APP-015-B

POWERTECH (USA) INC.

Dewey-Burdock Project
Application for NRC
Uranium Recovery License
Fall River and Custer Counties,
South Dakota
Technical Report

February 2009
Revised December 2013

Prepared for

U.S. Nuclear Regulatory Commission
11545 Rockville Pike
Rockville, MD 20852

Prepared by

Powertech (USA) Inc.
5575 DTC Parkway, Suite 140
Greenwood Village, Colorado 80111
Phone: 303-790-7528
Fax: 303-790-3885

Dewey-Burdock Project
Application for NRC
Uranium Recovery License
Fall River and Custer Counties
South Dakota
Technical Report

Table of Contents

List of Tables

List of Figures

List of Plates

Plate ***Title***

List of Appendices

Section 2.0

Section 3.0

Section 5.0

Section 6.0

Section 7.0

List of Acronyms and Abbreviations

AADT	annual average daily traffic
ACS	American Community Survey
AEA	Atomic Energy Act
AEB	aquifer exemption boundary
AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
ALI	annual limits of intake
AMS	air monitoring station
amsl	above mean sea level
AOR	area of review
ARR	rate of resuspension of radionuclides in surface soil
ARSD	Administrative Rules of South Dakota
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
Augustana	Archaeology Laboratory, Augustana College
AWDN	Automatic Weather Data Network
BEA	Bureau of Economic Analysis
bgs	below ground surface
BKS	BKS Environmental Associates, Inc.
BLM	U.S. Bureau of Land Management
BMP	best management practices
BNSF	Burlington Northern Santa Fe
B.P.	before present
C	Celsius
CBA	Cost Benefit Analysis
CESQG	Conditionally Exempt Small Quantity Generator
CEDE	committed effective dose equivalent
CFR	Code of Federal Regulations
cm/sec	centimeters per second
COO	Chief Operating Officer
CPP	Central Processing Plant
DDE	deep-dose equivalent
DDW	Deep Disposal Well
DENR	Department of Environment and Natural Resources
DES	Draft Environmental Statement
DQO	Data Quality Objectives
DR	Damage Ratio
EC	Electrical Conductivity
EDE	effective dose equivalent
EFN	Energy Fuels Nuclear
EPA	U.S. Environmental Protection Agency
ER	Environmental Report
ERG	Environmental Restoration Group
ESP	Exchangeable Sodium Percentage

ET	evapotranspiration
EXREFA	Extended Reference Area
F	Fahrenheit
FAC	facultative
FACU	facultative upland
ft	foot/feet
ft^2/day	square feet per day
GDP	gross domestic product
gpm	gallons per minute
GPS	global positioning system
ha	hectares
HPRCC	High Plains Regional Climate Center
HEPA	high efficiency particulate air
HS&E	health, safety and environmental
HV	high volume air sampling site used synonymously with AMS
HVAC	heating, ventilating, and air conditioning
ICRP	International Commission on Radiological Protection
IDLH	immediately dangerous to life and health
IMPLAN	IMpact analysis for PLANning
IQR	interquartile range
ISL	in situ leach (In this document ISL is synonymous with ISR)
ISR	in situ recovery
IX	ion exchange
kg	kilogram
km	kilometer
km^2	square kilometer
lbs	pounds
L	liter
LAN	land application area north (Dewey)
LAS	land application south (Burdock)
LLD	lower limit of detection
LDE	lens dose equivalent
LPF	Leak Path Factor
LSA	Low Specific Activity
m	meter
m^2	square meter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
meq	milliequivalents
mi	mile(s)
MCL	maximum contaminate level
MDA	minimum detectable activity
MDL	minimum detection limits
mg	milligram
MIG	Minnesota IMPLAN Group, Inc.
MIT	mechanical integrity test
Mph	miles per hour

mrem	millirem
MW	monitoring well
NAAQS	National Ambient Air Quality Standards
NAU	National American University
NCDC	National Climatic Data Center
NEPA	National Environmental Policy Act
NFF	National Flood Frequency
NFS	National Forest Service
NIST	National Institute of Standards and Technology
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service
NVLAP	National Voluntary Laboratory Accreditation Program
NWP	Nation Wide Permit
NWS	National Weather Service
OW	open water
OWUS	other waters of the United States
PAA	Proposed Action Area
PABJh	Palustrine Aquatic Bed Intermittently Flooded Diked
PCN	Pre-construction Notification
PEM	Palustrine Emergent
PGA	peak ground acceleration
PIC	Pressurized Ion Chamber
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
Powertech (USA)	Powertech (USA) Inc.
PPE	Personal Protective Equipment
PQL	Practical Quantitation Limit
psi	pounds per square inch
psig	pounds per square inch gauge
PUB	Palustrine Unconsolidated Bottom
PUSA	Palustrine Unconsolidated Shore Temporarily Flooded
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
R2EM	Riverine Lower Perennial Emergent
R4SB7	Riverine Intermittent Steambed vegetated
RCRA	Resource Conservation and Recovery Act
RESRAD	RESidual RADioactive
RMP	risk management program
RO	reverse osmosis
RPD	relative percent difference
RSC	residual sodium carbonate
RSO	Radiation Safety Officer
RST	Radiation Safety Technician
RTV	Restoration Target Value

RWP	Radiological Work Permit
SA	specific activity
SAR	Sodium Adsorption Ratio
SCFM	standard cubic feet per minute
SD	South Dakota
SD DENR	South Dakota Department of Environment and Natural Resources
SD DOL	South Dakota Department of Labor
SD DOT	South Dakota Department of Transportation
SD DRR	South Dakota Department of Revenue and Registration
SD GFP	South Dakota Department of Game, Fish and Parks
SD GOED	South Dakota Governor's Office of Economic Development
SD NHP	South Dakota National Heritage Program
SD SMT	South Dakota School of Mines and Technology
SD SU	South Dakota State University
SDWA	Safe Drinking Water Act
SERP	Safety and Environmental Review Panel
SF	satellite facility
SIC	Standard Industrial Classification
SKM	Silver King Mines
SMA	surface mine area
SMCL	Secondary drinking water standards
SOP	Standard Operating Procedure
SPAW	Soil-Plant-Atmosphere-Water
SQRU	scenic quality rating units
SSL	soil screening level
SWI	Susquehanna Western Inc.
TDS	total dissolved solids
TEDE	total effective dose equivalent
TENORM	Technologically enhanced naturally occurring radioactive material
TLDs	thermo luminescent dosimeters
TPQ	threshold planning quantities
TR	Technical Report
TRG	target restoration goal
TSS	total suspended solids
TSX	Toronto Stock Exchange
TVA	Tennessee Valley Authority
U-nat	natural uranium
UCL	upper control limits
UIC	underground injection control
umhos/cm	micromhos per centimetre
UPL	upland
USACE	U.S. Army Corps of Engineers
USCB	United States Census Bureau
USDA	United States Department of Agriculture
USDOI	United States Department of the Interior
USDW	underground source of drinking water

USFWS	United States Fish and Wildlife Services
USFS	United States Forest Services
VRM	Visual Resource Management
WDEQ	Wyoming Department of Environmental Quality
WDTI	Western Dakota Technical Institute
WIA	walk-in hunting area
WL	working level
WLM	working level months
WoUS	Waters of the United States
yr	year

Dewey-Burdock Project
Application for NRC
Uranium Recovery License
Fall River and Custer Counties
South Dakota
Technical Report

1.0 Proposed Activities

1.1 Licensing Action Requested

Powertech (USA) Inc. (Powertech (USA)) submits this Technical Report (TR) to the United States Nuclear Regulatory Commission (NRC) as part of a Uranium Recovery License (i.e., combined source material/11e.(2) byproduct material license) application to construct and operate the proposed Dewey-Burdock Project (hereinafter the “Proposed Action”) using in situ leach (ISL) methods. The Proposed Action Area (PAA) will be located near Edgemont, South Dakota in Custer and Fall River Counties and will consist of a series of sequentially developed well fields, a satellite ion exchange (IX) facility (SF) at the Dewey portion and the central processing plant and associated process facilities (hereinafter the “CPP”) to recover and process the final uranium product.

This TR has been prepared in accordance with:

<u>Regulatory Programs</u>

- 10 CFR Part 40 Appendix A as relevant and appropriate
- 29 CFR Part 1926.55 Gases, vapors, fumes, dusts, and mists
- 29 CFR Part 1910.119 and 1910.120 Hazardous Waste Operations and Emergency Response
- 40 CFR Part 68, 302.4, and 355 Emergency Planning and Community Right to Know Act
- 40 CFR Part 144 Underground Injection Control Program
- 40 CFR Part 146 Underground Injection Control Program Criteria and Standards
- 43 CFR §3809.401 BLM Plan of Operations

- Department of Transportation "Radioactive Materials Shipping Regulations," CFR Titles 49 and 10

- South Dakota Codified Laws Rule 45:6B and Administrative Rule 74:29

Nuclear Regulatory Commission Documents

- NRC Regulatory Guide 3.46 "Standard Format and Content of License Applications, Including Environmental Reports, for In Situ Uranium Solution Mining" (NRC, 1982).

- NUREG-1569 "Standard Review Plan for In Situ Leach Uranium Extraction License Application" (NRC, 2003).

- NUREG-1748 "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs" (NRC, 2003).

- NUREG-1910 "Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities (Draft Report)" (NRC, 2008).

- NUREG-1757, Vol. 3 "Consolidated NMSS Decommissioning Guidance-Financial Assurance, Recordkeeping, and Timeliness (Final Report)" (NRC, 2003).

- NUREG-1623 "Design of Erosion Protection for Long-Term Stabilization" (NRC, 2002).

- NUREG/CR 6733 "A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licensees" (NRC, 2001).

- NUREG/CR-6870 "Consideration of Geochemical Issues in Groundwater Restoration at Uranium In-Situ Leach Mining Facilities" (NRC, 2007).

- NRC Regulatory Guide 8.30 "Health Physics Surveys in Uranium Recovery Facility," Revision 1 (NRC, 2002).

- NRC Regulatory Guide 4.14 "Radiological Effluent and Environmental Monitoring at Uranium Mills," Revision 1 (NRC, 1980).

1.2 Project History

Uranium was first discovered in the Edgemont District in 1952 by professors from the SDSMT. They mined about 500 pounds of ore and hauled it to Grand Junction, Colorado. The Atomic Energy Commission (AEC) announcement of a new district at Edgemont led to a boom of staking, mining, and dealing in the summer of 1952. By 1953 the AEC had built a buying station in Edgemont. In July 1956 a 250-ton per-day mill went on stream and soon expanded to a 500-ton-per-day. In 1960 a vanadium circuit was added. Production from the Edgemont District (open pits and shallow underground operations in the Fall River), some mines in the Powder River basin and several mines in the Northern Black Hills continued until 1972. Susquehanna Western Inc. (SWI) bought the Edgemont mill and took control of the mines in the Edgemont District. Until the late 1960's early 1970's they were the only company active in the Edgemont District.

In 1967, Homestake Mining Company began exploration in the Dewey area. In 1974, Wyoming Mineral Corporation (Westinghouse) acquired the Dewey properties from Homestake. In 1974, TVA bought out the mill and mines from SWI. The mill was shut down, but exploration continued. Besides WMC and TVA, other companies exploring in the district were Union Carbide, Federal Resources, and Kerr McGee. TVA acquired the Dewey Project from WMC in 1978 and continued exploration until 1986. In total, over 4000 exploration drill holes were completed on this project.

In 1981 TVA completed a mine feasibility study on the project deposits. A DES was prepared by TVA to address the potential impacts of a proposed underground mine in the PAA, but the NEPA process was never completed by TVA. Due to falling uranium prices the project leases were allowed to expire. In 1994 EFN acquired the mineral interests within the PAA. Their intention was to mine the uranium deposits by ISL. EFN did no additional exploration drilling on the project. In 2000 the leases were dropped.

In 2005, Powertech (USA) acquired the leases for the property, consisting of approximately 10,580 acres. Since the spring of 2007, Powertech has drilled approximately 115 exploration holes, including 20 monitoring wells on the project. Both the historic and recent drill holes have helped to generate the geologic model and delineate the extent of the mineralized sands. Refer to Figure 2.6-3 for a map showing the location of all known drill holes and Appendix 2.6-A which includes a table summarizing all historical exploration drilling.

1.3 Corporate Entities

This TR is submitted by Powertech (USA), which is the United States based wholly owned subsidiary of the Powertech Uranium Corp., a Corporation registered in British Columbia. Powertech Uranium Corp. shares are publicly traded on the Toronto Stock Exchange (TSX) as PWE and the Frankfurt Stock Exchange as P8A. Powertech Uranium Corp. owns 100 percent of the shares of Powertech (USA). The corporate office of Powertech Uranium Corp. is located in Vancouver, British Columbia. Powertech (USA) is a United States based Corporation registered in the State of South Dakota.

Currently, 10 CFR Part 40 regulations and Appendix A criteria do not prohibit the issuance of a uranium recovery license to a United States based corporation that is a wholly owned subsidiary of a foreign entity (10 CFR § 40.38). For purposes of the Proposed Action, Powertech (USA) and not Powertech Uranium Corp. intends to serve as the licensee for the Proposed Action. Powertech (USA) owns and will operate all of the company's uranium properties in the United States, including the Proposed Action. Powertech (USA)'s headquarters office is located in Greenwood Village, Colorado, and other offices are located in Albuquerque, New Mexico and Edgemont, South Dakota.

1.4 Site Location and Description

The PAA is located approximately 13 miles north-northwest of Edgemont, South Dakota and straddles the area between northern Fall River and southern Custer County line. The PAA boundary encompasses approximately 10,580 acres (4,282 ha) of mostly private land on either side of S. Dewey Road (County Road 6463) and includes portions of Sections 1-5, 10-12, 14 and 15, Township 7 South, Range 1 East and Sections 20, 21, 27, 28, 29 and 30-35, Township 6 South, Range 1 East, Black Hills Meridian. Approximately 240 acres (97.1 ha) are under the control of the Bureau of Land Management (BLM) located in portions of Sections 3, 10, 11, and 12.

As proposed, PAA facilities will include well fields, one satellite IX process plant located within the Dewey area and one IX process plant built along with the central IX resin processing plant, which will be located at the proposed CPP and will be used to recover the final uranium product (yellowcake). Figure 1.4-1 shows the project location and license boundary.

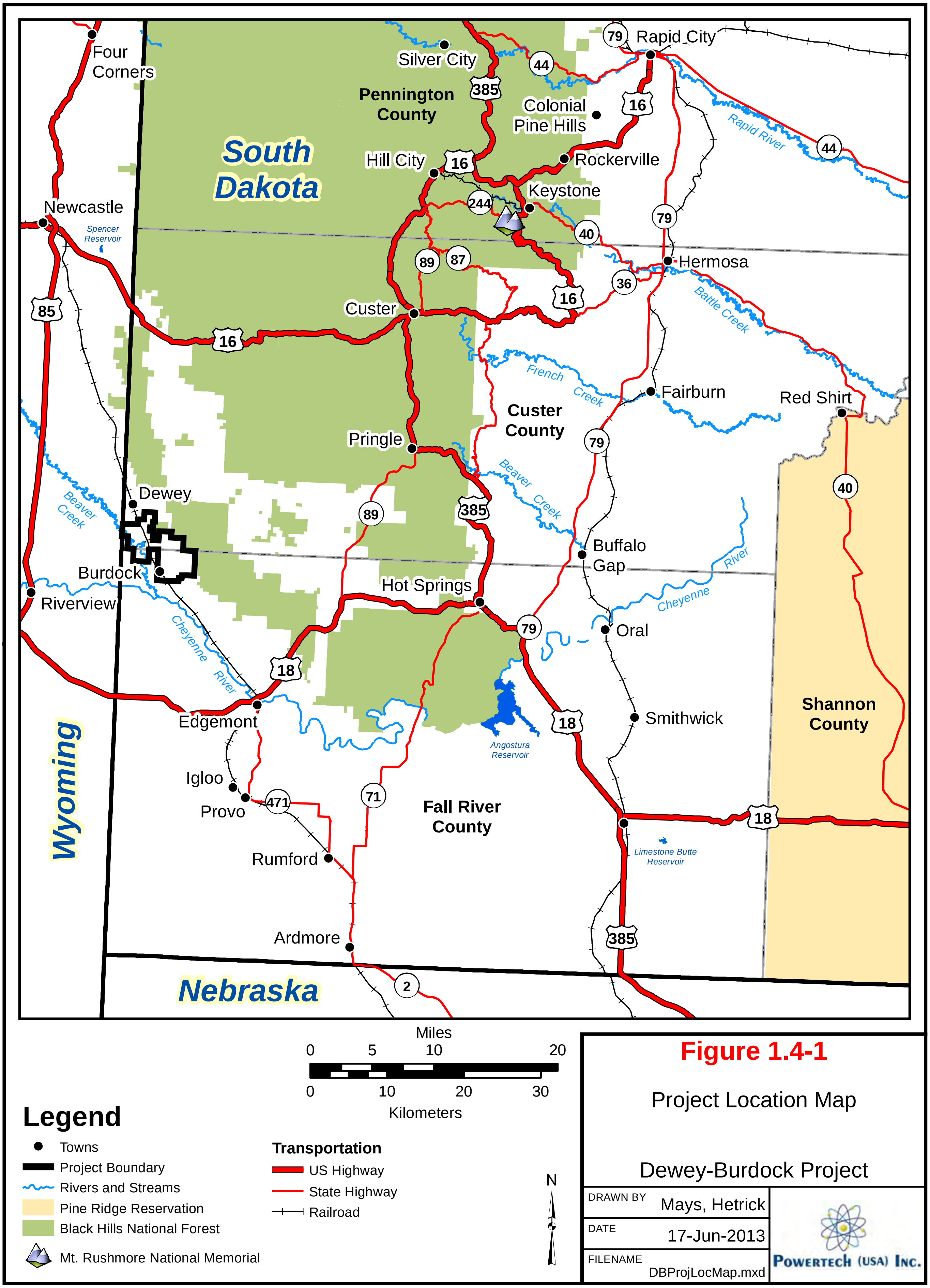


Figure 1.4-1

Project Location Map

1.5 Land Ownership

Plate 1.5-1 provides the breakdown of the mineral ownership and Plate 1.5-2 provides the breakdown of the surface use agreements of the proposed project.

1.6 Orebody Description

The Proposed Action uranium deposit occurs in the Inyan Kara Group of the lower Cretaceous age. Specifically, the targeted uranium occurs in both the Fall River Formation and the Chilson Member of the Lakota Formation. The Fall River and Chilson consist of permeable sandstones deposited in a major sand channel system that makes up a groundwater aquifer. The identified uranium orebody occurs in sandstones as classic roll front deposits with both oxidized and reduced zones located at both the Dewey and Burdock areas. These roll front deposits are usually “C” shaped in cross section, a few tens of feet wide and often thousands of feet long. Uranium minerals are deposited at the interface of the oxidized ground and reduced ground. As the uranium minerals precipitate, they coat the sand grains, and continual addition of uranium by oxidizing groundwater and re-solublization followed by re-deposition at the interface has increased the uranium concentration of the identified orebody. Thickness of the orebody is generally a factor of the thickness of the sandstone host unit. Uranium mineralization has occurred in more than one horizon within the Inyan Kara Group resulting in multiple roll fronts. The estimated mineable resource (compliant with Form 43-101) within the project boundary is 7.6 million pounds of U_3O_8 with an average grade of 0.21 percent.

1.7 ISL Method and Leaching Process

The ISL process involves the oxidation and solublization of uranium from its reduced state using leaching fluid (lixiviant). The leach fluid consists of ground water with an oxidant, such as gaseous oxygen, added to oxidize the uranium to a soluble valence and gaseous carbon dioxide to complex and solubilize the uranium ion causing it to go into solution in the leach fluid flowing through the ore zone. At the PAA, Powertech (USA) will add gaseous oxygen and gaseous carbon dioxide to the recirculated native ground water from the ore zone aquifer. Once solubilized, the uranium bearing ground water will be pumped by submersible pumps via well field production wells to the surface where it is bonded by IX forces onto IX resins. After the uranium is removed, the groundwater will be recirculated and reinjected via well field injection wells. When the IX resin is loaded with uranium, the loaded resin is moved to an IX elution (stripping) column where the uranium is eluted (stripped) off the resin by a salt water solution. The resulting barren (stripped) resin is then recycled to recover more uranium. The salt water eluate solution is pumped to a precipitation process where the uranium is precipitated as a yellow

solid uranium oxide. The precipitated uranium oxide is then filtered, washed, dried and packaged in sealed containers for shipment for further processing.

Typically, an ISL well field consists of a set of contiguous geometric shaped patterns of injection and production wells. Powertech (USA) generally will utilize square or rectangular patterns, and sometimes hexagons or triangles to cover the economically recoverable portions of the uranium orebody. This provides for uniform distribution of leach fluid (lixiviant) to efficiently contact the economically recoverable portions of the uranium orebody. The injection wells will be located at the corners of the geometric patterns and the production wells will be in the center of the geometric patterns. Powertech (USA) will withdraw 0.5 to 3 percent more ground water than is reinjected to maintain a flow of outside baseline quality ground water into the well field and to prevent the flow of leach fluid to the monitor well ring surrounding the orebody. The excess produced water (bleed) creates and maintains a cone of depression in the pressure surface of the aquifer so that the native ground water is continually flowing to the center of the production zone. This bleed also helps Powertech (USA) control and limit the increase in the sulfate and chloride concentration in the leach fluid. A bleed of 0.5 to 3 percent is removed from the lixiviant stream to create the hydraulic gradient that serves to contain lixiviant within the ore zone. Over-pumping the production wells maintains the cone of depression in the well fields, preventing the loss of the lixiviant outside of the intended production area and protecting ground water outside of the monitor well ring.

The lixiviant is prepared using native groundwater fortified with oxygen, and carbon dioxide. The lixiviant is pumped into the injection wells, flows between the injection and production wells through the mineralized zone by the imposed hydraulic gradient, and extracted by production wells. Production flow rates are estimated at 20-30 gallons per minute (gpm) per well.

At the surface, the pregnant lixiviant flows through IX columns, where the uranium is transferred to resin. The resin will be trucked or piped to the CPP for further refinement into final uranium product (yellowcake).

The barren lixiviant is re-fortified with oxygen and carbon dioxide and re-circulated through the orebody to leach uranium. A detailed description of the proposed ISL process can be found in Section 3.

1.8 Operating Plans, Design Throughput, and Production

The Proposed Action will utilize uranium ISL production facilities at both the Dewey and Burdock sites with a CPP located at the Burdock site. The lixiviant flow rate will be limited to 4,000 gpm on an annual average basis, excluding restoration flow. Yellowcake production will be limited to 1,000,000 pounds of U_3O_8 per year.

