Compaction
- Excavation
- Leveling
- Redistribution of soil
- Stockpiling

Severity of potential impacts to soil is dependent upon type of disturbance, duration of disturbance and quantity of acres disturbed. Construction and operation activities have the potential to compact soils. Soils most sensitive to compaction, clay loams, are not present within the permit area; however, due to the use of heavy machinery and high volume within certain area, some soils have the potential for compaction. Compaction of the soil can lead to decreased infiltration, thereby increasing runoff. Soils compacted during construction and operations will be restored (i.e., disced and reseeded) as soon as possible following use.

Based on the soil mapping unit descriptions, the hazard for wind and water erosion within the permit area varies from negligible to severe. The potential for wind and water erosion is mainly a factor of surface characteristics of the soil, including texture and organic matter content. Given the very fine and clayey texture of the surface horizons throughout the majority of the permit area, the soils are more susceptible to erosion from water than wind.

If land application is used to dispose treated wastewater, there could be potential impacts to the soil from the buildup of salts, changes in SAR, buildup of radionuclides, buildup of metals and metalloids, and decrease in soil fertility. Mitigation of each of these potential impacts is described in the GDP and summarized in the following section.

Facility development will displace topsoil temporarily, which could adversely affect the structure and microbial activity of the soil. Loss of vegetation would expose soils and could result in a loss of organic matter in the soil. Excavation could cause mixing of soil layers and breakdown of the soil structure. Removal and stockpiling of soils for reclamation could result in mixing of soil profiles and loss of soil structure. Compaction of the soil could decrease pore space and cause a loss of soil structure as well. This could result in a reduction of natural soil productivity. Increased erosion and decreased soil productivity may cause a potential long-term declining trend in soil resources. Long-term impacts to soil productivity and stability could occur as a result of large-scale surface grading and leveling, until successful reclamation is accomplished. Reduction in soil fertility levels and reduced productivity could affect diversity of reestablished vegetative communities. Infiltration could be reduced, creating soil drought conditions. Vegetation could undergo physiological drought reactions (Lost Creek, 2007).

Overall, the potential environmental impacts to the soil within the permit area may be increased compared to areas outside the permit area but typically will not result from the ISR process itself, but rather from ancillary activities such as wastewater disposal and construction. The facility will be operated to minimize erosion and surface disturbance and then restored, leaving little impact on soils.

5.6.2.2 Mitigation of Potential Soil Impacts

The following measures will be used to minimize the potential impacts to soil resources.

- Design of facilities to minimize surface disturbance.
- Salvage and stockpile soil from disturbed areas (refer to Section 5.3.7).

- Reestablish temporary or permanent native vegetation as soon as possible after disturbance utilizing the latest technologies in reseeding and sprigging, such as hydroseeding (refer to Section 6.4.3.4).

- Decrease runoff from disturbed areas by using structures to temporarily divert and/or dissipate surface runoff from undisturbed areas (refer to Section 5.3.9).

- Retain sediment within the disturbed areas by using silt fencing, sediment ponds, and other ASCMs (refer to Section 5.3.9).

- Fill pipeline and utility trenches with appropriate material and regrade and reseed surface soon after completion.

- Drainage design will minimize potential for erosion by creating slopes less than 4 to 1 and/or provide rip-rap or other soil stabilization controls.

- Construct roads using techniques that will minimize erosion, such as surfacing with a gravel road base, constructing stream crossings at right angles with adequate embankment protection and culvert installation.

- Implement spill prevention and cleanup standard operating procedures to minimize soil contamination from vehicle accidents and/or well field spills or leaks; collect and monitor soils and sediments for potential contamination including areas used for land application, transport routes for yellowcake and ion exchange resins, and well field areas where spills or leaks are possible.

- Excavate contaminated soil as described in Section 6.3.3 and replace with uncontaminated soil as needed.

- Specific mitigation measures for potential soil impacts from land application are addressed in the GDP and summarized as follows:
    - The expected land application water quality is described in Section 5.4.1.1.4.1. With an anticipated TDS concentration of 1,000 to 5,000 mg/L, the water will pose a low to moderate risk to the growth of moderately salt-sensitive crops such as alfalfa. Soil salinity levels will be controlled by blending the land application water in the ponds and by leaching salts below the root zone during land application. Powertech (USA) will operate the land application systems to balance the downward migration of water, which has potential alluvial groundwater impacts, with the leaching that will be used to control salt buildup in the root zone.
    - The anticipated SAR levels in the land application water are 2 to 6, which should pose a low risk to soil infiltration rates. Should soil SAR increase and pose a risk to soil infiltration, Powertech (USA) will apply amendments such as sulfur or gypsum at agronomic rates.

- Since Powertech (USA) will treat the land application water to meet effluent limits, including the 10 CFR 20, Appendix B, Table 2, Column 2 standards for release of radionuclides to the environment, it is unlikely that radionuclides will build up to potentially harmful levels. This will be verified through operational soil monitoring and additional surveys during decommissioning.
- During decommissioning, Powertech (USA) will conduct land cleanup in accordance with NRC license and DENR permit requirements. This includes cleaning up surface soils to standards for radium-226 and natural uranium that will be established as conditions in the NRC license as protective of human health and the environment. This applies to the entire permit area and is not limited to the land application areas.
- The concentrations of metals and metalloids, including arsenic and selenium, are anticipated to be low as shown in Table 5.4-3 Nevertheless, there is potential for buildup of metals and metalloids over time in the land application areas. Potential impacts will be mitigated by monitoring soil concentrations during operations and implementing a contingency plan if concentrations approach trigger values. The contingency plan will consist of one or more of the following items:
    - Verify sample results and precisely delineate affected areas through additional soil sampling and analysis.
    - Modify land application system operating parameters to reduce the discharge rate in specific pivots or throughout the land application area.
    - Implement water treatment if necessary for radionuclides, metals or metalloids.
    - Implement a phytoremediation plan to control buildup of selenium in soil.
    - Excavate soil contaminated above the reclamation standards established in the NRC license and LSM permit and dispose excavated soil in an appropriately permitted disposal facility.
- Powertech (USA) may apply fertilizer to the land application areas to maximize crop production and maintain adequate soil fertility.

5.6.3 Groundwater

5.6.3.1 Potential Groundwater Impacts

Potential groundwater impacts include groundwater consumption, drawdown in nearby water supply wells, and potential groundwater quality impacts. Each of these is discussed below.

5.6.3.1.1 Potential Groundwater Consumption

Inyan Kara Aquifer

ISR circulates significant quantities of water through the ore zone, but only a small fraction of that water is a net withdrawal because most water is reinjected into the deposit. During ISR operations (including both production and restoration), a small portion of the solution extracted from the aquifer will be "bled" from the system. Bleed is defined as excess production or restoration solution withdrawn to maintain a cone of depression so native groundwater continually flows toward the center of the production zone. This bleed constitutes the net water withdrawal from the Inyan Kara aquifer. Nominal bleed rates of 0.5 to 1% are planned over the life of the project, with a design average bleed rate of 0.875%. Instantaneous production bleed may vary in the range of 0.5 to 3% for short durations, from days to months. If necessary, additional aquifer restoration bleed (up to 17%) will be used briefly during aquifer restoration to recover additional solutions and draw a greater influx of water into the ore zone from the surrounding Inyan Kara aquifer. This is known as groundwater sweep.

Table 5.6-1 summarizes the typical Inyan Kara water usage for the Dewey-Burdock Project. During uranium recovery (production), Powertech (USA) proposes to pump up to 8,000 gpm from the Inyan Kara aquifer. The typical production bleed rate will be 0.875%. Therefore, the net production withdrawal will typically be up to 70 gpm. During aquifer restoration, Powertech (USA) proposes to pump up to 500 gpm from the Inyan Kara aquifer. The restoration bleed will vary from about 1% to 17%. Therefore, the net aquifer restoration withdrawal will be up to 85 gpm. During concurrent production and restoration, the anticipated maximum gross and net usage from the Inyan Kara (on an annual average basis) will be 8,500 gpm and 155 gpm, respectively.

Madison Limestone

Table 5.6-2 summarizes the anticipated typical water consumption from the Madison Limestone. This includes approximately 12 gpm usage at the CPP plus aquifer restoration water. In the DDW option, the water withdrawn from the well fields will be treated with RO, and resulting permeate will be reinjected along with Madison Limestone water into the well fields. Based on an estimated permeate recovery rate of 70%, the Madison Limestone requirement will be 65 to 145 gpm at 17% and 1% aquifer restoration bleed, respectively.

Table 5.6-1: Typical Inyan Kara Water Usage

Usage	Amount
Production Only	
Gross Inyan Kara Pumping, gpm	8,000
Net Inyan Kara Usage (0.875% bleed), gpm	70
Aquifer Restoration Only	
Gross Inyan Kara Pumping, gpm	500
Net Inyan Kara Usage (1% bleed), gpm	5
Net Inyan Kara Usage (17% bleed), gpm	85
Concurrent Production and Restoration	
Gross Inyan Kara Pumping, gpm	8,500
Net Inyan Kara Usage (1% aquifer restoration bleed), gpm	75
Net Inyan Kara Usage (17% aquifer restoration bleed), gpm	155

Table 5.6-2: Typical Madison Water Usage

Usage	Amount
Production Only	
CPP usage, gpm	12
Aquifer Restoration Only	
Deep Disposal Well Option	
CPP usage, gpm	12
Madison Usage (1% bleed), gpm	145
Madison Usage (17% bleed), gpm	65
Land Application Option	
CPP usage, gpm	12
Madison Usage (1% bleed), gpm	495
Madison Usage (17% bleed), gpm	415
Concurrent Production and Restoration	
Maximum Anticipated Madison Usage (DDW option), gpm	157
Maximum Anticipated Madison Usage (land application option), gpm	507

In the land application option, all of the water withdrawn during aquifer restoration will be treated and disposed. The water will be replaced with water from the Madison Limestone or another suitable aquifer except for the restoration bleed, which will vary from 1% to 17%. Since the aquifer restoration pumping rate will be up to 500 gpm, between 415 and 495 gpm from the Madison Limestone will be reinjected into well fields undergoing aquifer restoration.

5.6.3.1.2 Potential Drawdown

Inyan Kara Aquifer

Petrotek Engineering Corporation (Petrotek) prepared a numerical groundwater flow model using site-specific data to predict hydraulic responses of the Fall River and Chilson aquifers to ISR production and restoration operations at the Dewey-Burdock Project. A primary model objective was to predict drawdown on a local and regional scale.

The numerical groundwater model domain encompasses nearly 360 square miles with north-south and east-west dimensions of 100,000 ft (18.9 miles). The northern and eastern boundaries of the model domain represent the updip limits of saturated conditions within the Inyan Kara aquifer system. The southern and western boundaries of the model extend at least 10 miles beyond the permit area. The Dewey Fault forms a no-flow boundary along the northwestern and northern boundaries of the model domain. Four layers were modeled. From shallowest to deepest these include the Graneros Group, Fall River Formation, Fuson Shale, and the Chilson Member of the Lakota Formation.

The model was calibrated to average 2010-2011 water level data by varying recharge to the Fall River and Chilson aquifers. Transient calibrations also were performed by simulating results of the 2008 aquifer tests conducted in support of the NRC license application. The calibrated model was then verified through simulation of aquifer tests conducted in 1982 by TVA.

Operational simulations were performed for gross Inyan Kara production rates ranging from 4,000 to 8,000 gpm. Restoration was simulated as a 1% bleed for a 500 gpm, gross restoration flow rate (5 gpm net extraction). Additional restoration bleed also was simulated for the groundwater sweep option. The results of the numerical groundwater modeling are presented in Appendix 5.6-A. Figures 6-38 and 6-39 in Appendix 5.6-A depict the modeled maximum drawdown for the Fall River and Chilson, respectively, at an 8,000 gpm gross production rate with a 1% production bleed and 1% aquifer restoration bleed applied to a 500 gpm gross restoration rate plus groundwater sweep. This represents a maximum net Inyan Kara water usage

rate of 147.2 gpm, or an amount approximately equal to the typical net Inyan Kara usage during concurrent production and restoration in Table 5.6-1.

Figure 6-38 in Appendix 5.6-A shows the maximum predicted drawdown in the Fall River Formation, and Figure 6-39 in Appendix 5.6-A shows the maximum predicted drawdown in the Chilson. Maximum drawdown outside the permit area during the simulation was slightly greater than 12 feet within the Fall River and approximately 10 feet in the Chilson. The groundwater model report in Appendix 5.6-A shows that potential drawdown impacts will be short-lived, with recovery to within 1 to 2 feet of pre-ISR levels within one year after the end of ISR operations.

The potential to unlawfully impair existing water rights or domestic wells will be addressed in Inyan Kara aquifer water appropriation permits obtained through the DENR Water Rights Program. The Inyan Kara water rights applications demonstrate that Inyan Kara water is available for the proposed use and the proposed diversions can be developed without unlawful impairment of existing rights.

Madison Limestone

Powertech (USA) has developed a conceptual groundwater flow model of the Madison Limestone in the vicinity of the permit area. The model results are provided with the water appropriation permit application for the Madison that has been submitted to the DENR Water Rights Program. The conceptual model demonstrates that Madison water is available for the proposed use and the proposed diversions can be developed without unlawful impairment of existing rights.

5.6.3.1.3 Potential Groundwater Quality Impacts

Potential groundwater quality impacts include potential impacts to the ore zone, potential impacts to aquifers surrounding the ore zone, potential impacts to overlying and underlying aquifers, and potential impacts to the alluvium. Each of these is addressed below.

5.6.3.1.3.1 Potential Impacts to Ore Zone Groundwater Quality

A potential environmental impact to groundwater as a result of ISR is the degradation of water quality in the ore zone within the well field areas. The interaction of the lixiviant with the mineral and chemical constituents of the aquifer will result in an increase in trace elements and salinity during uranium recovery operations. This will result from oxidation of uranium and other trace constituents and through the IX process, which will exchange dissolved uranium for chloride or bicarbonate ions.

During aquifer restoration, Powertech (USA) will restore groundwater quality consistent with NRC license conditions, the primary restoration goals being baseline water quality or an EPA-established maximum contaminant level (MCL) on a parameter-by-parameter basis. Therefore, the potential impacts to ore zone groundwater quality will be temporary and will end with NRC approval of successful aquifer restoration in each well field.

5.6.3.1.3.2 Potential Impacts to Inyan Kara Groundwater Quality Outside of the Ore Zone

Horizontal excursions have the potential to contaminate groundwater horizontally outside of the ore zone. Horizontal excursions could be caused by a temporary well field imbalance, in which the inward hydraulic gradient normally maintained by production and restoration bleed is temporarily altered. Horizontal excursions, if left uncontrolled, would have the potential to impact the groundwater quality of USDWs surrounding the ore zone. However, as described in Section 5.6.3.2, an extensive monitoring system will be implemented to ensure that potential excursions are rapidly detected and corrected. Therefore, potential impacts to Inyan Kara groundwater quality outside of the ore zone would be brief and localized.

By properly designing, pump testing, and operating each well field and its associated monitor well network, Powertech (USA) will minimize the risk of excursions and the potential impacts resulting from excursions. By routinely sampling monitor wells for changes in water level and concentrations of highly mobile and conservative excursion parameters, Powertech (USA) will ensure that any potential excursions are identified and corrected quickly. As described by NUREG-1910, Supplement 1 (NRC, 2010), “An excursion is defined as an event where a monitoring well in overlying, underlying, or perimeter well ring detects an increase in specific water quality indicators, usually chloride, alkalinity and conductivity, which may signal that fluids are moving out from the wellfield … The perimeter monitoring wells are located in a buffer region surrounding the wellfield within the exempted portion of the aquifer. These wells are specifically located in this buffer zone to detect and correct an excursion before it reaches a USDW … To date, no excursion from an NRC-licensed ISR facility has contaminated a USDW.”

5.6.3.1.3.3 Potential Impacts to Overlying or Underlying Aquifers

Potential impacts to overlying or underlying aquifers could occur from a vertical excursion of ISR solutions into an overlying or underlying aquifer. This could be caused by vertical hydraulic head gradients between the production aquifer and the underlying or overlying aquifers. A vertical hydraulic head gradient could be caused by pumping from either the underlying or

overlying aquifers for water supply in the vicinity of the ISR facility. Discontinuities in the thickness and spatial heterogeneities in the vertical hydraulic conductivity of confining units could also lead to vertical movement of solutions and excursions.

Another potential source of vertical excursions is potential well integrity failures during ISR operations. Inadequate construction, degradation, or accidental rupture of well casings above or below the uranium-bearing aquifer could allow lixiviant to travel from the well bore into the surrounding aquifer. Deep monitor wells drilled through the production aquifer and confining units that penetrate aquitards could potentially create pathways for vertical excursions as well.

Section 5.6.3.2 describes how an extensive monitoring system and MIT program will be implemented to prevent vertical excursions and to provide rapid detection and corrective action in the event of a vertical excursion. Potential impacts to overlying or underlying aquifers would be brief and localized.

5.6.3.1.3.4 Potential Impacts to Alluvium

The primary potential to impact alluvial water quality would be a pipeline leak or spill. Potential impacts and mitigation measures for leaks and spills are addressed in Sections 5.6.4.1 and 5.6.4.2.

If land application is used for liquid waste disposal, the alluvial groundwater quality could be impacted in the vicinity of the land application areas. The GDP and Section 5.6.3.2 describe mitigation measures that will protect alluvial groundwater quality during land application.

5.6.3.1.4 Potential Impacts to Groundwater Hydrologic Balance

Any disturbance to the prevailing hydrologic balance of the affected land and of the surrounding area and to the quantity of groundwater both during and after ISR operations and during reclamation will be minimized in accordance with SDCL 45-6B-41. Powertech (USA) will be required to demonstrate that water is available for the proposed diversions in the Inyan Kara and Madison in order to obtain water appropriation permits from the DENR Water Rights Program. The water appropriation permit applications will demonstrate limited potential impacts to the groundwater hydrologic balance due to limited drawdown.

5.6.3.1.5 Potential Subsidence in ISR Well Fields

There is no potential for subsidence in the ISR well fields due to limited drawdown in the ore zone and other aquifers and due to the nature of uranium ISR, which does not affect the structural integrity of the ore zone sands. Refer to Section 5.6.3.1.2 and Appendix 5.6-A, which describe how potential drawdown in the Inyan Kara aquifer will be limited, and the potentiometric water level is anticipated to recover to pre-ISR levels rapidly after the end of ISR activities. Section 5.6.3.1.2 also describes how potential drawdown in the Madison Limestone will be only a small portion of the confining pressure above the top of the Madison.

The following information from the ISR GEIS addresses subsidence potential in ISR well fields in the Nebraska-South Dakota-Wyoming Uranium Milling Region, which includes the proposed permit area (NRC, 2009, Section 4.4.3.2):

> "The removal of uranium mineral coatings on sediment grains in the target sandstones during the uranium mobilization and recovery process will result in a change to the mineralogical composition of uranium-producing formations. However, the uranium mobilization and recovery process in the target sandstones does not result in the removal of rock matrix or structure, and therefore no significant matrix compression or ground subsidence is expected. In addition, the source formations for uranium in the Nebraska-South Dakota-Wyoming Milling Region occur at depths of tens to hundreds of meters [hundreds of feet] … and individual mineralization fronts are typically 0.6 to 7.5 m [2 to 25 ft] thick … At these depths and thicknesses and considering that rock matrix is not removed during the uranium mobilization and recovery process, it is unlikely that collapse in the target sandstones would be translated to the ground surface. Therefore, impacts to geology from ground subsidence would be expected to be SMALL."

5.6.3.2 Mitigation of Potential Groundwater Impacts

Following is a list of mitigation measures for potential impacts to groundwater. Specific mitigation measures for potential impacts to water supply wells and corrective actions for excursions are provided below.

- Perform MIT on all wells prior to use and repeat every 5 years.
- Minimize groundwater use during operations by limiting production and restoration bleed to the minimum amount needed to ensure hydraulic well field control.
- Monitor well pressures to detect leaks.
- Install and operate an extensive monitoring system to detect potential horizontal or vertical excursions of ISR solutions.
- Plug and abandon or mitigate any of the following should they pose the potential to impact the control and containment of well field solutions within the permit area:
    - Historical wells and exploration holes
    - Holes drilled by Powertech (USA) for delineation and exploration
    - Any well failing MIT
- Maintain pumping and injection rates (well field balance) to ensure radial hydraulic flow into and through the production zone.
- Monitor to detect and define unanticipated surface spills, releases, or similar events that may infiltrate into the groundwater system.
- Implement a spill prevention and cleanup plan to minimize potential impacts to groundwater, including rapid response cleanup and remediation capability, techniques, procedures, and training.
- Monitor nearby domestic, livestock, irrigation, and designated monitor wells as appropriate during operations.
- Select restoration method to minimize water consumption during groundwater restoration.
- During groundwater restoration, monitor groundwater using standard industry practices to determine the progression and effectiveness of restoration.
- Implement an extensive land application monitoring system that includes compliance wells, intermediate wells, and vadose zone monitoring.
- Site land application areas at locations where natural conditions make it highly unlikely that the land application water will reach the alluvium.
- Apply land application water at agronomic rates.
- Treat the land application water and/or DDW water to remove radionuclides.

Mitigation of Potential Impacts to Water Supply Wells

The following procedures will be followed to evaluate and mitigate potential impacts to water supply wells. During the design of each well field, all nearby water supply wells will be evaluated for the potential to be impacted by ISR operations or the potential to interfere with ISR operations. If needed, this evaluation also will include groundwater modeling. The results of the evaluation will be contained within a well replacement plan described in the hydrogeologic data package for each well field (refer to Section 5.3.3.4).

At a minimum, all domestic wells within the permit area will be removed from drinking water use and all stock wells within ¼ mile of well fields will be removed from private use. Depending on the well construction, location and screen depth, Powertech (USA) may continue to use the well for monitoring or plug and abandon the well.

The well owner will be notified in writing prior to removing any well from private use. Powertech (USA) will work with the well owner to determine whether a replacement well or alternate water supply is needed.

Section 5.5.2 describes the operational groundwater monitoring plan that will be used to assess potential impacts to domestic, livestock and irrigation wells. The monitor well ring will provide advance warning before any wells outside the ring have potential to be impacted. If routine monitoring of a water supply well indicates diminished water quantity or quality, the well owner will be notified in writing and the well will be removed from use. Powertech (USA) will work with the well owner to determine if well replacement is necessary. Well replacement procedures are described below. The monitoring and well replacement or abandonment procedures to be implemented by Powertech (USA) will assure that there will be no effects on anyone or any water well outside the monitor well ring.

Water Supply Well Replacement Procedures

Replacement wells will be located an appropriate distance from the well fields and will target an aquifer outside of the ore zone that provides water in a quantity equal to that of the original well and of a quality which is suitable for the same uses as the original well, subject to the lease agreement and South Dakota water law.

Lease agreements for the entire permit area currently allow Powertech (USA) to remove and replace the water supply wells as needed. The following is an excerpt from the lease agreements

with each landowner. (Note: all lease agreements formerly held by Denver Uranium have been assigned to Powertech (USA).)

> *DENVER URANIUM shall compensate LESSOR for water wells owned by LESSOR at the execution of this lease, as follows: Any such water which falls within an area to be mined by DENVER URANIUM, shall be removed from LESSOR's use. Prior to removal, DENVER URANIUM shall arrange for the drilling of a replacement water well or wells, outside of the mining area, in locations mutually agreed upon between LESSOR and DENVER URANIUM, as may be necessary to provide water in a quantity equal to the original well and of a quality which is suitable for all uses the original water well served at the time such well was removed from LESSOR's use.*

An example of a replacement well is provided in Figure 5.6-1, which shows use of the project Madison well to supply water by pipeline to local stock tanks.