1.9 Project Schedule

Following the issuance of an NRC source and byproduct materials license and other relevant permits it is anticipated that construction of the Burdock Well Field 1, CPP and ancillary facilities including storage ponds and deep disposal wells and/or land application pivots will commence. The construction of the Dewey Well Field 1 and ancillary facilities will follow shortly thereafter. Alternatively, Powertech (USA) may develop either the Burdock or Dewey well fields first, followed by the well fields in the other area. Startup of the Dewey and Burdock operations will commence upon completion of construction and will continue for approximately 7 to 20 years or more during which additional well fields will be completed along the roll fronts at both Dewey and Burdock sites. It is planned that groundwater restoration can be accomplished within NRC requirements for timeliness in decommissioning (10 CFR § 40.42); however, in the event restoration cannot be accomplished within this timeframe, Powertech (USA) will seek NRC approval for an alternate schedule. The projected construction, operation, restoration and decommissioning schedule is provided in Figure 1.9-1.

Decommissioning of the well fields including well abandonment, the removal of piping, tanks, ancillary buildings and equipment, cleanup of surface soil to applicable standards and revegetation of disturbed areas will be implemented following the cessation of ISL operations at the Dewey and Burdock sites. It is likely that the CPP at the Burdock site will continue to operate for several years following the decommissioning of the Proposed Action well fields. The CPP may continue to process uranium-loaded resin from other ISL projects such as the nearby Powertech (USA) satellite ISL projects of Aladdin and Dewey Terrace planned in Wyoming, as well as possible tolling arrangements with other operators.

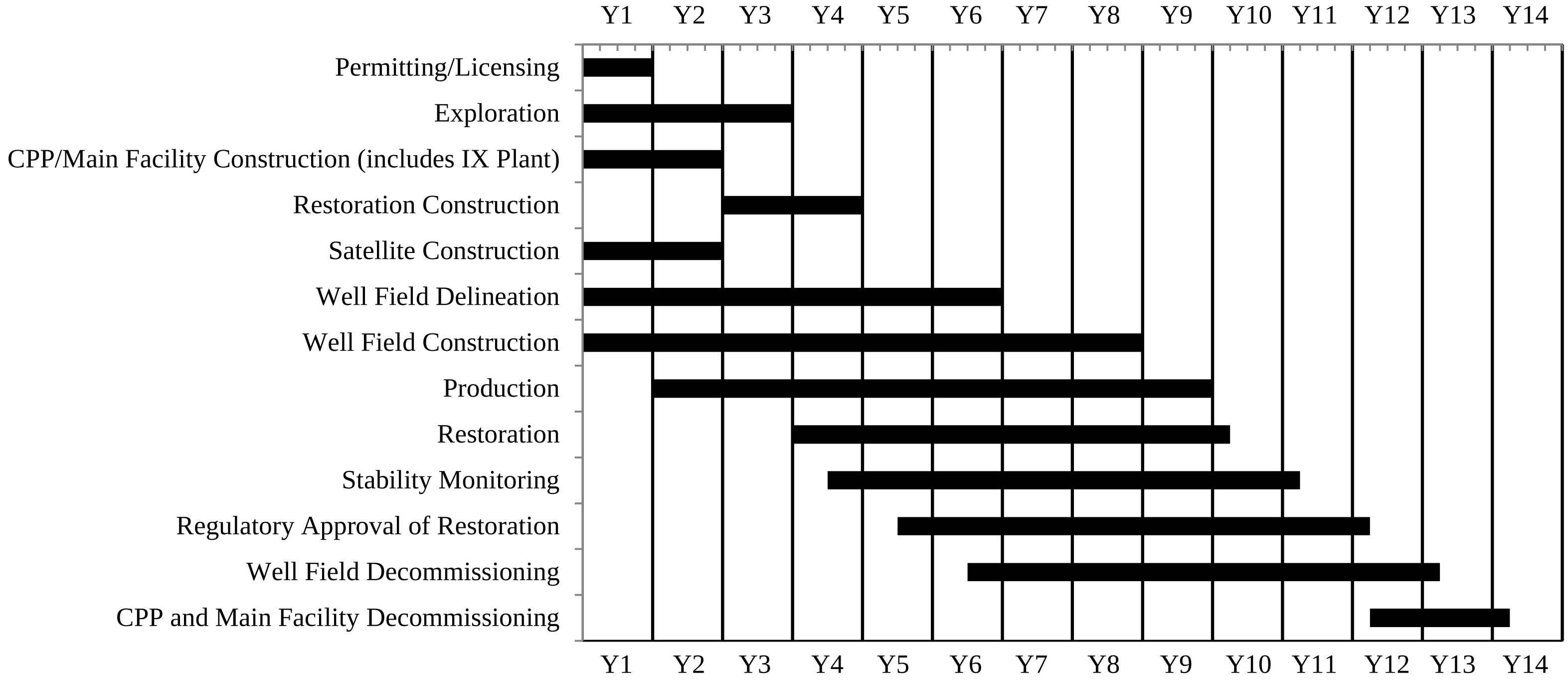


Figure 1.9-1: Projected Construction, Operation, Restoration and Decommissioning Schedule

1.10 Waste Management and Disposal

Wastewater from the Proposed Action ISL operations will consist primarily of spent CPP elution brines, production well field bleed, and restoration flows; these wastewaters will be treated and disposed of by injection in Class V injection wells and/or by land application. Specific liquid waste sources will include:

- Wastewaters from decontamination showers, sinks, and washing machines located in the restricted area
- Production bleed
- Spent eluant brines
- Spilled process liquids
- Wastewater from groundwater restoration
- Decontamination/decommissioning solutions from surface facilities

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 personal protective equipment (PPE) that cannot be decontaminated for unrestricted release are considered Atomic Energy Act (AEA) regulated wastes and will be disposed of at an NRC or agreement state-licensed facility. Non-regulated AEA solid wastes such as office trash and spent equipment parts not associated with uranium production will be disposed at an off-site appropriately permitted Subtitle D facility. Non-regulated AEA liquid wastes such as used oil, hydraulic fluid, cleaners, solvents and degreasers will be recycled or disposed offsite at a permitted hazardous waste facility or other EPA approved disposal methods. Domestic sewage will be disposed in an on-site septic system and leachfield or other disposal methods permitted under State of South Dakota regulations.

1.11 Groundwater Restoration, Decommissioning and Site Reclamation

Groundwater restoration will be implemented as part of routine ISL operations so that restoration can be performed after a well field is depleted of uranium but concurrently with the development of subsequent well fields for uranium production. The groundwater restoration program for all

well fields will be conducted pursuant to 10 CFR Part 40, Appendix A, Criterion 5. It is anticipated that a combination of phases and technologies may be utilized to restore groundwater. These restoration phases and technologies are described in detail in Section 6.

The decommissioning of well fields will commence following regulatory agency acceptance of the groundwater restoration program. The well field decommissioning will include well plugging and abandonment and the removal of well field piping, instrumentation and other support structures. At the time the CPP is decommissioned, all process equipment, buildings and ancillary equipment will be decontaminated for unrestricted release or disposed at an NRC or agreement state-licensed facility.

During site decommissioning and decontamination (D&D), areas that exceed NRC soil concentration limits will be cleaned and then surveyed for compliance with applicable standards. Surface topography and drainage patterns that have been disturbed during operations (including the surface impoundment) will be re-established and will be revegetated with native species.

1.12 Surety Arrangements

In accordance with 10 CFR Part 40, Appendix A, Criterion 9, related NRC guidance, and existing Commission administrative case law, ISL operators are required to submit detailed financial assurance cost estimates to NRC Staff for approval prior to the issuance of a license for ISL operations. Pursuant to these requirements, an ISL operator must submit a detailed, line-item cost estimate (breakdown) of the activities and their associated costs that are necessary to complete site-specific D&D, including groundwater restoration, and to release the project site for unrestricted use. As part of this license application, Powertech (USA) has prepared a detailed, line-item financial assurance cost estimate for the Proposed Action, including the mandatory minimum fifteen (15) percent contingency over and above the costs associated with site D&D. This financial assurance cost estimate is provided in Appendix 6.6-A and Section 6.6.

Powertech (USA) commits to supplying a financial assurance mechanism in a form and in an amount approved by NRC staff in accordance with 10 CFR Part 40, Appendix A, Criterion 9 prior to the commencement of operations. Powertech (USA) is required to supply financial assurance cost estimates for NRC staff approval for construction and the first year of operations based on best available information, including contractor and material costs, using standard industry practices (Hydro Resources, Inc., 51 NRC 227, May 25, 2000). However, based on the Commission's decision, Powertech (USA) is not required to commit to a specific financial assurance instrument during the license application review process, nor is it required to supply the actual financial assurance instrument for the proposed cost estimates prior to the commencement of licensed activities. Thus, while Powertech (USA) is planning on using an

irrevocable letter of credit, no commitment to a specific financial assurance instrument is made at this time.

In addition, Powertech (USA) recognizes that NRC's application of Criterion 9 to ISL operations requires annual financial assurance updates to account for potential changes in the approved financial assurance cost estimate such as inflation, increased workforce wages, and cost increases for materials. Powertech (USA) commits to this requirement and will submit annual financial assurance updates for NRC Staff approval in accordance with Criterion 9 and NUREG-1569 on a timely basis.

1.13 References

Tennessee Valley Authority, 1979, "*Draft Environmental Impact Statement - Edgemont Uranium Mine*", Tennessee Valley Authority, Chattanooga, Tennessee.

U.S. Nuclear Regulatory Commission, June 1982, "*Regulatory Guide 3.46 – Standard Format and Content of License Applications, Including Environmental Reports, for In Situ Uranium Solution Mining*", USNRC, Office of Nuclear Regulatory Research, Washington, D.C.

U.S. Nuclear Regulatory Commission, June 2003, "*NUREG-1569 – Standard Review Plan for In Situ Leach Uranium Extraction License Applications – Final Report*", USNRC, Office of Nuclear Material Safety and Safeguards, Washington, D.C.

2.0 Site Characteristics

2.1 Site Location and Layout

The PAA is located approximately 13 miles north-northwest of Edgemont, South Dakota and spans the area between northern Fall River and southern Custer Counties. The project boundary encompasses approximately 10,580 acres of mostly private land on either side of County Road 6463 and includes portions of Sections 1-5, 10-12, 14 and 15, Township 7 South, Range 1 East and Sections 20, 21, 27, 28, 29 and 30-35, Township 6 South, Range 1 East.

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 plant facilities and 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 Section of the proposed action area (PAA). Further to the north is the access road for the Dewey section of the PAA. This road joins with several other pre-existing roads. These pre-existing roads within the Burdock and Dewey sections of the PAA 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. Figures 3.1-1 and 3.1-2 depict the approximate primary access road, processing facility and initial well field locations in the land application and deep disposal well options, respectively.

THIS PAGE INTENTIONALLY LEFT BLANK

2.2 Uses of Adjacent Lands and Waters

2.2.1 General Setting

The PAA straddles the western county border between Custer and Fall River counties, South Dakota. Land within the project boundary is predominantly privately owned (97.7 percent) and the remaining 2.3 percent is managed by the Bureau of Land Management (BLM).

2.2.2 Land Use

Land use within the proposed project boundary primarily consists of agriculture related to grazing, as well as hunting and historical mining. A 2 km review area is not available for the project site because the four counties in the study area do not utilize zoning or land use plans outside of urban areas. Approximately 390 acres of land are irrigated for hay production along Beaver Creek. The majority of agricultural production is related to grazing. Most land serves as grazing land for cattle and a small number of pigs that are consumed locally and sold as food, as well as a small number of horses. Some of the local residents also have vegetable gardens.

According to the United States Department of Agriculture's (USDA) 2002 census, Custer County generated $11,536,000 and Fall River County generated $49,003,000 from the selling of livestock, poultry and their products. The results from the 2007 Census will not be available until February 4, 2009. According to the National Agriculture Statistics Service, in 2008 the two counties had a combined total 78,000 head of cattle (No data was available for poultry, pig, or sheep inventories). Table 2.2-1 shows the 2008 livestock inventory for Custer and Fall River Counties.

Table 2.2-1: 2008 Livestock Inventory for Custer and Fall River Counties

Type of Livestock	Number Custer County	Number Fall River County	Percent of Total (Custer and Fall River combined)
Beef Cows	17,000	45,000	22/58%
All Cattle and Calves – excluding Beef Cows	1,000	15,000	1/19%
Sheep and Lamb	N/A	N/A	N/A
Hogs and Pigs	N/A	N/A	N/A
Total Animals	18,000	60,000	100%

Source: USDA, 2008.

Recreation lands are present in Custer, Fall River and Pennington counties within a 50-mile radius of the PAA (Table 2.2-2). Major attractions include Mount Rushmore National Memorial and Wind Cave National Park which are set in the backdrop of the Black Hill National Forest. Within the PAA or within the surrounding 2 km there are no recreation lands present because most of the land is private with a small portion, approximately 240 acres, managed by the BLM.

Recreational use in and around the project area is limited primarily to large game hunting. Within the project area, hunting currently is open to the public on approximately 5,700 acres. Approximately 240 acres are public lands managed by the Bureau of Land Management. In addition, the South Dakota Department of Game, Fish and Parks (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.

Table 2.2-2: Recreational Areas within 50 Miles of the Proposed Project

Name of Recreational Facility	Managing Agency	Distance From PAA (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)

The WIAs are on privately owned lands. The State 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 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 project 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.

According to 43 CFR 3802.4, the owner of a mining claim may restrict public recreational use of/or public access across claims or portions of claims that are actively used for prospecting, mining, or processing operations in the following situations:

1) Where public recreational use of a claim would endanger or materially interfere with legitimate mining pursuits; or
2) In cases where the mining operation is hazardous and could lead to personal injury. The claimant may protect his mining equipment and operations area with appropriate signs or other lawful means.

Radiation exposure to hunters is not likely to occur, since radiation levels at ISR facilities are very low and hunters would normally be at least 100 yards from buildings such as the CPP, Satellite Facility, and header houses. Consequently, the risk to a hunter in or near the project area from radiation sources would always be less than that to a worker.

Table 2.2-3 lists the distance to the nearest resident from the center of the PAA according to 22.5-degree sectors centered on the 16 cardinal compass points. Residences are depicted on Figure 5.7-11. There are five residences within the PAA, including seasonal residences.

Table 2.2-3: Distance to Nearest Resident from Center of the Proposed Project

Sector	Distance from Project Center	
	Miles	Km
N	7.2	11.6
NNE	8.3	13.3
NE	6.7	10.8
ENE	13.1	21.1
E	6.8	11.0
ESE	10.7	17.3
SE	7.5	12.1
SSE	5.9	9.4
S	0.9	1.4
SSW	3.4	5.5
SW	21.0	33.7
WSW	1.7	2.7
W	20.3	32.6
WNW	6.2	10.0
NW	3.5	5.6
NNW	4.2	6.7

Data from US Census Bureau, 2000 Census.

2.2.2.1 Aesthetics

The PAA 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 PAA, the visual aspect of human influence on the area is minor with most of the area used for grazing activities and associated facilities (e.g., fences and stock wells). The area's infrastructure include the Burlington Northern Santa Fe (BNSF) Railroad that runs north through Edgemont towards Newcastle, County Road 6463 that parallels the BNSF railroad to the town of Dewey and overhead electricity lines and several gravel access roads.

2.2.2.2 Transportation and Utilities

The PAA will generally 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 connects Edgemont with Custer City. Annual Average Daily Traffic (AADT) counts on U.S.

Highway 18 between Edgemont and the junction with State Highway 89 is 2,000 vehicles (SDDOT 2007). The AADT count on State Highway 89 between Custer City and the junction with U.S Highway 18 is 515 vehicles (SDDOT 2007).

Records of the location of existing utilities within the PAA do not exist. Powertech (USA) is in the process of ground truthing the location of any public utilities within the PAA.

2.2.2.3 Fuel Cycle Facilities

The NRC provides a list of all of the source material facilities operating in the United States which include uranium mills and fuel cycle facilities. According to the NRC website there are no fuel cycle facilities within 50 miles of the PAA. The closest fuel cycle facility is the AREVA NP, Inc. uranium fuel fabrication in Richland, Washington. Also in Eunice, New Mexico the Louisiana Energy Services fuel cycle facility is currently under construction (NRC, 2008).

There are no Source Material Licenses for in situ uranium projects within 50 miles of the PAA. The nearest operational in situ facility is the Crow Butte ISL facility, SUA-1534, in Dawes County, near Crawford, Nebraska (NRC, 2008).

2.2.3 Uses of Adjacent Waters

2.2.3.1 Surface Water

The PAA drains into the Upper Cheyenne River basin, which extends through three states – Wyoming, Nebraska, and southwestern South Dakota (HUC # 10120106, 10120107, 10120108). Within these states the Cheyenne River basin above Angostura Reservoir in South Dakota drains an area of approximately 8,996 mi^2 (Beauvais, 2000). The northern and central portions of the watershed are in the Black Hills division of the Great Plains and the southern portion is in the Pierre Hills division of the Great Plains (Kalvels, 1982 and Ensz, 1990). Land elevation ranges from about 3,160 feet (963 m) to 7,015 feet (2,138 m) above mean sea level.

The PAA is drained by the Cheyenne River (Figure 2.2-1). Beaver Creek and Pass Creek pass through the project area and empty into the Cheyenne River downstream of the proposed project boundary. Beaver Creek drains the southeastern portion of Weston County in Wyoming before entering Custer County in South Dakota and discharging to the Cheyenne River south of Burdock in Fall River County. Beaver Creek drains approximately 1670 mi^2 (1,069,000 acres); 71 percent of the watershed is in Wyoming and 29 percent is in South Dakota. The Pass Creek watershed, characterized as a sub basin 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 mi^2 and is located in Custer, Fall River, and Pennington Counties in South Dakota and a very small portion of Weston County in Wyoming. Several smaller ephemeral tributaries are also located within or adjacent to the project area. These streams, including the Cheyenne River, often experience extended periods of no flow. During periods of flow, water quality varies considerably, mostly dependent on flow regime, with relatively high amounts of sediment and low dissolved solids during high flows, and clearer waters with higher dissolved solids during low flows (Krantz, 2006).

Beaver Creek is the primary surface water resource in the PAA. Pass Creek is a secondary surface water resource in the PAA, although the channel is almost always dry. The remaining surface water resources in the PAA are small ephemeral stream channels and small impoundments which are used by livestock when water exists. Section 2.7.3.1 presents an inventory of impoundments in and around the PAA. Several small, local drainage channels pass through the Burdock portion of the project area.

The approximate elevation of the PAA and the surrounding 2 km review area is 3,600 ft. The climate of the area is semi-arid with an annual precipitation of about 16.5 inches and high annual evaporation rates. Most of the precipitation accumulates during May, June, and July (48 percent of the annual). The peak discharge rates on the Cheyenne River watershed typically coincide with the late spring/early summer snowmelt, but are also influenced by summer thunderstorms.

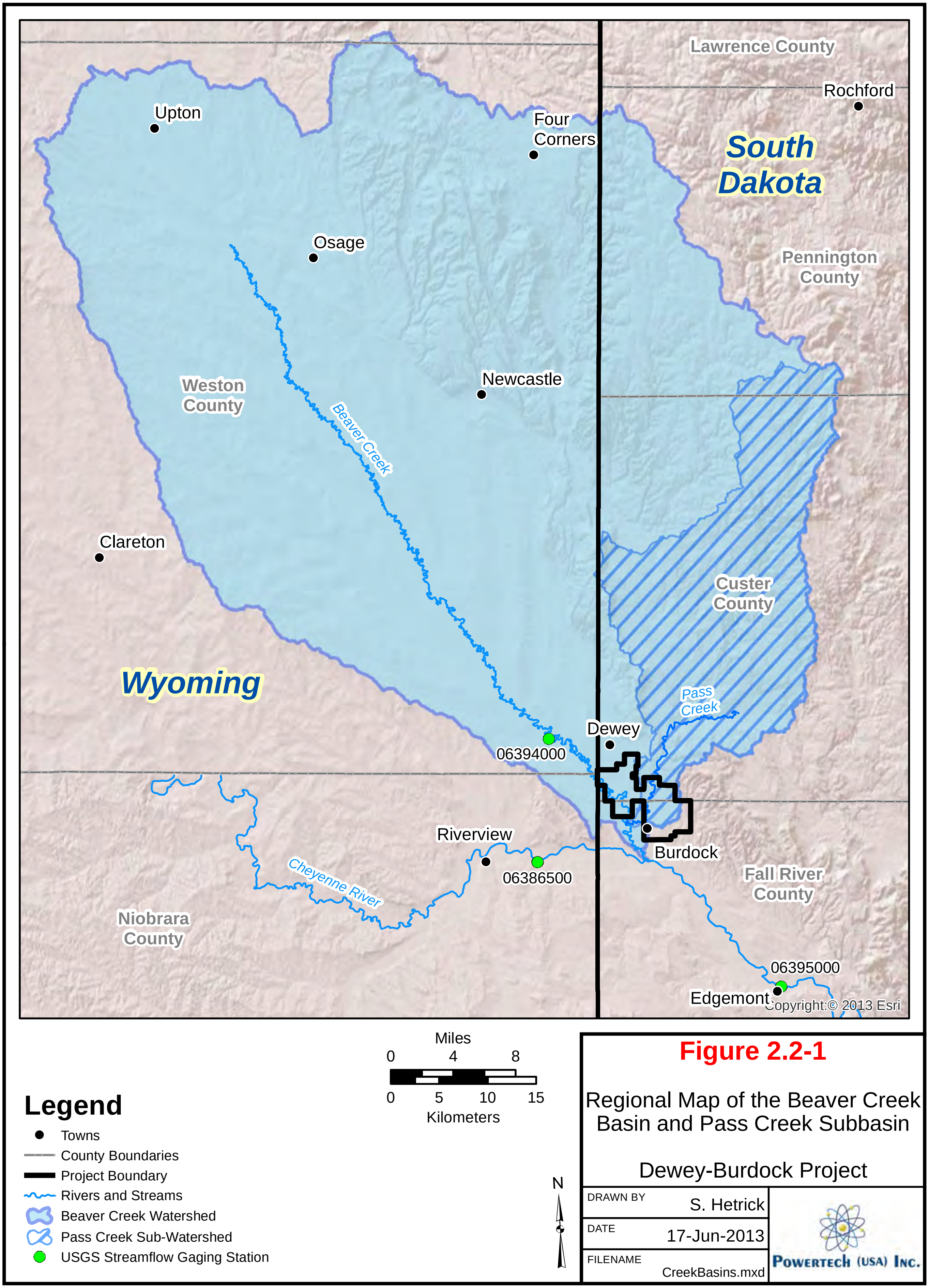


Figure 2.2-1

Regional Map of the Beaver Creek Basin and Pass Creek Subbasin

Dewey-Burdock Project

2.2.3.1.1 Surface Water Flow

The nearest discharge gage on the Cheyenne River upstream of its confluence with Beaver Creek is USGS gage 06386500 near Spencer, WY. The nearest discharge gage downstream of the confluence of Beaver Creek and the Cheyenne River is USGS gage 06395000 at Edgemont, SD. This gage captures the contribution of flow to the Cheyenne River from Beaver Creek and Pass Creek between Spencer, WY and Edgemont, SD. Streamflow data from these USGS stream gages were analyzed and water quantities were described in Section 2.7 of the Technical Report.