Excursion Control

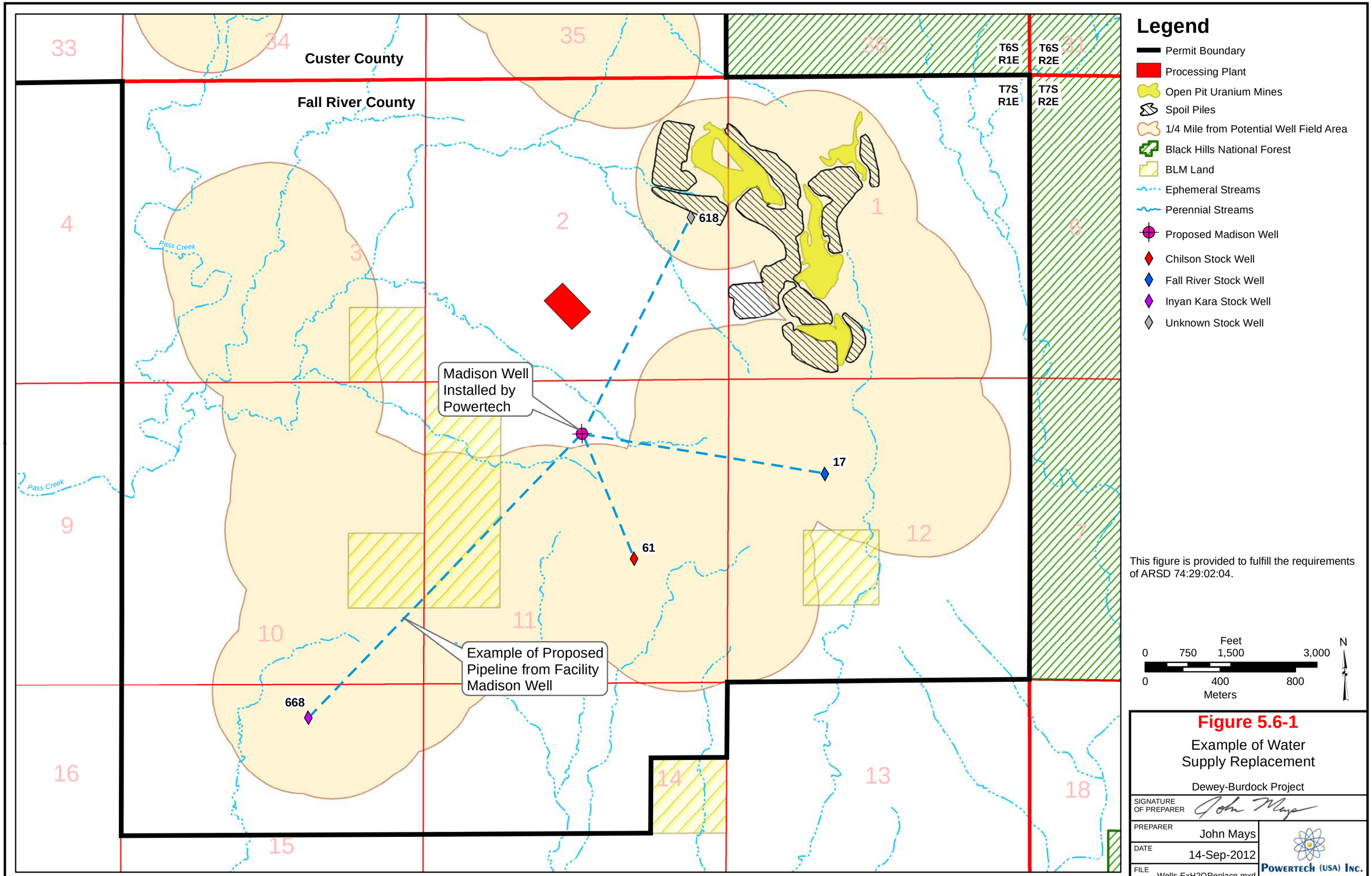
The following mitigation measures will be used to prevent potential horizontal or vertical excursions of ISR solutions.

Pre-operational excursion preventative measures will include, but will not be limited to:

1. Proper well construction and MIT of each well before use;
2. Monitor well design schema based upon delineation drilling to further characterize the zones of mineralization and to identify the target completion zones for all monitor wells; and
3. Pre-operational pumping tests with monitoring systems in place to obtain a detailed understanding of the local hydrogeology and to demonstrate the adequacy of the monitoring system.

Operational excursion preventative measures will include but will not be limited to:

1. Regular monitoring of flow and pressure on each production and injection well;
2. Regular flow balancing and adjustment of all production and injection flows appropriate for each production pattern;
3. Operation of bleed, and continuous measurement of bleed rate;
4. Monitoring hydrostatic water levels in monitor wells to verify the cone of depression; and


Custer County
Fall River County
33
34
35
36
31
4
3
2
1
6
9
10
11
12
7
16
15
14
13
18
T6S R1E
T6S R2E
T7S R1E
T7S R2E
Pass Creek
Pass Creek
618
17
61
668
Madison Well Installed by Powertech
Example of Proposed Pipeline from Facility Madison Well
Legend
Permit Boundary
Processing Plant
Open Pit Uranium Mines
Spoil Piles
1/4 Mile from Potential Well Field Area
Black Hills National Forest
BLM Land
Ephemeral Streams
Perennial Streams
Proposed Madison Well
Chilson Stock Well
Fall River Stock Well
Inyan Kara Stock Well
Unknown Stock Well
This figure is provided to fulfill the requirements of ARSD 74:29:02:04.
Feet
0 750 1,500 3,000
0 400 800
Meters
N
Figure 5.6-1
Example of Water Supply Replacement
Dewey-Burdock Project
SIGNATURE OF PREPARER
PREPARER John Mays
DATE 14-Sep-2012
FILE Wells-ExH2OReplace.mxd
POWERTECH (USA) INC.

5. Regular collection of samples from all monitor wells to determine the presence of any indicators of the migration of ISR solutions horizontally or vertically from the production zone.

6. Perform MIT on all wells prior to use and repeat every 5 years.

Monitor wells will be positioned to detect any ISR solutions that may potentially migrate away from the production zone due to an imbalance in well field pressure. The monitoring well detection system described in Section 5.3.3.1.2 is a proven method used at historically and currently operated ISR facilities. Prior to injecting chemicals into each well field, pre-operational pump testing will be conducted to demonstrate hydraulic connection between the production and injection wells and all perimeter monitor wells (see Section 5.3.3.3). The results of the pump testing will be included within the hydrogeologic data packages prepared for each well field as described in Section 5.3.3.4. Additional monitor wells will be installed within overlying and underlying hydrogeologic units. The pre-operational pump testing will demonstrate vertical confinement and hydraulic isolation between the production zone and overlying and underlying units. The monitoring system and operational procedures have proven effective in early detection of potential excursions of ISR solutions for a number of reasons:

- Regular sampling for indicator parameters (such as chloride) that are highly mobile can detect ISR solutions at low levels well before an excursion is created.
- Monitoring hydrostatic water levels in perimeter monitor wells will provide immediate verification of the cone of depression, draw rapid attention in the event of a change, and provide the ability for measurement and implementation of corrective response.
- Bleed will create a cone of depression that will maintain an inward hydraulic gradient toward the well field area.
- The natural groundwater gradient and slow rate of natural groundwater flow is small relative to ISR activities and the induced gradient caused by the production and restoration bleed.

Controls for preventing migration of ISR solutions to overlying and underlying aquifers consist of:

- Regular monitoring of hydrostatic water levels and sampling for analysis of indicator species;
- Routine MIT of all wells on a regular basis (at least every 5 years) to reduce any possibility of casing leakage;
- Completion of MIT on all wells before putting them into service or after work which involves drilling equipment inside of the casing;

- Proper plugging and abandonment of all wells which do not pass MIT or that become unnecessary for use;
- Proper plugging and abandonment of exploration holes with potential to impact ISR operations; and
- Sampling monitor wells located within the overlying and underlying hydrogeologic units on a frequent schedule.

These controls work together to prevent and detect ISR solution migration. Plugging any exploration holes that pose the potential to impact the control and containment of ISR solutions prevents connection of the production zone to overlying and underlying units. The EPA UIC requirements for MIT assure proper well construction, which is the first line of defence for maintaining appropriate pressure without leakage. Sampling the monitor wells will enable early detection of any ISR solutions should an excursion occur.

Excursion Corrective Actions

Powertech (USA) will implement the following corrective action plan for excursions occurring during production or restoration operations. Corrective actions to correct and retrieve an excursion may include but will not be limited to:

- Adjusting the flow rates of the production and injection wells to increase the aquifer bleed in the area of the excursion;
- Terminating injection into the portion of the well field affected by the excursion;
- Installing pumps in injection wells in the portion of the well field affected by the excursion to retrieve ISR solutions;
- Replacing injection or production wells; and
- Installing new pumping wells adjacent to the well on excursion status to recover ISR solutions.

In the event of an excursion, the sampling frequency will be increased to weekly. NRC will be notified within 24 hours by telephone or email and within 7 days in writing from the time an excursion is verified. DENR will be notified in writing within 7 days from the time an excursion is verified. In addition, if the excursion has potential to affect a USDW, EPA will be notified verbally within 24 hours and in writing within 5 days. A written report describing the excursion event, corrective actions taken and the corrective action results will be submitted to all involved regulatory agencies within 60 days of the excursion confirmation.

If wells are still on excursion status when the report is submitted, the report also will contain a schedule for submittal of future reports describing the excursion event, corrective actions taken,

and results obtained. If an excursion is not corrected within 60 days of confirmation, Powertech (USA) will terminate injection into the affected portion of the well field until the excursion is retrieved, or provide an increase to the reclamation financial assurance obligation in an amount that is agreeable to NRC and that would cover the expected full cost of correcting and cleaning up the excursion. The financial assurance increase will remain in force until the excursion is corrected. The written 60-day excursion report will state and justify which course of action will be followed. If wells are still on excursion status at the time the 60-day report is submitted to NRC, and the financial assurance option is chosen, the well field restoration financial assurance obligation will be adjusted upward. When the excursion is corrected, the additional financial assurance obligations resulting from the excursion will be removed.

5.6.4 Surface Water

5.6.4.1 Potential Surface Water Impacts

Potential surface water impacts include increased sediment load due to surface disturbance, very limited stream channel disturbance, potential encroachment on wetlands, and potential water quality impacts from leaks or spills. Each of these is described below.

5.6.4.1.1 Potential Sedimentation

Construction activities within the well fields, along the pipeline corridors and roads, and at the CPP and Satellite Facility have the potential to increase the sediment yield of the disturbed areas. The potential impacts will be minimal due to the relatively small size of the disturbance areas relative to the watershed areas and due to the implementation of the sediment control plan described in Section 5.3.9 and the mitigation measures described in Section 5.5.4.2.

5.6.4.1.2 Potential Impacts to Stream Channels and Riparian Areas

As described in Section 5.3.9, Powertech (USA) has evaluated flood inundation boundaries and will construct facilities outside of these boundaries to avoid potential impacts to facilities from flooding and potential impacts to the stream channels. Some facilities must be located within stream channels, such as pipeline corridors and access roads. These will cross the stream channels perpendicular to the flow direction to minimize disturbance. Primary and secondary access road stream channel crossings will include culverts as described in Section 5.3.8.

Ephemeral stream channels also will be disturbed temporarily at the upstream and downstream ends of the diversion channels described in Section 5.3.9.1, which describes the erosion protection measures that will be used for diversion channels.

Facilities potentially constructed in the cottonwood gallery riparian zone along Pass Creek include a limited number of access roads, pipelines and utility corridors. Following is a discussion of potential impacts associated with these facilities.

To a limited extent, access roads will be constructed within the cottonwood gallery riparian zone. Most of these roads will be light-use roads (tertiary access roads), which are described in Section 5.3.8 as essentially non-constructed, two-track trails. To the extent possible, existing two-track roads will be used. The route for any new light-use roads that will be required within the cottonwood gallery riparian zone will be selected to minimize impacts to the riparian zone and to minimize erosion.

One secondary access road is planned through the cottonwood gallery riparian zone. This road is depicted on Plate 5.3-5 (Sheet 2) in the NWNW Section 3, T7S, R1E. It is an existing road near a dwelling that crosses Pass Creek and the riparian zone using a well-established route. Since the proposed secondary access road will be an upgrade to an existing road, potential impacts to Pass Creek will be minimized. Powertech (USA) intends to continue to use the existing low-water crossing and not install a bridge or culvert at this location. Erosion control measures described in Section 5.3.9 will be used for any disturbance areas that could contribute sediment to Pass Creek.

The plant-to-plant pipeline(s), if constructed, will cross the riparian zone near the existing low-water crossing. In addition, a utility corridor consisting of an overhead power line and buried pipeline is planned across the Pass Creek riparian zone in the SESW Section 34, T6S, R1E (refer to Plate 5.3-1, Sheet 2). The pipeline and utility routes through the riparian zone will be selected to minimize potential impacts. The Pass Creek pipeline crossings will be trenched or bored. Mitigation measures to minimize impacts will include use of sediment control measures, avoiding construction during early spring while runoff from snowmelt is occurring, and complying with applicable U.S. Army Corps of Engineers permitting requirements.

Disturbance to the cottonwood gallery riparian zone will be relatively small due to the limited number of utility crossings and use of existing roads. Special care will be taken in this area to control sediment. During construction, silt fences, straw beds, and other sediment control measures will be used to minimize any potential water quality impacts.

5.6.4.1.3 Potential Impacts to Wetlands

The majority of the potential wetlands in the permit area occur along Beaver Creek and Pass Creek. Potential well field areas all occur away from Beaver Creek and Pass Creek, and potential wetlands along Beaver Creek and Pass Creek will not be impacted by construction activities. The remaining potential wetlands are dispersed throughout the permit area as small depressions and ponds, historical mine pits, and an area around a flowing artesian well. The wetlands within the historical mine pits are not planned to be disturbed. There may be some encroachment impacts to small, depressional wetland areas.

Construction, operation, or reclamation activities, which cause disturbance or impacts to jurisdictional wetlands, will be performed in accordance with appropriate Nationwide Permits issued by the U.S. Army Corps of Engineers, if applicable. These may include Nationwide Permit (NWP) 44 non-coal mining activities, which requires Pre-construction Notification (PCN) for all activities, NWP 12 utility line activities, which requires PCN for an area where a Section 10 permit is required, discharges that result in the loss of >0.1 acre, and NWP 14 linear transportation projects, which requires a PCN for 0.5 acre in non-tidal waters. NWP 44 has an acreage limit of 0.5 acre for Waters of the U.S. (WoUS). NWP 12 and 14 also have 0.5-acre disturbance limits. Impacts to Other Waters of the U.S. (OWUS) are not considered under the acreage limit. Appendix 3.8-B contains the USACE jurisdictional determination for the permit area.

5.6.4.1.4 Potential Surface Water Quality Impacts from Leaks or Spills

Potential surface water quality impacts from leaks or spills are addressed in Section 5.6.5.1. Mitigation measures are described in Section 5.6.5.2.

5.6.4.2 Mitigation of Potential Surface Water Impacts

The following procedures will be used to minimize the potential impacts to surface waters.

- Minimize disturbance of surface areas and vegetation which, in turn, will minimize erosion and runoff rates.
- Minimize physical changes to drainage channels unless changes are made to upgrade drainage.
- Use erosion and runoff control features such as proper placement of pipe, grading to direct runoff away from water bodies, and use of riprap (broken rock and/or concrete) at these intersections to make bridges or culverts more effective, if necessary.

- Use sediment trapping devices such as hay or straw bales, fabric fences, and devices to control water flow and discharges to trap sediments moved by runoff.
- Maintain natural contours as much as possible, stabilizing slopes and avoiding unnecessary off-road travel with vehicles; maintaining natural contours as much as possible, stabilizing slopes and avoiding unnecessary off-road travel with vehicles.
- The land application of treated wastewater will occur at agronomic rates to avoid irrigation runoff into surface water; catchment areas also will prevent land application water from entering surface water.
- Prepare and implement a Stormwater Pollution Prevention Plan that is consistent with state and federal standards for construction and operation activities.
- Facilities will be constructed outside of flood inundation areas to the extent practicable.
- Best management practices will be utilized during ISR operations.

5.6.5 Spills and Leaks

5.6.5.1 Potential Impacts from Spills and Leaks

Potential impacts from spills and leaks include potential impacts to soil, surface water, and groundwater resulting from a spill or leak in the well fields, processing facilities, transportation vehicles, or ponds. Each of these is described below.

5.6.5.1.1 Well Fields and Pipelines

Well field features such as header houses, well heads or pipelines could contribute to pollution in the unlikely event of a release of ISR solution due to pipeline or well failure. A spill or leak in these areas could potentially impacts soils, surface water and groundwater. Potential impacts will be minimized by routine MIT of all injection, production and monitor wells and hydrostatic leak testing of all pipelines during construction; implementing an instrumentation and control system to monitor pressure and flow and immediately detect and correct an anomalous condition; and implementing a spill response and cleanup program in accordance with NRC license requirements and DENR permit conditions.

5.6.5.1.2 CPP and Satellite Facility

The CPP will serve as the hub for production operations at the project; therefore, the CPP will likely have the greatest potential for spills or accidents potentially resulting in the release of pollutants. Potential releases also could occur from the Satellite Facility. Potential releases could result from a tank or process vessel failure, pipe rupture, or transportation incident.

Failure of a process vessel, tank, or pipeline within the CPP or Satellite Facility will be contained within the building via concrete containment curbs and directed into a sump (equipped with a level alarm) that will transport the solution the appropriate tank or disposal system. The concrete containment curb for the CPP has been designed to contain the entire contents of the two largest liquid-containing vessels (yellowcake thickeners) in the extremely unlikely event that both vessels should fail simultaneously and spill their entire contents. The sumps will provide additional temporary containment capacity such that the total containment capacity of curbs and sumps will be greater than 200% of the largest liquid-containing tank or vessel in the CPP. The Satellite Facility similarly will have a curb and sump system that together will provide approximately 350% of the volume of the largest liquid-containing vessel or tank (utility water tank).

The design of the CPP and Satellite Facility will be such that any spill will be contained within the respective building, regardless of sump pump operation. In the event of a total electrical failure, such that no pumps would be operational, a spill due to a vessel failure would be contained within the building in which the vessel failure occurred.

Chemical storage areas adjacent to the CPP will be provided with secondary containment as discussed in Section 5.3.1.

5.6.5.1.3 Transportation Vehicles

An accident involving transportation vehicles within or to and from the permit area could potentially release pollutants to the environment. Transportation vehicles will include, but are not limited to: vehicles delivering bulk chemical products, transport of uranium-loaded resin from the Satellite Facility or another satellite facility to the CPP, transport of solid 11e.(2) byproduct material from the project site to an approved disposal site, or transport of dried yellowcake product from the CPP.

Chemicals and products delivered to or transported from the permit area will be transported in accordance with all applicable federal and state regulations. As part of Powertech (USA)'s Environmental Management Program, emergency response procedures will be developed and implemented to ensure a rapid response to any transportation incidents. All personnel will be appropriately trained in emergency response procedures to facilitate proper response from Powertech (USA) employees in transportation incidents.

Potential impacts would differ according to material type, quantity and concentration. Transportation risks for yellowcake shipments, uranium-loaded resin shipments, process chemicals/fuel, and 11e.(2) byproduct material are described in the NRC license application. These are briefly summarized below.

Yellowcake Shipments

A specialized, appropriately licensed transportation company will transport the yellowcake to a conversion facility. Powertech (USA) will develop an Emergency Preparedness Program that will be implemented should a transportation accident occur. The primary potential impact associated with an accident involving the spill of yellowcake would be potential impacts to soil in the immediate spill area. The potential impacts will be minimized by implementing the Emergency Preparedness Program and salvaging affected soils.

Uranium-loaded Resin Shipments

Resin shipments typically will occur in bulk transport trailers. Resin shipments potentially will include uranium-loaded resin shipments between the Satellite Facility and CPP or between another satellite facility outside of the permit area to the CPP. They also would include barren or eluted resin shipments from the CPP to a satellite facility. A transportation accident involving uranium-loaded resin would have a lower risk than the relatively low risk from an accident involving yellowcake due to the much lower concentration of uranium in the resin and the chemical bond between the uranium and IX resin. The primary potential impact associated with an accident involving the spill of resin would be potential impacts to soil in the immediate spill area. The potential impacts will be minimized by salvaging affected soils.

Process Chemicals and Fuel

A number of shipments of chemicals and fuel will be made each week throughout operations. Process chemicals delivered to the permit area will include carbon dioxide, oxygen, salt, soda ash, barium chloride, hydrogen peroxide, sulfuric acid, hydrochloric acid, and caustic soda. All applicable DOT hazardous materials shipping regulations and requirements will be followed during shipment of process chemicals and fuel to minimize the potential for transportation accidents. Powertech (USA) also will develop standard operating procedures for unloading process chemicals and fuel within the permit area to minimize the potential for spills.

11e.(2) Byproduct Material

All solid 11e.(2) byproduct material generated in the permit area will be transported to an appropriately licensed disposal facility. Most of the solid 11e.(2) byproduct material shipping

will occur during site reclamation and decommissioning. The potential risk of a transportation accident is low, since solid 11e.(2) byproduct material is generally less radioactive than yellowcake and most of the waste will be in a solid form that is easy to contain. All applicable DOT regulations and requirements will be followed during shipment to minimize the potential for a spill resulting from a transportation accident. The primary potential impact associated with an accident involving the spill of solid 11e.(2) byproduct material would be potential impacts to soil in the immediate spill area. The potential impacts will be minimized by salvaging affected soils.

5.6.5.1.4 Ponds

A pond leak would have the potential to impact surface and groundwater in the vicinity of the pond. The risk and potential impacts will be minimized by natural conditions that make potential groundwater impacts unlikely, by the design and construction of liners and leak detection systems, and by routine inspection and monitoring. Natural conditions make it highly unlikely that a leaking pond would impact groundwater. In the Burdock area, the ponds will be underlain by approximately 50 to 100 feet of Graneros Group shales. The thickness of the Graneros Group beneath the Dewey area ponds will be approximately 500 feet. The confining properties of the Graneros Group will minimize the potential for vertical migration of solutions from a potential pond leak into groundwater.

Section 5.3.4.1 describes how the pond designs include lining systems that will vary according the pond use. At a minimum, ponds will be provided with a geosynthetic liner underlain by a clay liner. Ponds containing untreated wastewater or ponds used in the treatment process (e.g., radium settling ponds) will be provided with two geosynthetic liners, a clay liner, and a leak detection system. Routine inspection described in Section 5.3.4.5 includes daily checks for water accumulation in leak detection systems. The potential impacts from a primary liner leak will be minimized by implementing standard operating procedures to take the pond out of use and remove its contents to another pond. Sufficient freeboard will be maintained in each type of pond such that the contents of a leaking pond can be transferred to another pond with the same level of lining system.

5.6.5.2 Mitigation of Potential Impacts from Spills and Leaks

The following is a list of mitigation measures for potential impacts from spills and leaks.

- Conduct routine MIT of all injection, production and monitor wells.

- Perform leak testing on all pipelines and aboveground piping systems.
- Equip well field header houses with wet alarms for early detection of leaks.
- Bury well field pipelines for freeze protection and protection from vehicles.
- Implement engineering and administrative controls at the CPP to prevent both surface and subsurface releases to the environment, and to mitigate the effects should an accident occur.
- Train employees in the handling, storage, distribution, and use of hazardous materials.
- Provide rapid response cleanup and remediation capability, techniques, procedures, and training for potential spills.
- Develop written spill reporting procedures, including the procedures to report potential spills of reagents, fuel and other chemicals to the State of South Dakota and the personnel responsible for reporting spills.
- Design and construct ponds with lining and leak detection systems appropriate to the pond use.
- Perform routine inspection of pond leak detection systems to rapidly detect a potential leak from the primary liner.
- Implement standard operating procedures to take a pond out of use in the event of a leak and transfer its contents to another pond with the same lining system.
- Conduct fueling operations and storage of hazardous materials and chemicals in bermed/curbed areas and in a manner that minimizes potential impacts to surface water.
- Curb relevant facilities and structures at the CPP and Satellite Facility to minimize or eliminate escape of process fluids during spills.
- Perform all shipments of yellowcake, uranium-loaded resin, process chemicals/fuel, and 11e.(2) byproduct material in accordance with DOT regulations.
- Promptly salvage soils from any spill areas to avoid potential impacts to surface or groundwater.

5.6.6 Potential Accidents

The accident scenarios with potential to occur at the Dewey-Burdock Project are those typical of other ISR facilities. These scenarios have been evaluated in NUREG/CR-6733, A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licensees (NRC,

2001), and are discussed below. Three primary engineering controls will include 1) downflow, pressurized IX columns, 2) building ventilation, and 3) use of a modern vacuum yellowcake dryer. Also included in the engineering controls will be alarms to indicate suboptimal operating conditions of the effluent control systems and concrete curbs and sumps to contain any process spills. Administrative controls such as training for emergency scenarios will be in place to provide appropriate worker protection in the event that the effluent control systems fail under an emergency situation. In brief, the engineering controls coupled with appropriate administrative controls will mitigate any potential health and safety impacts of system failures at the facility.

A series of potential accident scenarios which could occur at an ISR facility were evaluated in NUREG/CR-6733 and included the following:

- Yellowcake thickener failure and spill
- Radon release in enclosed process areas
- Pregnant lixiviant and loaded resin spills
- Yellowcake dryer hazard analysis

The estimated radiological consequence resulting from these accidents ranged from no significant radiological exposures, in the case of the thickener failure and pregnant lixiviant/loaded resin spill, to a significant radiological exposure which could result in doses to workers exceeding those allowed in 10 CFR Part 20. Due to the short-term nature of the above scenarios and assuming spills and releases are mitigated promptly, no scenario was expected to result in a significant radiological dose to members of the public.

During an accident, administrative controls will be in place such as standard operating procedures for spill response and cleanup, programs for radiation and occupational monitoring, and training for workers in radiological health and emergency response. Administrative controls coupled with proper use of PPE such as respirators are the best tools to reduce worker doses and will be provided.

Other approaches to mitigate system failures that may result in exceeding exposure limits include but are not necessarily limited to the following:

1) A team of responders, trained for radiation health and emergency response, will be available. Specific training will include: response monitoring, PPE use and response to fires, large lixiviant spills or IX system failure.

2) Powertech (USA) will train local emergency response personnel in the potential hazards present within the permit area.