2.2.3.1.2 Surface Water Quality

All surface waters in the State of South Dakota are classified into one or more following beneficial uses:

1. Domestic water supply waters
2. Coldwater permanent fish life propagation waters
3. Coldwater marginal fish life propagation waters
4. Warm water permanent fish life propagation waters
5. Warm water semi-permanent fish life propagation waters
6. Warm water marginal fish life propagation waters
7. Immersion recreation waters
8. Limited contact recreation waters
9. Fish and wildlife propagation, recreation, and stock watering waters
10. Irrigation waters
11. Commerce and industry waters

Cheyenne River in South Dakota upstream and downstream of the proposed permit boundary is classified as having beneficial uses 5, 8, 9, and 10. According to the State of South Dakota 2006 303(d) list, the Cheyenne River from the Wyoming border to Beaver Creek is impaired with respect to beneficial uses fish and wildlife propagation, recreation, and stock watering (9), and irrigation (10) due to high levels of total dissolved solids (TDS), sodium adsorption ratio (SAR), and conductivity. The rivers support status related to warm water semi-permanent fish life propagation (5) and limited contact recreation (8) is listed as "insufficient info" (SD DENR,

2006). The Cheyenne River from Beaver Creek to Angostura Reservoir is listed as supporting the beneficial use of limited contact recreation (8), but is impaired for the other three uses (5, 9, 10) due to high levels of TDS, SAR, conductivity, and total suspended solids (TSS).

Beaver Creek in South Dakota has been classified as being suitable for the same uses as the Cheyenne River except that this stream has been classified as being suitable for cold water marginal fish life propagation rather than warm water semi-permanent fish life propagation. The State of Wyoming has classified Beaver Creek in the project vicinity as presently supporting game fish or having the potential to support game fish. Beaver Creek has also been classified by Wyoming as a warm water fishery. Beaver Creek is listed as impaired from the Wyoming border to the confluence with the Cheyenne River with respect to all assigned beneficial uses due to high conductivity, TDS, TSS, fecal coliform, SAR, and temperature.

Pass Creek is classified by the State of South Dakota as having the beneficial uses of fish and wildlife propagation, recreation, and stock watering (9), and irrigation (10). Pass Creek is listed as being in full support of assigned beneficial uses.

Powertech (USA) performed surface water quality sampling at eight stream sampling locations at the project site on a monthly basis from July 2007 through June 2008. The results of the water quality monitoring are summarized in Section 2.7 of the Technical Report.

2.2.3.2 Groundwater

2.2.3.2.1 Regional Groundwater Hydrology

Four major aquifers are utilized as groundwater resources in the Black Hills. These main aquifers are the Inyan Kara, Minnelusa, Madison, and Deadwood. The regional groundwater hydrology is described in Section 2.7.2.1.

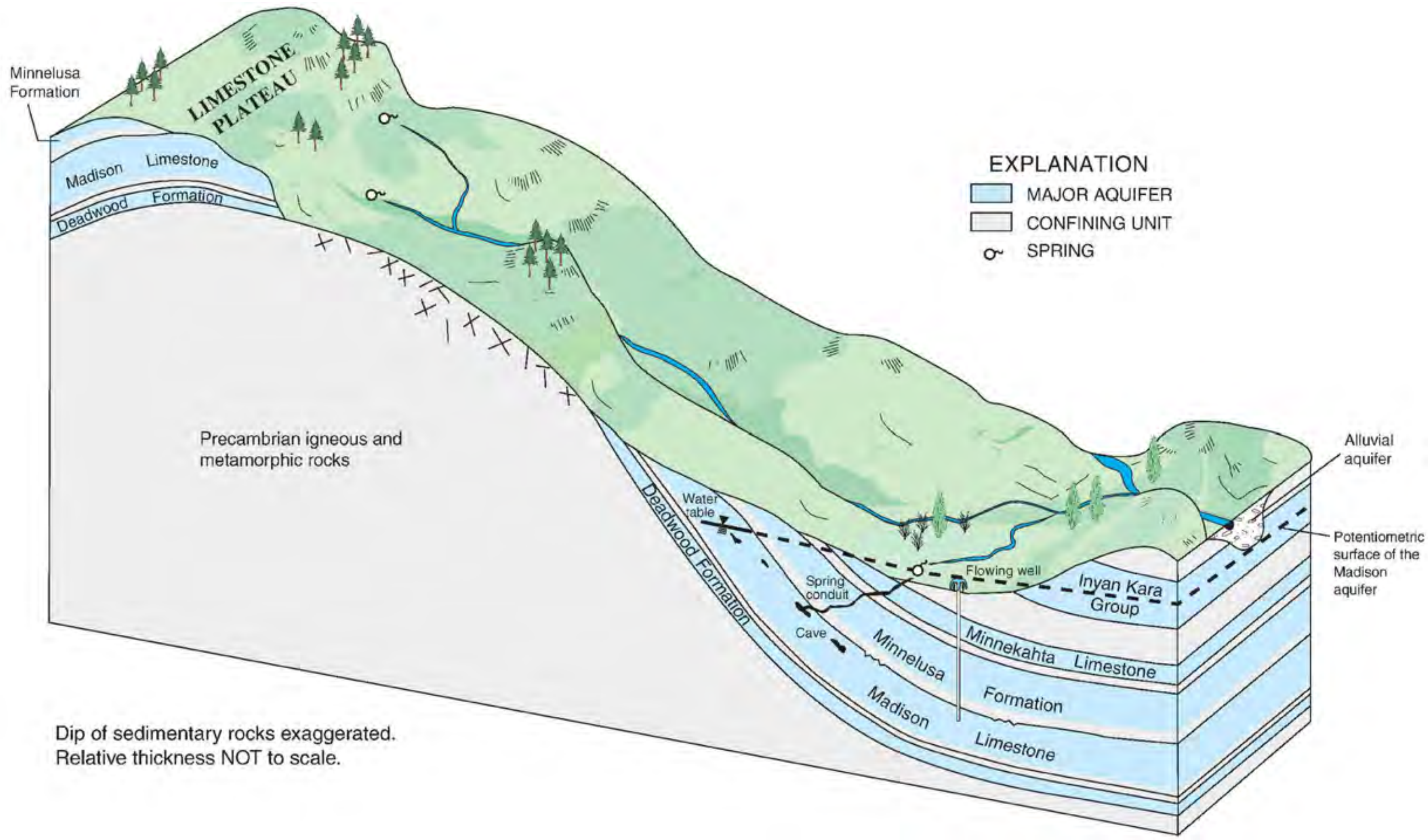
Figure 2.2-2 provides an overview of the hydrologic setting and general hydrogeologic flow within the Black Hills. Regionally, the general direction of groundwater flow is downdip or radially away from the central part of the Black Hills where the aquifers are recharged via infiltration from local rainfall. The aquifers transition from unconfined at the outcrop areas to confined away from the central highlands. At some distance away from the highlands the

groundwater often is under sufficient pressures for artesian conditions and flowing artesian wells to exist.

The water-bearing units in the Black Hills can be divided into four main aquifers. From shallowest to deepest, these include:

- Inyan Kara Aquifer
- Minnelusa Aquifer
- Madison Aquifer
- Deadwood Aquifer

The hydraulic units of interest within the Black Hills area are shown on the stratigraphic column in Figure 2.2-3. Detailed information on the geologic units within the study area is provided in Section 2.6. The properties of major aquifer systems and geologic formations applicable to the project are discussed in greater detail in Section 2.7.



Source: Ground-Water Resources in the Black Hills Area, South Dakota. Water-Resources Investigations Report 03-4049, by J. M. Carter, D. G. Driscoll and J. F. Sawyer, Rapid City, South Dakota, 2003, p. 7.

Figure 2.2-2

Diagram Showing a Simplified View of the Hydrogeologic Setting of the Black Hills Area

Dewey-Burdock Project

DRAWN BY	Mays, Hetrick
DATE	14-Jun-2013
FILENAME	Driscoll_L.dwg

POWERTECH (USA) INC.

Source:
Driscoll et al. (2002).

§ Modified based on drill-hole data

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	TRPs	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 LIMESTONE	25 - 65 §	Thin to medium-bedded, fine-grained, purplish gray laminated limestone.
		Po	OPECHE SHALE	25 - 150 §	Red shale and sandstone.
	PENNSYLVANIAN	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.
	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.

Figure 2.2-3

Stratigraphic Column of the Black Hills Area

Dewey-Burdock Project

DRAWN BY Mays, Hetrick

DATE 14-Jun-2013

FILENAME StratColBlackHills.dwg

POWERTECH (USA) INC.

Water use estimates for different water use types for Custer and Fall River Counties are presented in Table 2.2-4.

Table 2.2-4: Estimated Water Use in Custer and Fall River Counties, South Dakota

Water Use Type	Withdraws (MGD)	
	Custer County	*Fall River County*
Public Supply	0.45	0.8
Domestic GW	0.35	0.17
Industrial GW	0	0
Industrial SW	0	0
Irrigated Acres, sprinkler	1.07	4.67
Irrigated Acres, surface flood	0.62	8.39
Irrigated Acres, total	1.69	13.06
Irrigation GW	0.05	0.08
Irrigation SW	3.56	36.12
Irrigation, total	3.61	36.2
Livestock GW	0.14	0.27
Livestock SW	0.21	0.4
Livestock total	0.35	0.67
Mining GW	N/A	N/A
Mining SW	N/A	N/A
Mining Total	N/A	N/A
Thermoelectric, total	0	0
Total GW, fresh	0.97	1.32
Total GW, saline	0	0
Total GW	0.97	1.32
Total SW, fresh	3.77	36.52
Total SW, saline	0	0
Total SW	3.77	36.52

Source: Hutson et al. 2000
Notes: GW = Groundwater
SW = Surface water
MGD = Million gallons per day

2.2.3.2.2 Study Area Groundwater Quality

At the project site, baseline groundwater sampling was conducted in general accordance with NRC Regulatory Guide 4.14 (NRC, 1980). However, the guidelines were written for tailings impoundments so respective guidance has been interpreted as appropriate to ISL operations. A

summary of the results and methods for the groundwater quality monitoring program, as well as the historical TVA data, is presented in Section 2.7.

2.2.3.2.3 Study Area Groundwater Use

In the PAA, the Fall River Formation and Chilson Member of the Lakota Formation, the principal water-bearing formations of the Inyan Kara aquifer, are the principal sources of water. As discussed in Section 2.7.2.4, a preliminary inventory of private water-supply wells within an approximate 2 km radius of the proposed project boundary was conducted in June 2007. Additional surveys were conducted in 2011 to evaluate the use and condition of the wells. A total of 106 wells were located (see Appendix 2.2-A). The wells within 2 km of the site serve as water supply for livestock (41), domestic (19), or monitoring (46). Well completion reports and other related data are found in Appendix 2.2-B. Stock and domestic wells within 2 km of the project area are depicted on Figure 2.2-4.

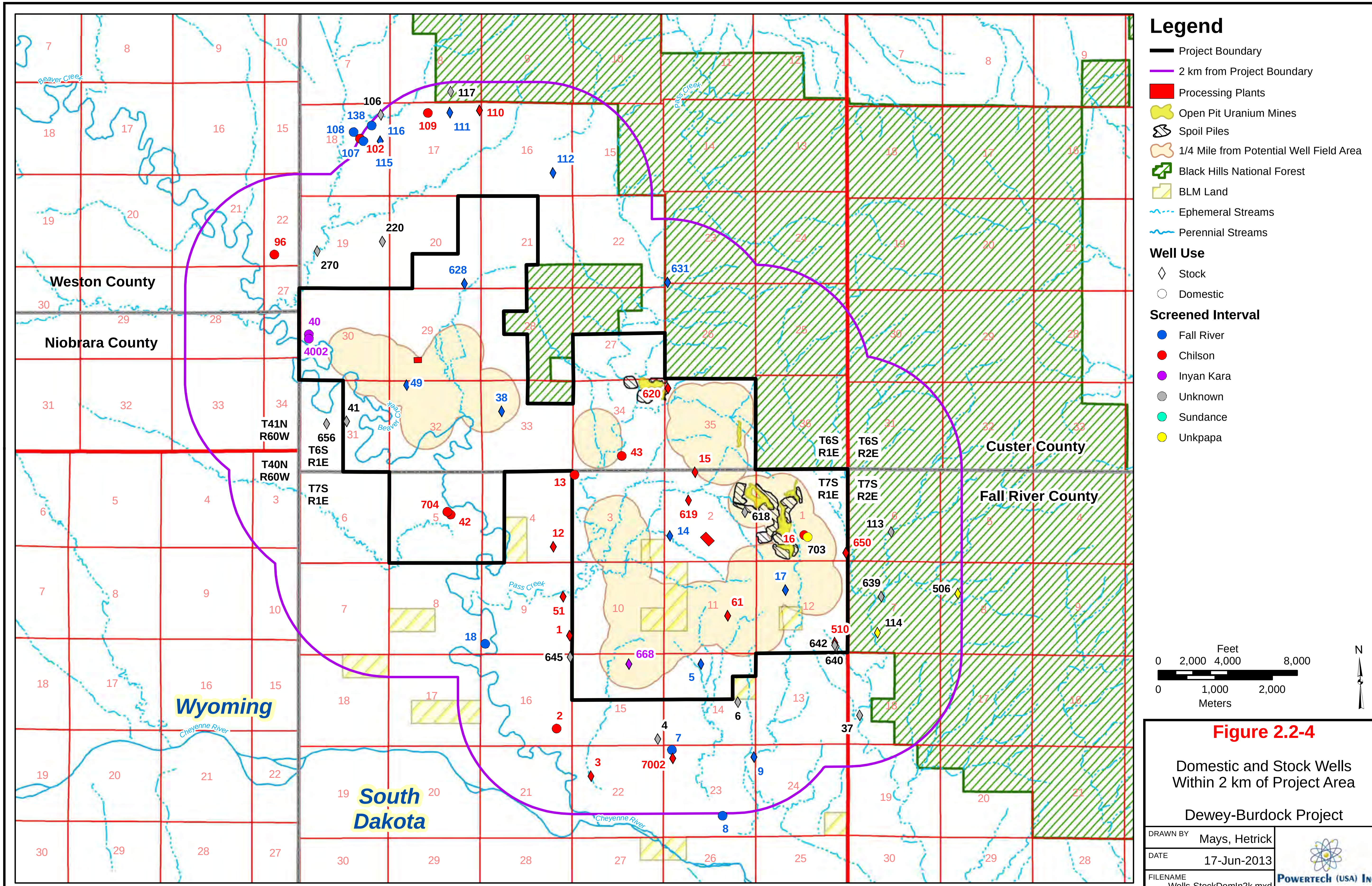


Figure 2.2-4

Domestic and Stock Wells Within 2 km of Project Area

Dewey-Burdock Project

The numerical groundwater model report in Appendix 6.1-A provides estimates of current water usage from the Inyan Kara aquifer within the groundwater model domain.

Based on population projections, future water use in the area is expected to remain consistent with present usage.

2.2.4 References

Beauvais, S.L. 2000, "*Angostura Unit Water Quality: Historical Perspectives and Recommendations for Future Research*", U.S. Geological Survey, Columbia Environmental Research Center, Columbia, MO.

Driscoll, D.G., Carter, J.M., Williamson, J.E., Putnam, L.D., 2002, "*Hydrology of the Black Hills Area*", U.S. Geological Survey Water-Resources Investigations Report 02-4094, 150 p.

Ensz, Edgar H. 1990, "*Soil Survey of Custer and Pennington Counties, Black Hill Parts*", South Dakota: United States Department of Agriculture, Soil Conservation Service and Forest Service.

Google Earth. "*South Dakota*", < http://earth.google.com> (June 20, 2008).

Hutson, S. S., Barber, N. L., Kenny, J. F., Linsey, K. S., Lumia, D. S. and M. A. Maupin, 2000 USGS, "*Estimated Use of Water in the United States in 2000*", [Web Page] http://water.usgs.gov/watuse/ Accessed June 16, 2008.

Kalvels, John, 1982, "*Soil Survey of Fall River County, South Dakota*", United States Department of Agriculture, Soil Conservation Service and Forest Service.

Krantz, E., Larson, A., 2006, "*Upper Cheyenne River Watershed Assessment and TMDL: Fall River, Custer and Pennington Counties, South Dakota*", Unpublished.

United States Department of Agriculture (USDA) National Agriculture Statistics Service (NASS), "*2008 Livestock Inventory for Custer and Fall River Counties, South Dakota*",

[Web Page] http://www.nass.usda.gov/QuickStats/Create_County_Indv.jsp Accessed June 23, 2008.

United States Department of Agriculture (USDA) National Agriculture Statistics Service (NASS), "*2002 Census of Agriculture – County Data*", [Web Page] http://www.nass.usda.gov/census/census02/volume1/sd/st46_2_001_001.pdf Accessed June 26, 2008.

United States Geological Survey (USGS), 2008, "*National Water Information System (NWIS) for USGS Stream Gages in South Dakota*", 06395000, [Web page] http://nwis.waterdata.usgs.gov/sd/nwis/qwdata/?site_no=06395000&agency_cd=USGS Accessed June 16, 2008.

United States Nuclear Regulatory Commission (U.S. NRC), 1980, Regulatory Guide 4.14. "*Radiological Effluent and Environmental Monitoring at Uranium Mills, Revision 1*", Nuclear Regulatory Commission Office of Standards Development, Washington, D.C.

United States Nuclear Regulatory Commission (U.S. NRC), 2008, "*Locations of Fuel Cycle Facilities*", [Web Page] http://www.nrc.gov/info-finder/materials/fuel-cycle/, Accessed June 9, 2008.

South Dakota Department of Transportation (SDDOT), 2007, "*Statewide Traffic Flow Map*", [Web Page] http://www.sddot.com/pe/data/traf_maps.asp, Accessed June 12, 2008.

South Dakota Department of Environment and Natural Resources (SDDENR), "*The 2006 South Dakota Integrated Report for Surface Water Quality Assessment: Pierre, SD*".

United States Environmental Protection Agency (EPA), 2008, "*Total Maximum Daily Loads. List of Impaired Waters. Section 303(d) Fact Sheets*", [Web Page] http://oaspub.epa.gov/tmdl/enviro.control?p_list_id=SD-CH-R-CHEYENNE_01&p_cycle=2004, Accessed June 16, 2008.

2.3 Population Distribution

The study area for the project socioeconomic baseline study includes population centers within an 80-km radius of the project's geographic center (latitude 43° 28' 50.071" N, longitude 103° 59' 34.559" W), considered to represent the likely maximum commuting distance for regular employees of the project (taking into account that actual road miles traveled from communities within the defined radius to the project may be in excess of the "direct line" distance).

A project's direct zone of social influence may be defined as the area within which the proposed project's socioeconomic impacts and benefits are reasonably anticipated to be concentrated, including the population areas most likely to contribute to the project's local workforce and to provide ongoing sources of supplies and commodities during construction and operations. The

direct social zone of influence adopted for the project socioeconomic baseline report primarily includes the townships, towns, and unincorporated areas within the two South Dakota counties hosting the deposits, Custer and Fall River. Approximately 1 mile (1.6 km) of the project's western border follows the Wyoming / South Dakota state line south of Dewey, South Dakota. Therefore, the Wyoming locations of Newcastle and Osage[1] in Weston County are also included in the project's direct social zone of influence. These locations are within a 50-mile (80-km) radius of the PAA's approximate center, and are thus close enough to reasonably supply workers or supplies to the project on a regular basis. No areas of appreciable population size were located within the same radius from the project in other Wyoming counties or to the south in Nebraska.

Within the direct social zone of influence, this baseline study report focuses on the Custer and Fall River counties as being the host counties for the project and thus the most likely to benefit directly from project implementation, including receipt of tax revenues. Towns within these two counties include:

- Custer County:
  - Buffalo Gap, Custer City, Fairburn, Hermosa, and Pringle
- Fall River County:
  - Edgemont, Hot Springs, and Oelrichs

Rapid City, South Dakota, the closest urban area to the project, is approximately 100 miles (161 km) via road northeast of the PAA, in Pennington County, and may serve as a regional logistics hub and source of workers and supplies for the project as well. Because of its greater distance from the project, Rapid City is considered to be part of the project's indirect social zone of influence. Two other towns in Pennington County also fall within the project's indirect social zone of influence, Hill City and Keystone.

2.3.1 Population

The majority of population and demographic information contained in this baseline report was obtained from Census 2000 data and from the 2006 ACS, the most recent Federal demographic

[1] Osage is not an incorporated town but is defined as a "CDP" or census-designated place by the USCB in partnership with State agencies. CDPs are areas of significant population outside of any incorporated municipality and that are locally identified by a name.

survey. Other sources of demographic information include the U.S. Department of Commerce's Bureau of Economic Analysis (BEA), South Dakota Governor's Office of Economic Development (SD GOED), the University of South Dakota's Business Research Bureau, and county and city websites.

NUREG-1569 obliges consideration of population data within a 50-mile (80-km) radius from the project's approximate center; the data is shown in Figure 2.3-1.

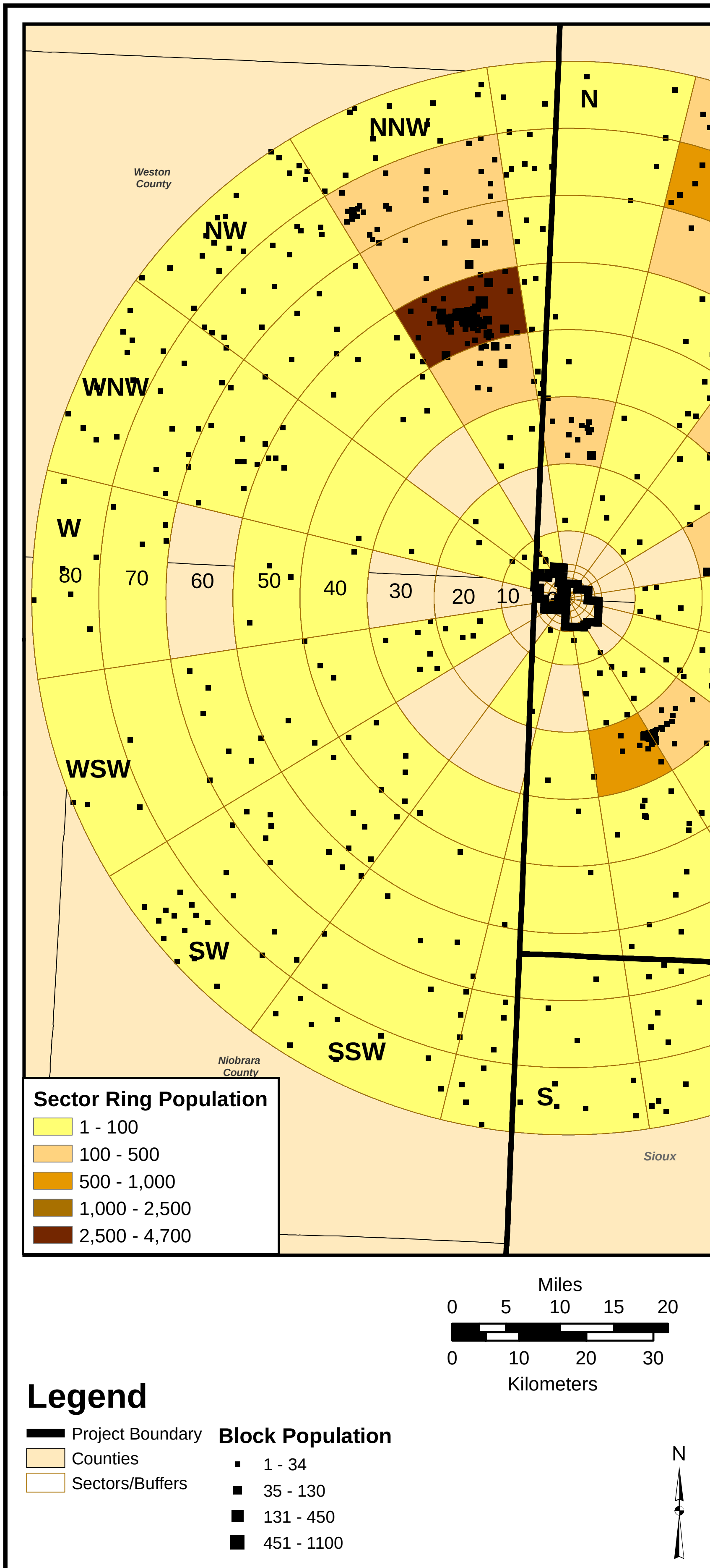


Figure 2.3-1

Population Sector-Block Analysis

Dewey-Burdock Project

DRAWN BY	RESPEC, Hetrick
DATE	10-Oct-2013
FILENAME	Fig 2.3-1 PopSectBlkAnalysis.mxd

POWERTECH (USA) INC.

In general, detailed information on population distribution and demographics is only provided for the towns within the proposed project's direct social zone of influence, as defined in the preceding section, with emphasis on the two South Dakota counties in which the proposed project is located, Custer and Fall River. For some datasets (such as population), estimations based on data trends are cited to provide more updated information; these estimations are acknowledged as projections rather than defined data where used. Population by sector and cumulative population by sector based on Figure 2.3-1 are presented in Table 2.3-1.

Table 2.3-1: Population within a Given Distance from Project Center

	Distance from Project Center, km							
Sector	**0 - 10**	**10 - 20**	**20 - 30**	**30 - 40**	**40 - 50**	**50 - 60**	**60 - 70**	**70 - 80**
N	0	26	165	54	25	25	39	58
N, cumulative	*0*	*26*	*191*	*245*	*270*	*295*	*334*	*392*
NNE	0	12	8	59	64	229	780	386
NNE, cumulative	*0*	*12*	*20*	*79*	*143*	*372*	*1,152*	*1,538*
NE	0	10	15	494	3,852	391	1,825	3,427
NE, cumulative	*0*	*10*	*25*	*519*	*4,371*	*4,762*	*6,587*	*10,014*
ENE	0	0	154	282	21	73	268	539
ENE, cumulative	*0*	*0*	*154*	*436*	*457*	*530*	*798*	*1,337*
E	0	24	47	501	4,651	278	70	95
E, cumulative	*0*	*24*	*71*	*572*	*5,223*	*5,501*	*5,571*	*5,666*
ESE	0	21	26	76	329	183	143	136
ESE, cumulative	*0*	*21*	*47*	*123*	*452*	*635*	*778*	*914*
SE	0	12	342	18	32	12	13	34
SE, cumulative	*0*	*12*	*354*	*372*	*404*	*416*	*429*	*463*
SSE	2	18	649	52	7	30	20	30
SSE, cumulative	*2*	*20*	*669*	*721*	*728*	*758*	*778*	*808*
S	11	1	7	6	18	2	17	44
S, cumulative	*11*	*12*	*19*	*25*	*43*	*45*	*62*	*106*
SSW	3	7	0	2	2	25	21	48
SSW, cumulative	*3*	*10*	*10*	*12*	*14*	*39*	*60*	*108*
SW	0	0	0	29	18	21	23	61
SW, cumulative	*0*	*0*	*0*	*29*	*47*	*68*	*91*	*152*
WSW	6	19	14	15	4	28	8	9
WSW, cumulative	*6*	*25*	*39*	*54*	*58*	*86*	*94*	*103*
W	0	0	0	2	10	0	22	18
W, cumulative	*0*	*0*	*0*	*2*	*12*	*12*	*34*	*52*
WNW	8	6	2	2	18	57	58	33
WNW, cumulative	*8*	*14*	*16*	*18*	*36*	*93*	*151*	*184*
NW	6	2	0	10	22	30	50	72
NW, cumulative	*6*	*8*	*8*	*18*	*40*	*70*	*120*	*192*
NNW	2	0	35	234	4,129	121	316	77
NNW, cumulative	*2*	*2*	*37*	*271*	*4,400*	*4,521*	*4,837*	*4,914*
Ring Population, all Sectors	**38**	**158**	**1,464**	**1,836**	**13,202**	**1,505**	**3,673**	**5,067**

Data from: US Census Bureau, 2006 American Community Survey population estimates.

The distance to the nearest resident within each sector was calculated from querying the geographic data in Figure 2.3-1 and is presented in Table 2.3-2.

Table 2.3-2: Distance to Nearest Residents from Center of the Proposed Project Area

Sector	Number of Residents	Distance from Project Center	
		Miles	Km
N	38	7.2	11.6
NNE	112	8.3	13.3
NE	423	6.7	10.8
ENE	154	13.1	21.1
E	24	6.8	11.0
ESE	110	10.7	17.3
SE	69	7.5	12.1
SSE	88	5.9	9.4
S	23	0.9	1.4
SSW	23	3.4	5.5
SW	39	21.0	33.7
WSW	27	1.7	2.7
W	14	20.3	32.6
WNW	39	6.2	10.0
NW	49	3.5	5.6
NNW	250	4.2	6.7

Data from US Census Bureau, 2000 Census.

2.3.2 Demography

Demographic data for Custer and Fall River county populations collected for this baseline study includes information regarding population breakdown by sex, age, race, and household size, and is summarized and compared to similar data for the State of South Dakota in Table 2.3-3. Demographic data was collected from the Census 2000 statistical pool at both the county and state levels to provide a descriptive picture of the populations within the two counties in comparison to that of the State of South Dakota as a whole.

Review of the tabulated data indicates that the populations of Custer and Fall River counties are older than the state average, with older median ages, lower percentages of households with children, and higher percentages of households with persons 65 years of age or older. Additionally, family and household sizes for both counties were slightly smaller than the State averages.

Table 2.3-3: Proposed Action Area Demographic Data, South Dakota

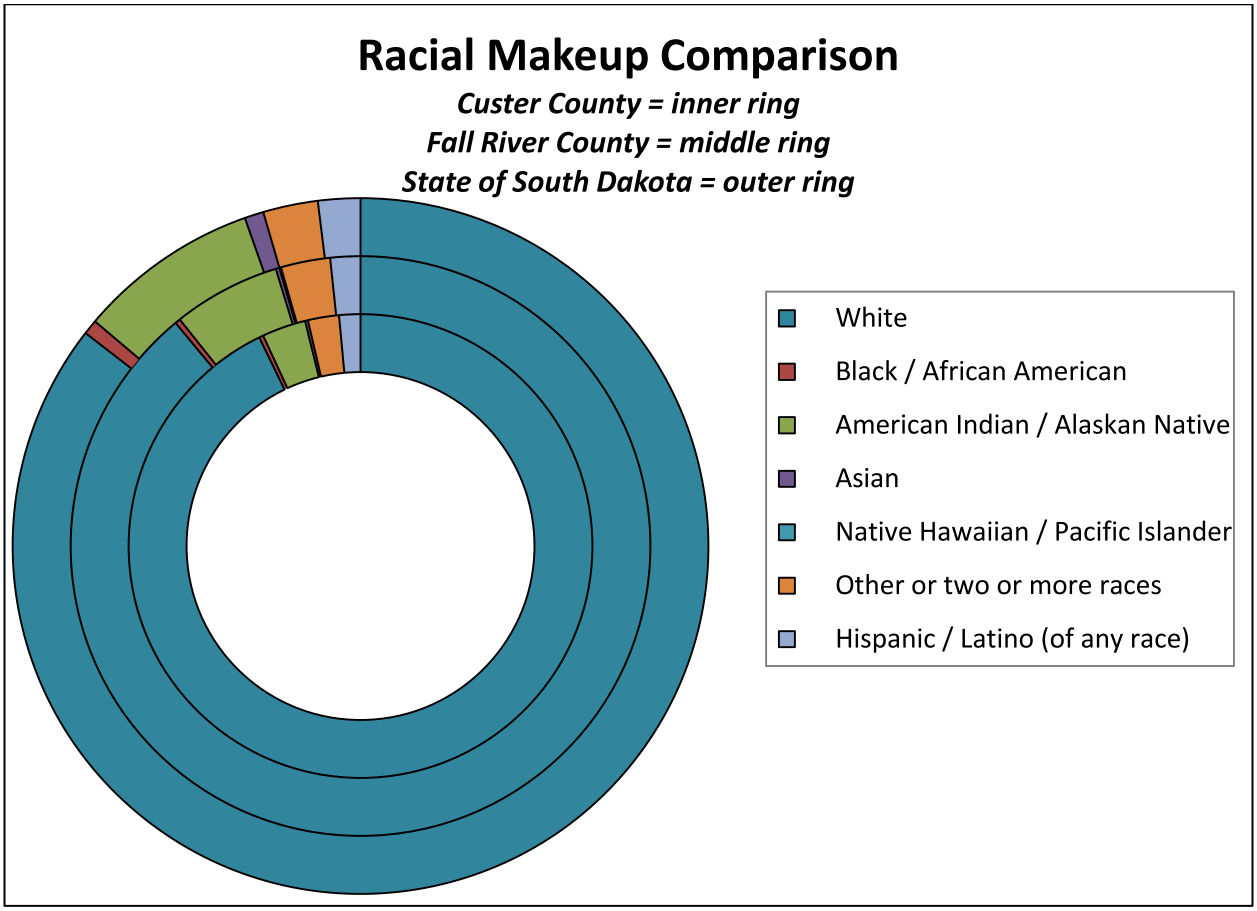
Data Type	Custer County	Fall River County	South Dakota
Male / female ratio, %	51.1 / 48.9	52.3 / 47.7	49.6 / 50.4
Median age, years	43.2	45.5	35.6
Average household size, people	2.35	2.23	2.50
Average family size, people	2.80	2.82	3.07
Households with individuals under 18 years, %	29.1	25.9	34.8
Households with individuals 65 years and over, %	27.4	33.4	25.0
Female householder with no husband present, %	6.6	8.5	9.0
Above, with own children under 18 years, %	4.0	5.2	6.1
Race, %			
White	94.2	90.5	87.2
Black / African American	0.3	0.3	0.7
American Indian / Alaskan Native	3.1	6.1	8.6
Asian	0.2	0.2	0.9
Native Hawaiian / Pacific Islander	0.0	0.1	0.0
Other or two or more races	2.2	2.8	2.6
Hispanic / Latino (of any race)	1.5	1.7	2.0

Data from Census 2000, US Census Bureau

Female-headed households with no husband present accounted for 6.6 percent and 8.5 percent of the total households during the 2000 Census for Custer and Fall River counties, respectively, somewhat lower than the State average of 9 percent. In both counties, 61 percent (4.0 out of 6.6 in Custer County, and 5.2 out of 8.5 in Fall River County) of these households included children under the age of 18 years; lower than the State average of 68 percent (6.1 out of 9.0 in the State of South Dakota) of female-headed households.

Racial data for the two counties show that the local population is predominantly white, with American Indian/Alaskan Native the predominant minority group. At 6.1 percent, the percentage of American Indians in Fall River County is roughly twice that of Custer County, but

still below the State average of 8.6 percent. A graphic depiction of the area's racial makeup is shown in Figure 2.3-2 below, again compared to the State average.



Data from US Census Bureau, Census 2000.

Figure 2.3-2: Racial Makeup Comparison

For comparative purposes, similar data was tabulated for the two Wyoming counties bordering the project, Niobrara and Weston, as shown in Table 2.3-4 below, compared against the state-wide data, this time for Wyoming. As with the South Dakota counties hosting the project, the populations of Niobrara and Weston counties are older than the State average, with smaller household and family sizes, lower proportions of children in the home, and higher percentage of senior citizens. The percentage of female-headed households was also similar to the PAA counties, and lower than the State-wide average. Both Wyoming counties also have lower percentages of Native American populations than the State average, and substantially lower than either Custer or Fall River counties.

Table 2.3-4: Proposed Action Area Demographic Data, Wyoming

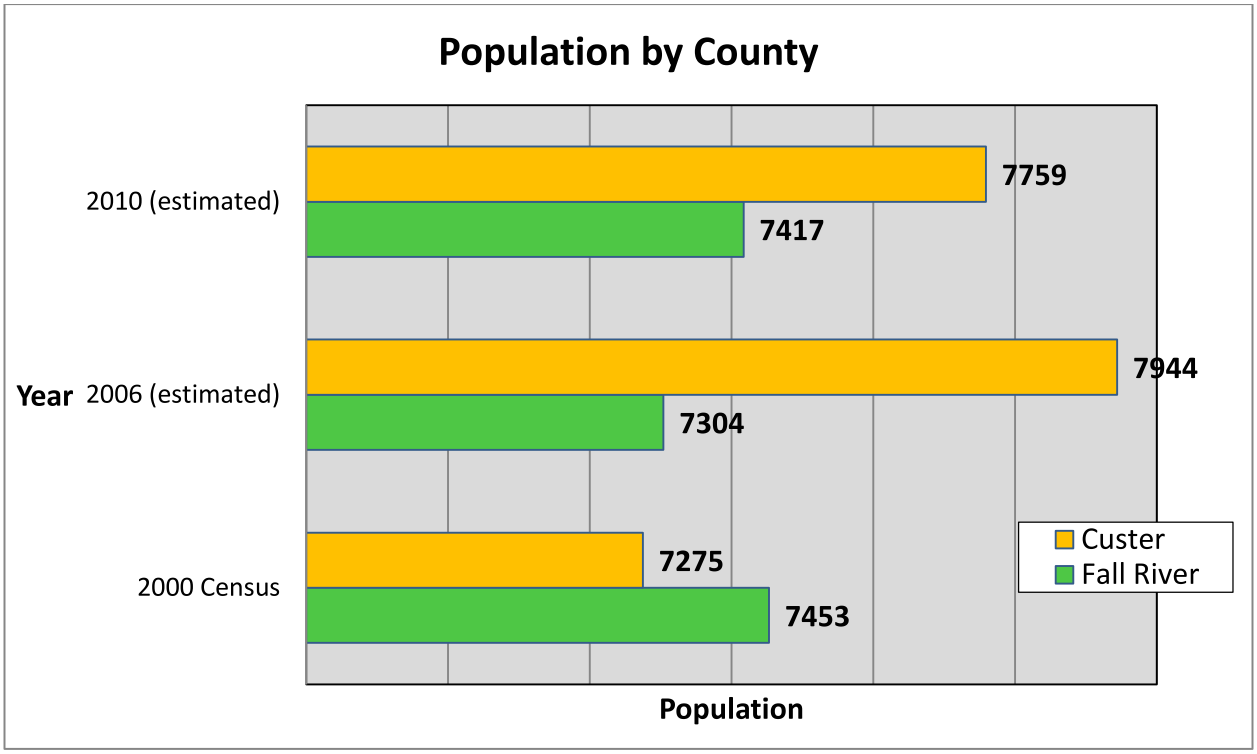
Data Type	Niobrara County	Weston County	Wyoming
Male / female ratio, %	48.8 / 49.1	50.8 / 49.2	50.3 / 49.7
Median age, years	42.8	40.7	36.2
Average household size, people	2.28	2.42	2.48
Average family size, people	2.81	2.88	3.00
Households with individuals under 18 years, %	28.7	33.0	35.0
Households with individuals 65 years and over, %	33.1	26.9	20.8
Female householder with no husband present, %	6.0	7.3	8.7
Above, with own children under 18 years, %	4.2	4.6	6.0
Race, %			
White	98.0	95.9	92.1
Black / African American	0.1	0.1	0.8
American Indian / Alaskan Native	0.5	1.3	2.3
Asian	0.1	0.2	0.6
Native Hawaiian / Pacific Islander	0.0	0.0	0.1
Other or two or more races	1.2	2.4	4.3
Hispanic / Latino (of any race)	1.5	2.1	6.4

Data from US Census Bureau, Census 2000.

2.3.2.1 Population Projections

The most recent verifiable population data for Fall River and Custer counties comes from the last Federal census, in 2000. Estimations of population changes for South Dakota counties were calculated by the USCB for 2006 and by the SD GOED (based on the USCB's projections) for 2010. As Figure 2.3-3 below shows, Fall River is projected to have lost almost 2 percent of its population between 2000 and 2006, in comparison to a 9 percent gain in population in Custer County over the same time period.

Projections for the 2010 county populations show a 1.5 percent gain for Fall River County and a slight decrease of 2.3 percent for Custer County, both over the 2006 estimates.



Data from US Census Bureau.

Figure 2.3-3: Population by County

A breakdown of population per town within each county is shown in Table 2.3-5, based again on Census 2000 data and 2006 USCB population projections. Custer City and Hot Springs, the county seats of Custer and Fall River counties, respectively, are also the largest towns in each county.

Table 2.3-5: Population Change, Custer and Fall River Counties, 2000 – 2006

County / Town	Population	
	2000 Census	2006 (estimate)
Custer		
Buffalo Gap	164	161
Custer City	1860	1984
Fairburn	80	78
Hermosa	315	354
Pringle	125	118
Fall River		
Edgemont	867	810
Hot Springs	4129	4102
Oelrichs	145	143

Data provided by US Census Bureau, 2000 and 2006

General population trends within both counties are shown Figure 2.3-4, and indicate that while Custer County overall is projected to gain in population, the three smallest towns in the county (Fairburn, Pringle, and Buffalo Gap) were estimated to lose between 1.8 percent (at Buffalo Gap) to 5.6 percent (at Pringle) of their populations between 2000 and 2006.

The two larger towns, Hermosa and Custer City, both were projected to gain in population over the same time period, with Hermosa's rate of increase nearly twice as high as that of Custer City. In keeping with the general county population trend, all three towns in Fall River County show estimated population decreases from 2000 to 2006, with the highest percent decrease in Edgemont (the closest town to the project site), at 6.6 percent.

Rapid City, the largest urban area nearest to the project, had a 2000 population of 59,607, projected to increase by 5.2 percent to 62,715 by 2006.

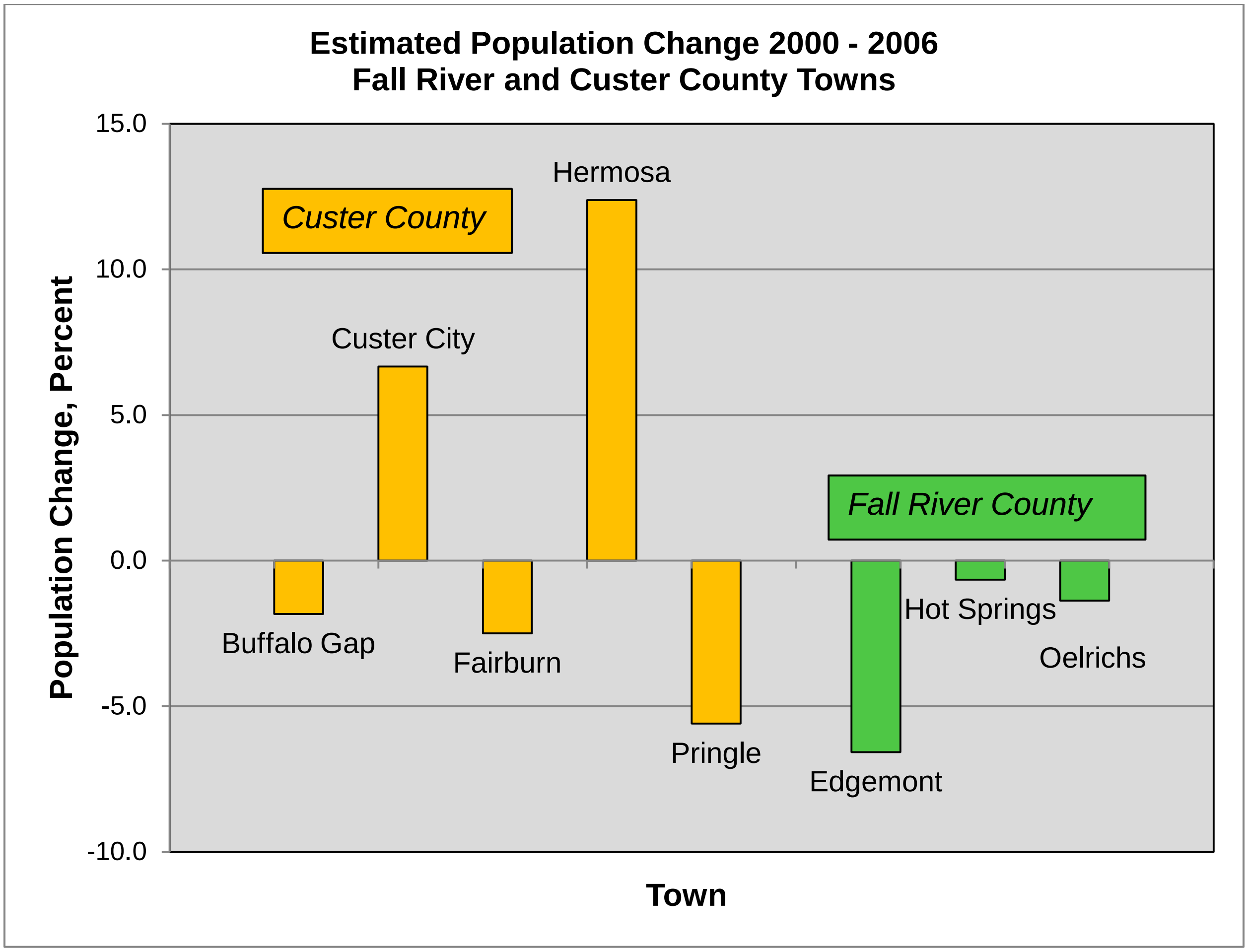


Figure 2.3-4: Estimated Population Change 2000 – 2006, Fall River and Custer Counties

Estimated 2006 population densities for both Custer and Fall River counties were quite low, at approximately four to five people per mi^2 (two people/ km^2). In comparison, the state average population density estimate for 2006 was approximately 10 people per mi^2 (four people/km^2).