3) A yellowcake thickener failure and spill would result in the immediate evacuation of normal operating personnel within the spill area and cleanup of the saturated product prior to drying. Employees performing the cleanup would utilize the appropriate PPE to minimize exposure to any product that may dry during cleanup. Yellowcake residue that may remain within the thickener area would be washed into a sump, thus mitigating the potential for exposure to employees.

4) Unplanned radon release into an enclosed area would result in manual shutdown of the release point (if automated shutoff system failed) and promotion of ventilation within the area manually (if automated ventilation system failed). Employees performing manual shutdown within the area of the release would utilize the appropriate PPE (such as atmosphere-supplying respirators designed to protect against gases) to minimize exposure to radon and radon decay products. Radon samples would be taken and if above normal working levels, normal operating workers would be evacuated and only return to normal duties within the release area upon re-establishment of normal working levels.

5) A pregnant lixiviant spill would be mitigated in a manner consistent with the location and degree of spill. Response personnel would utilize the appropriate PPE to protect against radon and radon decay products exposure as discussed above and cleanup would result.

6) A yellowcake dryer upset response would be dictated by the severity of the upset. Mitigation response may include a combination of additional site-specific response actions such as:

   - Workers, including the spill response team, will have access to respiratory equipment in the yellowcake dryer area.
   - All practicable measures will be taken to control emissions at the source. The operator will reduce exposure to airborne effluent releases by implementing emission controls (such as wetting) and institutional controls (such as extending the area of upset so as to exclude any personnel not responding to the upset).
   - Siting of the CPP near the center of the proposed license area will serve to protect against off-site exposures in the event of a yellowcake dryer upset.
   - Individual dose standards will be strictly implemented to assure exposures are limited and reduced to the maximum extent reasonably achievable and to limit contamination to the designated upset area.
   - All drying and packaging operations will terminate until cleanup is complete, the area has been cleared for potential exposure, and equipment has been restored to proper operating conditions and efficiencies.
   - Cessations, corrective actions and restarts will be reported to NRC within 10 days of the upset or off-normal performance.

5.6.7 Potential Natural Disaster Risk

NRC guidance in NUREG/CR-6733 evaluates potential risks associated with ISR facilities for the release of radioactive materials or hazardous chemicals due to the effects of an earthquake or tornado strike. The NRC determined that in the event of a tornado strike, chemical storage tanks could fail, resulting in the release of chemicals. This risk will be minimized by implementing the secondary containment measures for chemical storage described in Section 5.3.1. NUREG/CR-6733 concluded that the risk of a tornado strike on an ISR facility is very low and that no design or operational changes are necessary to mitigate the potential risks, but that it is important to locate chemical storage tanks far enough from each other to prevent contact of reactive chemicals in the event of an accident. Chemical storage tanks will be separated at the Dewey-Burdock Project as described in Section 5.3.1.

Considering the relative remoteness of the permit area, the potential consequences of a tornado strike would be considerably less than if the facilities were in a more populated area. Nevertheless, there are risks to workers that will be addressed. Powertech (USA) will prepare and have available onsite for regulatory inspection an Emergency Response Plan that will contain emergency procedures to be followed in the event of severe weather or other emergencies. Included in the plan will be procedures for notification of personnel, evacuation procedures, damage inspection and reporting. It also will address cleanup and mitigation of spills that may result from severe weather. In advance of preparing the Emergency Response Plan, Powertech (USA) offers the following discussion on these issues.

Initially, Powertech (USA) will provide adequate training to its employees and visitors regarding communication systems used at the facilities. In the event of a report of a tornado sighting in the vicinity of the facility, the Radiation Safety Officer (RSO), Radiation Safety Technician (RST) and/or Safety Engineer will ensure that the proper alarm (preset signal) has been sounded at both the Burdock and Dewey facilities. Additionally, all supervisors will be personally contacted via phone or radio and advised of the emergency. The supervisors and radiation safety staff will direct the evacuation of employees to one or more previously-specified nearby locations. Once it is safe to access the facilities, supervisory staff and radiation safety staff will begin the process of assessing potential damage to the facilities, including header houses and well heads. This process will include radiological surveys and assessment of potential non-radiological hazards as well. NRC, DENR, BLM and other regulatory agencies as appropriate will be notified and advised of the damage, if any was observed. After consultation with the regulatory agencies the cleanup and mitigation efforts will commence.

NRC determined that the potential radiological consequences of materials released and dispersed due to earthquake damage at an ISR facility are no greater than for a tornado strike. NUREG-0706 (NRC, 1980b) determined that mitigation of earthquake damage could be attained following adequate design criteria. NUREG/CR-6733 concluded that risk from earthquakes is very low at uranium ISR facilities and that no design or operational changes are required to mitigate the risk, but that it is important to locate chemical storage tanks far enough from each other to prevent contact of reactive chemicals in the event of an accident.

All buildings, structures, foundations, and equipment will be designed in accordance with recommendations in the latest versions of the International Building Code and ASCE-7 published by the American Society of Civil Engineers. Maps published in ASCE-7, and the latest version of the USGS Earthquake Ground Motion Tool, along with information regarding soil characteristics provided by the project professional geotechnical engineer, will be used to determine seismic loadings and design requirements.

5.6.8 Potential Fire and Explosion Risk

Accident Consequences – Fires and Explosions

An explosion, although unlikely, could result from: a prematurely sealed drum of yellowcake, in a dryer, from the use of propane in the thermal fluid heater or space heaters, or from the mixing of oxygen gas with combustible materials. Of these, an explosion from the drum of yellowcake has the greatest potential to impact radiological safety of the workers. An explosion in a sealed drum would be contained within the dryer room. Powertech (USA) will develop a standard operating procedure for measuring the temperature in yellowcake drums prior to drum sealing.

According to NRC, multiple hearth dryers pose a greater hazard than the vacuum dryers that will be used by Powertech (USA) (NUREG-1910, NRC, 2009). Multiple hearth dryers operate at higher temperatures and may be fed directly with gas. The vacuum dryers to be used at the Dewey-Burdock Project operate at lower temperatures and are not fed directly by gas. They therefore pose less of a hazard for explosion. In the unlikely event of an unmitigated explosion accident of a yellowcake dryer, doses to the workers could have a moderate impact depending on the type of accident, but exposure to the general public would result in a dose below the 10 CFR Part 20 public dose limit, resulting in only a small impact to the public (NUREG-1910).

Preventative and Mitigation Measures – Fires and Explosions

As noted in Section 5.3.1, the design criteria for chemical storage and feeding systems includes applicable sections of the International Building Code, International Fire Code, OSHA

regulations, RCRA regulations, and Homeland Security regulations. Propane-fired heating devices will be installed to meet applicable NFPA/FM safety standards. Additional measures for preventing fires and explosions include:

- The oxygen tanks will be located a safe distance from the CPP and other storage tanks and will be designed to meet industry standards of NFPA-50.
- Cleaning of equipment for oxygen storage and conveyance systems will follow the standards specified in CGA G-4.1.
- Powertech (USA) will develop emergency response procedures for oxygen accidents. All employees who may be exposed to hazards associated with oxygen will be properly trained with regard to the hazards, accident prevention and mitigation, and emergency response procedures.
- Header houses will be equipped with fans to provide continuous ventilation in order to prevent buildup of oxygen.
- The oxygen lines to each header house will be equipped with automatic low pressure shut-off valves to minimize the delivery of oxygen through a broken pipe or a valve stuck in the open position, which could potentially supply oxygen to a fire.
- Procedures will be in place for confined space work or hot work for monitoring of oxygen build-up prior to start of work.
- Fire extinguishers will be placed at accessible locations in all buildings and vehicles for quick response and training will be provided for appropriate personnel in use of fire extinguishers.
- Powertech (USA) personnel and local emergency responders will receive training for responding to a fire or explosion.
- The CPP and Satellite Facility are designed to contain and reduce the exposures to individuals in the event of an accident. Emergency response procedures would be implemented and employees would be directed as to what actions to perform in the event of an accident. For instance, a respiratory protection program will be in place and will be executed as necessary for worker protection during accident assessment and cleanup phases. In addition to the above mentioned protections other safeguards and mitigatory protocols are always in place during operation of a CPP facility. For example, a bioassay program for worker safety and contamination control programs involving personnel survey, clothing survey and equipment survey before release to unrestricted areas are common practices workers are subject to on a regular basis. These types of protocols are also utilized to assess if an accidental exposure took place during the course of an unintentional incident.

Preventative and Mitigating Measures – Wildfire

In order to protect facilities from wildfires, all facility buildings will be located within an area that is maintained in a vegetation-free state by the use of a crushed aggregate or asphalt surface

and by appropriate weed-control measures. The creation of this buffer zone is expected to prevent fire from damaging equipment that could lead to a chemical accident by acting as a firebreak.

Within the well fields, vegetation will be controlled around each header house and around each well head cover to reduce the amount of combustible material adjacent to these structures. In the event of an approaching wildfire, operators will be trained to shut down well field operations and, if necessary, to evacuate facilities until the danger to personnel has passed. Damage, if any, will be assessed and remediated prior to re-starting operations.

Powertech (USA) will maintain firefighting equipment on site and will provide training for local emergency response personnel in the specific hazards present in the permit area.

The emergency response plan will include descriptions of the following provisions of 29 CFR Part 1910:

- Notification and evacuation procedures
- Personal protective equipment
- General firefighting safety rules
- Reporting procedures
- Electrical and gas emergencies

5.6.9 Potential Radiological Impacts and Effluent Control System

5.6.9.1 Potential Radiological Impacts

In accordance with NRC guidance, Powertech (USA) modeled the potential radiological impacts on human and environmental receptors (e.g., air and soil) using site-specific radionuclide release estimates, meteorological and population data, and other parameters. The estimated radiological impacts resulting from routine site activities then were compared to applicable public dose limits as well as naturally occurring background levels. The complete analysis is available in the NRC license application. Following is a brief summary of the results.

The primary radioactive airborne effluent will be radon-222 gas. Radon-222 is dissolved in the pregnant lixiviant that comes from the well field into the facility for separation of uranium. At the locations where the lixiviant solution is initially exposed to atmospheric pressure and ambient temperatures, radon gas will be evolved. The locations where this will occur (IX vessels and shaker screens in the CPP and IX vessels in the Satellite Facility) will be provided with dedicated local exhaust, which will be vented outside of the buildings. Small amounts of radon-

222 also may be released from the well field, solution spills, filter changes, RO system operation during groundwater restoration, DDW surge tanks, land application areas, and maintenance activities.

The potential radiological impact analysis considered all potential exposure pathways from all potential sources in the permit area. Atmospheric radon gas is expected to be the predominant pathway for impacts on human and environmental media. Impacts of radon-222 releases can be expected in all quadrants surrounding the site, the magnitude of which is driven predominantly by wind direction and atmospheric stability. As a noble gas, radon-222 itself has very little radiological impact on human health or the environment. Radon-222 has a relatively short half-life (3.2 days) and its decay products are short lived, alpha emitting, nongaseous radionuclides. These decay products have the potential for radiological impacts to human health and the environment. Potential exposure pathways include ingestion, inhalation, direct exposure, and adsorption. All exposure pathways, with the possible exception of absorption, can be important depending on the environmental media impacted. All of the pathways related to emissions of radionuclides are evaluated by modeling, including potential exposure from air, water, soil, flora and fauna.

The potential radiological impact analysis concludes that the primary sources of radon-222 releases will be production well fields, the CPP and Satellite Facility. Lesser releases are anticipated to occur from DDWs, land application areas, and other minor activities. Modeling was used to simulate potential impacts to receptors including the nearest residence. The modeling shows that the maximum annual total effective dose equivalent (TEDE) for an adult at the nearest residence will be approximately 2% of the 10 CFR Part 20 public dose limit of 100 mrem/year. If land application is not used, the calculated TEDE is less than 2% of the public dose limit.

Powertech (USA) also evaluated the potential public and occupational doses for public exposure to radon decay products. Conservatively assuming that a worker not associated with the Dewey-Burdock Project (e.g., a rancher) is in the permit area for 2,000 hours per year, the expected annual occupational dose would be less than 2% of the of the public dose limit.

Modeled impacts to soils in the general permit area resulting from deposition of radium-226 indicate that the radium-226 concentration after ISR operations will be within the range of normal background variability observed during baseline characterization. In the land application areas, modeled impacts to soils show that the radiological impacts of the land application process

will be minimal and meet the criteria for license termination for unrestricted use in 10 CFR § 20.1402.

5.6.9.2 Effluent Control System

Potential radiological impacts to human and environmental receptors will be mitigated through implementation of an effluent control system satisfying NRC license requirements and using best available control technology. The effluent control system is described in detail in the NRC license application and will include controls for radon and radon decay products as well as controls for radionuclide particulates.

Radon

Potential impacts from radon will be controlled through use of pressurized, downflow IX vessels and ventilation systems. The IX vessels normally will operate as sealed, pressurized vessels, so that radon releases from the IX vessels only will occur during resin transfer operations. Dedicated local exhaust at the IX vessels and shaker screens will be directed to a manifold that is exhausted to the atmosphere outside the building via an induced draft fan. The primary release point will be located away from building intakes to prevent introducing exhausted radon back into the facility. Exhausting radon-222 gas to the atmosphere outside the plant minimizes opportunity for in-growth of radon particulate decay products in occupied work areas and therefore minimizes employee airborne exposure.

The general HVAC systems in the CPP and Satellite Facility will reduce employee exposure further by removing radon from plant air. The general HVAC systems will be exhausted through separate vents. These systems will be connected via ductwork and manifolds to the process vessels. Airflow through any openings in the vessels will be from the process areas into the vessels and then into the ventilation systems, maintaining negative flow into the vessels and controlling any releases. Tank ventilation of this type has been utilized successfully at other ISR facilities and proven to be an effective method for minimizing employee exposure. Redundant exhaust fans will direct collected gases to discharge piping that will exhaust to the outside atmosphere. Fan redundancy will minimize employee exposure should any single fan fail.

The general building ventilation systems will be designed to maintain air flow from the process areas with the least potential for airborne releases to areas with the most potential for airborne releases and then exhaust to outside areas. Ventilation systems will exhaust outside the buildings and draw in fresh air. During favorable weather conditions, open doorways and convection vents in the roofs will provide supplemental work area ventilation.

The CPP will be located near the center of the permit area, and the radon exhaust point will be located on or near the CPP roof. Based on use of modern ISR equipment, engineering controls such as building ventilation, and routine sampling and monitoring described below, radon effluent and worker exposure to radon decay products will be maintained at levels that are as low as reasonably achievable (ALARA).

An operational monitoring program will be utilized to measure radon-222 that may result in the atmosphere outside the buildings and other specified locations within the permit area. This will be done in accordance with NRC license conditions. Potential release points as well as general air in the plant will be sampled routinely for radon decay products to assure that concentration levels of radon and decay products are maintained ALARA. Results of monitoring obtained during initial plant operation will be used to adjust monitoring programs (location, frequency, etc.) and upgrade ventilation and/or other effluent control equipment as may be necessary.

Radionuclide Particulates

Potential radiological air particulate effluents will be generated primarily from dried uranium concentrate in the yellowcake drying and processing areas. The yellowcake drying and packaging area will be serviced by a dedicated ventilation system. By design, vacuum dryers do not discharge uranium. The vacuum drying system is proven technology, which is being used successfully at several facilities where uranium oxide is being produced, including ISR facilities. The off-gas treatment system of the vacuum dryers will include a baghouse, condenser, vacuum pump, and packaging hood. The potential radionuclide particulate releases from the drying process and associated off-gas treatment system are discussed below.

The yellowcake will be dried at approximately 250°F in the rotary vacuum drying process. The off-gases generated during the drying cycle will be filtered through a baghouse, which will be located on the top of the dryer, to remove particles down to approximately 1 micron in size. The gases then will be cooled and scrubbed in a surface condenser to further remove the smaller size fraction particulates and the water vapor during the drying process. Two rotary vacuum dryers will be located in a separate building attached to the CPP. This attached building will contain the dryers, the baghouses on the dryers, and a condenser scrubber and vacuum pump system for each dryer.

The vacuum dryers will be steel vessels heated externally and fitted with rotating plows to stir the yellowcake. Each drying chamber will have a top port for loading the wet yellowcake and a bottom port for unloading the dry powder. A third port will be provided for venting through the

baghouse during the drying procedure. The baghouse and vapor filtration unit will be mounted directly above the drying chamber so that any dry solids collected on the bag filter surfaces can be batch discharged back to the drying chamber. The baghouse will be heated to prevent condensation of water vapor during the drying cycle. It will be kept under negative pressure by the vacuum system.

The condenser will be located downstream of the baghouse and will be water cooled. It will be used to remove the water vapor from the non-condensable gases emanating from the drying chamber. The gases will be moved through the condenser by the vacuum system. Dust passing through the bag filters will be wetted and entrained in the condensing moisture within this unit. The vacuum pump will be rotary water sealed, providing negative pressure on the entire system during the drying cycle. It also will be used to provide negative pressure during transfer of the dry powder from the drying chamber to 55-gallon steel drums. The water seal of the rotary vacuum pump will capture entrained particulate matter remaining in the gas streams.

The packaging system will be operated on a batch basis. When the yellowcake is dried sufficiently, it will be discharged from the drying chamber through a bottom port into 55-gallon steel drums. A level gauge, a weigh scale, or other suitable device will be used to determine when a drum is full. Particulate capture will be provided by a sealed hood that fits on the top of the drum, which will be vented through a sock filter to the condenser and the vacuum pump system when the powder is being transferred.

There will be three discharge locations associated with the yellowcake drying and packaging system. These include: i) the yellowcake discharge valve located directly below the dryer, through which drums are filled with yellowcake, ii) the condensed water vapor that is removed from the condenser and recycled to the yellowcake thickener, and iii) very small amounts of air that are drawn through the vacuum pump and are exhausted into the dryer room of the CPP. The system of treating gases emanating from the dryer chamber with baghouse filters and water condenser is designed to capture virtually all particles from the vapor stream leaving the dryer (NUREG-1910, NRC, 2009). Furthermore, NUREG-1569 (NRC, 2003) states, “When a vacuum dryer is used for yellowcake, then dust emissions from drying may also be assumed to be negligible.”

The emission control system will be instrumented sufficiently to operate automatically and to shut itself down for malfunctions such as heating or vacuum system failures. The system will alarm if there is an indication that the emission control system is not performing within operating

specifications. If the system is alarmed due to the emission control system, the operator will follow standard operating procedures to recover from the alarm condition, and the dryer will not be unloaded or reloaded until the emission control system is returned to normal service.

To ensure that the emission control system is performing within specified operating conditions, instrumentation will be installed that signals an audible alarm at the dryer and in the CPP control room if the air pressure (i.e., vacuum level) falls below the specified threshold. The operation of this system will be monitored routinely during dryer operations. The operator will perform and document inspections of the vacuum level hourly or more frequently during dryer operations. Additionally, the air pressure differential gauges for other emission control equipment will be observed and documented at least once per shift during dryer operations.

The discharge locations associated with the yellowcake drying and packaging systems will be monitored routinely via filter collection and radiochemical analysis in accordance with NRC license conditions. General plant air also will be monitored routinely for airborne radionuclides.

5.6.10 Air Quality

This section describes the potential non-radiological air quality impacts. Potential radiological impacts are described in Section 5.6.9.

5.6.10.1 Potential Air Quality Impacts

Potential air quality impacts during construction activities will include emissions from heavy equipment, vehicles, and drill rigs; dust from traffic; and dust from surface-disturbing activities. Most dust will be generated from vehicular traffic on the unpaved roads; therefore, speed limits will be imposed for employee vehicles and transport trucks in order to mitigate the amount of dust generated from unpaved roads. Temporarily disturbed areas also will be reseeded and restored as soon as possible to minimize erosion of soil and fugitive dust emissions.

During operation, non-radiological gaseous emissions will include fugitive dust, vehicle combustion emissions, and stationary source emissions, including propane heating emissions and carbon dioxide released during uranium processing in the CPP. Fugitive dust will be lower during operation than construction due to decreased surface disturbing activities.

Powertech (USA) has prepared a detailed emissions inventory for all project phases (construction, operation, aquifer restoration, and reclamation/decommissioning). The emissions inventory has been provided to NRC and will be provided to the DENR Air Program. Based on

the emissions inventory, stationary source emissions of criteria pollutants are not expected to meet the minor or major source thresholds for air quality construction permitting. This includes NO_x, PM_{10}, CO, SO_2, and hazardous air pollutants (which exclude CO_2).

5.6.10.2 Mitigation of Potential Air Quality Impacts

Mitigation measures for potential air quality impacts, including potential impacts to areas defined as critical air quality resources by SDCL 45-6B-92(8) such as nearby residences and recreation areas, will include but will not be limited to the following:

- Reduce fugitive dust emissions via standard dust control measures (e.g., water application on roads and disturbed areas and implementation of speed limits).
- Encourage employee carpooling.
- Reduce fugitive dust by coordinating dust-producing activities during construction and minimizing disturbed areas.
- Promptly reclaiming and reseeding disturbed areas.
- Maintain vehicles to meet applicable EPA emission standards.
- Obtain a South Dakota air quality permit, if required. Powertech (USA) has submitted a permit application to the DENR Air Quality Program requesting an exemption from South Dakota air permitting as a minor source of emissions. The permit application includes a detailed emissions inventory that demonstrates that total stationary sources of emissions of criteria pollutants will be well below the 25 tons/year threshold.
- Maintain emission control systems to ensure that the annual TEDE is within the 10 CFR Part 20 public dose limit (refer to Sections 5.6.9.1 and 5.6.9.2).
- Model potential air quality impacts. Powertech (USA) currently is performing detailed ambient air quality modeling that is being coordinated with NRC and EPA. The modeling will evaluate the potential impacts of emissions from the Dewey-Burdock Project on ambient air quality to nearby residences and potential near-field impacts within 50 km of the proposed permit area (including Jewel Cave National Monument). In addition, the modeling specifically will address potential impacts on air quality related values (AQRVs) at the Wind Cave National Park, the nearest Class I area. The modeling results will be publicly available and will be submitted to DENR upon request.

5.6.11 Ecological Resources

5.6.11.1 Potential Ecological Resources Impacts

The following section discusses the potential ecological impacts of operations at the project site.

5.6.11.1.1 Vegetation

Well field and production facilities will be constructed within Big Sagebrush Shrubland, Greasewood Shrubland, Ponderosa Pine Woodland, and Upland Grassland vegetation communities. Potential direct impacts include the short-term loss of vegetation (modification of structure, species composition, and aerial extent of cover types). Potential indirect impacts include the short-term and long-term increased potential for non-native species invasion, establishment, and expansion; exposure of soils to accelerated erosion; shifts in species composition or changes in vegetative density; reduction of wildlife habitat; reduction in livestock forage; and changes in visual aesthetics.

Construction activities and increased soil disturbance could stimulate the introduction and spread of undesirable and invasive, non-native species within the permit area. Non-native species invasion and establishment has become an increasingly important result of previous and current

disturbance in South Dakota. No threatened or endangered vegetation species were observed within the permit area; therefore, no impacts are anticipated.

Potential impacts to riparian areas and wetlands will be very limited. Section 5.6.4.1.3 describes mitigation of potential impacts to wetlands, including constructing facilities away from Beaver Creek and Pass Creek and conducting construction, operation, or reclamation activities that have the potential to disturb jurisdictional wetlands in accordance with appropriate USACE permits. Riparian areas occur primarily in a relatively narrow corridor along Pass Creek (refer to the mapped Cottonwood Gallery on Plate 3.7-1). A comparison between Plates 3.7-1 and 3.5-1 shows that the extents of the Cottonwood Gallery are generally within the 100-year flood inundation boundary along Pass Creek. Section 5.6.4.1.2 describes how Powertech (USA) will construct facilities outside of the flood inundation boundaries with few exceptions such as individual wells and pipelines. This is supported by Plate 3.5-1, which shows that facilities have been designed to avoid the Pass Creek flood inundation area including land application areas and well fields.

5.6.11.1.2 Wildlife and Fisheries

ISR uranium production is unlike open-pit mining, since it uses less intrusive extraction methods that have less impact on the surrounding area.

Despite the relatively limited surface disturbance, there are potential direct and indirect impacts on local wildlife populations. These potential impacts are both short-term (until successful reclamation is achieved) and long-term (persisting beyond successful completion of reclamation). However, the latter category is not expected to be significant due to the relatively limited habitat disturbance. The potential direct impacts on wildlife include: injuries and mortalities caused by collisions with project-related traffic or habitat removal actions such as topsoil stripping, particularly for smaller species with limited mobility such as some rodents and herptiles; and restrictions on wildlife movement due to construction of fences. The likelihood for the impacts resulting in injury or mortality is greatest during the construction phase due to increased levels of traffic and physical disturbance during that period. Overall traffic will increase from current levels and will persist during operations, but should occur at a reduced and possibly more predictable level than during the construction phase. Speed limits will be enforced during all construction and maintenance operations to reduce impacts to wildlife throughout the year, but particularly during the breeding season.