Population data for some other areas of interest to the project are shown in Table 2.3-6, and include population statistics for two towns in Pennington County (which includes Rapid City) – Hill City and Keystone, and two locations in Weston County, Wyoming – Newcastle and Osage, all considered close enough to the project to be within in its direct social zone of influence.

Table 2.3-6: Population Data for Other Areas of Interest, 2000-2006

County, State / Town	Population		
	2000 Census	2006 (estimate)	*% Change*
Pennington Co, SD			
Hill City	780	871	***+ 11.7***
Keystone	311	315	***+ 1.3***
Weston Co, WY			
Newcastle	3065	3272	***+ 6.8***
Osage	215	n/a	***n/a***

Data provided by US Census Bureau, 2000 and 2006; "n/a" = inter-census data not available.

2.3.2.2 Schools

Public schools (kindergarten through 12th grade) in South Dakota are generally organized at the county or sub-county level by school district. The five public school districts in and around the PAA and their attendant schools and age levels are:

- **Custer School District:**
  - Custer Elementary, Pre-Kindergarten (PK) - 5th
  - Custer Middle, 6th – 8th
  - Custer High, 9th – 12th
  - Hermosa Elementary, PK – 8th
  - Fairburn Elementary, Kindergarten (K) – 8th
  - Spring Creek Elementary, K – 8th
- **Elk Mountain School District:**
  - Elk Mountain Elementary, K – 6th
- **Hot Springs School District:**
  - Hot Springs Elementary, PK - 5th
  - Hot Springs Middle, 6th - 8th
  - Hot Springs High, 9th – 12th

- **Edgemont School District:**
  - Edgemont Elementary, K – 6th
  - Edgemont Junior High, 7th – 8th
  - Edgemont High, 9th – 12th
- **Oelrichs School District:**
  - Oelrichs Elementary, K – 6th
  - Oelrichs Junior High, 7th – 8th
  - Oelrichs High, 9th – 12th

There are no private or charter primary or secondary schools in Custer County. Bethesda Lutheran School in Hot Springs is the only private school in Fall River County, and serves grades PK – 5th.

Primary and secondary school attendance rates in Custer and Fall River counties were higher than the State-wide rates from kindergarten onward and typically higher in Fall River than in Custer County (Table 2.3-7). However, the percentage of the population of either county attending college or graduate school in 2000 was less than half the State attendance rate.

Table 2.3-7: Primary and Secondary School Attendance Rates, 2000 & 2006

School Category	Percent of Population ≥ 3 Years Old Attending School		
	Custer County (1)	Fall River County (1)	South Dakota (1), (2)
Nursery, pre-kindergarten, and pre-school	4.0	5.92	6.1, 6.7
Kindergarten	4.8	6.1	5.4, 4.9
Elementary (grades 1st – 8th)	42.7	51.8	44.6, 41.9
High (grades 9th – 12th)	37.7	27.4	23.4, 21.5
College or graduate school	10.7	8.8	20.6, 25.0

Data from US Census Bureau: (1) Census 2000, (2) 2006 American Community Survey estimates.

The closest post-secondary schools to the project are in Rapid City, approximately 100 miles via northeast via road, and include the Western Dakota Technical Institute (WDTI), the South

Dakota School of Mines and Technology (SDSMT), and the Rapid City Campus of the National American University (NAU).

The WDTI is one of four State-run technical institutes in South Dakota, and offers 25 career programs leading to the Associate of Applied Science degree, as well as many non-credit classes, workshops, short-term training programs, and online courses. Approximately 850 full-time students are currently enrolled at WDTI, with over 4,000 students participating in full-, part-time, or non-credit courses annually.

The SDSMT is one of the six state public universities governed by the South Dakota Board of Regents, and offers undergraduate (Associate of Arts, Bachelor of Science) and graduate degrees (Master and Doctor of Science) in various science and engineering fields. Current enrollment is 1,572 full-time and 498 part-time students.

The Rapid City campus is one of NAU's 20 campuses in six states, including an on-line campus also based in Rapid City. NAU is a private institute of higher learning, offering regionally accredited and degree programs in a variety of fields, both at its campuses and on-line. Current enrollment at NAU's Rapid City campus is 1,005, including 646 full-time and 359 part-time students.

2.3.3 Local Socioeconomic Baseline Conditions

2.3.3.1 Major Economic Sectors

The SD DOL defines "labor force" as all civilians not in institutions, 16 years of age and older, and who are employed or unemployed and actively seeking employment. SD DOL develops its labor force estimates in cooperation with the US Bureau of Labor Statistics. "Labor supply" is defined by the SD DOL as the number of persons who would be available to staff a new or expanding business in the area of interest, and includes people who are currently employed but are seeking to change jobs and people who are unemployed but actively seeking jobs, and also considers workers who would commute into the area to work. Labor supply statistics are developed solely by SD DOL, as provided in Table 2.3-8.

Table 2.3-8: Proposed Action Area Labor Statistics, December 2007

	Custer County	Fall River County	South Dakota*
Labor force, persons	3,955	3,680	440,085
Labor force, % of total population	49.8	50.4	56.3
Employed, persons	3,810	3,520	426,815
Unemployed, persons	145	160	13,270
Unemployment rate, annual %	3.2%	3.6%	3.1%
Labor supply, persons	470	535	67,570
Labor supply, % of labor force	11.9	14.5	15.4

Data from Labor Market Information Center, South Dakota Department of Labor
*State-wide data is seasonally adjusted

The percentage of the total county populations represented by their labor forces is roughly the same for Custer and Fall River counties, but lower than the State-wide rate, potentially due to the older populations in the area, as noted in Section 2.3.2. Annual unemployment rates in both counties were higher than the State-wide rate of 3.1 percent, with unemployment higher in Fall River County.

The majority of workers between the ages of 25 to 64 in both counties have only 12 years of formal education (high-school level), as shown in Table 2.3-9.

Table 2.3-9: Labor Force Educational Attainment (25 to 64 Years of Age), 2000

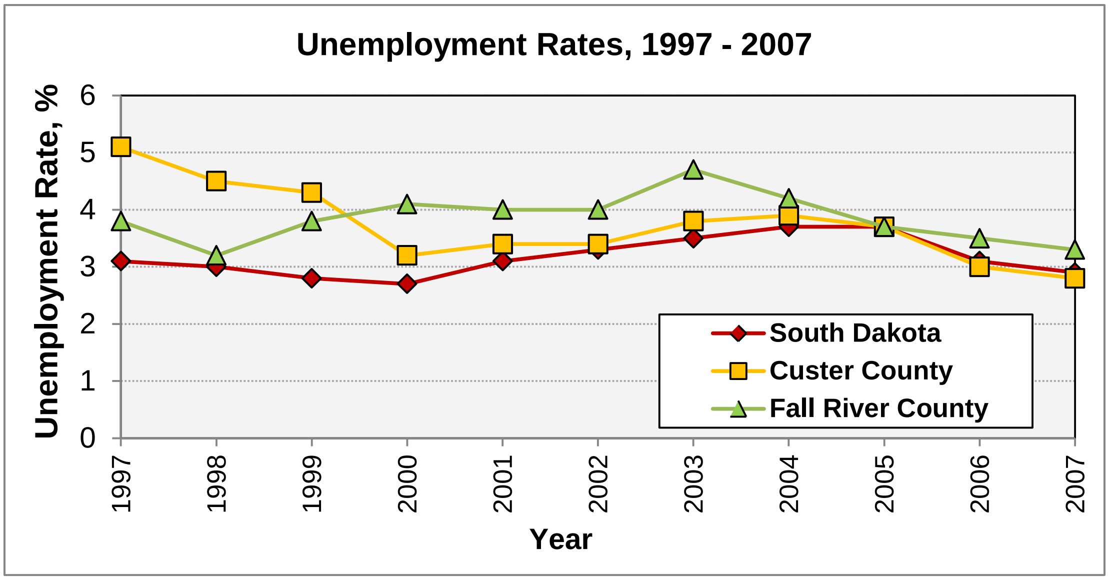
	Custer County, %	Fall River County, %	South Dakota
Less than 12 years of school	6.3	12.1	15.5
High school (12 years of school)	31.1	35.0	32.9
Some college (no degree)	27.1	28.6	23.0
Associate degree	7.5	3.8	7.1
Bachelor's degree	20.3	13.1	15.5
Graduate degree	7.7	7.4	6.0

Data from South Dakota Governor's Office of Economic Development and the US Census Bureau, 2000

2.3.3.2 Unemployment Trends

Unemployment trends for Custer and Fall River counties and South Dakota's state-wide rate over the last decade are shown in Figure 2.3-5, which plots the average unemployment rate for

each year determined from monthly county and state data from the SD DOL's Labor Market Information Center.



Data from South Dakota Department of Labor, Labor Market Information Center

Figure 2.3-5: Unemployment Rates, 1997 - 2007

As the chart shows, the disparity between county and State unemployment rates has been decreasing, so that since 2005 Custer and Fall River county unemployment rates are closely matched to that of the State. This trend adjustment has been most pronounced for Custer County, which had an unemployment rate of nearly twice the State average in 1997, but which now is within 4 percent of the State average. Fall River County's 2007 average unemployment rate was approximately 16 percent higher than the State-wide rate of 3.1 percent.

2.3.3.3 Employment

Employment data from 2006 for major sectors of employment including private sector enterprises and local, state, and federal government for Custer and Fall River counties are shown in Table 2.3-10 and illustrated in Figure 2.3-6. "Covered workers" are defined by the SD DOL as workers at firms for whom unemployment insurance is provided. Workers excluded from the "covered" category include the self-employed, unpaid family workers, elected government officials, railroad employees, election officials, work-study students, some religious and non-profit organization employees, smaller business employees, and part-time or seasonal workers.

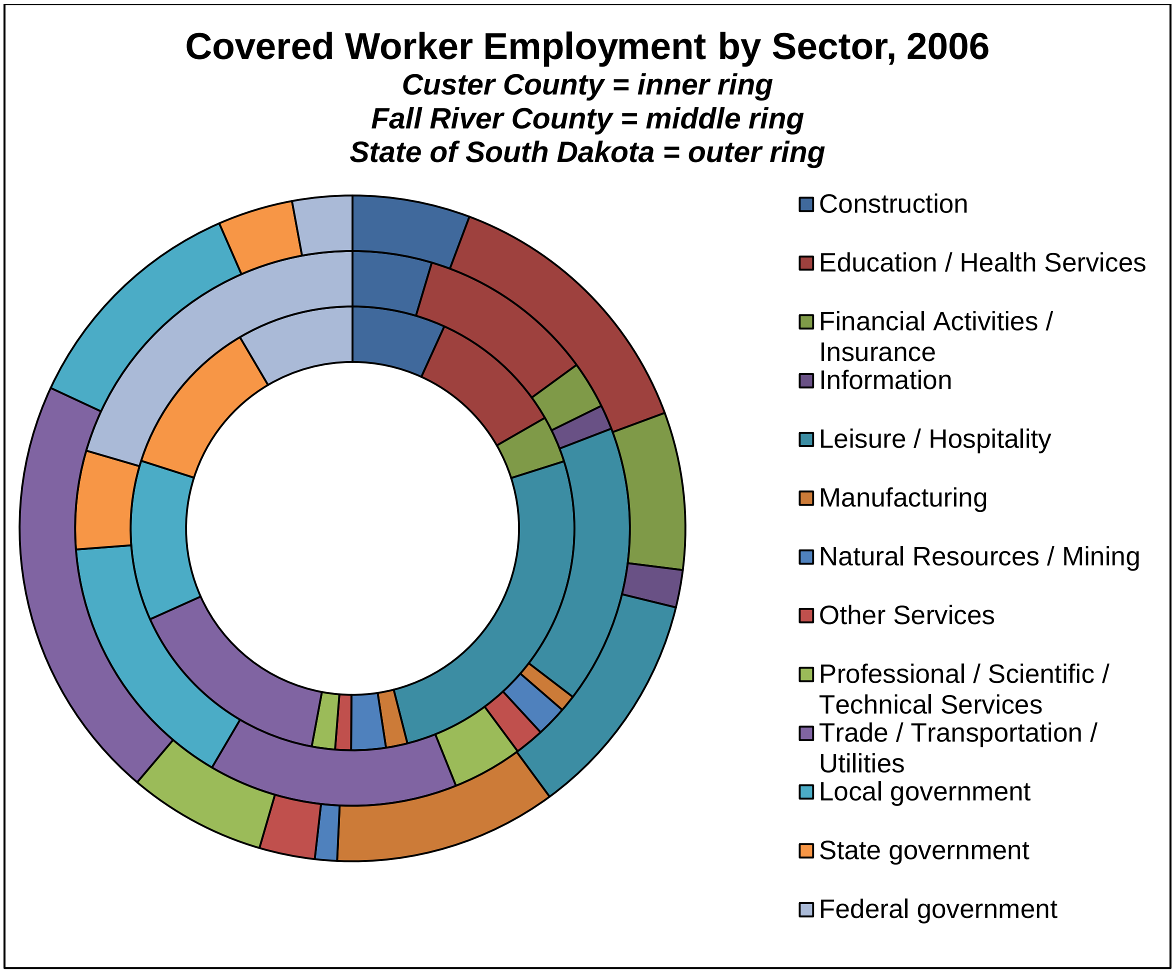
According to correspondence (email, 7 March 2008) with Ron Meier, Senior Economic Analyst with the SD DOL's Labor Market Information Center, covered worker data will be updated to reflect the 2007 annual statistics in late June / early July 2008.

Table 2.3-10: Proposed Action Area Covered Worker Employment by Sector, 2006

Employment Sector	Custer County, % Employed (1)	Fall River County, % Employed (1)	South Dakota, % Employed (2)
Construction	6.59	4.62	5.69
Education / Health Services	9.62	10.36	13.6
Financial Activities / Insurance	3.31	2.75	7.61
Information	NR	1.43	1.81
Leisure / Hospitality	25.15	16.26	11.06
Manufacturing	1.52	0.96	10.78
Natural Resources / Mining	2.44	1.79	1.07
Other Services	1.12	1.71	2.69
Professional / Scientific / Technical Services	1.64	4.07	6.66
Trade / Transportation / Utilities	14.89	14.55	20.66
% Total, Private Ownership (3)	***66.28***	***58.50***	***82.00***
Local government	11.30	15.34	11.47
State government	11.26	5.74	3.63
Federal government	8.22	20.49	2.90
% Total, Government (3)	***30.78***	***41.57***	***18.00***
Total Covered Workers:	**2505**	**2509**	**383,856**

Data from South Dakota Governor's Office of Economic Development and South Dakota Department of Labor, Labor Market Information Center, 2006.
Notes: (1) County data are from 2007; (2) State data are from 2006; (3) Totals exceed 100% due to rounding; NR = not reported

Government (local, state, or federal) was the largest employment sector for both Custer and Fall River counties. In 2006, slightly under half of all covered workers in Fall River County were employed by some form of government, in comparison to 31 percent of the covered workforce in Custer County and 18 percent of the workforce State-wide. Major private enterprise sectors of employment for both counties were leisure/hospitality (including arts, entertainment, recreation, food service, and accommodations) and trade/transportation/utilities (including retail, wholesale, transportation, warehousing, and utilities), see Figure 2.3-6.



Data from South Dakota Governor's Office of Economic Development and South Dakota Department of Labor, Labor Market Information Center, 2006.

Figure 2.3-6: Covered Worker Employment by Sector, 2006

A more detailed breakdown of private and public sector employers for both counties is provided in Table 2.3-11, based on 2006 data collected by the SD GOED from local development corporations. Major employers in Custer County include the US Department of Agriculture Forest Service (whose Black Hills National Forest headquarters are in Custer City), local school districts, and various health care providers. Major employers in Fall River County include the US Department of Veteran's Affairs (which operates a VA Medical Center in Hot Springs) and the National Park Service, in addition to local school districts and health care providers.

Table 2.3-11: Major Employers, Custer and Fall River Counties, 2006

Employment Sector	Total Employed Custer / Fall River	Major Employers	Custer County # Employed – Town	Fall River County # Employed – Town
Construction	34 / 11	Jorgenson Log Homes	34 – Custer City	
		Barker Concrete Construction		11 - Edgemont
Education / Health Services	283 / 321	Custer Regional Senior Center	100 - Custer City	
		Custer School District	183 – Custer City	
		Cactus Hills Retirement Community		9 - Edgemont
		Edgemont School District		47 - Edgemont
		Castle Manor Nursing Home		140 – Hot Springs
		Hot Springs School District		125 – Hot Springs
Financial Activities	4 / -	Battle Creek Agency	4 - Hermosa	
Leisure / Hospitality	79 / 20	Cuny Table Café	4 - Buffalo Gap	
		Crazy Horse Memorial	60 – Custer City	
		Trails West	5 - Hermosa	
		Waterhole Restaurant & Bar	10 - Hermosa	
		Super 8 Motel		15 – Hot Springs
		State Line Club		3 - Oelrichs
		Horsehead		2 – Oelrichs
Natural Resources / Mining	33 / -	Pacer Corporation	33 – Custer City	
Other Services	- / 36	Black Hills Special Services		36 – Hot Springs
Trade / Transportation / Utilities	84 / 115	Black Hills Electric Cooperative	30 – Custer City	
		Buffalo Gap Repair	2 - Buffalo Gap	
		Rancher Feed & Seed	2 - Buffalo Gap	
		Lynn's Dakotamart	35 – Custer City	43 – Hot Springs
		Fresh Start	15 - Hermosa	
		Nelson's Oil & Gas		4 - Edgemont
		Maverick Junction		33 – Hot Springs
		Pamida		35 – Hot Springs
Local Government	74 / 7	Custer County	74 – Custer City	
		City of Edgemont		7 - Edgemont
State Government	30 / 106	Custer State Park	30 – Custer City	
		State Veterans' Home		106 – Hot Springs
Federal Government	583 / 504	Black Hills National Forest	583 - Custer City	
		VA Medical Center		402 – Hot Springs
		Wind Cave National Park		100 – Hot Springs
		U.S. Post Office		2 – Oelrichs

Data from South Dakota Department of Labor and Governor's Office of Economic Development

2.3.3.4 Income Levels

Information regarding median and per capita incomes and poverty statistics for Custer and Fall River counties is only available from the decennial federal census; state-level information is updated during the USCB's annual American Community Survey. Therefore, the county- and town-level information in Table 2.3-12 is presented in 1999 dollars, and has not been adjusted for inflation; State-wide data are for 2006 (2005 dollars).

Table 2.3-12: Proposed Action Area Income Levels

Location	Covered Workers, Annual Average Pay (1)	Median Household Income (2)	Median Family Income (2)	Per Capita Income (2)
Custer County	*$25,141*	*$36,303*	*$43,628*	*$17,945*
Custer County - Adjusted for inflation		*$41,917*	*$50,376*	*$20,721*
Buffalo Gap		$25,000	$28,750	$14,680
Custer City		$31,739	$41,313	$17,216
Hermosa		$23,750	$33,125	$20,832
Fall River County	*$26,727*	*$29,631*	*$37,827*	*$17,048*
Fall River County – Adjusted for inflation		*$34,214*	*$43,678*	*$19,685*
Edgemont		$24,919	$36,667	$17,273
Hot Springs		$27,079	$35,786	$16,618
Oelrichs		$27,222	$28,906	$13,454
South Dakota (3)	***$30,282***	***$42,791***	***$53,806***	***$22,066***

Data provided by South Dakota Department of Labor, Labor Market Information Center and US Census Bureau.
Note: (1) 2006 data; (2) Census 2000 data (1999 dollars) except State data; (3) State data = 2006 American Community Survey.

Median incomes at the household and family level were higher for both Custer and Fall River counties than for the individual towns within each county, indicating that unincorporated county residents contribute substantially to the area's gross income. Income values for both counties were lower than the comparable State-wide values, due in part to the time disparity of the available data. To facilitate comparison, the county-level data was adjusted for inflation to 2005 dollars (2006 data) using a web-based gross domestic product (GDP) deflator calculator (http://www.measuringworth.com/calculators/uscompare/result.php) based on the ration of

nominal GDP to real GDP, a broad measure of inflation representing the price of all goods and services in the economy. The county adjusted median values are still lower than the comparable State-wide incomes in each category, but Custer County median income values range from 2 percent (household income) to less than 7 percent (family income) below their State analogs, while Fall River County median values are diverge by almost 11 percent (per capita income) to 20 percent (household income) from comparable State-wide values.

2.3.3.5 Tax Base

South Dakota does not impose a state income tax on its citizens or businesses, and abolished its estate tax in 2001. The majority of State revenue is generated from the 4 percent State-wide sales and use (services) tax, with other sales and use taxes levied by many municipalities, typically an additional 1–2 percent. The South Dakota Department of Revenue and Registration (SD DRR) is the entity responsible for collection and regulation of various taxes at the State level, including:

- Non-income business taxes – including sales and use, contractor's excise, and municipal (city) and special jurisdiction (tribal) taxes;
- Special taxes – including tobacco excise, bank franchise, ore and energy mineral severance, gaming excise, coin-operated laundromat licensing, and various alcohol taxes; and
- Motor vehicles taxes – including titles, licensing, motor fuel, and dealer licensing.

Towns with a municipal sales and use tax may also impose a gross receipts tax on various sales, including lodging, restaurants, alcoholic beverage sales, and admissions to places of amusement and cultural and sports events. SD DRR is responsible for collection of municipal taxes. Only towns imposing a municipal sales and use tax in the PAA are listed in Table 2.3-13 below.

Table 2.3-13: Proposed Action Area Municipal Tax Rates - 2007

Location	Municipal Tax Rate	Gross Receipts Tax Rate
Custer County		
Custer City	2%	1%
Hermosa	2%	No
Pringle	2%	No
Fall River County		
Edgemont	2%	1%
Hot Springs	2%	1%

Data from South Dakota Department of Revenue and Registration, 2008.

Local governments are solely responsible for collection of property taxes, which are the primary source of funding for school systems, counties, municipalities, and other local government units.

Table 2.3-14 presents the total taxable amounts for calendar year 2007 on sales and services for the larger towns in Custer and Fall River counties, and shows the amounts as a percent of South Dakota's total taxable sales over the same time period. The county total rates are approximate as they do not take into account any sales taking place in the unincorporated areas of the county.

Table 2.3-14: Total Taxable Sales for Project-Area Towns - 2007

Location	Total Taxable Sales	% of State Taxable Sales
Custer County		*~ 5.52*
Buffalo Gap	$404,188	0.03
Custer City	$79,332,055	5.08
Fairburn	$106,078	0.01
Hermosa	$5,768,664	0.37
Pringle	$552,539	0.04
Other cities	$351,520	0.02
Fall River County		*~ 4.2*
Edgemont	$6,863,927	0.44
Hot Springs	$57,148,891	3.66
Oelrichs	$714,584	0.05
Other cities	$704,086	0.05

Data from South Dakota Department of Revenue and Regulation, South Dakota Sales and Use Tax Report, Calendar Year 2007.

Figure 2.3-7 shows the percentage various business sectors contributed to the total taxable sales and use revenue for Custer City and Hot Springs, the respective county seats for Custer and Fall River counties, and the largest cities in each county. Businesses are grouped by standard industrial classification (SIC) as defined by SD DRR, and data reflect 2007 calendar year totals from SD DRR's annual report. The chart shows that the manufacturing, mining, transportation and public utilities, and services sectors were more important to Custer County than to Fall River, while agriculture, forestry, and fishing; construction; and retail trade were more important to Fall River County than to Custer. Wholesale trade and finance, insurance, and real estate sectors were approximately equal in terms of revenue generated for each county.

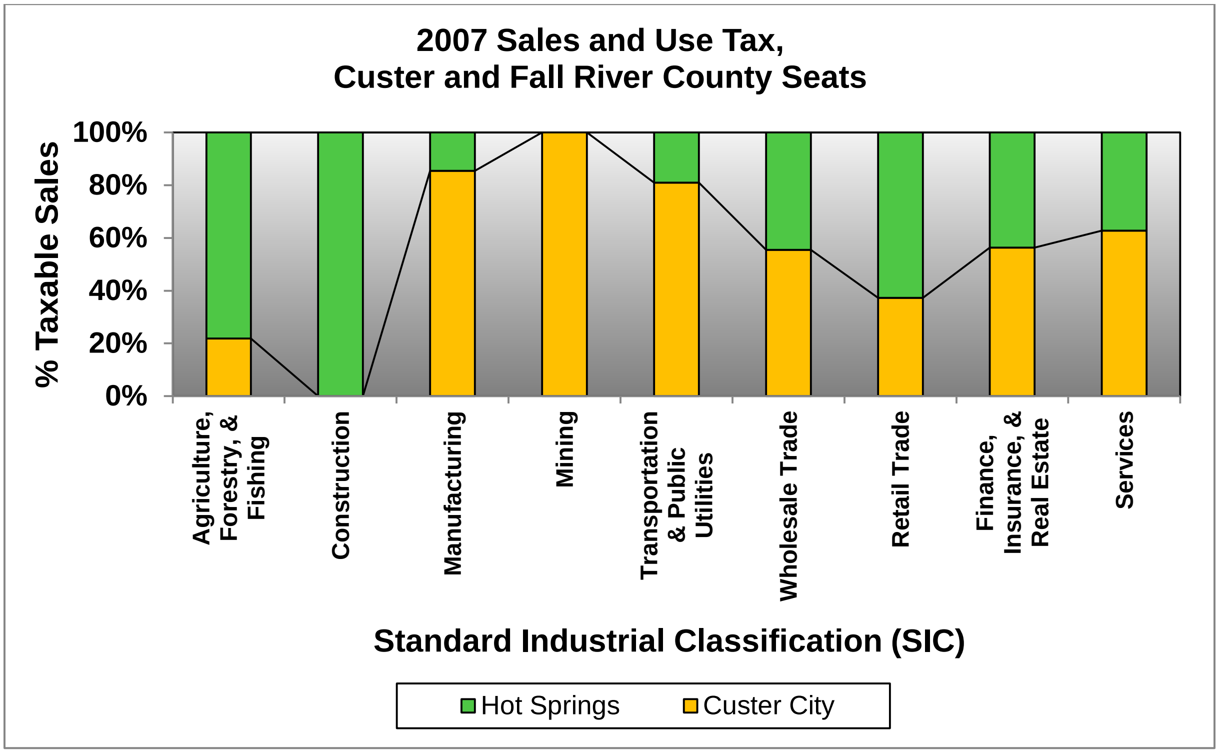


Figure 2.3-7: Sales and Use Tax for Custer and Fall River Counties, 2007

SIC categories generating the most taxable sales for Custer City in 2007 were services ($30,987,910), retail trade ($30,916,880), and transportation and public utilities ($12,340,925), accounting for 94.3 percent of the city's total sales and use tax revenue. SIC categories generating the most taxable sales for Hot Springs in 2007 were retail trade ($37,494,437), services ($12,989,107), and transportation and public utilities ($2,056,135), generating 94 percent of the city's total sales and use tax revenue.

Property tax categories include agricultural land, owner-occupied property, and other valuations (such as residential property not occupied by the owner, commercial property, and utility property). Each county is responsible for administering and collecting its own property tax system and monies, which are the primary source of funding for school systems and local government entities. Table 2.3-15 below lists the property tax base for Custer and Fall River counties in 2007, and compares them to the State-wide totals. In 2007, agricultural land accounted for only 14 percent of the property tax base in Custer County, in comparison to 24.6 percent of the property tax base in Fall River County and 24.9 percent State-wide. Owner-occupied housing accounted for 47.9 percent of Custer County's tax base, compared to

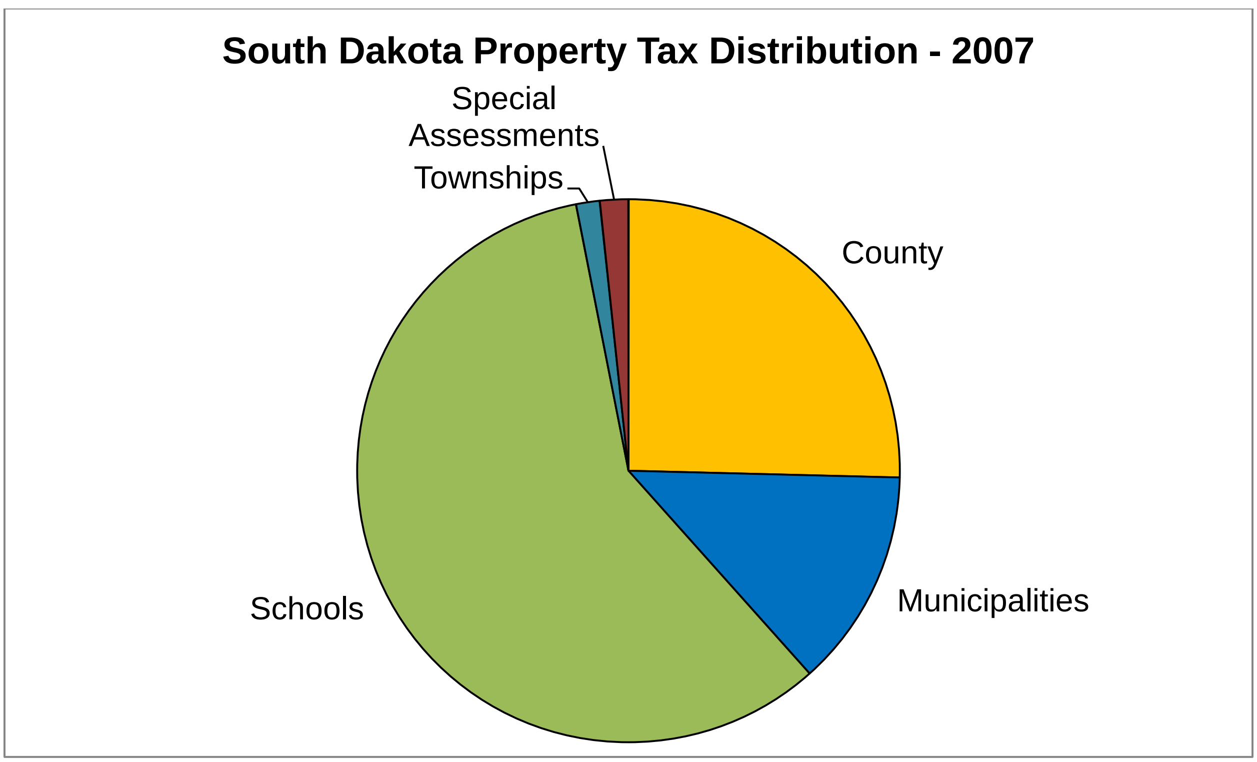
38.7 percent in Fall River County and 39.0 percent State-wide. Other valuation percentages for both counties were similar to the State-wide rate of 36.1 percent of total property taxes collected in 2007.

Table 2.3-15: Project-Area Property Tax Base - 2007

Property Tax Category	Custer County	Fall River County	South Dakota
Agricultural Real Valuation	$84,160,015	$96,691,027	$211,381,559
Owner-Occupied Real Valuation	$285,740,111	$152,274,225	$330,332,434
Other Valuation	$227,203,660	$144,165,093	$306,178,271
Total Valuation	**$597,103,786**	**$393,130,345**	**$847,892,264**

Data from South Dakota Department of Revenue and Regulation, 2007 Annual Report.

Figure 2.3-8 below shows that the majority (58.5 percent) of property taxes collected in South Dakota are used to fund local school districts. Another 38.4 percent of property tax revenue is used to fund county (25.4 percent) and municipality (13.0 percent) governments, with the remaining 3.1 percent used for funding townships and for special assessment purposes, generally for use by improvement districts for infrastructure (road, bridge, water, sewer, etc.) improvements (Goldman et al., 2001).



Data from South Dakota Department of Revenue and Regulation, 2007 Annual Report.

Figure 2.3-8: South Dakota Property Tax Distribution, 2007

South Dakota provides property tax relief for agricultural and owner-occupied property owners by using a portion of its General Fund ($120 M in 2007) to pay school taxes for these taxpayers.

2.3.3.6 Housing

Housing data was obtained from the USCB, which compiles various housing statistics from the most recent census on a state-wide or county-wide basis. Data used for this baseline study included information about the number and type of housing units, homeownership rates, and median home values. USCB also updates certain municipal data on an annual basis via the American Community Survey (ACS), including building permits issued and number of housing units present, so that this data reflects more current trends and can be used in economic forecasting. Housing data for Newcastle and Osage in Weston County, Wyoming are also provided as these locations could also serve as potential host communities for Project employees.

2.3.3.7 Dwelling Types

Census 2000 data was collected for various types of housing units, including single-family detached and attached homes, multi-unit dwellings (apartments), mobile homes, and rooms or groups of rooms designed as separate living quarters with direct occupant access. Census 2000 data is subdivided by single unit (detached and attached), specific housing unit type, the USCB does provide the information on housing units in multi-unit structures as a percentage of total housing units. Table 2.3-16 summarizes the Census 2000 housing data for the PAA, including owner-occupied (generally equivalent to for sale) and rental unit vacancy rates and seasonal/recreational/occasional use unit vacancy rates. Custer County has the highest seasonal unit vacancy rate (more than double Fall River and the two adjacent Wyoming counties), indicative of its proximity to the many recreational and scenic areas in the Black Hills.

Table 2.3-16: Proposed Action Area Housing Unit Statistics - 2000

Housing Unit Type	Custer County, SD		Fall River County, SD		Niobrara County, WY		Weston County, WY	
	Units	% of Total	Units	% of Total	Units	% of Total	Units	% of Total
Total housing units	3624	100%	3812	100%	1338	100%	3231	100%
Single family homes	2358	65.0%	2429	63.7%	1096	81.9%	2186	67.6%
Multi-unit housing	261	7.2%	568	14.9%	104	7.8%	203	6.3%
Mobile homes	990	27.3%	807	21.2%	133	9.9%	823	25.5%
Other (boat, RV, van, etc.)	15	0.4%	8	0.2%	5	0.4	19	0.6%
Rental units	615	17.0%	901	23.6%	222	16.7%	549	17.0
Owner-occupied vacancy	-	2.3%	-	4.8%	-	7.5%	-	4.8%
Rental vacancy	-	9.1%	-	9.6%	-	18.2%	-	12.0%
Seasonal / recreational / occasional use vacancy	-	10.1%	-	7.5%	-	4.7%	-	4.4%
Units lacking complete plumbing	26	0.9%	47	1.5%	17	1.7%	11	0.4%
Units lacking complete kitchen facilities	51	1.7%	49	1.6%	4	0.4%	13	0.5%
No telephone service	77	2.6%	123	3.9%	44	4.4%	113	4.3%

Data from US Census Bureau, Census 2000 Summary File 3 Dataset

At the time of the last census, the majority of residencies in all four counties were single-family owner-occupied homes on less than 10 acres of land.

Periodic estimations are made by the USCB to update the total number of housing units available within a given geography, based on building permits issued, mobile home shipments, and estimates of housing unit loss since the last census. The most recent housing unit estimation at the county level in South Dakota was in 2006; however data is not divided into housing unit types. Fall River County had an estimated 4,007 housing units in 2006 (United States Census Bureau [USCB]), an increase of 5.1 percent over Census 2000 data, although the county suffered an approximate 2 percent population decline over the same period (Section 2.2.1). In comparison, Custer County posted a 16.5 percent increase in housing units since 2000, with a total of 4,223 units in 2006. These data support economic forecasting that lists Custer County as one of South Dakota's 10 fastest-growing counties (Business Research Bureau, 2007).

The 2006 estimation data for the bordering Wyoming counties showed a much more modest increase in housing units since the last census, with an increase of 1.1 percent (15 additional units) in Niobrara County and an increase of 2.5 percent (81 additional units) in Weston County.

2.3.4 Environmental Justice

The U.S. Census 2000 Decennial Population program provides information about race and poverty for the area surrounding the ISL project. The 2000 Census data for South Dakota was used to compare the demographic data for the counties surrounding the PAA. These data were also used to determine if there was a disproportionate percentage of minorities or low-income populations that might be affected by the ISL Project relative to the State.

As shown in Table 2.3-17, minorities make up less than 7.0 and 11.0 percent of the total population for Custer and Fall River Counties, respectively, which is less than the state average of 12.0 percent. No concentration of minorities was identified to reside near the PAA, which is located in a rural area, while most of the minority population lives urban centers such as Custer City (Census Tract 9952) or Hot Springs (Census Tract 9942).

Census Tract information regarding median household incomes and poverty statistics for Custer and Fall River counties is only available from the decennial federal census. Median household income levels were $36,303 for Custer County and $29,631 for Fall River County compared with $35,282 for the State average. The two census tracts within Fall River County (9941 and 9942) are below the State average for median household income levels, but they are all well above the

2000 poverty level of $17,603 for a family of four, while the average of Custer Counties two census tracts was well above the State's average. The poverty rate in Custer County was 9.4 percent and 13.6 percent in Fall River County. Compared to the state-wide average of 13.2 percent, Fall River's poverty rate is only slightly higher, while Custer County is well below the state-wide average; therefore, there is not a disproportionate concentration of low-income populations and no concentration of minorities was identified within the study area compared to the State as a whole (USCB, 2000).

Table 2.3-17: Race and Poverty Characteristics for Areas Surrounding the Dewey-Burdock Project

	Custer County CT - 9951	Custer County CT- 9952	Custer County	Fall River County CT - 9941	Fall River County CT - 9942	Fall River County	State of South Dakota
White, non-Hispanic Population	95.0	90.8	93.4	92.4	87.5	89.3	88.0
Total Racial Minority Population	5.0	9.2	6.6	7.6	12.5	10.7	12.0
White, Hispanic Population	1.4	1.7	1.5	1.3	2.0	1.7	1.4
Native American Population	2.1	4.8	3.1	4.1	7.2	6.1	8.3
Median Household Income in 1999 dollars	$37,083	$34,837	$36,303	$31,759	$27,337	$29,631	$35,282
Percent Below Poverty Level	10.0	8.4	9.4	13.3	13.8	13.6	13.2
Total Population	4,517	2,758	7,275	2,767	4,686	7,453	754,844

Data from U.S. Census Bureau, Census 2000.

Per capita income level based on 1999 dollars was 17,945 for Custer County and $17,048 for Fall River County; these numbers are near the State average of $17,562. The median income in 2000 was $36,303 for Custer County and $29,631 Fall River compared with $35,282 for the State average, all well above the 2006 poverty level of $20,614 for a family of four members household. The poverty rate in Custer County was 9.4 percent and 13.6 percent in Fall River County. Compared to the state-wide average of 13.2 percent, Fall River's poverty rate is only slightly higher, while Custer County is well below the state-wide; therefore, there is not be a disproportionate concentration of low-income populations within the study area compared to the state as a whole.

It is possible that some low-income individuals or minorities may reside within the study area, but not disproportionately compared with the state-wide averages. Also, since the proposed project is not expected to generate any adverse environmental impacts to the area's natural resources, there will not be any disproportionate environmental consequences to minority groups or low income populations.

2.3.5 References

Bureau of Land Management, Montana/Dakotas, United States Department of the Interior, 2007 Annual Report, http://www.blm.gov/mt/st/en/info/newsroom/07annualreport.2.html, retrieved 18 March 2008, 8 pp.

Bureau of Land Management Wyoming, United States Department of the Interior, Report to the Public 2007, http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/annualreports.Par.81694.File.dat/2007anrpt.pdf, retrieved 1 April 2008, 8 pp.

Business Research Bureau, Beacom School of Business, University of South Dakota, "Population Estimates for Counties 2006" *in* South Dakota Business Review, March 2007, p 12.

Goldman, T, S. Corbett, and M. Wachs, 2001, Local Option Transportation Taxes in the United States, Appendix for South Dakota, Research Report UCB-ITS-RR-2001-3, Institute of Transportation Studies, University of California at Berkeley, http://www.its.berkeley.edu/research/localoptiontax/southdakota.pdf, retrieved 12 March 2008.

Labor Market Information Center, South Dakota Department of Labor, "Is There a Shortage of Dentists in South Dakota?" *in* South Dakota e-Labor Bulletin, June, 2007, http://www.state.sd.us/dol/lmic/lbartJune07dentists.htm, retrieved 16 March 2008.

Mortgage Bankers Association, September 30, 2007, National Delinquency Survey, Third Quarter 2007 Special Summary Report, 5 pp.

Office of Agricultural Policy, South Dakota Department of Agriculture, Agricultural Statistics, Custer and Fall River Counties, http://www.state.sd.us/doa/Ag%20Policy/zoning.htm, retrieved 17 March 2008.

Office of Air, Rail and Transport, South Dakota Department of Transportation, Official South Dakota Rail Map, February 2006, http://www.sddot.com/fpa/railroad/images/railmap.pdf, retrieved on 16 March 2008.

Office of Schools and Public Lands, 2007 Annual Report, http://www.sdpubliclands.com/facts/FY07AnnualReport.pdfhttp://www.sdpubliclands.com/facts/FY07AnnualReport.pdf, retrieved on 17 March 2008, 28 pp.

South Dakota Department of Environment and Natural Resources, Press Release, March 2007, http://www.state.sd.us/denr/dfta/informationservices/PressReleases/PR2007/march07.htm, retrieved 16 March 2008.

South Dakota Department of Revenue and Regulation, January 9, 2008, South Dakota Sales and Use Tax Report, Returns Filed: Calendar Year 2007, 114 pp., http://www.state.sd.us/drr2/businesstax/statistics/2007/statistics/cy/CY07CityDivision-CountybyCitybyMG.pdf, retrieved 10 March 2008.

South Dakota Department of Revenue and Regulation, 2007 Annual Report, 44 pp., http://www.state.sd.us/drr2/publications/annrpt/07_annual_report.pdf, retrieved 11 March 2008.

South Dakota Housing Authority, South Dakota Housing Update, Winter 2008, http://www.sdhda.org/Main/winter%2008.pdf, 5 pp, retrieved 27 February 2008.

Sperling's Best Places, http://www.bestplaces.net/Default.aspx, retrieved 16 March 2008.

United States Census Bureau, American Community Survey, 2006, http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=ACS&_submenuId=population_0&_lang=en&_ts=, retrieved 28 February 2008.

United States Census Bureau, Decennial Census, 2000, http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=DEC&_submenuId=datasets_2&_lang=en&_ts=,. Retrieved 28 February 2008.

United States Bureau of Land Management, Visual Resource Inventory Manual H-4810-1, http://www.blm.gov/nstc/VRM/8410.html#Top, retrieved 22 February 2008.

University of South Dakota, Business Research Bureau, South Dakota Regional Economic Analysis Project, SD-REAP: Graphic Trend Analysis: Custer and Fall River County Populations, 1969 – 2005, http://www.pnreap.org/PNREAP.Report, retrieved 19 February 2008.

Wyoming, Field Office, United States Department of Agriculture, Wyoming Agricultural Statistics 2006, http://www.nass.usda.gov/Statistics_by_State/Wyoming/Publications/Annual_Statistical_Bulletin/bulletin2006.pdf, retrieved 31 March 2008.

2.4 Historic, Scenic and Cultural Resources

2.4.1 Historic Archeological, and Cultural Resources

A Level III Cultural Resources Evaluation was conducted for the PAA. Personnel from the Archaeology Laboratory, Augustana College (Augustana), Sioux Falls, South Dakota, conducted on-the-ground field investigations between April 17 and August 3, 2007 (Appendix 2.4-A).

Augustana documented 161 previously unrecorded archaeological sites and revisited 29 previously recorded sites within the PAA 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 non relocated sites were previously documented as either prehistoric isolated finds or diffuse prehistoric artifact scatters.

Prehistoric sites account for approximately 87 percent of the total number of sites recorded. Historic sites comprise approximately five percent of total sites recorded, while multi-component sites (pre-historic/historic) comprise the remaining eight percent. Ten of the sites documented have only prehistoric and historic components.

The small number of Euro American sites documented was not unanticipated given the peripheral nature of the PAA in relation to the Black Hills proper. The disparity existing between the number of historic and prehistoric sites observed in the PAA 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 regards to the number of documented sites, and is typical of the periphery of the Black Hills.

The high density of sites observed in the PAA, 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 PAA is erosional in nature, leading to many sites being heavily deflated. The extent 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 PAA. 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 site 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].

Protection by way of avoidance of archaeological sites was maintained during the exploration phase of the project, and site avoidance is the continued goal during development and operations. Where required, sites in the area of production activity will be flagged and/or fenced and personnel will be made aware of their presence. In the event that a new site is discovered, the site will be protected and the state archaeologist will be notified. Powertech (USA) has been working closely with the state of South Dakota's Archaeological Research Center, and will

continue to do so throughout the life of this project. A Memorandum of Agreement has been executed between Powertech (USA) and the State Archaeologist (Appendix 2.4-B).