Most of the habitat disturbance associated with the ISR facilities will consist of scattered, confined drill sites for well fields that will not result in large expanses of habitat being dramatically transformed from its original character, as would be the case with open-pit mining. Therefore, most potential indirect impacts relate to the displacement of wildlife due to increased noise, traffic, or other disturbances associated with the development and operation of the project, as well as from small reductions in existing or potential cover and forage due to habitat alteration, fragmentation, or loss. Indirect impacts typically persist longer than direct impacts. However, because ISR results in fewer large-scale habitat alterations, there will not be a need for reclamation actions that result in dramatic differences between pre-mining and post-mining vegetative communities.

Multiple site visits and targeted surveys conducted for the baseline surveys, combined with existing agency databases that encompass the permit area and input from local residents, indicate that the permit area and surrounding vicinity are occupied by a wide variety of common wildlife and fish species, with only a few species of particular concern occurring in the area. The most notable species of interest is the bald eagle, which is still considered threatened at the state level. Bald eagle winter roost sites and a successful nest site were documented within the permit area during surveys conducted in 2007 and 2008. Two other species tracked by the SDNHP were confirmed or suspected to have nested in the permit area in 2008, the long-eared owl and long-billed curlew. Eight additional SDNHP species were documented in or near the permit area during baseline surveys. However, those observations consisted of birds flying over the area, or sightings made in the surrounding perimeter. No grouse leks have been recorded within 6 miles of the permit area during agency or project-specific surveys completed in recent years.

Suitable habitat (trees and native uplands) for all three nesting SDNHP species occurs in the permit area. However, the limited disturbance of ISR and the presence of apparently suitable (due to low density of other nesting individuals) alternate nesting habitat throughout the permit area and surrounding area combine to minimizing the potential for both direct and indirect impacts for those species and others that require similar habitats. One of those species, the long-eared owl, nested within 75 meters, but largely beyond view of, an existing gravel county road, suggesting the pair has at least some level of tolerance for vehicular traffic near active nest sites. Other wildlife species of concern, such as other nesting raptors, that occur in the area also may experience direct and/or indirect impacts from increased travel and noise in the area during project construction and operation. However, the presence of potential alternate nesting and foraging habitat in the immediate vicinity, the mobility of those species, and the location of most

nest sites relative to planned disturbance combine to reduce impacts to most nesting SDNHP birds as well as other species of interest.

Some vegetative communities present currently in the permit area can be difficult to reestablish through artificial plantings, and natural seeding of those species would likely take many years. However, the current habitat of greatest concern (Big Sagebrush Shrubland) occurs only in scattered stands that are relatively small and widely-spread across the permit area. Results from lek searches, breeding bird surveys, and small mammal trapping, as well as regular site visits in all seasons, strongly suggest that sage obligates other than pronghorn occur in limited numbers in the permit area, if at all. The vegetative communities that indicated the strongest associations between terrestrial species and habitats during baseline surveys (Cottonwood Gallery and Ponderosa Pine) will not be significantly impacted by construction or operation of the proposed project. It is possible that the potential implementation of land application systems may enhance nesting, brood-rearing, and/or foraging habitat for some species. Consequently, although individual animals associated with some specific habitats could be impacted by the proposed ISR operations, the small percentage of projected surface disturbance within the permit area relative to its overall size, and the low density of nesting efforts relative to habitat presence in that area, suggest that their populations as a whole will experience minimal impacts from the project. Advanced planning of construction siting and activities in concert with continued monitoring can reduce impacts further and assist with the development of mitigation options, if necessary. Potential impacts to these species and others are discussed in greater detail in the following sections.

5.6.11.1.3 Big Game

Big game could be displaced from portions of the permit area to adjacent areas, particularly during construction of the well fields and facilities, when disturbance activities will be greatest. Disturbance levels will decrease during actual ISR operations, and will consist primarily of vehicular traffic on new and existing improved and unimproved (two-track) roads throughout the permit area. Similar disturbance already is present in the area due to existing ISR exploration, ranching, and railroad operations. Pronghorn antelope would be most affected, as they are most prevalent in the area. However, no areas classified as crucial pronghorn habitat occur on or within several miles of the permit area, and this species is not as common in the general area as elsewhere within the region due to the limited presence of sagebrush in the area. Mule deer would not be impacted substantially given their somewhat limited use of these lands, the paucity of winter forage and security cover, and the availability of suitable habitat in adjacent areas.

SDGF&P does not consider the permit area to be within the crucial habitat range of any big game species. A letter from SDGF&P confirming this statement and updating the status of big game species as of May 2010 is provided in Appendix 5.6-B. Sightings of those species in that vicinity are often seasonal and less common.

5.6.11.1.4 Other Mammals

Medium-sized mammals (such as lagomorphs, canids, and badgers) may be displaced temporarily to other habitats during the initial construction activities. Direct losses of some small mammal species (e.g., voles, ground squirrels, mice) may be higher than for other wildlife due to their more limited mobility and likelihood that they would retreat into burrows when disturbed, and thus be potentially impacted by topsoil scraping or staging activities. However, given the limited area expected to be disturbed by the project, such impacts would not be expected to result in major changes or reductions in mammalian populations for small or medium-sized animals. This is supported by NRC guidance in NUREG-1910 (NRC, 2009), which states, "Displaced species may re-colonize in adjacent, undisturbed areas or return to their previously occupied habitats after construction ends and suitable habitats are reestablished." Few bats were recorded in the area despite extra efforts to observe them during the baseline surveys. Those that were seen were near water bodies near treed habitats, which are not currently scheduled for disturbance. The mammalian species known to be, or potentially, present in the permit area have shown an ability to adapt to human disturbance in varying degrees, as evidenced by their continued presence in other mining and residential areas of similar, or greater, disturbance levels elsewhere in the region. Additionally, small mammal species in the area have a high reproductive potential and tend to re-occupy and adapt to altered and/or reclaimed areas quickly.

5.6.11.1.5 Raptors

ISR activities in the permit area would not impact regional raptor populations, though individual birds or pairs may be affected. ISR activity could cause raptors to abandon nest sites proximate to disturbance, particularly if activities encroach on active nests during a given breeding season. Powertech (USA) will develop a bald eagle mitigation plan for review and verification by SDGF&P. A copy of the plan will be provided to DENR. Other potential direct impacts would be injury or mortality due to collisions with project-related vehicular traffic. Construction activities that occur within or near active raptor territories could also cause indirect impacts such as reduction or avoidance of foraging habitats for nesting birds. However, surface disturbance will only occur in a small percentage of the overall permit area, and the low density of nesting

raptors relative to the apparent availability of suitable habitat suggests that alternate nesting habitat is available for all known nesting raptor species in the permit area.

Eight intact raptor nests were documented within the project survey area (permit area and 1-mile perimeter) during 2008. Six of the eight nest sites are within the permit area, with the remaining two located in the 1-mile perimeter. USFWS guidelines recommend avoiding construction activities within 660 feet if the activity will be visible from a nest (USFWS, 2007). Construction activities in relation to bald eagles and other raptors will be addressed in the bald eagle mitigation plan previously described.

Except for the bald eagle, the same species that nest in the permit area are known to regularly nest and fledge young at or near surface mines and ISR facilities throughout the region. Those efforts have succeeded due to a combination of raptors becoming acclimated to the relatively consistent levels of disturbance and gradual encroachment of production operations, and successfully executed state-of-the-art mitigation techniques to maintain viable raptor territories and protect nest productivity. Some individuals nest on active production facilities themselves, including both great horned owls and red-tailed hawks. The lack of bald eagle examples is more likely related to the general absence of nesting bald eagles in the vicinity, rather than an increased sensitivity to production activities. Bald eagles are discussed further in Section 5.6.11.1.11. Due to the paucity of river cliffs in the permit area, falcons and other raptors known to nest in that habitat are not as abundant as those that nest in trees or even on the ground.

Based on the location of known nest sites relative to future construction sites, no raptor nests will be disturbed physically by the project during either construction or operations. Additionally, Powertech (USA) has incorporated the baseline wildlife information into the planning process and sited all plant facilities (areas of greatest sustained future disturbance) outside the recommended buffer zone for all raptor nests in the permit area, including the bald eagle nest site. Some new infrastructure will be located within the suggested buffer areas. However, pipelines will be buried, and new overhead power lines will be constructed using designs and specifications to reduce injuries and mortalities on overhead power lines. Land application center pivots, if used, can be put into place prior to the nesting season, and run automatically with little human contact once they are turned on. Additionally, new roads, power lines, and pipelines will be constructed in the same corridors to the extent possible to reduce overall disturbance, and along existing access roads when available to minimize new surface disturbance.

5.6.11.1.6 Upland Game Birds

ISR activities in the permit area would potentially impact the foraging and nesting habitat of mourning doves, though such disturbance is not expected to have any marked impacts on this species. No woody corridors will be disturbed by the proposed activities, and additional trees are present in the cottonwood gallery along the Cheyenne River, located approximately 2 miles south of the permit area. Additionally, doves are not restricted to treed habitats, nor are they subject to any special mitigation measures for habitat loss.

Annual monitoring surveys conducted by SDGF&P biologists and a year-round baseline study for the project have demonstrated that sage-grouse do not currently inhabit that area, and have not for many years. As described previously, those surveys encompassed the entire permit area and the vast majority of its 2.0-km (1.2-mi) perimeter, particularly as part of baseline monitoring. The nearest known sage-grouse lek is approximately 6 miles north of the permit area (SDGF&P records). Given the lack of sage-grouse observations in the area and the scattered stands of marginal quality sage-grouse habitat, the project will not result in negative impacts to existing or potential sage-grouse leks, or important sagebrush habitats.

5.6.11.1.7 Other Birds

The project could potentially impact nine avian species tracked by SDNHP that are known to occur or could potentially occur as seasonal or year-round residents. Direct impacts could include injury or mortality due to encounters with vehicles or heavy equipment during construction or maintenance operations. Indirect impacts could include habitat loss or fragmentation and increased noise and activity that may temporarily deter use of the area by some species. Surface disturbance would be relatively minimal and would be greatest during construction. Enforced speed limits and use of common right-of-way corridors will reduce impacts to wildlife throughout the year, particularly during the breeding season.

5.6.11.1.8 Waterfowl and Shorebirds

Construction and operation of the ISR project would have a negligible effect on migrating and breeding waterfowl and shorebirds. Existing habitat is limited and seasonally available in the permit area, so it does not currently support large groups or populations of these species. Multiple approaches are being considered to minimize impacts to wildlife that may be associated with the operation of the ponds. Any new treated water sources could enhance current habitat conditions for these species, though such effects would be temporary in nature.

5.6.11.1.9 Reptiles and Amphibians

As with waterfowl, potential habitat for aquatic and semi-aquatic amphibians and reptiles is limited within the permit area and occurs primarily along Beaver Creek in the western portion of the area. Other water bodies are ephemeral, and thus offer only short-term habitat. Activities associated with the project are not expected to disturb existing surface water or alter the topography in the area. Those species residing in rocky outcrops located in potential disturbance areas could be impacted by construction and maintenance operations. However, few non-aquatic herptile species were observed in the permit area and surrounding perimeter. Any impacts that would occur would affect individuals, but would not likely impact the population as a whole.

5.6.11.1.10 Fish and Macro-Invertebrates

The planned locations for new facilities and infrastructure do not overlap any perennial aquatic features; therefore, no loss of aquatic habitat would occur as the result of their construction. The risk of impaired water quality will be reduced or avoided through project siting, and implementation of standard construction erosion and sediment control measures. The location of project facilities (CPP, Satellite Facility, pipelines, well fields, access roads and power lines), as well as the proposed land application sites (center pivot irrigation sites), will avoid direct impacts to perennial streams.

Due to the arid climate and proposed location of new project facilities, operation of the well fields is not expected to alter aquatic habitat or water quality in perennial streams. No surface water will be diverted for use in the operation, and no process water will be discharged into aquatic habitat.

Pass Creek provides only seasonal drainage and does not support fish or significant amphibian habitat. Some of the proposed land application sites west of the Satellite Facility would be located in general proximity to Beaver Creek, the primary aquatic habitat in the project vicinity. All land application areas will be surrounded by catchment areas that will prevent runoff. Beaver Creek will not be directly affected by the well field operations or land application sites. Section 3.5.4.1.1 describes how Beaver Creek and the Cheyenne River near the permit area are classified as warmwater, semipermanent fisheries. No coldwater fisheries are present in the permit area, and no impacts to coldwater fisheries will occur as a result of the Dewey-Burdock Project.

5.6.11.1.11 Threatened, Endangered, or Candidate Species and Species Tracked by SDNHP

Federally Listed Species

As described in the preceding sections of this document, no federally listed vertebrate species were documented in the project survey area (permit area and 1-mile perimeter) during the year-long survey period, or during previous targeted surveys conducted for the original claims (TVA, 1979). Additionally, the USFWS has issued a block clearance for black-footed ferrets in all black-tailed prairie dog colonies in South Dakota except northern Custer County, and in the entire neighboring state of Wyoming. That clearance indicates that ferrets do not currently, and are not expected to, occupy the permit area. Only one small black-tailed prairie dog colony was present in the permit area itself during the 2007-2008 baseline surveys, and local landowners are actively working to remove the animals from their lands. Consequently, the proposed project will have no direct, indirect, or cumulative effects on black-footed ferrets.

State-Listed Species

ISR activities within the permit area are not likely to adversely affect bald eagles, the only state-listed species known to inhabit the permit area. Bald eagles were documented at winter roosts and an active nest within the permit area. However, most roost sites and the lone nest site are at least 1.0 mile from the nearest planned facility. Additionally, no more than two or three bald eagles were observed during any given winter survey despite the numerous available (and unoccupied) mature trees along Beaver Creek, Pass Creek, and the pine breaks located in and near the permit area. Three proposed land application sites (center pivot irrigation systems) would fall within the one-mile buffer of the bald eagle nest. However, those systems are typically automated, and the minimal disturbance associated with potential maintenance of those systems should not be significant enough to impact nesting or roosting bald eagles along Beaver Creek.

Potential direct impacts to bald eagles include the potential for injury or mortality to individual birds foraging in the permit area due to electrocutions on new overhead power lines. Although not expected, disturbance activities near an active nest could result in abandonment and, thus, the loss of eggs or young. The increased human presence and noise associated with construction activities, if conducted while eagles are wintering within the area, could displace individual eagles from using the area during that period.

Given the low number of wintering and nesting bald eagles in the permit area, potential impacts would be limited to individuals rather than a large segment of the population. The use of

existing or overlapping right-of-way corridors along with best management practices will minimize potential direct impacts associated with overhead power lines. If necessary, the majority of other potential impacts could be mitigated if construction activities were conducted outside the breeding season and/or winter roosting months, or outside the daily roosting period, should eagles be present within 1 mile of construction. Any bald eagles that might roost or nest in the area once the project is operational would be doing so in spite of continuous and ongoing human disturbance, indicating a tolerance for such activities.

Indirect impacts as a result of noise and human presence associated from project-related operations could include area avoidance by avian species. Potential winter foraging habitat could be further fragmented by linear disturbances such as overhead power lines and new roads associated with the project. Given the size of the project, those disturbances would occur within narrow corridors over relatively short distances. Nevertheless, the use of common right-of-way corridors to consolidate new infrastructure will reduce these potential indirect impacts.

The only other state-listed species recorded in the general area was the river otter. An otter carcass was discovered lodged in debris in the stream channel at fisheries sampling station BVC04 in mid-April 2008. That site is approximately 12 river miles upstream from the permit area boundary in eastern Wyoming. The carcass had washed away by the July 2008 fisheries sampling session. The monthly sampling at BVC04 during the monitoring period confirmed no additional observations of otters. Likewise, no evidence of otters was report by biologists along any drainage elsewhere in the survey area during the year-long baseline survey period. Given the fact that no stream channels will be physically impacted in the permit area, the lack of otter sightings or sign in the permit area itself, and the stringent water processing and water quality monitoring that will occur, this project is not likely to directly or indirectly impact river otters.

Species Tracked by SDNHP

Ten terrestrial species tracked by the SDNHP were recorded during baseline surveys, including the bald eagle. Seven of the ten were observed within the permit area, and three were seen in the 2-km perimeter. One additional species, the plains topminnow, was observed in Beaver Creek and the Cheyenne River, at least 1 mile outside the permit area. Three SDNHP species are known or suspected to have nested in the permit area in 2008. However, two of the three nest sites are at least 1 mile from the nearest planned new facility, and all three were closer to existing disturbances in 2008 than they would be to new activities outside those existing areas.

The seven SDNHP species recorded in or flying over the permit area could potentially experience the same type of direct and/or indirect impacts from construction and operation of the proposed operation as those described previously for other species: e.g., injury, mortality, avoidance, displacement and increased competition for resources. Those potential impacts will be minimized by the timing, extent, and duration of the proposed activities. Enforced speed limits during all phases of the project will further reduce potential impacts to wildlife throughout the year, particularly during the breeding season. Once facilities and infrastructure are in place, animals remaining in the permit area would demonstrate an acclimation to those disturbances.

5.6.11.2 Mitigation of Potential Ecological Resources Impacts

The following is a list of proposed mitigation measures for such potential impacts:

- Design fencing to permit big game passage to the extent practicable.
- Use existing roads when possible and limit construction of new access roads to provide for access to more than one well site or well field, if possible.
- Enforce speed limits to minimize collisions with wildlife, especially during the breeding season.
- Adhere to timing and spatial restrictions within specified distances of active raptor nests during the breeding season as determined by appropriate regulatory agencies.
- Develop a bald eagle mitigation/management plan for review and approval by the USFWS. The plan also will be provided to the SDGF&P for review and input, although the USFWS will have the final approval authority. The approved plan and any associated permits will be incorporated into the LSM permit. The bald eagle mitigation/management plan is anticipated to address the following:
    - Ensure that annual bald eagle monitoring and survey data for nest and winter roost sites are available within the permit area and buffer area for the life of mine to:
        - determine normal habitat use and movements,
        - determine the location and status of nests and winter roost sites, and
        - document the occurrence and outcome of nesting bald eagle pair(s).
    - Establish buffer zones protecting important bald eagle habitat where necessary and stipulating seasonal restrictions on ISR-related disturbances within buffer areas in order to avoid jeopardizing bald eagles during any project phase. Such buffer zones and their associated seasonal restrictions would be established:

        - in keeping with current USFWS recommendations,
        - around nest sites, and
        - around documented winter roost sites).
    - If necessary, obtain a USFWS-issued permit and any necessary State permits for eagle take and/or nest relocation or removal, the application for which would address the following:
        - demonstration that the proposed activity meets the requirements of 50 CFR § 22.26 or § 22.27, which contain the federal requirements for take and removal/relocation of eagle nests, respectively;
        - methods to relocate the nest(s) or construct an alternate nest and/or improve conditions at alternate nest sites, if mitigation measures are required around documented winter roost sites);
        - a demonstration that suitable nesting and foraging (including winter) habitat is available to the area nesting population of bald eagles that could accommodate any bald eagles displaced by the take or nest removal/relocation; and
        - implementation of monitoring and reporting procedures to determine the response of bald eagles to the take or nest relocation(s).
- If direct impacts to raptors or other migratory bird species of concern occur, a Monitoring and Mitigation Plan for those species will be prepared and approved by the USFWS, including one or more of the following provisions:
    - Relocation of active and inactive raptor nests that could be impacted by construction or operation activities in accordance with the approved raptor monitoring and mitigation plan.
    - Creation of raptor nests and nesting habitat through enhancement efforts such as nest platforms to mitigate other nest sites impacted by ISR operations.
    - Obtaining appropriate permits for all removal and mitigation activities.
    - Establishing buffer zones protecting raptor nests where necessary and restricting ISR-related disturbances from encroaching within buffers around active raptor nests from egg-laying until fledging to prevent nest abandonment, or injury to eggs or young.

  - Reestablishing the ground cover necessary to attract and sustain a suitable raptor prey base after drilling, construction, and future ISR operations and site reclamation/decommissioning
  - Required use of raptor-safe construction for overhead power lines according to current guidelines and recommendations by the USFWS

- Restore pre-mining native habitats for species that nest and forage in those vegetative communities.
- Restore diverse landforms, replace topsoil, and construct brush piles, snags, and/or rock piles to enhance habitat for wildlife.
- Conduct weed control as needed to limit the spread of undesirable and invasive, non-native species on disturbed areas.

Adjusting the timing of various construction, operational, and reclamation activities to avoid the breeding season can also be an effective way to minimize impacts related to such activities in the permit area. As a practical matter, worker crews conducting construction or reclamation activities typically work during daylight hours, so potential impacts to year-round residents, particularly more nocturnal species such as bats, rodents and others, should not be increased significantly. Following completion of construction in a given area, access roads would be blocked with berms or fencing to prevent use by casual traffic. Site reclamation/ decommissioning, including surface reclamation, will be completed in the same manner, with activities timed to minimize disturbance to nesting or migrating species. Relevant agency standards for reclamation will be followed and this phased, systematic approach will allow more mobile wildlife species to relocate into adjoining, undisturbed habitat and then return following completion of construction or reclamation in a particular area. Thus, the sequential, phased nature of this approach will decrease potential direct and indirect impacts on all wildlife species and their habitat.

5.6.12 Cultural Resources

5.6.12.1 Potential Cultural Resources Impacts

As discussed in Section 3.11, a Level III Cultural Resources Evaluation was conducted in the permit area. Personnel from the Archaeology Laboratory, Augustana College, Sioux Falls, South Dakota, conducted on-the-ground field investigations between April 17 and August 3, 2007. Potential impacts to historic and cultural resources will be minimized by implementing the mitigation measures described below.

5.6.12.2 Mitigation of Potential Cultural Resources Impacts

The following summary of protection of historic and cultural resources within the proposed permit area was obtained from the Draft Supplemental Environmental Impact Statement (Draft SEIS) for the Dewey-Burdock Project (NRC, 2012, p. xxxix):

> Within the area of potential effect at the proposed Dewey-Burdock site, 18 historic sites are either listed in the National Register of Historic Places (NRHP) or eligible for listing in the NRHP. Based on the proposed location of ISR facilities and infrastructure, avoidance of 12 of these sites is possible during the construction phase and, therefore, no impacts are anticipated. Avoidance and mitigation, such as fencing and data recovery excavations, are recommended for the remaining six NRHP-eligible sites. In addition, avoidance is recommended for two unevaluated historic burial sites located in proximity to proposed construction activities until their NRHP eligibility is determined. Avoidance and mitigation is also recommended for 4 unevaluated site[s] located within 76 m (250 ft) of proposed wellfields or land application areas.

The mitigation measures to protect historic and cultural resources will include but will not be limited to:

- Administering a historic and cultural resources inventory before engaging in any development activity not previously assessed by NRC or any cooperating agency.
- Any disturbances to be associated with such development will be addressed in compliance with the National Historic Preservation Act (NHPA), the Archeological Resources Protection Act, and their implementing regulations.
- Prior to construction, establishing an agreement between NRC, South Dakota State Historic Preservation Office (SHPO), BLM, interested Native American tribes, Powertech (USA) and other interested parties that outlines the mitigation process for each affected historic resource. As part of this agreement, Powertech (USA) will develop an Unexpected Discovery Plan that will outline the steps required if unexpected historic and cultural resources are encountered (Draft SEIS, p. xxxix).
- Avoidance, where possible, of eligible or potentially eligible sites.
- Fencing known historic properties in areas where construction, well field development, and ISR operations will occur so disturbance to these areas can be avoided.
- Making the location of historic properties known to employees in advance of ground disturbing activities.
- Addressing any disturbances in compliance with Powertech's (USA) Memorandum of Agreement (MOA) with the South Dakota State Archeologist and any future MOAs developed by Powertech (USA) or NRC under the NHPA. Powertech (USA) executed the MOA with the South Dakota State Archeologist in September 2008. The MOA, which is provided in Appendix 3.11-B, establishes procedures to avoid or mitigate

potential effects on archaeological and historic sites pursuant to SDCL 45-6D-14 and 45-6B. Provisions include:

- Investigating archeological or historic sites threatened or potentially threatened by proposed ground disturbing activity prior to disturbance to determine their significance or research potential.
- Notifying ARC at least 30 days in advance of surface disturbance that could potentially impact an archeological or historic site.
- Providing a quarterly report to ARC summarizing Powertech (USA)'s efforts to carry out the terms of the MOA.
- Temporarily halting surface disturbance activities if historic or archeological sites are discovered or unanticipated effects on historic or cultural sites are found during any phase of the project. Powertech (USA) will not resume activities until clearance to proceed is granted by ARC.

- Implementing mitigation measures if it becomes necessary to disturb an eligible or potentially eligible site, potentially including data recovery excavations coordinated with ARC.
- Immediately ceasing any work resulting in the discovery of previously unknown cultural artifacts to ensure that no unapproved disturbance occurs. Powertech (USA) will notify appropriate authorities per any license conditions and will not proceed with activities without appropriate approvals from NRC or other agencies as appropriate. Any such artifacts will be inventoried and evaluated, and no further disturbance will occur until authorization to proceed has been received. Powertech (USA) recognizes that the NHPA environment is not static, but rather is ongoing up to and through final financial assurance release following successful reclamation.