2.4.2 Visual and Scenic Resources

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) is an attempt to assess and classify landscapes in order to properly manage their visual and scenic resources (BLM, 1984).

2.4.2.1 Visual Resource Management Classes

In order to determine the VRM class of the landscape within the PAA and the surrounding 2 km area were rated in accordance with the U.S. BLM Manual 8400 – Visual Resource Management. The visual resource inventory classes are used to develop visual resource management 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.com.

- 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 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 2.4-1, provided by the BLM, was used to determine the visual resource inventory class.

Table 2.4-1: 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						

* 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

2.4.2.2 Visual Resource Management Rating

In order to determine the scenic quality rating of the PAA and the surrounding 2 km 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 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 2.4-2 and Table 2.4-3.

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.

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.

Table 2.4-2: Scenic Quality Inventory and Evaluation of the SQRU 001 for the Proposed Action 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 dirt road and railway and grazing activities	**0**
	Total Score	**11**

Table 2.4-3: Scenic Quality Inventory and Evaluation of the SQRU 002 for the Proposed Action 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 dirt road and railway and grazing activities	**0**
	Total Score	**13**

According to NUREG-1569, if the visual resource evaluation rating is 19 or less, no special management is required (NRC, 2003). Based on the visual resource inventory conducted in June 2008, the total score of the two Scenic Quality Rating Units within the PAA were 11 and 13; therefore, no further evaluation of the existing scenic resources or future changes to the scenic resources of the area due to the proposed project will be required.

2.4.3 References

United States Department of Interior (USDOI), Bureau of Land Management (BLM), "*Manual 8400 – Visual Resource Management 1984*", [Web Page] <http://www.blm.gov/nstc/VRM/8400.html> Accessed June 9, 2008.

United States Department of Interior (USDOI), Bureau of Land Management (BLM), "*Manual H-8410-1 - Visual Resource Inventory 1986*", [Web Page] <http://www.blm.gov/nstc/VRM/8410.html> Accessed June 9, 2008.

U.S. Nuclear Regulatory Commission, NUREG-1569, "*Standard Review Plan for In-Situ Leach Uranium Extraction License Application*", 2003.

2.5 Meteorology

2.5.1 Introduction

The proposed project 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 PAA 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 at approximately the center of the PAA, in accordance with NUREG-1569, 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.

Along with the site weather station, data compiled from several sites surrounding the project area (listed in Table 2.5-1 and shown in Figure 2.5-12) 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, heating, and cooling degree days. The site that best represents the long-term precipitation and temperature of the project area is the Edgemont site, which is the closest in proximity and elevation to the project area. The Newcastle WRC 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).

Table 2.5-1: 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 WRC	IML[(c)]	104.21	43.85	4,333	2002-2011

Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008; IML, 2011
(a) National Climatic Data Center.
(b) South Dakota State University Climate Web site.
(c) IML, compliance monitoring results.

2.5.2 Regional Overview

To determine whether the period of data collection (July 18, 2007 to July 17, 2008) was representative of long-term meteorological conditions, weather data from the Newcastle WRC meteorological station for the same period was compared to data collected at the Newcastle WRC site over the long term (2002 through 2010).

IML Air Science (IML) in Sheridan, Wyoming, operates a meteorological station in Newcastle, Wyoming, which generated more than nine years (2002 through May 2011 at the time of this writing) of hourly meteorological data. The Newcastle WRC site is approximately 30 miles north-northwest of the Dewey-Burdock project area and provides a better comparison to the project area than the Chadron NWS site, which is the nearest NWS station to the project area, in terms of elevation, surrounding topography and proximity to the southwestern flank of the Black Hills.

The Newcastle WRC site is used to supplement the ambient air quality compliance demonstration. The station meets the requirements of Ambient Air Monitoring Guidelines for the Prevention of Significant Deterioration (EPA, 1987). Table 2.5-1a identifies the instruments and associated specifications at this station.

The specifications in Table 2.5-1a meet or exceed the requirements set forth in Regulatory Guide 3.63, Section C3. All instruments are audited for accuracy on a semiannual basis. Representative audit reports, spanning the baseline monitoring period for the Dewey-Burdock Project, are attached as Appendix 2.5-A. Data recovery for all parameters at the Newcastle WRC site exceeded 96% for both long-term (2002 through 2010) and concurrent-year (7/18/2007 to 7/17/2008) periods. The parameters analyzed were temperature, wind speed, wind direction (sigma theta), and relative humidity.

Table 2.5-1b summarizes the one-year and nine-year averages for the Newcastle WRC site alongside the one-year average at the Dewey-Burdock project area. This table shows that average wind speeds and fluctuations in wind direction (sigma theta) at the Newcastle WRC site were comparable for the two periods of record. Wind speeds averaged slightly higher at the Dewey-Burdock project area, with temperatures slightly lower and relative humidity slightly higher (a consequence of the lower temperatures). The similarities drawn between the two sites are not intended to imply equivalence. Rather, they are meant to suggest that the prominent meteorological forces affecting regional weather patterns exert themselves at both sites. If this case can be made, then year-to-year variations at one site may imply parallel, temporal variations at the other site. A comprehensive discussion of wind patterns at the Newcastle WRC site is presented in Section 2.5.2.4 and Appendix 2.5-A.

Table 2.5-1a: Newcastle WRC MET Station Equipment List

Parameter	Instrument	Range	Accuracy	Threshold	Instrument Height
Wind Speed	RM Young 05305 Wind Monitor AQ	0 to 112 mph	±0.4 mph or 1% of reading	0.9 mph	10 meters
Wind Direction	RM Young 05305 Wind Monitor AQ	0 to 360º	±3º	1.0 mph	10 meters
Temperature	Fenwal Electronics 107 Temperature Probe	-25º to 50º C	±0.2º C @ 0 - 60º C, ±0.4º C @ -35º C	--	2 meters
Precipitation	Met One Tipping Bucket	0 to 12 inches	±0.5% @ 0.5 in/hr rate	0.01 inch	1 meter
Barometric Pressure	Campbell Scientific - 105	600 – 1060 millibar	±0.5 mb @ 20º C	--	2 meters
Relative Humidity	CS 500-L Temp/RH probe	0 – 100% -40º to 60ºC	±3% RH 10% to 90%	--	2 meters
Data Logger	CS CR510	--	--	--	--

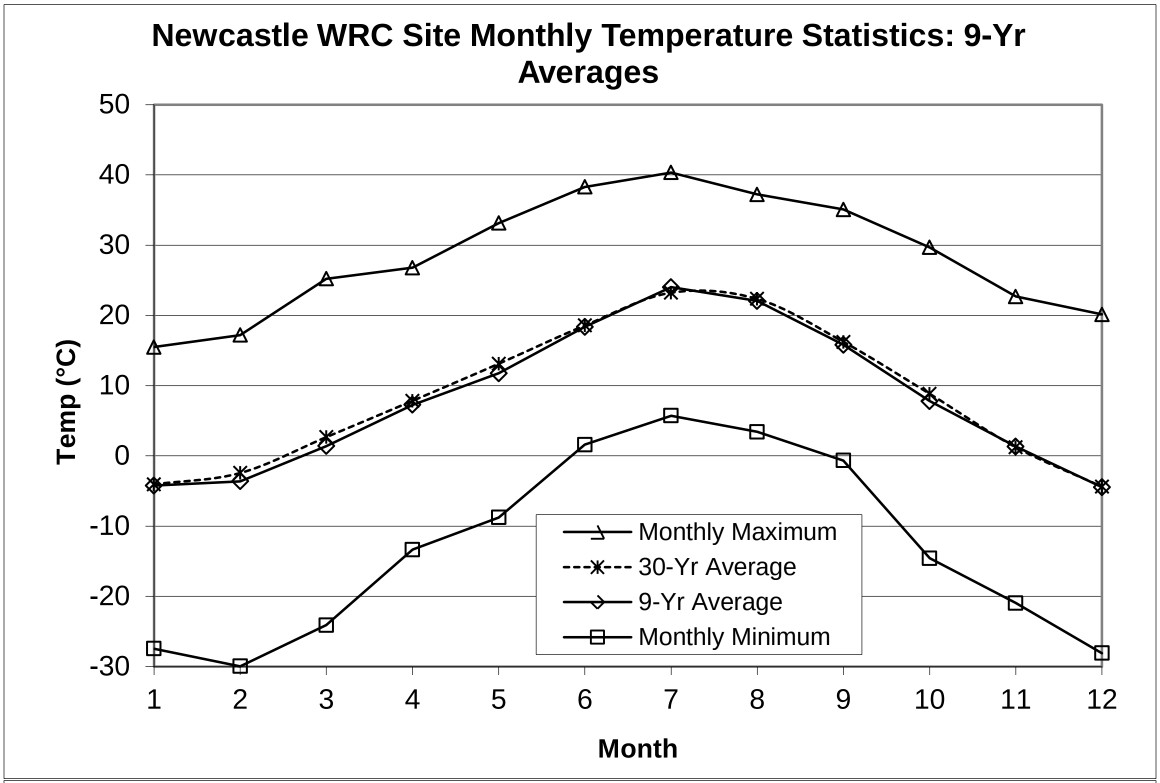
Source: IML, 2011

Table 2.5-1b: Regional (Newcastle WRC) vs. On-Site Meteorology

Parameter	Newcastle WRC 9-Year Average	Newcastle WRC 1-Year Average	Dewey-Burdock 1-Year Average
Wind Speed (mph)	6.8	7.0	8.7
Sigma Theta (º)	19.3	19.6	18.7
Temperature (ºF)	47.0	51.9	45.5
Relative Humidity (%)	58.1	55.3	60.9

The average daily temperature over the baseline monitoring year at the Newcastle WRC site was 51.9°F, which is slightly warmer than the 9-year average (historical) daily temperature of 47.2°F. Figure 2.5-1 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 9-year graph also includes 30-year average temperatures for Newcastle, obtained from the Western Regional Climate Center, demonstrating the 9-year average temperatures at the Newcastle 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 WRC site over the baseline monitoring year was 7.0 miles per hour (mph), very close to the 9-year historical average of 6.8 mph. Figure 2.5-2 compares the monthly average and maximum wind speeds for the short and long-term periods.



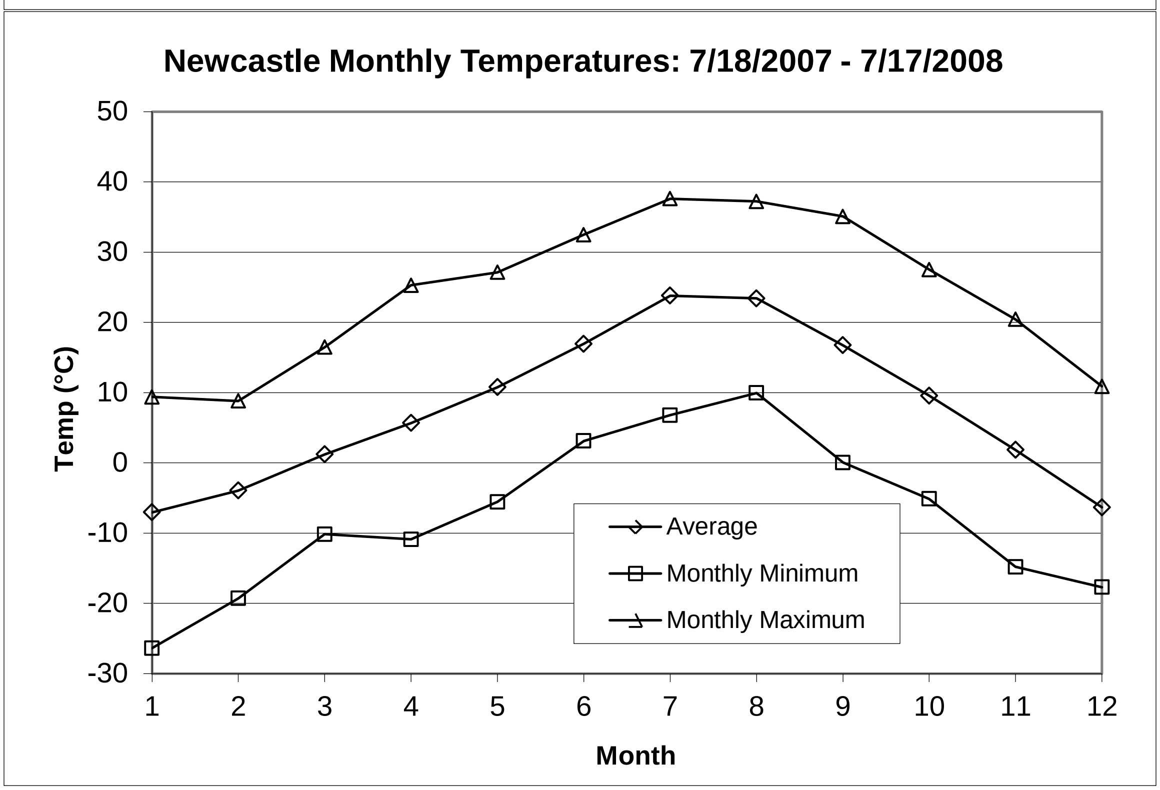
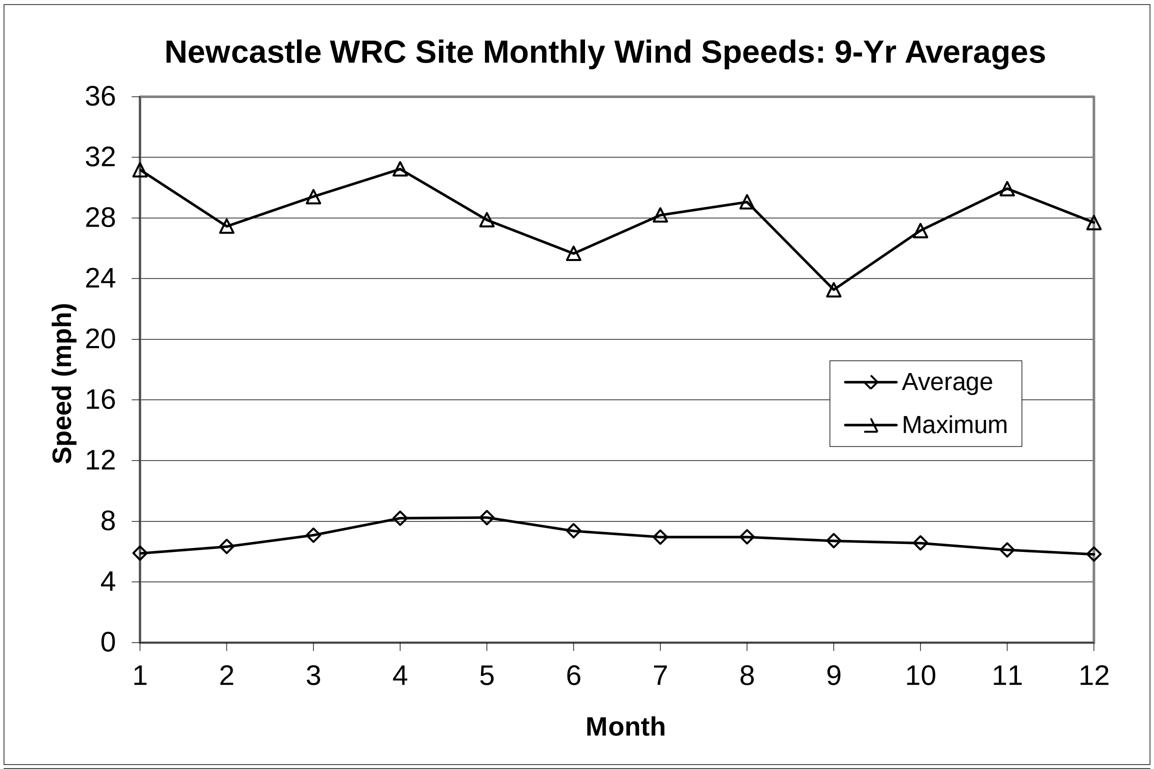


Figure 2.5-1: 1-yr and 9-yr Temperatures at the Newcastle WRC Site



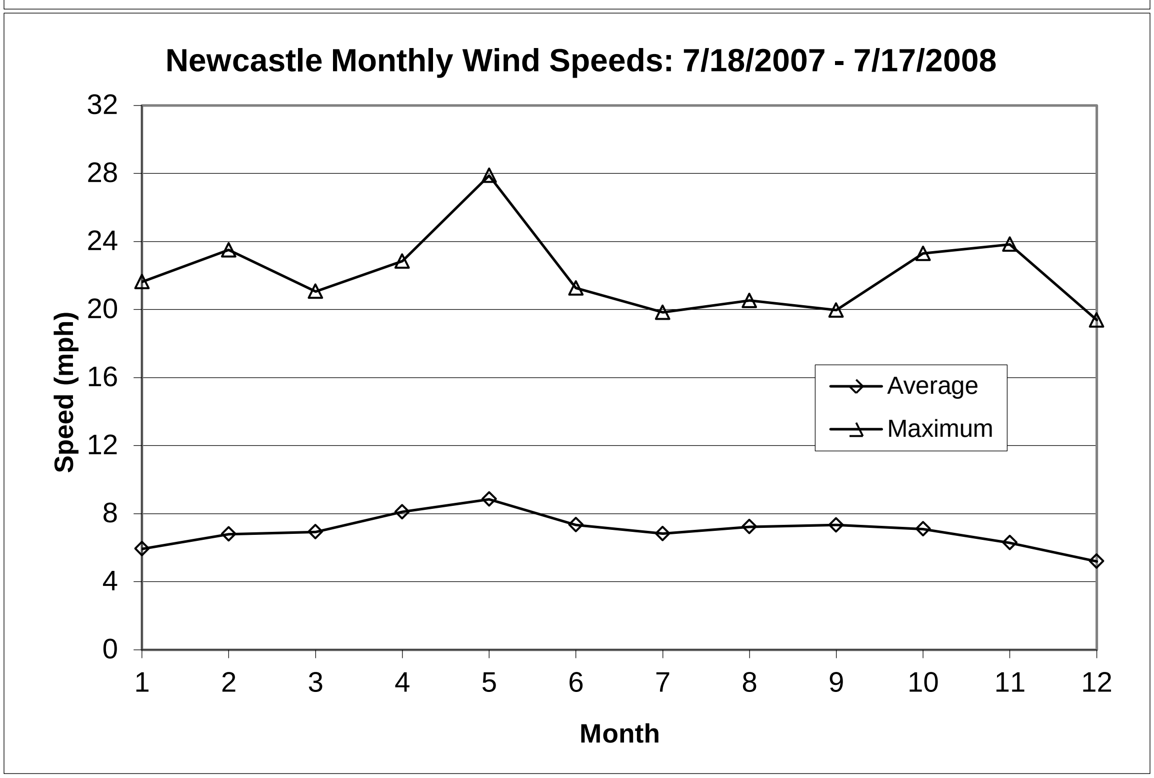
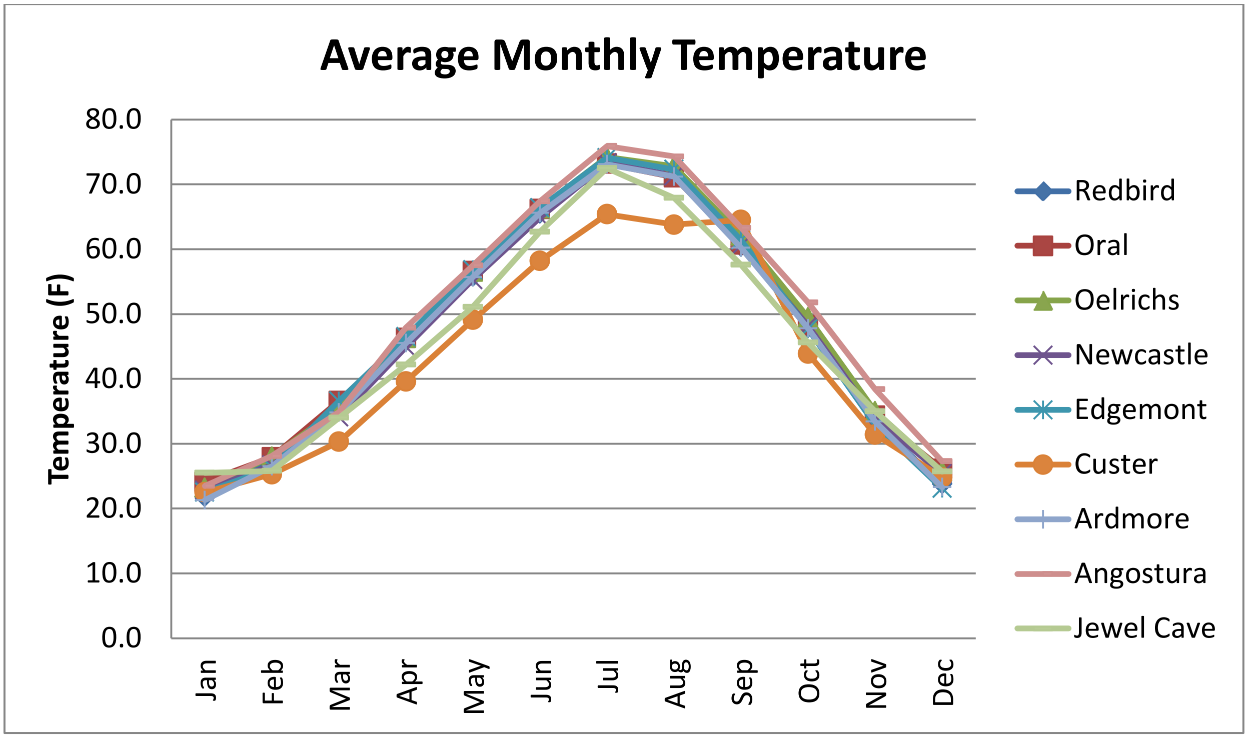


Figure 2.5-2: 1-yr and 9-yr Wind Speeds at the Newcastle WRC Site

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).

2.5.2.1 Temperature

Long-term temperature statistics were also obtained from regional NWS sites. The annual average temperature in this region is 46.7°F. Figure 2.5-3 and Table 2.5-2 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.