5.6.13 Noise

5.6.13.1 Potential Noise Impacts

Potential noise impacts will result from the operation of construction equipment, passenger vehicle and material shipment vehicle traffic, and, to a very limited extent, from the operation of ISR and wastewater facilities including center pivots if used for land application. The potential impacts to nearby receptors will be small due to the remote location, limited disturbance, and lack of nearby residences.

Section 3.12 describes how the minimum distance between a residence and the primary county road in the permit area (S. Dewey Road) is 3,700 feet. Based on the analysis in Section 3.12, the maximum anticipated noise from a heavy truck traveling on the S. Dewey Road at a residence within the permit area will be 41 dBA, which is well within the 55 dBA level identified by EPA as preventing activity interference and annoyance. Based on this analysis, increased vehicle

traffic associated with passenger vehicles and material shipment vehicles will not have significant impacts on nearby residences.

Noise originating from construction equipment will be apparent locally over the short term where construction activities are occurring. This primarily will include facility construction at the CPP and Satellite Facility and well field construction. Table 5.6-3 identifies typical noise levels 50 feet away from construction equipment. These noise levels were obtained from NRC guidance document NUREG-1910 (NRC, 2009). As described in Section 3.12, noise from point sources diminished by about 6 dBA for each doubling of distance according to the following relationship, where it is assumed that the noise radiation is uniform, non-directional, and freely propagating (Bell and Bell, 1994):

$$N_1 - N_2 = 20 \log (r_2/r_1)$$

In this equation, N_1 and N_2 are the noise levels (sound pressure levels) at points 1 and 2, and r_2 and r_1 are the distances from the receptor to point 2 and 1, respectively.

Table 5.6-3 includes estimates of noise levels from construction equipment using this relationship for distances of 1,600 feet and 5,900 feet, which are the minimum anticipated distances between a residence and a well field and CPP, respectively. This table shows that noise levels resulting from construction equipment typically will be lower than the annoyance threshold level even at the minimum distance from a residence. Since most construction activity will be located at a much greater distance from residences, the noise levels generally will be lower than those shown in Table 5.6-3. Due to distance and topographic interference, potential noise impacts likely will be within the range of normal baseline variability for most construction activities and most residences.

5.6.13.2 Mitigation of Potential Noise Impacts

Potential noise impacts include the generation of noise resulting from operating heavy equipment and process machinery. Noise from process machinery will be contained within process structures and, as such, should have no discernible impacts on the public or the environment. With respect to potential noise impacts from heavy equipment, typical mitigation measures that will be implemented at the project to minimize noise impacts may include the following:

- Minimize construction activities during the night.

Table 5.6-3: Noise Levels for Construction Equipment

Equipment Type	Noise Level at 50 feet[1] (dBA)	Noise Level at 1,600 feet[2] (dBA)	Noise Level at 5,900 feet[3] (dBA)
Heavy Truck	82-96	52-66	41-55
Bulldozer	92-109	62-79	51-68
Grader	79-93	49-63	38-52
Excavator	81-97	41-67	40-56
Crane	74-89	44-59	33-48
Concrete Mixer	75-88	45-58	34-47
Compressor	73-88	43-58	32-47
Backhoe	72-90	42-60	31-49
Front Loader	72-90	42-60	31-49
Generator	71-82	41-52	30-41
Jackhammer/Rock Drill	75-99	45-69	34-58
Pump	68-80	38-50	27-39

Notes: [1] NUREG-1910, Table 4.2-1 (NRC, 2009).
[2] Minimum anticipated distance between potential perimeter monitor well and nearby residence.
[3] Minimum distance between CPP and nearby residence.

- Use sound abatement controls on operating equipment and facilities.
- Use personal hearing protection for workers in any high noise areas.

These mitigation measures will ensure that noise levels will remain within relevant EPA guidelines for off-site receptors and OSHA standards for workers.

5.6.14 Visual and Scenic Resources

5.6.14.1 Potential Visual and Scenic Resources Impacts

Potential short-term impacts to visual and scenic resources during construction will result from surface disturbance activities and facility construction. Temporary disturbance areas will be reclaimed upon completion of construction and debris created during construction will be removed as soon as possible to limit the areal extent affected during construction.

The sources of potential longer-term impacts to visual and scenic resources will include the presence of the CPP, Satellite Facility, well head covers, header houses, access roads, overhead power lines, ponds, and wastewater disposal facilities (DDWs and/or land application systems). These potential longer-term visual and scenic resources impacts will remain until the completion of reclamation/decommissioning, upon which the permit area will closely resemble the pre-mining condition.

5.6.14.2 Mitigation of Potential Visual and Scenic Resources Impacts

Mitigation measures for potential visual and scenic resources impacts will include:

- Use exterior lighting only where needed to accomplish facility tasks and improve safety.
- Limit the height of exterior lighting units.
- Use shielded or directional lighting to limit lighting only to areas where it is needed.
- Design of facilities to minimize surface disturbance.
- Construction and placement of structures taking into consideration the topography in order to conceal well heads, plant facilities, and roads from public vantage points.
- Satisfy BLM guidelines by using building materials and paint that complement the natural environment.
- During construction of roads, consider the topography that a given road follows as well as the potential area of disturbance.

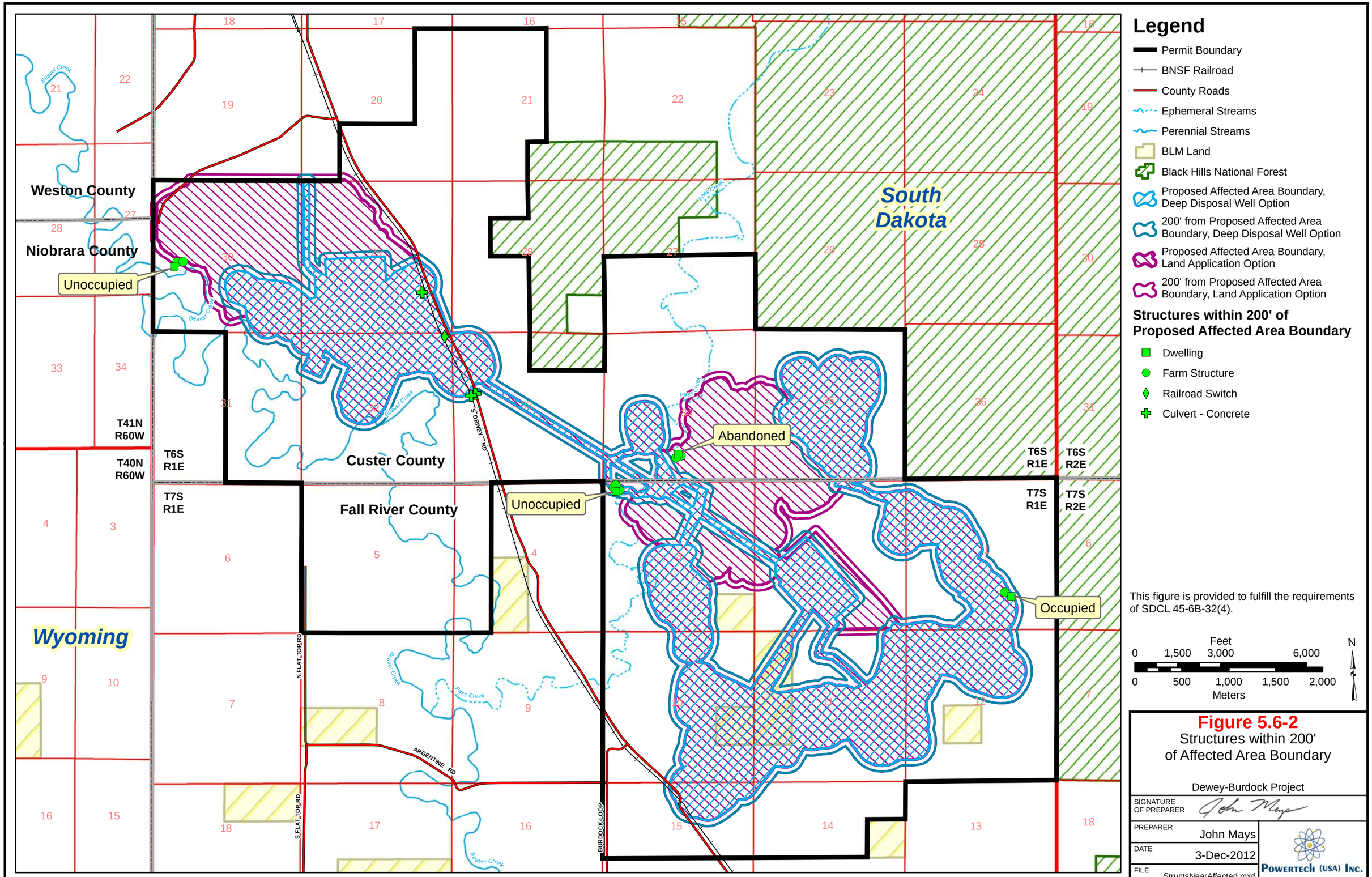
- Minimize access road construction through the use of existing roads.
- Locate access roads and utilities in common corridors where possible.
- Implement speed limit policies and dust control measures including routinely applying water spray to roads and construction areas to minimize fugitive dust.
- Promptly reclaim and reseed temporary disturbance areas.
- Promptly remove debris associated with construction activities.

5.6.15 Protection of Man-Made Structures

Figure 5.6-2 depicts man-made structures within 200 feet of the proposed affected area boundaries. These include dwellings, farm structures (e.g., barns and sheds), a railroad switch house, and concrete culverts. Following is a summary of how these structures will be protected in accordance with SDCL 45-6B-32(4).

Several dwellings and farm structures are within 200 feet of the proposed affected area boundaries. Currently these include one occupied dwelling, two unoccupied but habitable dwellings, and one abandoned dwelling that is not habitable. There are no habitable dwellings within potential well field pattern areas. It is anticipated that construction activities within 200 feet of dwellings or farm structures will be limited to the installation of perimeter monitor wells, pipelines and overhead power lines. Powertech (USA) does not anticipate drilling any wells within 50 feet or installing any pipelines within 25 feet of any habitable dwelling or any usable farm structures, except that Powertech (USA) may install small-diameter domestic water supply pipelines to replace domestic water supply wells as described in Section 5.6.3.2. Potential impacts will be minimized by avoiding these structures during facility design and construction.

The railroad, railroad switch house, and concrete railroad culverts will be protected by avoiding construction activities near the railroad. The only construction activity anticipated within 200 feet of the railroad is the installation of perimeter monitor wells in or near the railroad right-of-way in the vicinity of D-WF1 and B-WF2. Any perimeter wells inside the railroad right-of-way would be offset from the railroad a sufficient distance to allow the work to be performed safely and to protect the stability of the railroad. In addition, Powertech (USA) may install one or more plant-to-plant pipelines between the CPP and Satellite Facility. As depicted on Figures 5.3-1 and 5.3-2, such pipelines would cross the railroad right-of-way near the Satellite Facility. These pipelines, if installed, would be bored underneath the railroad, and the bored length would be encased in a protective material such as steel well casing. Any construction activities within the BNSF right-of-way would be coordinated with the railroad to avoid impacts.


Legend
Permit Boundary
BNSF Railroad
County Roads
Ephemeral Streams
Perennial Streams
BLM Land
Black Hills National Forest
Proposed Affected Area Boundary, Deep Disposal Well Option
200' from Proposed Affected Area Boundary, Deep Disposal Well Option
Proposed Affected Area Boundary, Land Application Option
200' from Proposed Affected Area Boundary, Land Application Option
Structures within 200' of Proposed Affected Area Boundary
Dwelling
Farm Structure
Railroad Switch
Culvert - Concrete
Weston County
Niobrara County
Custer County
Fall River County
South Dakota
Wyoming
Unoccupied
Abandoned
Unoccupied
Occupied
T41N R60W
T40N R60W
T6S R1E
T7S R1E
T6S R1E
T6S R2E
T7S R1E
T7S R2E
S DEWEY RD
N FLAT TOP RD
S FLAT TOP RD
ARGENTINE RD
BURDOCK LOOP
Beaver Creek
Pass Creek
This figure is provided to fulfill the requirements of SDCL 45-6B-32(4).
Feet
0 1,500 3,000 6,000
0 500 1,000 1,500 2,000
Meters
N
Figure 5.6-2
Structures within 200' of Affected Area Boundary
Dewey-Burdock Project
SIGNATURE OF PREPARER
PREPARER John Mays
DATE 3-Dec-2012
FILE StructsNearAffected.mxd
POWERTECH (USA) INC.

No significant disturbance will occur to the S. Dewey Road as a result of the Dewey-Burdock Project. Powertech (USA) will coordinate the construction of access road approaches with Custer and Fall River counties.

5.7 Operations

During operation of the facility, Powertech (USA) via the company's Safety and Environmental Review Panel (SERP) will ensure that the facility will apply to all applicable laws and regulations. Powertech (USA) will maintain the health and safety of the workers, general public, and the environment while the facility is in operation. This includes maintaining potential occupational and public exposures to ionizing radiation ALARA in accordance with NRC license conditions.

5.7.1 Corporate Organization and Administrative Procedures

This section provides functional positions within the Powertech (USA) organization that have direct responsibility to ensure corporate commitment to operating the facility in a manner that is protective of human health and the environment, including the principle of ALARA. The organizational accountability of these functional positions is also presented.

5.7.1.1 Corporate and Facility Organization

The organizational structure of Powertech (USA) and the facility is shown in Figure 5.7-1. The organization structure defines the Chief Operating Officer (COO) as having direct supervision over the Vice President of Environmental Health & Safety Resources and the Facility Manager of the Dewey-Burdock Project.

5.7.1.2 Chief Operating Officer

The COO is empowered by the Board of Directors to have the responsibility and authority for the radiation safety and environmental compliance programs at all Powertech (USA) facilities. The COO is directly responsible for ensuring that Powertech (USA) personnel comply with corporate industrial safety, radiation safety, and environmental protection programs. The COO is also responsible for company compliance with all regulatory license/permit conditions/stipulations, regulations, and reporting requirements. The COO has the responsibility and authority to terminate immediately any activity that is determined to be a threat to employees, public health,

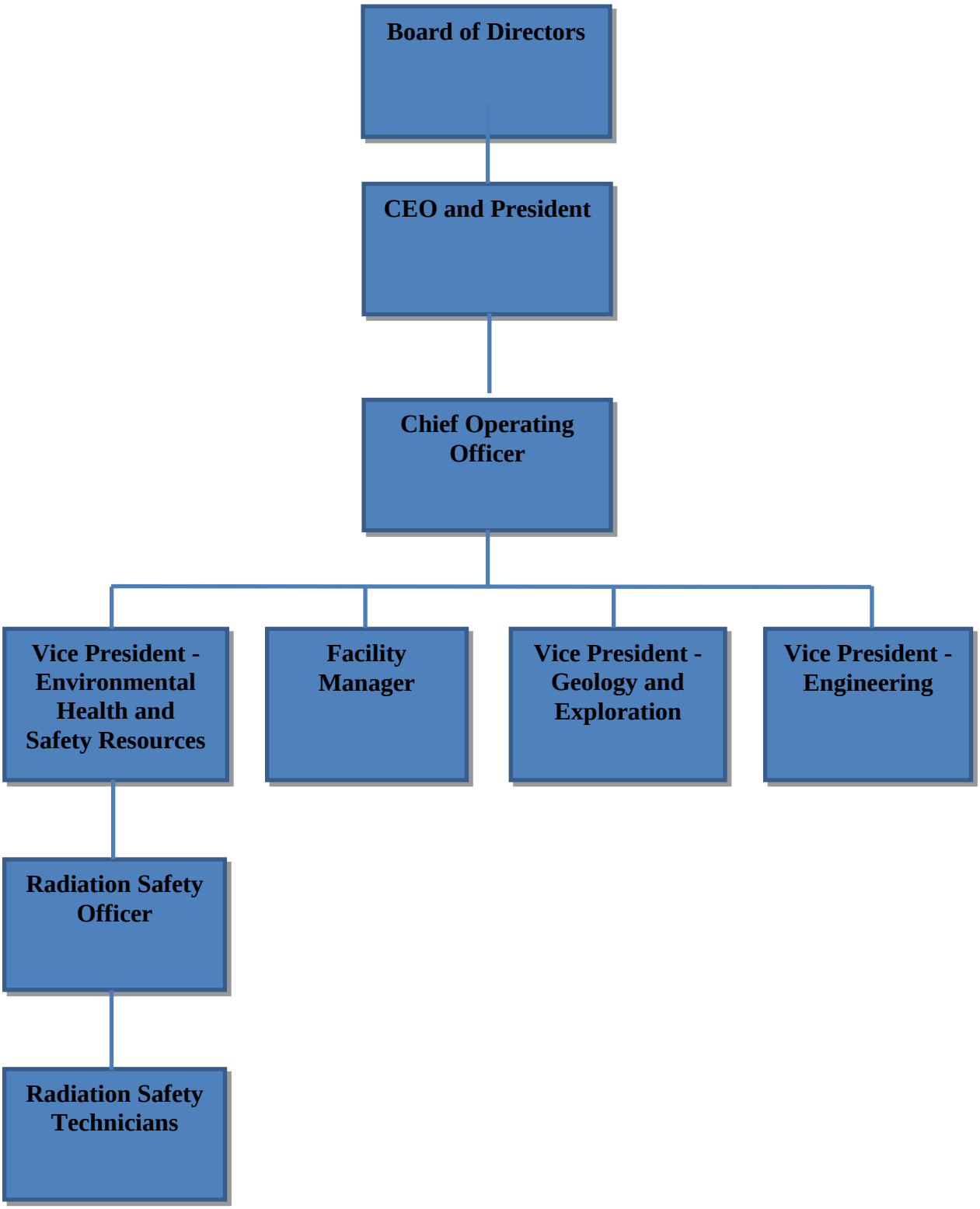


Figure 5.7-1: Organizational Structure

or the environment, or a violation of state or federal regulations. The COO has the authority to assign corporate resources (e.g., capital equipment, personnel, budget) to ensure corporate environmental, health, and safety goals and directives are met.

5.7.1.3 Vice President of Environmental Health & Safety Resources

The Vice President of Environmental Health & Safety Resources is responsible for all radiation protection, health and safety, and environmental programs for Powertech (USA) and ensuring these programs meet applicable regulatory requirements and industry best management practices. The Vice President is responsible for ensuring that all company operations comply with all applicable laws and regulations. The Vice President reports directly to the COO.

5.7.1.4 Facility Manager

The Facility Manager will be responsible for all operations at the project facility. The Facility Manager will be responsible for compliance with all applicable laws and regulations as well as corporate health, safety and environmental programs. The Facility Manager will have the authority to terminate immediately any operation of the facility that is determined to be a threat to employees, public health, or the environment, or a violation of laws or regulations. The Facility Manager reports directly to the COO. The Facility Manager has the authority to assign facility resources (e.g., capital equipment, personnel, budget) to ensure corporate environmental, health, and safety goals and directives are met. The Facility Manager will act promptly on recommendations made by the Radiation Safety Officer (RSO) to correct deficiencies identified in the radiation or environmental monitoring programs, but will not have the authority to unilaterally override the RSO's decision to suspend, postpone, or modify an activity.

5.7.1.5 Radiation Safety Officer

The RSO will be the person in charge of and responsible for the radiation protection and ALARA programs. The RSO will ensure that equipment and laboratory facilities are adequate for monitoring and evaluating the relative attainment of the ALARA objective. The RSO will develop, review, and enact changes in the program so that protection against uranium, radon and decay products and the ALARA principle are maintained during the operation of the facility. These changes include new equipment, process changes, and changes in the operating procedures.

The RSO will possess the authority to enforce regulations and administrative policies that may affect any aspect of the radiological protection program. The RSO will have the authority to suspend, postpone, or modify any activity that the RSO determines is not in compliance with

regulations and administrative policy. The RSO will also be a member of the SERP described in Section 5.7.2.3 and will meet the qualifications outlined in NRC guidance.

The RSO will report directly to the Vice President of Environmental Health & Safety Resources.

5.7.1.6 Radiation Safety Technicians

Powertech (USA) will utilize Radiation Safety Technicians (RSTs). The RSTs will be members of the radiation safety staff. Qualifications and training requirements will be in accordance with NRC license requirements. The RST will meet the minimum training requirements of the RSO and will be a qualified designee to replace the RSO in daily visual inspection of all work and storage areas in the facility to determine if standard operating procedures (SOPs) are being followed properly and good radiation practices are being implemented. The RST will perform this function when the RSO is not available, e.g., during off shifts.

5.7.2 Management Control Program

This section describes administrative controls within the Powertech (USA) organization that are intended to ensure the facility is operated in a manner that is protective of human health and the environment, including the principle of ALARA.

5.7.2.1 Routine Activities

All routine activities involving handling, processing, or storing of radioactive or hazardous material at the Dewey-Burdock Project will be documented by written SOPs. Each SOP will be reviewed and approved in writing by the RSO or RST prior to implementation. Any proposed changes to an SOP must also be reviewed and approved in writing by the RSO or the RST. The RSO will review each SOP at least annually to ensure it follows any newly established radiation protection practices.

Up-to-date copies of the SOPs, along with accident response and radiological fire protection plans, will be made available to all employees. All SOPs will be managed in a manner which allows for tracking of revisions and dates of the revisions.

5.7.2.2 Non-Routine Activities

Any activities with potential for significant exposure to radioactive material and not documented by existing SOPs will require radiological work permits (RWPs). RWPs are job-specific permits that will describe the details of the job to be performed, precautions necessary to maintain

radiation exposures ALARA, and the necessary radiological monitoring and sampling. The RSO or RST must review and sign off on the RWP before the associated work is to be performed.

5.7.2.3 Safety and Environmental Review Panel

A SERP consisting of at least three members will be established. One member will be the RSO. Another member will be someone with authority to implement managerial and financial changes (e.g., the Facility Manager). Another member will be someone with authority to make operational changes (e.g., the Production Superintendent, who will report to the Facility Manager). The SERP may include others on a temporary or permanent basis whenever the SERP requires additional technical or scientific expertise; these may be other employees or consultants. At least one member of the SERP shall be designated as chairman.

The purpose of the SERP will be to evaluate, discuss, approve, and record any changes to any SOP, the facility, or tests and experiments involving safety or the environment. The changes will not require an NRC license amendment pursuant to 10 CFR § 40.44 as long as the changes do not:

- Create a possibility of an accident unlike what is evaluated in the NRC license application (as updated),
- Create a possibility of a malfunction of a structure, system, or control unlike what is evaluated in the NRC license application (as updated), or
- Result in a departure from the method of evaluation described in the NRC license application (as updated) used in establishing the final safety evaluation report or the environmental assessment or technical evaluation reports or other analyses and evaluations for NRC license amendments.

Records of the evaluations made by the SERP will be made. Any change approved by the SERP will be documented in writing by showing the affected operating procedure, facility, and/or test and experiment before and after the change along with the date of the change. The SERP will evaluate each well field hydrogeologic data package as it is developed. The SERP evaluation will determine whether the results of the hydrologic testing and the planned ISR operations are consistent with SOPs and technical requirements stated in the NRC license. The evaluation will include review of the potential impacts to human health and environment. If anomalous conditions are present, the SERP evaluation indicates potential to impact human health or the environment, or it is required by NRC license conditions, the well field hydrogeologic data

package will be submitted to NRC for review. All well field packages and written SERP evaluations will be maintained at the site and available for regulatory review.

The SERP will have the authority to raise issues regarding the health and safety of the workers, general public, and/or the environment due to the operation of the facility to the Facility Manager and the Vice President of Environmental Health & Safety Resources.

An annual report will be prepared which describes actions taken by the SERP including changes to operating procedures, the facility, or tests and experiments that involve safety or the environment enacted since the previous report was issued. The report also will document the reason for each change, whether the change required an NRC license amendment, and the basis for determination.

5.7.2.4 Radioactive Material Postings

All entrances to the facility will be conspicuously posted with the following statement: "ANY AREA WITHIN THIS FACILITY MAY CONTAIN RADIOACTIVE MATERIAL."

5.7.2.5 Recordkeeping

All records will be maintained as hard copy originals or stored electronically.

The following information will be permanently maintained both on-site and at an off-site location until NRC license termination:

- Records of the results of measurements and calculations used to evaluate the release of radioactive effluents to the environment.
- Records of spills, excursions, facility stoppages, contamination events, and unusual occurrences.
- Records of inspections of ponds.
- Records of the occupational monitoring.
- Information related to the radiological characterization of the facility.
- Drawing and photographs of structures, equipment, restricted areas, well fields, and storage areas with radioactive materials and all of their modifications.
- Records of survey and calibrations will be maintained for at least 3 years.

All records will be stored in manner to prevent record loss from fire, flood, or other unforeseen events beyond the control of Powertech (USA). All records will be legible throughout the retention period described above.

5.7.2.6 Reporting

Powertech (USA) has committed to developing written operating procedures within the management control program to address all NRC license reporting requirements. These will be prepared after NRC license issuance but prior to ISR operations. Specific reporting requirements will include items such as reports of theft or loss of licensed material, notification of incidents, reports of exposures of radioactive material exceeding limits, and effluent monitoring reporting.

Powertech (USA) will prepare and submit reports in accordance with the requirements of SDCL 45-6B-36, ARSD 74:29:05:18 and ARSD 74:29:05:20. The following reports will be provided to DENR at the specific frequency.

Updated Baseline Surface and Groundwater Report

Powertech (USA) has committed to collecting additional surface water and groundwater samples prior to operations (refer to Sections 5.5.2 and 5.5.3). The results will be provided to DENR in an updated baseline surface and groundwater report prior to ISR operations.

Annual Environmental Monitoring Report

Powertech (USA) will prepare and provide to DENR an annual environmental monitoring report, which will include the results of the following operational monitoring programs.

- Operational groundwater monitoring, including domestic wells, stock wells, irrigation wells and monitor wells.
- Operational surface water monitoring, including streams and impoundments.
- Soil sampling, including soil samples collected from the air particulate monitoring locations and from the land application areas (if used).
- Vegetation sampling, including vegetation samples collected from the air particulate monitoring locations and from the land application areas (if used).
- Livestock and fish sampling.
- Environmental air monitoring, including air particulate and radon gas sampling at operational environmental air monitoring stations.

Annual Financial Assurance Report

Powertech (USA) will provide an annual financial assurance report to DENR within 60 days prior to the anniversary date of the permit each year including the following elements:

- Annual filing of map and fee in accordance with SDCL 45-6B-36.
- A brief discussion of the coming year's operational plans including any anticipated revisions that might require department or board approval.
- An annual disturbance and reclamation summary, including:
    - Total amount of disturbed lands;
    - Total amount of land that has undergone interim reclamation;
    - Total amount of land that has undergone final reclamation but has not yet satisfied the postclosure reclamation requirements; and
    - Total amount of land that has undergone final reclamation and has satisfied the postclosure reclamation requirements.
- An updated financial assurance cost estimate that accounts for economic and site-specific factors such as inflation, changes in costs of materials, changes in waste disposal costs, changes in specific reclamation costs such as well plugging, and changes in other site-specific decommissioning/reclamation costs such as the level of effort and duration required for groundwater restoration. The updated financial assurance cost estimate will account for the next year of proposed activities.

Land Application System Reporting

Powertech (USA) will establish and maintain records and prepare and submit reports for land application system operation in accordance with the requirements of ARSD 74:29:05.

Prior to operating the land application systems each year, Powertech (USA) will provide written notice to the DENR of the intent to implement land application. In accordance with ARSD 74:29:05:18, the written report will include the following information:

1) The date on which application will start;
2) The amount of solution to be applied to land;
3) The estimated duration of land application; and
4) The chemical characterization of the solution in the storage ponds.

Per ARSD 74:29:05:20, Powertech (USA) will submit a written report to DENR following each land application cycle, which is defined as the last land application operational period during each calendar year. Prior to the end of each year, Powertech (USA) will prepare and submit a written report including the following information for each of the land application systems (Dewey and Burdock):

1) The total amount of land application solution applied;
2) The total hydraulic loading rate per acre;
3) The total metals loading rate per acre, including all of the trace and minor elements and radiological parameters in Table 6.2-1;
4) The duration of the land application cycle;
5) All land application effluent and storage pond sampling data; and
6) A general discussion of the success of the system.

Well Completion Reports

Powertech (USA) will submit well completion reports within 1 month of completing each injection, production, or monitor well. Well completion will be defined as the point at which the well screen has been installed and initial well development has occurred. In accordance with SDCL 46-6-11, the well completion reports will be provided to DENR on a form supplied by the Chief Engineer.

Well Plugging Reports

Powertech (USA) will provide an annual well plugging report to DENR including the following elements for each plugged well in accordance with ARSD 74:02:04:71:

1) The name and complete mailing address of the owner;
2) The legal description of the well or hole location;
3) The completion date;
4) The casing or hole size, type of well, and well or hole depth;
5) A general description of the condition of the well;
6) A description of the plugging procedure;
7) The grout or material used to plug the well or test hole; and
8) The date and the signature of the license representative.

Postclosure Monitoring Report

During postclosure monitoring, Powertech (USA) will provide an annual report to DENR describing the following:

- Treatment system operation (if applicable);
- Operation of monitoring systems;
- Monitoring results; and
- Inspection and maintenance activities.

5.7.2.7 Historical and Cultural Resources Inventory

Powertech (USA) will administer a historic and cultural resources inventory before engaging in any development activity not previously assessed by NRC or any cooperating agency. Any disturbances to be associated with such development will be addressed in compliance with the NHPA, the Archeological Resources Protection Act, and their implementing regulations. Any disturbances also will be addressed in compliance with Powertech (USA)'s MOA with the South Dakota State Archeologist and any future MOAs developed by Powertech (USA) or NRC under the NHPA. Powertech (USA) executed the MOA with the South Dakota State Archeologist in September 2008. The MOA, which is provided in Appendix 3.11-B, establishes procedures to avoid or mitigate potential effects on archaeological and historic sites pursuant to South Dakota statutes 45-6D-14 and 45-6B.

Powertech (USA) will immediately cease any work resulting in the discovery of previously unknown cultural artifacts to ensure that no unapproved disturbance occurs. Powertech (USA) will notify appropriate authorities per any license conditions and will not go forward without appropriate approvals from NRC or other agencies as appropriate. Any such artifacts will be inventoried and evaluated, and no further disturbance will occur until authorization to proceed has been received. The procedure described in this section will continue up to and through final license termination.

5.7.3 Management and Audit Program

Powertech (USA) will conduct a management and audit program in accordance with NRC license requirements that will evaluate compliance with and effectiveness of the radiation protection, operational monitoring, and environmental monitoring programs. The management and audit program will function to ensure vigilance toward the protection of human health and the environment. It will be designed to provide quality assurance based upon reviews and evaluations of the effectiveness of radiation protection provided for workers and members of the public. A brief summary of the management and audit program includes:

- Daily health physics inspections to determine if good radiation practices are being implemented.
- Weekly health physics inspections of all facility areas to examine the general radiation control practices and observe the required changes in procedure and equipment.
- Monthly health physics review of all radiation monitoring and exposure data for the month.
- Implementation of a radiation protection program ensuring compliance with NRC license conditions.
- Establish the effluent control and monitoring systems and ensure effluent monitoring locations are optimized for the intended function.
- Implement a waste storage system that will include a pond monitoring program to ensure the ponds are operated and maintained in a manner that prevents the movement of waste(s) to undesirable areas. Contingency plans will be built into the program to address all reasonable system failures.
- Implementation of an annual ALARA and radiation protection program audit.

5.7.4 Qualifications for Personnel Implementing the Radiation Safety Program

Powertech (USA) will establish the minimum qualifications, including education and experience, for the RSO and RST in accordance with NRC license conditions.

5.7.5 Radiation Safety Training

Powertech (USA) will establish radiation safety training programs to ensure all employees and visitors have an adequate level of knowledge to recognize and be aware of potential radiological hazards associated with activities they will be involved with at the facility. Written procedures will be established for initial training, refresher training, visitor training, contractor training, RSO training, and training documentation.

5.7.6 Facility Security

The following describes the security measures that will be implemented to prevent unauthorized site access and removal or access of NRC-licensed materials stored within the permit area:

- All areas where licensed material is stored (e.g., well fields, CPP, Satellite Facility) will be fenced.
- All gates accessing areas where licensed material is stored will be posted as described in Section 5.7.2.4 and locked when facility personnel are not immediately available to prevent unauthorized access to or removal of licensed materials.

- Facility fences, gates, and postings will be inspected daily as part of the inspection programs.
- A 24-hour per day, 7-day per week staff will be on duty at the facility.
- Visitors to the facility will enter through an access point at the main CPP entrance where they will sign in and receive required radiation safety training.

Powertech (USA) will control and maintain constant surveillance of licensed material that is in a controlled or unrestricted area and is not in storage. An example of licensed material not being in storage is licensed material being transported from the Satellite Facility to the CPP. Passive and administrative controls to prevent unauthorized access to and removal of licensed material not in storage include:

- SOPs assessing the possible transportation security risks and identifying measures to mitigate these risks.
- Locks and/or tamper indicators on all openings where licensed material is kept.
- Off-site vehicles transferring licensed materials will always be secure if left unattended.
- Off-site vehicles transferring licensed materials will be visible by an employee at all times when left unattended outside of a restricted area.

The requirements of 49 CFR 172 will apply to shipments of licensed material which Powertech (USA) offers for transport for commercial use. Powertech (USA) will develop SOPs for these cases and will evaluate the ability of potential commercial contractors offering transportation services to comply with the requirements of 49 CFR 172 prior to entering into a contracting agreement.

5.7.7 Radiation Safety Controls and Monitoring

Active and passive effluent control techniques and monitoring will ensure that occupational and public doses of ionizing radiation will be ALARA. Effluent control techniques are briefly summarized in Section 5.6.9.2 and will include use of pressurized, downflow IX vessels, ventilation systems, modern vacuum yellowcake dryers, and emission control systems. Radiation safety monitoring is described in Section 5.6.9.2 and will include monitoring air quality and potential worker exposure within the processing facilities and environmental monitoring throughout the permit area.

6.0 RECLAMATION PLAN

6.1 Introduction

This reclamation plan was developed by WWC Engineering personnel including Mr. John Berry and Mr. Dale Brown and Powertech (USA) personnel including Mr. Richard Blubaugh and Mr. John Mays. These individuals are competent and have experience managing and planning for reclamation in accordance with ARSD 74:29:07:18.

The initial and most critical goal of reclamation is to stabilize the primary disturbance (surface and subsurface) to reduce off-site impacts. The overall long-term objective of reclamation is to return future areas of disturbance to a beneficial land use after ISR activities have ceased. During the period of active ISR, interim management of disturbed lands through revegetation techniques, sediment control, dust, and management of noxious weeds will be conducted to minimize potential impacts to land, water, air, wildlife, and humans. As uranium ISR and groundwater restoration are completed within various portions of the permit area, long-term reclamation treatments will be implemented to ensure the creation of a stable and environmentally sound postmining land use.

6.2 Groundwater Restoration

The plans for groundwater restoration are discussed below. Groundwater restoration in each well field will be conducted in accordance with NRC license requirements.

6.2.1 Target Restoration Goals

Groundwater restoration, or aquifer restoration, will be performed pursuant to NRC requirements to protect USDWs. The groundwater restoration program for all well fields will be conducted pursuant to 10 CFR Part 40, Appendix A, Criterion 5, which sets forth groundwater quality standards for uranium milling facilities. Currently, Criterion 5 states that groundwater quality at such facilities shall have primary goals of baseline (background) or an MCL, whichever is higher, or an alternate concentration limit (ACL). An ACL is a site-specific, constituent-specific, risk-based standard that demonstrates that maintaining groundwater quality at the requested level at a designated point of compliance (POC) will be adequately protective of human health and the environment at the point of exposure (POE) and that groundwater quality outside the boundary of the aquifer exemption approved by EPA will meet background (baseline) levels or MCLs. Satisfaction of prior class-of-use can be proposed as a factor in demonstrating justification for an ACL.

In the event that an ACL is requested, Powertech (USA) will be required by NRC license conditions to submit an ACL application to NRC staff in accordance with regulatory requirements under 10 CFR Part 40, Appendix A, Criterion 5(B)(5). Any ACL application will be in the form of a license amendment application that addresses, at a minimum, all of the relevant factors in 10 CFR Part 40, Appendix A, Criterion 5(B)(6), including but not limited to:

(a) Potential adverse effects on ground-water quality, considering:
- (i) The physical and chemical characteristics of the waste in the licensed site including its potential for migration;
- (ii) The hydrogeological characteristics of the facility and surrounding land;
- (iii) The quantity of ground water and the direction of ground-water flow;
- (iv) The proximity and withdrawal rates of ground-water users;
- (v) The current and future uses of ground water in the area;
- (vi) The existing quality of ground water, including other sources of contamination and their cumulative impact on the ground-water quality;
- (vii) The potential for health risks caused by human exposure to waste constituents;
- (viii) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents;
- (ix) The persistence and permanence of the potential adverse effects.

(b) Potential adverse effects on hydraulically-connected surface water quality, considering:
- (i) The volume and physical and chemical characteristics of the waste in the licensed site;
- (ii) The hydrogeological characteristics of the facility and surrounding land;
- (iii) The quantity and quality of ground water, and the direction of ground-water flow;
- (iv) The patterns of rainfall in the region;
- (v) The proximity of the licensed site to surface waters;
- (vi) The current and future uses of surface waters in the area and any water quality standards established for those surface waters;
- (vii) The existing quality of surface water including other sources of contamination and the cumulative impact on surface water quality;
- (viii) The potential for health risks caused by human exposure to waste constituents;
- (ix) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents; and
- (x) The persistence and permanence of the potential adverse effects.

Should it become necessary to submit an ACL application, Powertech (USA) will follow relevant NRC guidance and policy in effect at the time that an ACL would be requested.

Prior to operation, the baseline groundwater quality will be determined through the sampling and analysis of water quality indicator constituents in wells screened in the mineralized zone(s)

across each well field. Section 5.5.1.2.1 describes the methods used to select baseline wells, sample the wells, and calculate baseline water quality statistics. Table 6.2-1 lists the parameters to be analyzed in baseline sampling. The target restoration goals (TRGs) will be established as a function of the average baseline water quality and the variability in each parameter according to statistical methods approved by NRC.

6.2.2 Groundwater Restoration Process

Groundwater restoration will be conducted in accordance with NRC license requirements in a manner that will protect human health and the environment. The methods for achieving this objective are discussed in the following sections.

6.2.2.1 Groundwater Restoration Methods

During groundwater restoration, Powertech (USA) will restore groundwater quality consistent with the groundwater protection standards contained in 10 CFR Part 40, Appendix A, Criterion 5(B)(5), in accordance with NRC license requirements. The technology selected will depend on the wastewater disposal option as described below. In the deep disposal well option, reverse osmosis (RO) treatment with permeate injection will be the primary restoration method. If land application is used, then groundwater sweep with injection of clean makeup water from the Madison Limestone or another suitable formation will be used to restore the aquifer. In either case, groundwater restoration will be conducted in accordance with NRC license requirements, which will establish the minimum number of pore volumes and the pore volume calculation method. Refer to Powertech (2011) for additional information.

6.2.2.1.1 Deep Disposal Well Option

In the deep disposal well option, the primary method of groundwater restoration will be RO treatment with permeate injection. In this method, water will be pumped from one or more well fields to the CPP or Satellite Facility for treatment. Treatment will begin with removal of uranium and other dissolved species in IX columns. The water then will pass through the restoration RO unit, which will remove over 90% of dissolved constituents using high pressure RO membranes. The treated effluent, or permeate, will be returned to the well field(s) for injection. The RO reject, or brine, will undergo radium removal in radium settling ponds and then will be disposed in one or more deep disposal wells.

The RO units will operate at a recovery rate of approximately 70%. Therefore, about 70% of the water that is withdrawn from the well fields and passed through the restoration RO unit will be

Table 6.2-1: Water Quality Parameter List

Test Analyte/Parameter	Units	Analytical Method
Physical Properties		
pH ≠	pH units	A4500-H B
Total Dissolved Solids (TDS) +	mg/L	A2540 C
Conductivity	µmhos/cm	A2510 B
Common Elements and Ions		
Alkalinity (as $CaCO_3$)	mg/L	A2320 B
Bicarbonate Alkalinity (as $CaCO_3$)	mg/L	A2320 B (as HCO_3)
Calcium	mg/L	E200.7
Carbonate Alkalinity (as $CaCO_3$)	mg/L	A2320 B
Chloride, Cl	mg/L	A4500-Cl B; E300.0
Magnesium, Mg	mg/L	E200.7
Nitrate, NO_3^- (as Nitrogen)	mg/L	E300.0
Potassium, K	mg/L	E200.7
Sodium, Na	mg/L	E200.7
Sulfate, SO_4	mg/L	A4500-SO4 E; E300.0
Trace and Minor Elements		
Arsenic, As	mg/L	E200.8
Barium, Ba	mg/L	E200.8
Boron, B	mg/L	E200.7
Cadmium, Cd	mg/L	E200.8
Chromium, Cr	mg/L	E200.8
Copper, Cu	mg/L	E200.8
Fluoride, F	mg/L	E300.0
Iron, Fe	mg/L	E200.7
Lead, Pb	mg/L	E200.8
Manganese, Mn	mg/L	E200.8
Mercury, Hg	mg/L	E200.8
Molybdenum, Mo	mg/L	E200.8
Nickel, Ni	mg/L	E200.8
Selenium, Se	mg/L	E200.8, A3114 B
Silver, Ag	mg/L	E200.8
Uranium, U	mg/L	E200.7, E200.8
Vanadium, V	mg/L	E200.7, E200.8
Zinc, Zn	mg/L	E200.8
Radiological Parameters[1,2]		
Gross Alpha††	pCi/L	E900.0
Gross Beta	pCi/L	E900.0
Radium, Ra-226[§]	pCi/L	E903.0

≠ Field and Laboratory
+ Laboratory only
††Excluding radon, radium, and uranium
[1] For alluvial compliance and interior well sampling, the concentrations of trace and minor elements and radiological parameters will be the dissolved portion, except mercury, which will be the total, unfiltered concentration in accordance with ARSD 74:54:01:04.
[2] The parameter list for alluvial compliance and interior wells also will include radon-222 and radium-228.

recovered as nearly pure water, or permeate. In order to avoid excessive restoration bleed and consumptive use of Fall River and Chilson groundwater, permeate will be supplemented with clean makeup water from the Madison Limestone or another suitable formation. Permeate and makeup water will be reinjected into the well field(s) at an amount slightly less than the amount withdrawn from the well field(s). This will be done to maintain a slight restoration bleed, which will maintain hydraulic control of the well field(s) throughout active aquifer restoration. The restoration bleed typically will be 1% of the restoration flow rate unless groundwater sweep is used in conjunction with RO treatment with permeate injection, in which case the restoration bleed will average approximately 17%. Refer to the "Optional Groundwater Sweep" discussion in Section 6.2.2.1.3.

6.2.2.1.2 Land Application Option

In the land application option, the primary method of groundwater restoration will be groundwater sweep with Madison Limestone water injection. A GDP application through DENR was submitted in March 2012 for the land application option. This method will begin the same as the method described above for RO treatment with permeate injection; water will be pumped to the CPP or Satellite Facility for removal of uranium and other dissolved species in IX columns. The partially treated water will undergo radium removal in radium settling ponds and then will be disposed in the land application systems.

RO will not be used if there are no deep disposal wells available to accept the RO brine. Instead, clean makeup water from the Madison Limestone or another suitable formation will be injected into the well field(s) at a flow rate sufficient to maintain the restoration bleed. As before, the restoration bleed typically will be 1% of the restoration flow rate unless the optional groundwater sweep method is used.

The water quality of the Madison Limestone is expected to be equal to or better than the baseline ore zone water quality, and injection of Madison Limestone water therefore will be similar to injection of permeate under the deep disposal well option.

6.2.2.1.3 Optional Groundwater Sweep

Although a 1% restoration bleed will be adequate to maintain hydraulic control of well fields undergoing active aquifer restoration, additional bleed may be required at times. For example, additional restoration bleed may be used to recover flare of ISR solutions outside of the well field pattern area. In addition to the restoration methods described above, Powertech (USA) may

withdraw up to one pore volume of water through groundwater sweep over the course of aquifer restoration. This will result in an average restoration bleed of approximately 17%.

6.2.2.2 Effectiveness of Groundwater Restoration Techniques

This section describes how the groundwater restoration process that will be conducted in accordance with NRC license requirements is the same process that has been used successfully at other NRC and agreement state-licensed facilities. The preferred groundwater restoration method is RO treatment with permeate injection. This is the aquifer restoration method that will be used if deep disposal wells are used to dispose treated wastewater. As described in Section 2.5.3 of NUREG-1910 (NRC, 2009), this method of aquifer restoration is responsible for returning "total dissolved solids, trace metal concentrations, and aquifer pH to baseline values." RO treatment with permeate injection has proven effective at achieving successful aquifer restoration as described in Uranium One (2008):

> Results of the effectiveness of groundwater sweep (or lack of it) were clearly demonstrated in the Christensen Ranch Wellfield Restoration report (CRWR) (COGEMA 2008[a]). Example plots from that report of mean well field water quality at the end of mining, groundwater sweep, RO and stabilization monitoring… indicate minimal improvement following groundwater sweep at MU3 and MU5 and an actual increase [in dissolved constituents] at MU6. Following application of RO, the TDS values at MU5 and MU6 decreased to levels below the target Restoration Goal. Uranium increased in MU5 and MU6 following groundwater sweep…and then was significantly lowered during RO. Approximately 1.8, 4.8 and 1.5 PVs of groundwater were removed from MU3, MU5 and MU6, respectively, during groundwater sweep. This water removal was totally consumptive by design, in that none of it was returned to the aquifer.
>
> Based on the results, minimal benefit, if any, was derived from [the groundwater sweep] phase of restoration. Eliminating groundwater sweep, an unnecessary, ineffective and consumptive step in the restoration process, will reduce the number of PVs required to reach restoration goals.
>
> Terminating RO once water quality has stabilized will minimize the consumptive use of groundwater and reduce the number of PVs of treatment.

6.2.2.3 Pore Volume Calculations and Restoration Pore Volumes

The formulas for determining the pore volume and the volume of restoration composite (RC) to be withdrawn during groundwater restoration are as follows:

Pore volume = (well field pattern area) x (thickness) x (porosity) x (flare factor)

RC volume = (pore volume) x (number of pore volumes for groundwater restoration)

The thickness is the average thickness of the mineralized zones as determined by down-hole radiological logging. This is the same as the average screened interval, since screens will be completed only across the targeted ore zone (see Section 5.3.3.1.1). The average thickness in the permit area is 4.6 feet.

The porosity (collective open space of the formation) of the ore zone within the permit area was determined by laboratory analysis of core samples. Based on 11 measurements of ore zone porosity from core samples of the Fall River and Chilson host sands, the average porosity of the ore zone sands within the permit area is 30 percent (0.30).

The proposed flare factor is 1.44, accounting for both horizontal and vertical flare of lixiviant during ISR operations. Support for the flare factor is contained in the numerical groundwater modeling results presented in Appendix 6.2-A. Appendix 6.2-A describes how horizontal flare from a modeled balanced well field was determined to be 1.19. Vertical flare is expected to be similar to or less than the horizontal flare since the horizontal conductivity is greater than vertical conductivity. An overall flare factor of 1.44 is supported by the numerical modeling results presented in Appendix 6.2-A.

The flare factor and number of pore volumes required for groundwater restoration are both a function of the properties of the particular sandstone formations and ore deposits, as well as the operational factors of aquifer bleed rates, the balancing of pattern flow rates, the use of RO during groundwater restoration and the timeliness of beginning groundwater restoration operations following cessation of recovery operations. For the Dewey-Burdock Project, the values of the flare factor and the number of pore volumes removed for groundwater restoration are comparable to those that have been approved recently for other ISR facilities and are consistent with the best practicable technology for groundwater restoration.

The overall (horizontal and vertical) flare factor for ISR uranium projects has varied from 1.44 at Irigaray/Christensen Ranch (COGEMA, 2008 and COGEMA, 2005) to 1.95 at Churchrock/Crownpoint (HRI, 2001). The overall well field flare factor for the Dewey-Burdock Project is estimated to be 1.44, which is equal to the flare factor in approved NRC license applications at ISR facilities located nearby in the State of Wyoming and is supported by numerical groundwater modeling.

The number of pore volumes, including flare, of groundwater to be removed to achieve aquifer restoration is estimated to be 6.0. This number has been proposed for NRC review and verification (Powertech, 2011) and is subject to change pending NRC review of the financial assurance estimate prior to ISR operations. This number is consistent with the best practicable technology that includes the following operational practices:

(i) Daily balancing of injection and extraction flow rates during production. This flow rate balancing is designed to ensure that a proper aquifer bleed is maintained both at the well field level and also within each 5-spot pattern within the well field.
(ii) Timeliness of beginning restoration operations. For any particular well field, aquifer restoration operations will begin as soon as is reasonably possible following the cessation of recovery operations.
(iii) Maintenance of aquifer bleeds. Hydraulic control of well fields through the net withdrawal of the aquifer bleed stream will be continuously maintained from the beginning of recovery operations until the end of active aquifer restoration.

While the number of pore volumes required for aquifer restoration historically has proven to have been significantly higher for some of the early ISR uranium projects, the methods and timing of restoration likely contributed to these larger numbers. The following information was obtained from the Moore Ranch license application (Uranium One, 2008).

> The average number of PVs extracted and treated/reinjected/or disposed was 13.6 for Irigaray and 12.4 for Christensen … Circumstances at both those ISR projects resulted in increased PVs to achieve restoration goals including the following:
>
> - Production and restoration were not conducted sequentially, and were plagued with extended periods of shut-in and standby, with delays of up to several years in some cases;
> - Groundwater sweep, the initial phase of restoration, was often largely ineffective and in some cases may have exacerbated the problem; and
> - RO was continued in some well fields after it was apparent that little improvement in water quality was occurring.
>
> Restoration was not performed immediately following the completion of production, and in some cases, there were long periods of inactivity during the production and restoration phases. At Irigaray, production was interrupted for a period of almost six years in MU1 through MU5 … Similarly, there was a three-year break in production in MU6 through MU9, when the operation was in standby status. Restoration did not commence at MUl through MU3 until a year after production had ended. At MU4 and MU5, restoration

operations did not begin until two years following production. Restoration commenced shortly after the end of production at MU6 through MU9. However the project was on standby status between the completion of groundwater sweep and the beginning of the RO phase of production, resulting in a break of one to two years, depending on the MU. Restoration was initiated sooner after the end of production at Christensen Ranch, with the exception of MU3 and MU4. However, there were periods of standby between groundwater sweep and RO treatment/injection of up to a year. These delays between and during production and restoration operations most likely increased the number of PVs required to complete aquifer restoration.

Pore volume and restoration composite calculations are presented in Appendix 6.7-A.

6.2.2.4 Potential Environmental Impacts of Groundwater Restoration

Based on the success of groundwater restoration at other ISR facilities, Powertech (USA) expects that the proposed groundwater restoration techniques will be successful at returning the production zones to TRGs. The purpose of restoring the groundwater to these indicator parameters is to protect USDWs adjacent the aquifer exemption boundary. Using proven best practicable technology for groundwater restoration combined with federal and state regulatory requirements will ensure that potential impacts to groundwater quality outside the production zone are mitigated.

The preferred method of restoration consists of using the groundwater treatment method with RO reject brines being treated for radium removal and disposed in Class V disposal wells. This method minimizes the amount of groundwater that will be consumed during restoration, and minimizes the surface disturbance to land within the permit boundary. Disposal of wastewater in deep disposal wells is the best practicable technology and is the standard method used at most ISR facilities. The alternate method of land application would consume more groundwater since none of the restoration water would be recycled to the well field, but would be used in a once-through process leading to land application.

The proposed restoration methods will consume groundwater. Groundwater recovered during groundwater restoration is typically disposed of directly in the wastewater system. Consumption of groundwater is an unavoidable consequence of groundwater treatment; potential impacts and water usage during operations is discussed in more detail in Section 5.6.3.

6.2.2.5 Groundwater Restoration Monitoring

Refer to Section 5.5.1.3 for a discussion of groundwater restoration monitoring, including monitoring the progress of active restoration, excursion monitoring during groundwater restoration, and stability monitoring.

6.3 Decontamination and Decommissioning

Following regulatory approval of successful groundwater restoration in all well fields, Powertech (USA) will decommission all well fields, processing facilities, ponds, and equipment within the permit area. Decontamination and decommissioning activities will be done in accordance with NRC license and DENR LSM permit requirements. During decommissioning, all well field equipment (including pumps, tubing, pressure transducers, well head covers and surface piping and equipment), pipelines, header houses, processing buildings/equipment, and pond liners will be surveyed for radiological contamination and decontaminated for unrestricted release, transferred to an NRC or NRC agreement state-licensed facility, or disposed at an appropriately permitted facility. Surface soils will be surveyed for radiological contamination and affected soils removed and appropriately disposed. Surface reclamation and revegetation will be conducted in accordance with DENR LSM permit requirements. The decontamination and decommissioning program described below will ensure that the permit area is closed in a manner that permits release for unrestricted use.

6.3.1 Disposal of Process Buildings, Equipment and Other Facilities

The procedures for removing and disposing of structures and equipment include the establishment of surface contamination limits, preliminary radiological surveys of process building surfaces, equipment and piping systems; strategic cleanup and removal of process building materials and equipment, sorting materials according to contamination levels and salvageability, and preparing materials for transport and offsite use or disposal. Although not mentioned hereafter, the procedures also apply to tools and other equipment, such as backhoes.

All decommissioning activities will be done in accordance with NRC license requirements and the provisions of ARSD 74:29:07:13.

6.3.1.1 Establishment of Surface Contamination Limits

Powertech (USA) will use surface contamination release limits approved by NRC to release material and equipment that potentially has come into contact with NRC licensed material.

Surface contamination release limits for surfaces on structures intended for unrestricted release following decommissioning are subject to Criterion 6(6) of Appendix A to 10 CFR 40. Acceptable dose-based surface contamination release limits will be established using the RESRAD-Build model or an equivalent model and will be provided in the final decommissioning plan, which will be submitted to NRC 12 months prior to any planned decommissioning. In the decommissioning plan, Powertech (USA) will assume that all premises, equipment, or scrap likely to be contaminated in excess of limits, but that cannot be measured, is contaminated in excess of limits and will be treated accordingly.

6.3.1.2 Preliminary Radiological Surveys and Contamination Control

Powertech (USA) will develop one or more characterization plans will be followed to demonstrate compliance with the surface contamination limits for building materials, systems, and equipment. The characterization plan(s) will include guidance and SOPs to conduct the preliminary surveys and control contamination. Powertech (USA) will prepare procedures for performing radioactivity measurements on the interior surfaces of pipes, drain lines, and ductwork, and include the procedures in the decommissioning plan. Such plans will include measurements at all traps and other access points where contamination is likely to be representative of system-wide contamination.

Areas within buildings showing evidence of possible penetration of process solutions will be evaluated for possible subsurface contamination. If building materials, slabs and soils beneath the slabs are not contaminated, the buildings shall be released for unrestricted use, provided the building surfaces meet the release criteria and radiological monitoring requirements of the characterization and verification plans. Otherwise, the buildings will be demolished, the slabs removed, and the underlying soils removed (if contaminated). All materials contaminated above release limits will be prepared for offsite disposal at a licensed disposal facility. Contamination control will be addressed using operational SOPs, in conjunction with radiological surveys.

Concrete slabs will be surveyed and if found to contain radionuclides in excess of the release limits, an attempt will be made to decontaminate the concrete slab(s). If after a second survey radionuclides are in excess of the release limits, the concrete will be broken up and disposed at a licensed 11e.(2) disposal site. If the survey results indicate that the concrete is not contaminated above release limits, it may be disposed in an appropriately permitted landfill, used for fill elsewhere, or left in place for use by the landowner.

6.3.1.3 Removal of Process Building and Equipment

Powertech (USA) will develop plans for the strategic removal of process building and equipment, based on inventory, the results of the radiological surveys, decontamination options and available methods, reuse/disposal pathways, and information obtained during the effort. To the extent possible, Powertech (USA) intends to decontaminate salvageable equipment for unrestricted release. Decontamination methods may include a combination of washing, high pressure sprays, or steam cleaning. Cleaned surfaces will be air-dried prior to radiological monitoring. The ALARA principle applies to decommissioning activities. As such, surface contamination will be reduced to levels as far below applicable limits as practical.

Powertech (USA) will document the results of radiological surveys for all building materials, systems, and equipment. These items will be sorted as follows:

- Salvageable and contaminated above release limits (not releasable but potentially disposable or transferrable)
- Salvageable and contaminated below release limits (releasable) for unrestricted use
- Not salvageable and contaminated above release limits (offsite disposal at a facility licensed to accept 11e.(2) byproduct material)
- Not salvageable and contaminated below release limits (offsite disposal at a permitted facility)

In the first case, the item may be transferred to another NRC or agreement state licensee. If it cannot be transferred or decontaminated to be released for unrestricted use, it will be disposed at a licensed disposal facility. In all cases, Powertech (USA) will strictly maintain an inventory of all process building and equipment and the results of radiological surveys.

6.3.1.3.1 Building Materials, Equipment and Piping to be Released for Unrestricted Use

Powertech (USA) will develop an approved SOP for release of items for unrestricted use and thoroughly document all items eligible for release for unrestricted use. To the extent possible, releasable items having a salvageable value will be sold on the industrial market. Releasable items having no net salvageable value will be sent to a municipal landfill.

6.3.1.3.2 Preparation for Disposal at a Licensed Facility

All materials and plant equipment unsuitable for unrestricted release will be prepared for offsite disposal at a licensed facility. Building materials, tools, and equipment destined for offsite

disposal will be prepared for transportation and disposal in accordance with 49 CFR and other applicable requirements.

6.3.1.4 Pond Decommissioning

All liquid waste from ponds will be disposed by deep well injection in one or more deep disposal wells within the permit area or by land application. Any sludge accumulated in the ponds and the primary pond liners will be removed and disposed as 11e.(2) byproduct material. The leak detection equipment, including piping, aggregate, and secondary liners, will be surveyed for contamination. The soil underneath the ponds also will be surveyed for radiological contamination. Any materials in which concentrations exceed limits for unrestricted use will be disposed as 11e.(2) byproduct material at a licensed disposal facility. All pond materials including secondary liners will be removed and disposed as 11e.(2) byproduct material or as solid waste. Confirmation surveying and sampling will be conducted in accordance with applicable requirements to ensure all contaminated material has been removed. The excess pond material used to construct pond embankments or stored in designated spoil stockpiles will be used to backfill the ponds. The backfill will be compacted to avoid subsidence. The area then will be contoured, topsoil replaced, and revegetated as described in Section 6.4.3.

6.3.2 Well Field Decommissioning

6.3.2.1 Injection, Production and Monitor Wells

All pumps and tubing will be removed from the wells along with well head covers and surface piping and equipment. Pressure transducers also will be removed from the wells. Piping, pumps, and equipment will be surveyed for radiological contamination and decontaminated or disposed following procedures described in Sections 6.3.1.2 and 6.3.1.3.

Injection, production and monitor wells will be plugged and abandoned following the procedures in Section 6.3.3.

6.3.2.2 Header House Decommissioning

During decommissioning of each well field, the affected header houses will be moved to a new location in the permit area, decontaminated for unrestricted release or disposed at licensed facility. The soil underneath and surrounding the header houses will be surveyed for radiological contamination and contaminated soil will be disposed at a licensed disposal facility. The area around each header house then will be contoured, topsoil replaced, and revegetated as described in Section 6.4.3.

6.3.2.3 Pipeline and Utility Decommissioning

Topsoil will be windrowed along pipeline and utility routes, and buried piping and utilities will be excavated. Piping will be decontaminated for unrestricted release or disposed in a licensed disposal facility. A grinder or shredder may be used to reduce the volume of disposed pipe material. Topsoil will then be replaced and the area will be seeded as discussed in Section 6.4.3.

6.3.3 Well Plugging and Abandonment

Powertech (USA) will plug all wells in accordance with ARSD 74:02:04:67 with bentonite or cement grout. The weight and composition of the grout will be sufficient to control artesian conditions and meet the well abandonment standards of the State of South Dakota. Cementing will be completed from total depth to surface using a drill pipe. Records will be kept of each well cemented including at a minimum the following information:

- well ID, total depth, and location
- driller, company, or person doing the cementing work
- total volume of grout placed down hole
- viscosity and density of the grout

Powertech (USA) will remove surface casing or cut off surface casing below ground and set a cement surface plug on each well plugged and abandoned.

6.3.4 Soil Decontamination

Surface soils will be cleaned up in accordance with NRC license requirements and DENR permit requirements. The following section describes the methods for establishing site-specific cleanup criteria, monitoring during excavation of contaminated soil, and verification sampling following clean up.

6.3.4.1 Cleanup Criteria

Surface soils will be cleaned up in accordance with requirements contained in 10 CFR Part 40, Appendix A, including considerations of ALARA goals and the chemical toxicity of uranium. In accordance with NRC license conditions, Powertech (USA) will establish a radium benchmark dose, determine the natural uranium soil standard as a function of background concentrations and potential impacts, and perform a uranium chemical toxicity assessment. Cleaning up soils within the permit area to meet cleanup criteria approved by NRC will ensure that public exposure is within permissible limits and that radionuclide levels in soil are ALARA.

6.3.4.2 Excavation Control Monitoring

The purpose of excavation control monitoring will be to guide the removal of contaminated material to the point where it is highly probable that an area meets the cleanup criteria.

Gamma surveys will be relied on to guide soil remediation efforts. At least 12 months prior to commencing reclamation, Powertech (USA) will submit a decommissioning plan to NRC that will contain descriptions of methodology for both pre- and post-reclamation gamma-ray surveys This will include the use of a methodology for gamma-ray surveys for excavation control monitoring and final status surveys that will provide 95% confidence that the survey units will meet the cleanup guidelines.

The post-operation (pre-decommissioning) radiological survey will consist of an integrated area gamma survey and confirmation soil sampling and analysis to verify the areas requiring cleanup. The areas that will receive particular attention are those that are expected to have higher readings than surrounding areas and include diversion ditches, surface impoundment areas, well fields (particularly those areas where spills or leaks may have occurred), process structures, storage areas, and on-site transportation routes for contaminated material and equipment. Areas associated with wastewater disposal also will receive close attention. The surveys will identify soil contamination that exceeds the cleanup criteria and will be used to guide the cleanup efforts. After cleanup, the surveys will be used, in conjunction with surface soil sample analyses, to verify cleanup to the site cleanup criteria. Remediation will continue in areas not meeting action levels. This iterative procedure will be applied until all areas are determined to meet the action levels.

6.3.4.3 Surface Soil Cleanup Verification and Sampling Plans

Powertech (USA) will comply with the NRC license cleanup standards to ensure that public exposure is within permissible limits and that radionuclide levels in soil are ALARA. Compliance with cleanup criteria will be evaluated in terms of soil concentrations, which will be supplemented by field surveys employing gamma-ray measurements. A final gamma survey of the affected area and buffer zone will be performed using the GPS-based equipment or conventional equipment. Affected areas are those areas that have greater potential to be impacted by uranium solutions, dried uranium product (yellowcake) or liquid or solid waste streams that contain uranium or other radionuclides associated with uranium recovery operations. The areas that are most likely to be considered affected areas include diversion ditches, surface impoundment areas, well fields (particularly those areas where potential spills or leaks may have occurred),

process structures, storage areas, on-site transportation routes for contaminated material and equipment, and areas associated with wastewater disposal.

A calculation of the potential peak annual total effective dose equivalent (TEDE) within 1,000 years to the average member of the critical group that would result from applying the radium standard (not including radon) on the site will be submitted to NRC for approval. Details will be provided in the decommissioning plan to be submitted for NRC review at least 12 months prior to decommissioning activities.

6.3.4.4 Quality Assurance

Prior to operations, Powertech (USA) will prepare a Quality Assurance Project Plan (QAPP) in accordance with NRC regulatory requirements. The QAPP will establish the quality assurance and control measures for field measurement, sample collection, and laboratory analysis for all decommissioning activities. The QAPP also will establish performance criteria for field and laboratory data precision, accuracy, completeness, and representativeness. The program will be designed to ensure that the permit area is closed in a manner that permits release for unrestricted (i.e., any) use.

Powertech (USA) management will check all aspects of data collection and input to verify that procedures are being followed. The collection and handling of samples from the facility decommissioning, soil cleanup, and other radiological cleanup areas will be reviewed and approved by management. Laboratory results for these samples will be evaluated and validated to requirements in the QAPP. Other aspects of the reclamation including adherence to the SOPs and adherence to the decommissioning plan will be evaluated periodically by Powertech (USA) management. The construction process will be monitored to confirm that appropriate physical and radiological safety procedures are followed. Excavation processes will be monitored to ensure that contaminated materials are not handled carelessly and that any spillage is collected and contained. The conveyance of contaminated materials through the site, e.g., to stockpiling areas, will be monitored to prevent dispersal of these materials in the environment. Construction and sampling activities will be documented and reviewed throughout the reclamation process.

6.3.5 Health Physics and Radiation Safety during Decommissioning

The health physics and radiation safety program for decommissioning will ensure that occupational radiation exposure levels will be kept ALARA during decommissioning. A radiation safety officer or radiation safety technician will be on site during any decommissioning activities where a potential radiation exposure hazard exists. In general, the radiation safety

program will be used as the basis for development of the decommissioning health physics program. Health physics surveys conducted during decommissioning will be guided by applicable NRC regulations and license conditions.

6.3.6 Records and Reporting Procedures

At the conclusion of site decommissioning and surface reclamation, a report containing all applicable documentation will be submitted to the NRC. Records of all contaminated materials transported to a licensed disposal site will be maintained for 5 years, or as otherwise required by applicable regulations at the time of decommissioning.

6.4 Plans and Schedules for Reclaiming Disturbed Lands

Final reclamation will be initiated during the course of ISR on affected lands that will not be disturbed again and where it will not adversely affect other ISR activities in accordance with ARSD 74:29:08:03. All disturbed lands will be reclaimed to meet the designated postmining land uses. All buildings and structures will be decontaminated to regulatory standards and demolished and trucked to an approved disposal facility. Baseline soils, vegetation, and radiological data will be used as a guide in evaluating the final reclamation. As required by ARSD 74:29:08:01, concurrent reclamation will be conducted during all phases of the operation.

6.4.1 Postmining Land Use Plan

Surrounding existing land uses include rangeland and woodland grazing, residential development, and agriculture. A multiple-use Reclamation Plan was formulated that is in keeping with the land use objective for the adjacent properties and will provide a significant beneficial use of the permit area at closure. The specific types of reclamation proposed are rangeland (ARSD 74:29:07:20) and agricultural or horticultural crops (ARSD 74:29:07:21). In conformance with ARSD 74:29:06:01, these reclamation types were discussed in conference with DENR and the property owners of the affected area in a meeting held on May 10, 2012. Appendix 6.4-A contains the postmining land use consultation forms for all landowners within the permit area. As discussed in Section 3.1.2, there are existing residences within the permit area. Powertech (USA) does not plan to build any homesites within the permit area.

According to ARSD 74:29:06:02 (2), the rangeland and agricultural or horticultural crop land use types must be compatible with surrounding lands and must be: (a) obtainable according to data on expected need and market; (b) supported by commitments from public agencies where appropriate; (c) practicable on the basis of private financial capability for completion of the proposed operation; (d) planned pursuant to a schedule included in the reclamation plan that

integrates the mining operation and reclamation with the postmining land use; (e) consistent with existing state and local land use plans and programs; and (f) of a beneficial use. Following is a description of how the postmining land uses of rangeland and agricultural or horticultural crops meet all of the criteria listed above.

(a) Obtainable According to Data on Expected Market and Need

Appendix 6.4-D describes how for rangeland, two of the criteria to determine revegetation success will be usable forage production and revegetation sustainability. These two parameters will demonstrate that the reclaimed rangeland has at least the same livestock carrying capacity as reference areas. For agricultural or horticultural cropland, the final bond release criterion will be a demonstration that the productive capacity is equal to or exceeds that of similar crop production areas in nearby comparison areas. Powertech (USA) will maintain adequate financial assurance to ensure that areas can be reclaimed to the approved postmining land uses.

(b) Supported by Commitments from Public Agencies where Appropriate

Powertech (USA) is not aware of the need for any commitments from public agencies to support the postmining land uses of rangeland or agricultural or horticultural cropland.

(c) Practicable based on Powertech (USA)'s Financial Ability to Perform Reclamation

As described in Section 6.7.1, Powertech (USA) will maintain financial assurance instruments to cover the cost of all reclamation and decommissioning activities, including reclamation and revegetation of affected areas.

(d) Planned Pursuant to a Schedule that Integrates Mining and Reclamation with Each Postmining Land Use

Sections 6.5 and 6.6 present the schedules for reclamation and reclamation monitoring. Well field reclamation will be carried out concurrently with ISR operations. After uranium recovery is no longer economical in each well field, groundwater restoration will be completed followed by well field reclamation. The minimum period of vegetation establishment for rangeland and agricultural or horticultural cropland prior to evaluation for final financial assurance release will be 3 years.

(e) Consistent with Existing State and Local Land Use Plans and Programs

The postmining land uses of rangeland and agricultural or horticultural cropland are the same as the predominant premining land uses in the proposed permit area. Therefore, they are expected to be consistent with existing state and local land use plans and programs.

(f) Beneficial Use

The postmining land uses of rangeland and agricultural or horticultural cropland are the same as the predominant premining land uses in the proposed permit area. These uses will have economic value to the landowners and thus they meet the definition of "beneficial use" in ARSD 74:29:01:01.

The proposed postmining land uses within the permit boundary are presented on Plate 6.4-1, which also depicts the proposed postmining topography. Due to limited disturbance, the proposed postmining topography is the same as the premining topography and is consistent with the postmining land use.

6.4.1.1 Rangeland

In conformance with ARSD 74:29:06:02(1), rangeland reclamation will follow guidelines established in ARSD 74:29:07:20 including: the reclaimed rangeland will have the capability to support a livestock carrying capacity that is equivalent to that of the surrounding area or to that of the reference area, if used; reclaimed slopes will not exceed 3:1 unless steeper slopes are approved by DENR; newly seeded areas will be fenced if it is necessary to preclude livestock or wildlife from impairing establishment of the required vegetation; and reclamation will be considered complete when the reclaimed range is capable of withstanding proper stocking rates for 2 consecutive years prior to bond release. Powertech (USA) has developed reclamation practices through consultation with the Custer County and Fall River County conservation districts and DENR to ensure that the requirements for reclaiming the land to rangeland are accomplished. Monitoring per the recommendations outlined in Powertech (USA)'s Dewey-Burdock Project Reclamation Performance Criteria document (provided in Appendix 6.4-D) will determine rangeland reclamation success. The monitoring plan has been developed in accordance with ARSD 74:29:06:02(3), which requires support and maintenance activities documenting successful implementation of reclamation.

6.4.1.2 Agricultural or Horticultural Crops

In conformance with ARSD 74:29:06:02(1), agricultural or horticultural crops reclamation will follow guidelines established in ARSD 74:29:07:21. The reclaimed agricultural or horticultural land will have the capability of producing crops consistent with similar crop production areas in the surrounding region, and the reclamation will be considered complete when productive capability is equivalent to or exceeds similar crop production areas in the surrounding region for 2 consecutive crop years. Monitoring will be performed in accordance with ARSD 74:29:06:02(3), which requires support and maintenance activities documenting successful implementation of reclamation.

Alfalfa is the only crop currently proposed for reclamation of designated agricultural or horticultural cropland in the proposed permit area. Alfalfa is the only crop currently grown in the proposed permit area and is grown in several areas nearby, so comparative production figures from nearby areas will be readily available.

All disturbed areas with a delineated postmining land use of agricultural or horticultural crops will have an alternate postmining land use of rangeland. In the event that these agricultural or horticultural croplands are not desired by the landowner to be used as cropland following reclamation, the land will be designated as rangeland and will follow guidelines established in ARSD 74:29:07:20 for rangeland reclamation, as described above.

6.4.2 Interim Revegetation

Interim revegetation is the process of temporarily stabilizing grounds which are scheduled to be re-disturbed before the completion of mining. Portions of the permit area which will receive interim revegetation treatments include topsoil stockpiles, well fields, and pipelines. Because of the limited availability of salvageable topsoil material, some disturbed areas subject to interim reclamation will be directly seeded without the replacement of topsoil material. Straw mulch may be applied at the time of seeding to further improve and accelerate planting success; however, such applications will be site specific. Topsoil stockpiles which are to remain undisturbed for more than 2 years will be regraded to a stable configuration, bermed, and seeded in accordance with ARSD 74:29:08:02. Interim seeding will be done with the same seed mixture as the final seeding mixture shown in Table 6.4-1 to ensure that all interim reclamation is compatible with final reclamation when it occurs. The letter of concurrence with this seed mixture from the local NRCS office is provided in Appendix 6.4-B, and letters of concurrence with this seed mixture from landowners are presented in Appendix 6.4-A.

6.4.3 Surface Disturbance Reclamation

Due to the nature of ISR activities, minimal and intermittent surface disturbance will be associated with the project, and will be mainly associated with the CPP, Satellite Facility, and ancillary facilities such as ponds. Additional intermittent disturbance will occur in the well fields, including well drilling, pipe installations, and road construction.

Surface disturbances associated with the construction of the CPP, Satellite Facility, and ponds will be for the life of those activities. Topsoil will be stripped and stockpiled from these areas prior to construction. Disturbances associated with the well field drilling and pipeline installation are limited and will be reclaimed as soon as possible after these components are completed. The topsoil will be temporarily stripped and stockpiled from well field disturbance areas prior to well field construction. Surface disturbance associated with the development of

Table 6.4-1: Reclamation Seed Mixture

Seed Species	PLS Full Rate (lb/ac)	Percent in Mixture	PLS Rate (lb/ac)
Western wheatgrass	9.72	20	1.94
Sideoats grama	7.26	20	1.45
Slender wheatgrass	7.03	20	1.41
Green needlegrass	7.26	20	1.45
Little bluestem	4.57	20	0.91
Total		100	7.16

Source: NRCS, 2012; see Appendix 6.4-B

Note: This mix was specified by NRCS for a "drill" seeding application. If mix is to be broadcast, a packing/covering operation must be performed after the seeding. Also, seeding rates must be increased by 2.5 times for a broadcast operation.

access roads also will occur; topsoil will be stripped from the road areas and stockpiled prior to construction.

The total anticipated topsoil stripping area over the life of the Dewey-Burdock Project is estimated to be approximately 250 acres in the deep disposal well option and 440 acres in the land application option.

Powertech (USA) will restrict grazing on newly seeded areas if it is necessary to preclude livestock or wildlife from impairing establishment of the required vegetation. Possible means to restrict grazing could include, but are not limited to, fencing and working with landowners to voluntarily withhold grazing from areas containing reclamation.

6.4.3.1 Spoil Replacement and Grading

Following is a description of the general spoil replacement and grading activities followed by specific methods for mud pits, processing areas, land application areas, and access roads.

General Methods

During reclamation, spoil will be replaced from areas previously excavated, including pond and diversion channels. Spoil will be replaced in lifts and compacted as necessary to match premining conditions.

Due to the nature of uranium ISR, there will be very few construction activities that will require significant grading or contouring during reclamation. Finish grading will be achieved with typical earth moving equipment such as motor graders. Disturbed areas will be contoured to blend in with the natural terrain. Reclaimed slopes will not exceed 3:1 unless DENR approves steeper slopes. The postmining contours will be approximately the same as premining contours, as shown on Plate 6.4-1.

The finished, contoured surface will be ripped as needed prior to topsoil replacement to relieve compaction, aid infiltration, promote root penetration, and prevent topsoil slippage and instability.

A sediment control plan will be implemented during all project phases, including final grading, to reduce soil loss within the proposed permit area. The sediment control measures discussed in Section 5.3.9 will be maintained and inspected until contributing areas are reclaimed. Sediment control structures are described in Section 5.3.9.3 and include silt fence, check dams, sediment

traps, and sediment ponds. During final grading, Powertech (USA) will identify potential sources of pollution and determine BMPs to be used, including erosion and sediment controls.

In accordance with ASD 74:29:07:04(4) and (5), all disturbed areas will be graded to eliminate depressions that could accumulate water and to match premining topography, and any altered drainages will be returned to original functionality during the final grading process.

Specific Methods

Following is a description of the spoil replacement and grading methods for well field mud pits, processing facilities, land application areas, and access roads.

Mud Pits

As described in Section 5.3.7, topsoil will be separated from subsoil during excavation of mud pits. When use of each mud pit is complete, the subsoil will be redeposited in the mud pit followed by replacing topsoil. Prior to topsoil replacement, the subsoil will be graded to match premining topography.

CPP and Satellite Facility

During reclamation, the CPP and Satellite Facility process buildings and equipment will be removed as described in Section 6.3.1.3. The processing facility areas will be regraded to approximate premining topography, and topsoil stockpiled near the facilities will be replaced. Section 6.5 describes how facility reclamation, including the CPP and Satellite Facility, will occur following well field reclamation. The expected duration of final grading and reclamation activities at the CPP and Satellite Facility is approximately 2 years, as shown in Figure 5.2-1.

Land Application Areas

The topography in the land application areas will remain unchanged except for minor areas of grading to reduce slopes. Prior to disturbance, topsoil will be stripped from these areas. Topsoil will be temporarily replaced in the areas of minor grading. Topsoil may be spread on the catchment areas and catchment berms, or it may be temporarily stockpiled near the catchment areas for replacement during final reclamation. Following groundwater restoration in all well fields and disposal of all wastewater via deep disposal wells and/or land application, land application areas will be reclaimed. Disturbed areas will be regraded to approximate premining contours, including areas of minor grading to reduce slopes or construct catchment areas and catchment berms. Topsoil will be stripped prior to regrading and replaced after regrading. The

anticipated duration of land application reclamation is 1 year. It will be done during the CPP and main facility decommissioning phase shown on Figure 5.2-1.

Access Roads

Access road reclamation is described in Section 6.4.3.3.

6.4.3.2 Topsoil Replacement

Refer to Section 5.3.7 for a description of topsoil handling during construction. In areas that will be disturbed for prolonged periods during the life of the project (i.e., more than one construction season), topsoil will be salvaged and stored in designated topsoil stockpiles. Topsoil will be removed by scrapers under most circumstances, although other mobile equipment may be used occasionally. The topsoil salvaged for pipeline construction corridors may be bladed to the side to permit pipeline construction and then bladed back after construction is complete. Field salvage operations will be monitored by qualified field personnel. Topsoil stripping depths will vary throughout the permit area, but are expected to average approximately 19.5 inches (refer to Appendix 3.3-A). During reclamation, topsoil temporarily stored in stockpiles will be redistributed over the originally disturbed area. The replacement depth will be calculated based on the stockpile volume and the area to be reclaimed. The amount of topsoil salvaged is estimated to be the same as the amount replaced, such that there is not anticipated to be excess or limited topsoil. Powertech does not anticipate using topsoil substitutes. The topsoil will be graded to blend with the adjacent topography.

In areas of temporary disturbance such as those affected by the installation of monitor wells and pipelines, topsoil will be separated from subsoil during construction and replaced following subsoil replacement. The topsoil will be replaced over the entire disturbed area using a uniform depth based on the amount of topsoil that was salvaged.

In areas of poor baseline vegetative cover, Powertech (USA) may analyze the topsoil to determine whether fertilizer or other amendments will be required to establish and sustain a vegetative cover on reclaimed areas. See also Section 6.4.3.4 for a discussion of areas with low vegetative cover densities that likely will have low revegetation potential if disturbed. These include the Darrow Mine surface pits/spoil piles and the “alkali area.” In only very limited areas, which are anticipated to include the historical mine pits and the alkali area, Powertech (USA) will sample the topsoil and subsoil prior to disturbance. If the evaluation demonstrates that its chemical or physical characteristics would seriously inhibit plant growth and that it is not feasible to remedy by chemical treatment, overburden replacement, or like measures, Powertech

(USA) will request that the revegetation performance criteria not apply for these limited areas as allowed by SDCL 45-6B-46(2).

6.4.3.3 Access Road Reclamation

All roads and portions of roads constructed and utilized for access to the facilities and well fields will be removed and reclaimed unless exempted from reclamation by the request of the landowner/lessee, in which case the landowner/lessee will accept the responsibility for their long-term maintenance and ultimate reclamation. In this case, Powertech (USA) will request in writing to the board that a road or portion of a road remain un-reclaimed in accordance with ARSD 74:29:07:12(10).

Prior to reclamation, any contamination which resulted from the ISR operation will be cleaned to NRC-approved standards and the contaminated material disposed offsite at an appropriately permitted facility.

Access roads will be reclaimed by removing imported road surfacing material and ripping road surfaces and shallow subsoil to loosen the subsoil. Culverts will be removed and premining drainages re-established. Any spoil temporarily stockpiled during access road construction will be replaced. Access road areas will be graded to approximate premining contours. Topsoil will be replaced in a uniform manner and the area revegetated.

Access roads will be reclaimed when they are no longer needed. Well field access roads will be reclaimed during reclamation of each well field unless they are used to access other well fields or monitoring locations. The primary access roads will be reclaimed during the CPP and main facility decommissioning phase shown on Figure 5.2-1. The expected duration of access road reclamation is less than 1 year for each access road, but may occur over several years due to phased well field decommissioning/reclamation.

6.4.3.4 Revegetation Methods and Final Seed Mix

The permanent seed mixture for the rangeland reclamation type is presented in Table 6.4-1. Per DENR regulations, the seed mix has been chosen to be compatible with the postmining rangeland use. The local conservation district, landowners and DENR were consulted when selecting the seed mix (Appendices 6.4-A and 6.4-B). To reduce wind and water erosion, topsoil stockpiles and other various temporary disturbances in the well field area will be seeded. The temporary seed mix is the same as the permanent seed mixture.

Based on existing cropland within the permit area, alfalfa is the only agricultural or horticultural crop currently proposed for reclamation of designated agricultural or horticultural cropland in the permit area.

Seeding may be done with a rangeland drill or with a broadcast seeder where practical. If broadcast, the seeding rate will be increased in accordance with NRCS recommendations. After topsoil preparation is completed affected lands will be seeded during the first normal period of favorable planting conditions unless an alternative plan has been approved. Areas seeded with the rangeland seed mixture will not be treated with any type of soil amendment or irrigated to improve reclamation success unless required to address problems resulting from the land application of treated wastewater (see Section 6.8.4). Any gullies or rills that would preclude the successful establishment of vegetation or achievement of the postmining land use will be removed or stabilized as part of the revegetation and reclamation process. Techniques utilized to monitor reclamation success are discussed in Section 6.6.

Some areas have low baseline vegetative cover densities and likely will have low revegetation potential if disturbed. These include the Darrow Mine surface pits/spoil piles and the "alkali area." The historical mine pits and spoil piles have low revegetation potential primarily due to the physical characteristics of the soil (i.e., lack of organic matter). The alkali area is an area of known discharge from the Fall River and/or Chilson through historical exploration holes. This area may have high levels of salinity and alkalinity that are currently devoid of vegetation and would continue to inhibit vegetation if disturbed. In accordance with SDCL 45-6B-46(2), planting may not be required on affected land with chemical and physical characteristics that are "toxic, deficient in plant nutrients, or composed of sand, gravel, shale, or stone to such an extent to seriously inhibit plant growth and such conditions cannot feasibly be remedied by chemical treatment, fertilization, replacement of overburden, or like measures." In only very limited areas, which are anticipated to include the historical mine pits and the alkali area, Powertech (USA) will sample the topsoil and subsoil prior to disturbance. If the evaluation demonstrates that its chemical or physical characteristics would seriously inhibit plant growth and that it is not feasible to remedy by chemical treatment, overburden replacement, or like measures, Powertech (USA) will request that the revegetation performance criteria in Appendix 6.4-D not apply for these limited areas as allowed by SDCL 45-6B-46(2).

6.4.3.5 Weed Control and Refuse Management

Powertech (USA) will maintain an active weed control program for noxious weeds occurring on the property in accordance with ARSD 74:29:07:15 and SDCL 45-6B-43. Objectives of the program will be:

- Conduct a yearly property inspection.
- Identify locations of weed growth.
- Treat weeds annually through chemical control.

Powertech (USA) has consulted with the local weed and pest boards in preparation of the weed control program for the Dewey-Burdock Project. The weed control plan is provided in appendix 6.4-C along with consultation letters.

Along with the weed control program, Powertech (USA) will manage refuse according to state and federal requirements in accordance with ARSD 74:29:07:05. Powertech (USA) is not proposing to use any of the land in the permit area for deposit or disposal of refuse.

6.4.3.6 Erosion Control Practices

Erosion control measures will be implemented during all phases of construction, operation, reclamation, and closure. Refer to Section 5.3.9 for details on erosion control measures. Temporary sedimentation, erosion control, and drainage control structures will be removed when

no longer needed. Sediment and erosion control structures will be inspected on a quarterly basis to ensure compliance with all applicable reclamation, design, and operating criteria. Maintenance and repair work needed to keep the structures in proper operating order will be performed as necessary. This work will include the removal and proper disposal of sediment captured by the structures and repair or replacement of old ASCM structures. If during the term of the postclosure period erosion and sedimentation becomes a problem in any area, new structures will be installed to adequately address any problems. Conversely, if the need for sediment and erosion controls in an area becomes unnecessary, the synthetics will be removed for aesthetic purposes.

6.4.4 Revegetation of Land Application Areas

The revegetation techniques for land application areas will depend on the vegetation grown in the land application areas. If native vegetation is irrigated and the species composition of the native vegetation does not change significantly during irrigation, then reseeding is not anticipated to be necessary to meet the reclamation performance criteria. However, if the species composition of the native vegetation significantly changes during the course of land application, Powertech (USA) will develop a plan that either demonstrates that after termination of land application a permanent, self-perpetuating ground cover at least equal in character and extent to the original will remain or detail a revegetation program that has been approved by SDGF&P and the local conservation district.

If crops such as alfalfa or wheatgrass are planted in the land application areas, Powertech (USA) will revegetate the land application areas during reclamation by preparing the topsoil and using the seeding mixture and methods described in Section 6.4.3.4.

6.5 Reclamation Timetable

Reclamation will be carried out in an ongoing process concurrent with ISR operations in accordance with NRC license conditions and ARSD 74:29:08. It is anticipated that groundwater restoration, including stability monitoring, will be completed for each well field in less than 2 years. Decontamination, decommissioning, and surface reclamation will follow after regulatory approval of successful groundwater restoration. The reclamation for each well field will be carried out with all reasonable diligence. Each phase of reclamation, including each well field and final facility reclamation, is expected to be completed within 5 years in accordance with SDCL 45-6B-46. Figure 6.5-1 depicts the proposed project schedule including phased

decommissioning/reclamation for each well field. Facility reclamation (CPP, Satellite Facility, and ponds) will occur following well field reclamation.

6.6 Reclamation Monitoring

Powertech (USA) will monitor revegetation success for compliance with ARSD 74:29:07:06. The goal of the reclamation program is to stabilizes the soil and return the disturbed areas to a function similar to undisturbed areas. Primary revegetation success will be determined using performance standards for current carrying capacity and vegetative ground cover. The Dewey-Burdock Project Reclamation Performance Criteria document is included as Appendix 6.4-D. The minimum period of vegetation establishment for rangeland and agriculture land prior to evaluation for final financial assurance release will be 3 years. The success of the final revegetation and final financial assurance release will be determined by DENR.

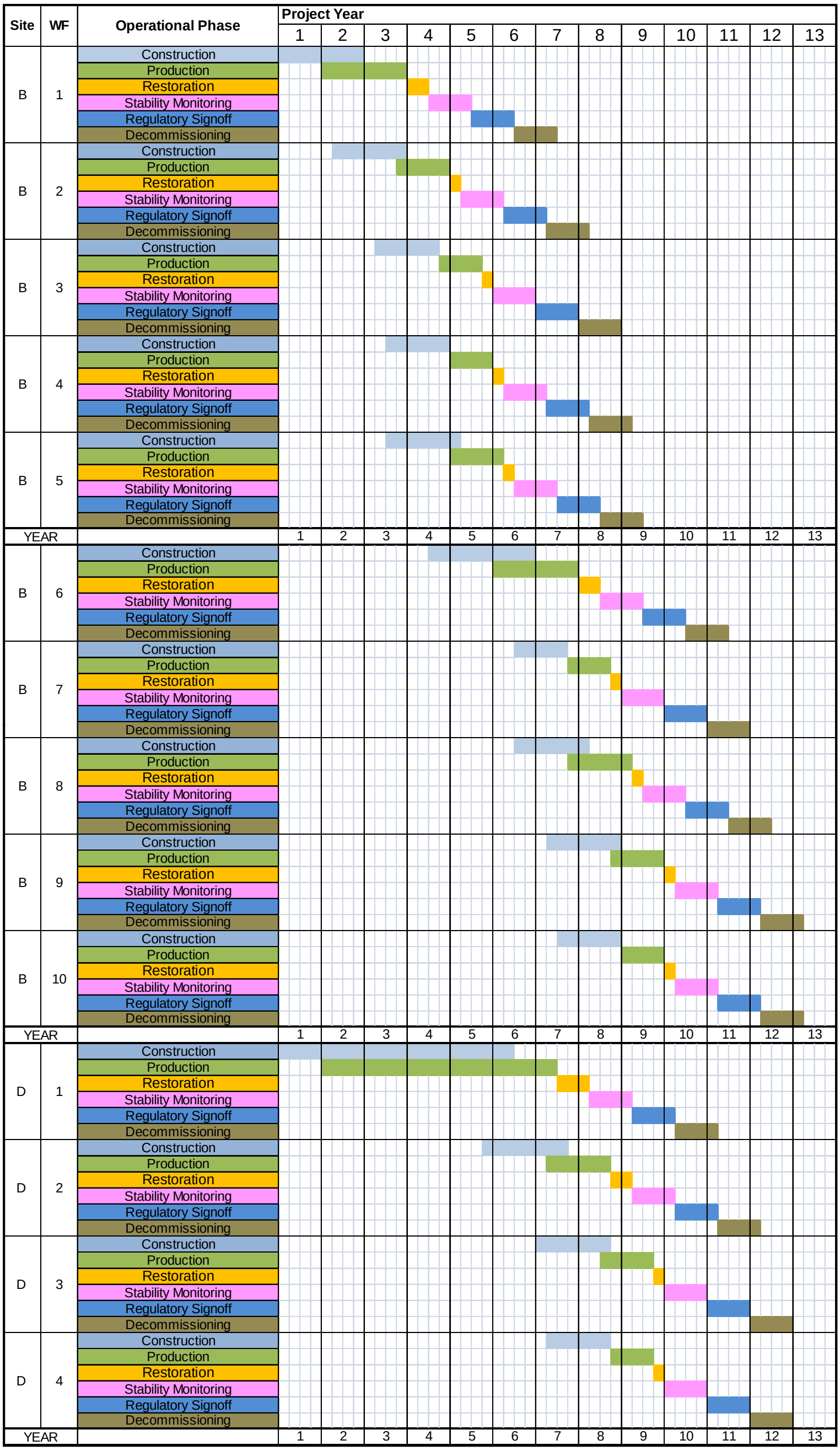


Figure 6.5-1

Proposed Project Operations and Restoration Schedule

Dewey-Burdock Project

SIGNATURE OF PREPARER	John Mays
PREPARER	John Mays
DATE	14-Sep-2012
FILE	OpRestSched.mxd

POWERTECH (USA) INC.

This figure is provided to fulfill the requirements of ARSD 74:29:02:05 and SDCL 45-6B-6(10).

6.7 Financial Assurance

6.7.1 Financial Assurance Estimate

In compliance NRC license conditions and with ARSD 74:29:02:08, Powertech (USA) will maintain financial assurance instruments to cover the cost of reclamation including the costs of groundwater restoration; well plugging and abandonment; decommissioning, dismantling and disposal of all buildings and other facilities; reclamation and revegetation of affected areas; and postclosure monitoring.

Powertech (USA) commits to supplying a financial assurance mechanism in a form and in an amount approved by NRC, DENR, EPA and BLM prior to the commencement of operations.

A financial assurance estimate is provided in Appendix 6.7-A. This appendix provides a summary of costs by year for the deep disposal well option and the land application option, respectively. The financial assurance model is based on the Dewey-Burdock Project being in operation for one full year prior to a third party taking over reclamation of the facility. Reclamation would include facility decommissioning, groundwater restoration, stability monitoring, well field reclamation, soil reclamation, and radiological surveys. The by-year costs are based on year 1 being the pre-operational construction phase, year 2 the full year of ISR operations, and year 3 the beginning of the financial assurance-funded reclamation activities. Groundwater restoration and stability monitoring would be conducted in years 3-4. Final decommissioning, including building demolition and soil reclamation, would be conducted during years 5-6.

The financial assurance estimate in Appendix 6.7-A assumes that the Dewey and Burdock portions of the permit area would be developed simultaneously. This would begin with construction of the CPP, Satellite Facility, and initial well field in each area. Subsequent well fields would be developed sequentially in both of the Dewey and Burdock portions of the permit area. As an alternative to this development scenario, Powertech (USA) is considering developing the Satellite Facility and Dewey-area well fields initially, followed by the CPP and Burdock-area well fields. If Powertech (USA) chooses to pursue this alternate development scenario, a revised financial assurance estimate will be provided, likely prior to LSM permit issuance.

The financial assurance cost estimate reflects costs as of 2009. The cost factors found in Appendix 6.7-A, Table 2 and elsewhere were obtained from vendor quotes, from the 2009 RS Means cost estimating handbooks, from recent ISR license applications, and from calculations as

described. All electrical power costs are conservatively based on a per kWh hour cost of $0.07; the results of a power study (Lyntek, 2010) showed estimated 2013 power costs of $0.0595 to $0.0691 per kWh, depending on the supplier. The costs of 11e.(2) byproduct material disposal, as listed in Appendix 6.7-A are based on the assumption that Powertech (USA) will secure a byproduct disposal contract with Denison Mines Corporation for disposal at their byproduct disposal facility at White Mesa, UT. The cost estimate is based on a transportation distance of 785 miles from the permit area to the White Mesa facility near Blanding, UT. Transportation costs to alternate 11e.(2) byproduct material disposal facilities will be similar or less. For example, the Pathfinder Mines Corporation Shirley Basin Facility is approximately 250 miles away, the Energy Solutions LLC Clive Disposal Site near Clive, UT is approximately 700 miles away, and the Waste Control Specialists LLC facility near Andrews, TX is approximately 900 miles away.

While it is likely that the facility buildings will have a salvage value, the demolition cost estimate assumes that all buildings will be shredded and disposed at an appropriate landfill. Decommissioning costs include a final gamma survey.

Labor costs associated with the reclamation operations will be a combination of contract labor and direct hires, listed in Appendix 6.7-A. A full-time Radiation Safety Officer will be employed through final decommissioning.

Powertech (USA) will revise these financial assurance cost estimates after NRC license and LSM permit issuance based on NRC, DENR, EPA and BLM approval of the methodologies for cost estimate calculations. In the event that additional factors are utilized for adding or subtracting from approved cost estimates, Powertech (USA) will provide a written explanation of such factors when submitting revised cost estimates after license and permit issuance.

Powertech (USA) commits to providing annual financial assurance updates to DENR as described in Section 5.7.2.6.

6.8 Postclosure Monitoring Plan

When ISR operations are completed and reclamation is in the final stages of vegetation establishment, Powertech (USA) will inspect and maintain activities to ensure compliance and reduction of potential environmental impacts in accordance with SDCL 45-6B-91. It is not anticipated that any new environmental impacts will be identified after this stage of the project.

Following is a description of the proposed postclosure monitoring plan for various environmental media.

6.8.1 Water Quality Monitoring

Postclosure surface water monitoring will be conducted to ensure that there will not be future impacts to surface water resources, including Beaver Creek, Pass Creek, potentially affected tributaries, and impoundments. Monitoring will be performed annually at the operational surface water monitoring sites described in Tables 5.5-2 and 5.5-3. The samples will be analyzed for the parameters listed in Table 5.5-4.

If land application is used, postclosure alluvial groundwater monitoring will be conducted for each perimeter of operational pollution (POP) zone as described in the GDP. Postclosure monitoring of bedrock groundwater resources is not proposed due to the following reasons:

1) An extensive operational monitoring program will be performed, including monitoring overlying and underlying hydrogeologic units and monitoring the perimeter of the production zone. This will ensure that any potential horizontal or vertical excursions are rapidly detected and corrected.

2) Ore zone groundwater quality will be restored in accordance with NRC license conditions. Prior to NRC approval of successful groundwater restoration, Powertech (USA) will demonstrate that the target restoration goals or ACLs have been achieved and that groundwater restoration has been conducted in a manner that will protect human health and the environment. This will be demonstrated through a minimum 12-month stability monitoring period following groundwater restoration activities.

3) Protection of USDWs outside of the aquifer exemption boundaries will be assured by EPA, which has the authority and responsibility to do so through administration of the Class III and V UIC permits.

4) NRC will release the site for unrestricted (i.e., DENR-approved postmining) use only after NRC approval of successful groundwater restoration, well field decommissioning, and site decommissioning. The timely return of the surface to the landowners will be the primary focus of the reclamation and decommissioning activities.

6.8.2 Air Quality Monitoring

No postclosure air quality monitoring is proposed for the Dewey-Burdock Project on the basis that no potential air quality impacts will remain following DENR approval of successful reclamation.

6.8.3 Vegetation Monitoring

Reclaimed land will be inspected on an annual basis, coinciding with the growing season, to ensure compliance with the final Reclamation Plan and postmining land use. If the vegetation is not achieving the goals of the final Reclamation Plan and postmining land use, steps will be taken to correct or mitigate the situation. If a change in the seed mixture is necessary to ensure vegetative success, these changes will be submitted to DENR for approval.

Monitoring methods used to document reclamation success are included in Powertech (USA)'s Dewey-Burdock Project Reclamation Performance Criteria (Appendix 6.4-D).

6.8.4 Land Application Monitoring

As discussed in Section 5.4.1.1.2, Powertech (USA) may use land application as a method of disposing treated wastewater. If land application is used, there could be potential impacts to the soil and vegetation from the buildup of salts, changes in SAR, buildup of radionuclides, buildup of metals and metalloids, and decrease in soil fertility.

In conformance with ARSD 74:29:05:19, Powertech (USA) has formulated a monitoring and mitigation plan to detect potential soil and vegetation impacts related to land application of treated wastewater. The specific monitoring and mitigation measures are addressed in Sections 5.5.6.1 and 5.5.7.1 and GDP Sections 6.4 and 6.5. Revegetation of land application areas is addressed in Section 6.4.4.

6.8.5 Sediment and Erosion Control Structures

Sediment and erosion control structures will be inspected on a quarterly basis to ensure compliance with all applicable reclamation, design, and operating criteria. Maintenance and repair work needed to keep the structures in proper operating order will be performed as necessary. This work will include the removal and proper disposal of sediment captured by the structures and repair or replacement of ASCMs as needed. If during the term of the postclosure period erosion and sedimentation becomes a problem in any area, new structures will be installed to adequately address any problems. Conversely, if the need for sediment and erosion controls in an area becomes unnecessary, the synthetics will be removed for aesthetic purposes.

6.8.6 Postclosure Financial Assurance

Prior to release of the reclamation financial assurance instrument by DENR, a portion of the reclamation financial assurance will be dedicated to the postclosure bond. A detailed financial

assurance estimate for postclosure activities will be submitted to DENR for approval prior to the beginning of the postclosure monitoring period.

6.8.7 Postclosure Monitoring Duration

Powertech (USA) will conduct postclosure monitoring for 30 years following operations, or until release of this requirement has been granted by DENR.

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