Source: High Plains Regional Climate Center, 2008, South Dakota State University, 2008

Figure 2.5-3: Average Monthly Temperatures for Regional Sites

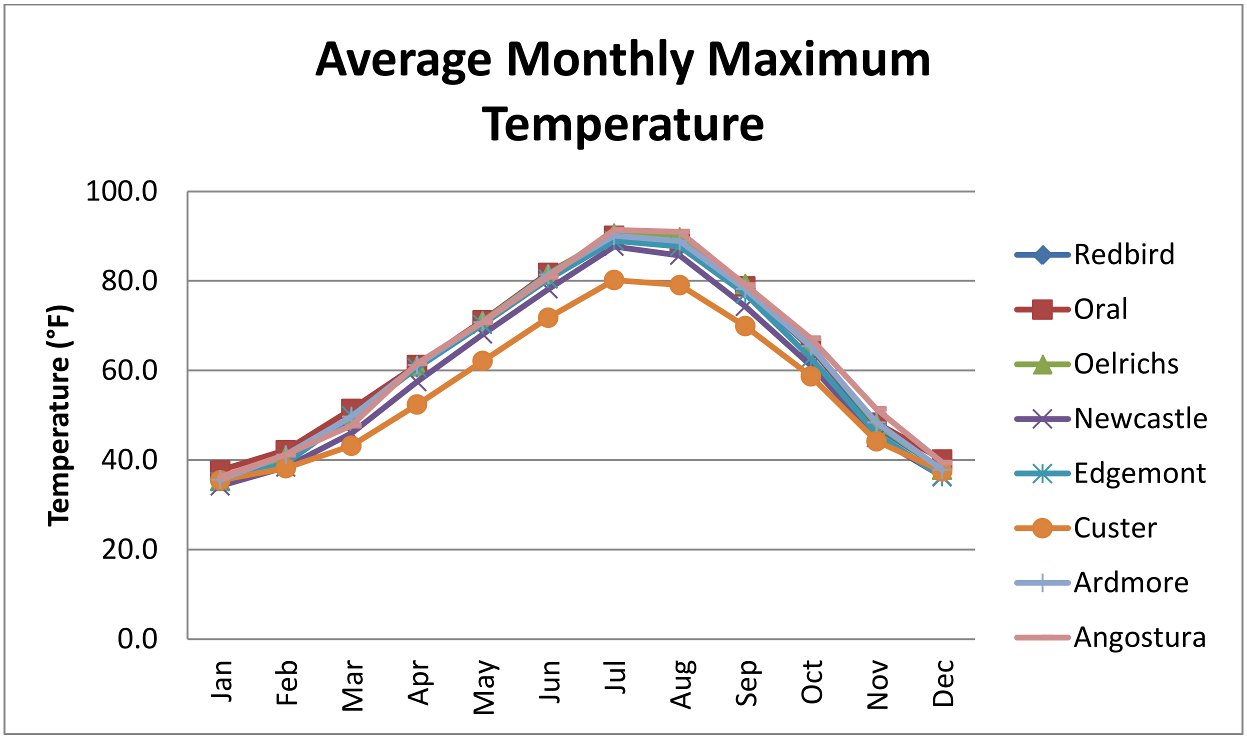
POWERTECH (USA) INC.

Table 2.5-2: Average Monthly, Annual, and Seasonal 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

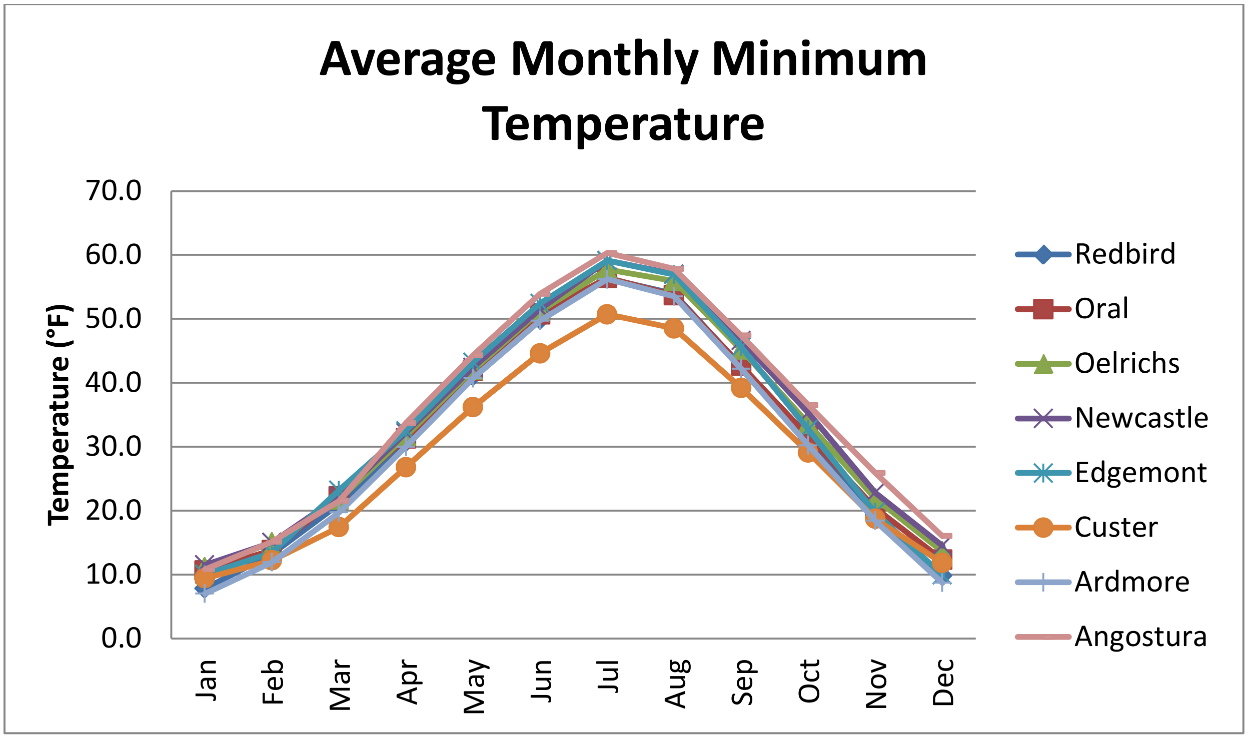
Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

Figures 2.5-4 and 2.5-5 show the average 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 2.5-3 and 2.5-4. The highest average monthly maximum temperatures in the region usually fall during the month of July (88.3°F). The lowest average monthly minimum temperatures can be found in January with a regional average of 10.4°F.



Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

Figure 2.5-4: Average Monthly Maximum Temperatures for Regional Sites



Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

Figure 2.5-5: Average Monthly Minimum Temperatures for Regional Sites

Table 2.5-3: 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

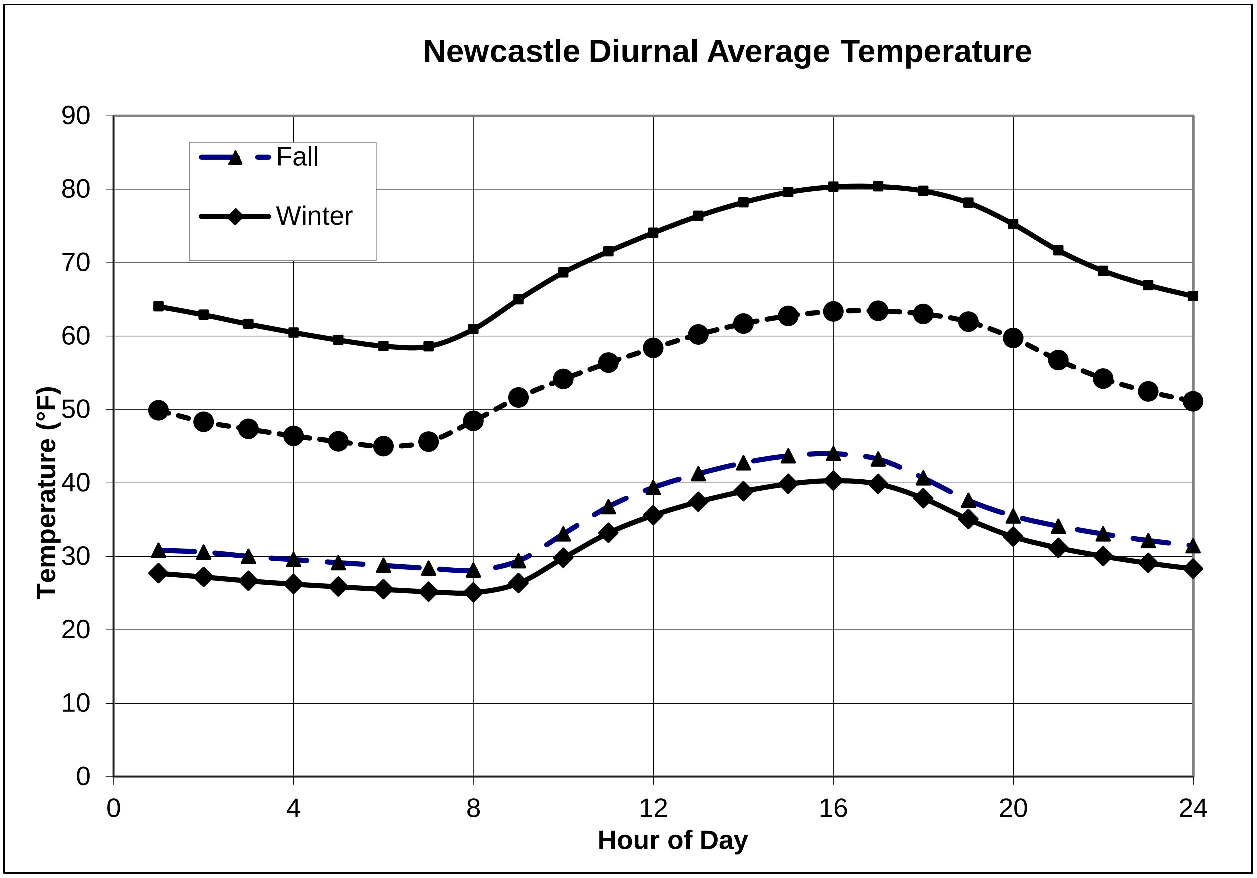
Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

Table 2.5-4: 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: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

Figure 2.5-6 displays diurnal temperature variations by season for the Newcastle WRC site from 2002 through 2010. The figure shows large variations in average diurnal temperatures, especially during the summer months.

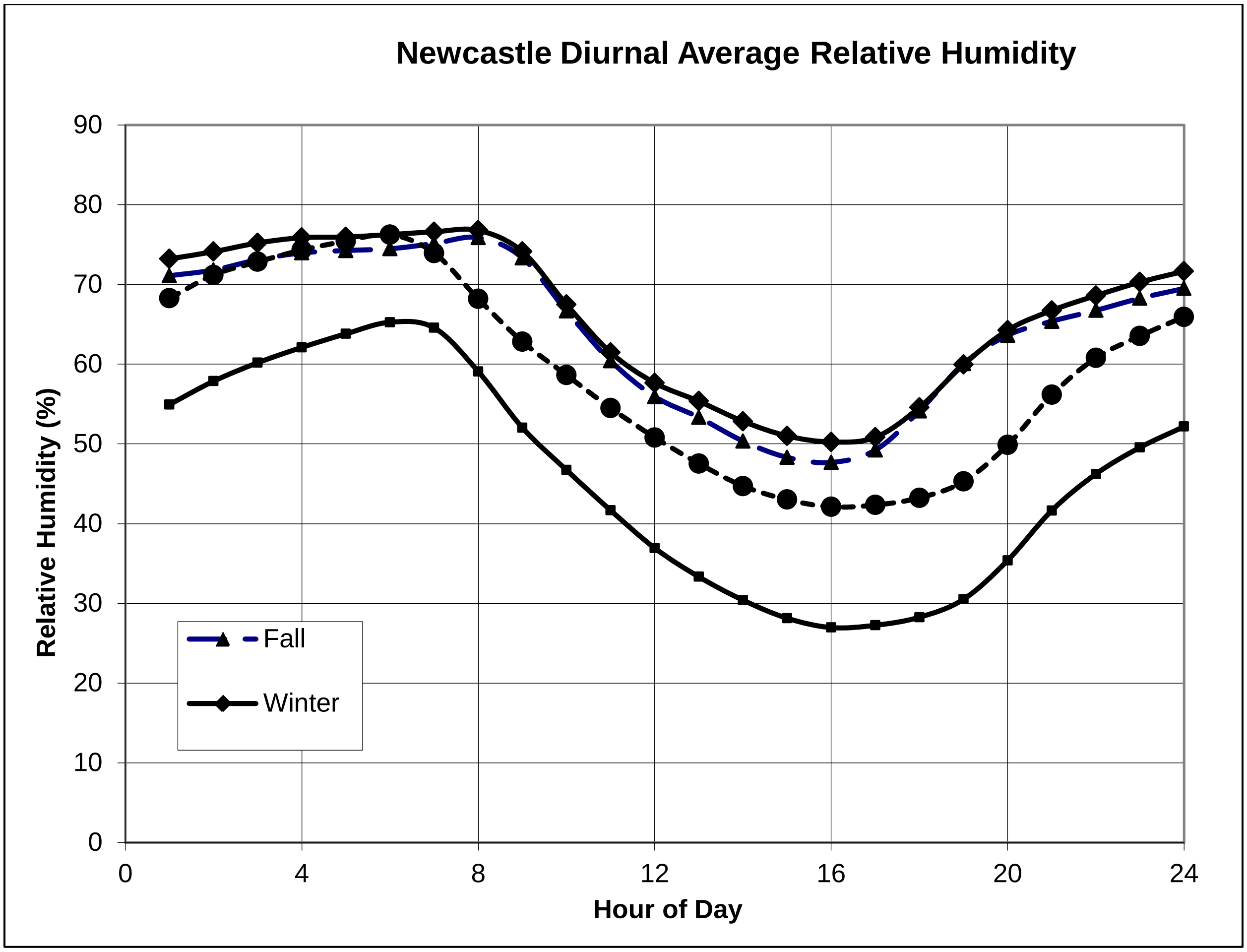


Source: IML, 2011

Figure 2.5-6: Newcastle WRC Site Seasonal Diurnal Temperature Variations

2.5.2.2 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 2.5-7 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.



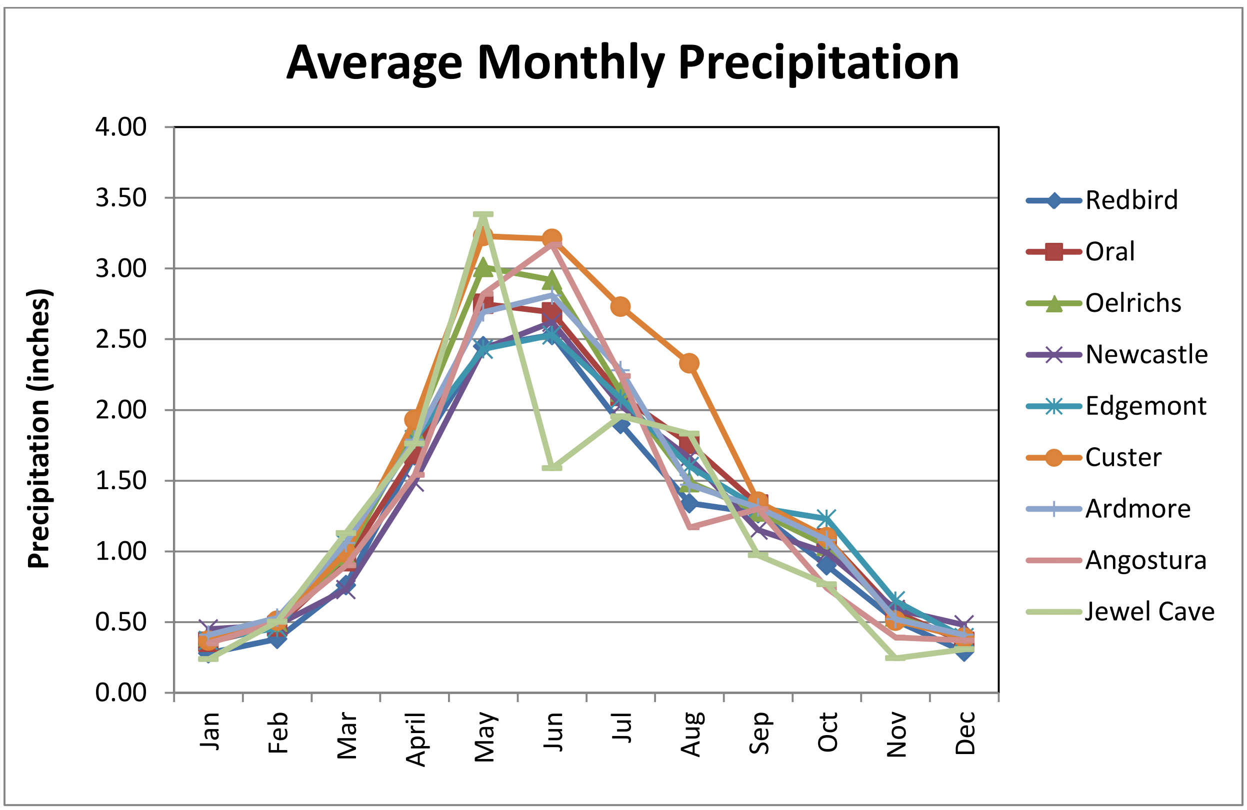
Source: IML, 2011

Figure 2.5-7: Newcastle WRC Site Seasonal Diurnal Relative Humidity Variations

2.5.2.3 Precipitation

Figure 2.5-10 and Table 2.5-5 show average monthly and seasonal precipitation amounts for all of the regional NWS sites. This area can be very dry at times with a regional annual average precipitation of 16.5 inches. Most of the precipitation accumulates 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.

Figure 2.5-10a shows average monthly precipitation at the Newcastle NWS Coop site for the past 30 years. For comparison, Figure 2.5-10b 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.



Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

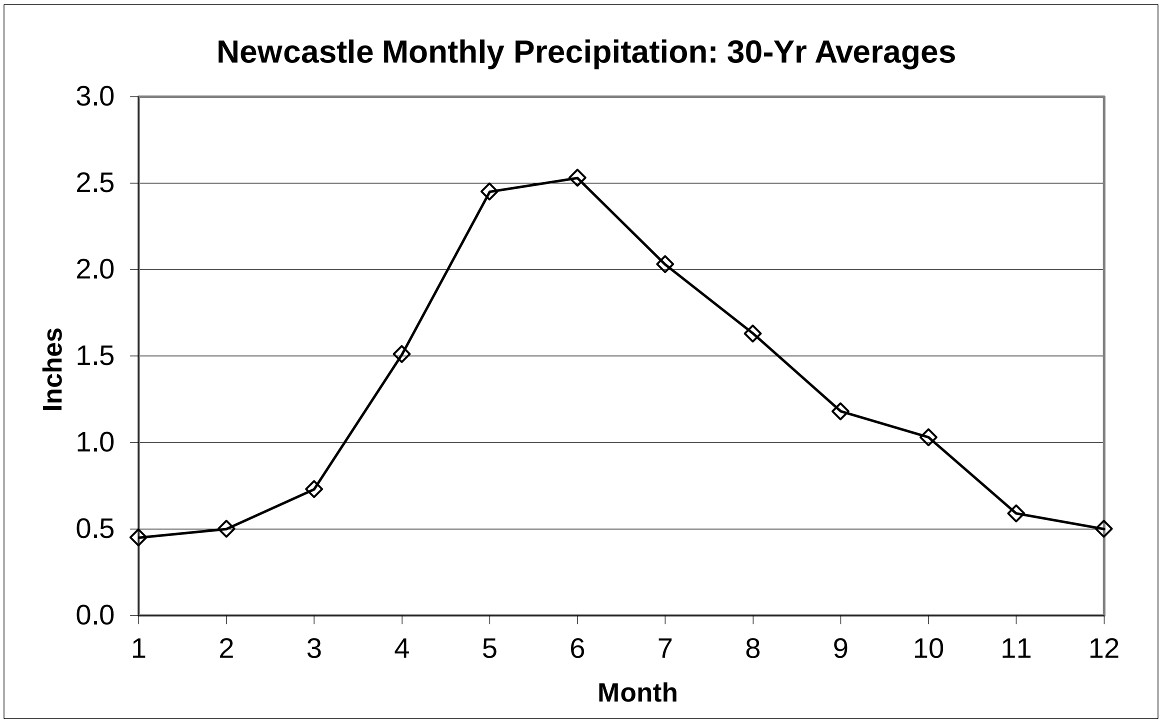
Figure 2.5-10: Average Monthly Precipitation for Regional Sites

Table 2.5-5: 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

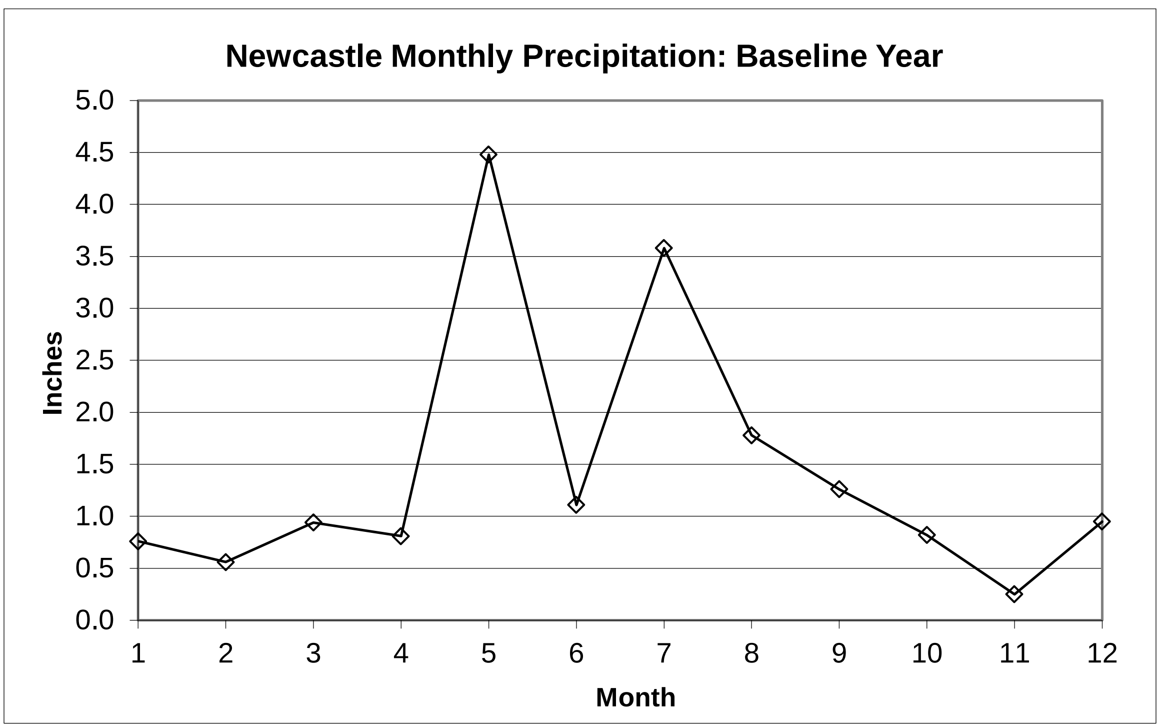
Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

This region receives an average of 38 inches of snowfall each year. As shown in Figure 2.5-11, most snowfall accumulates 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 2.5-12).



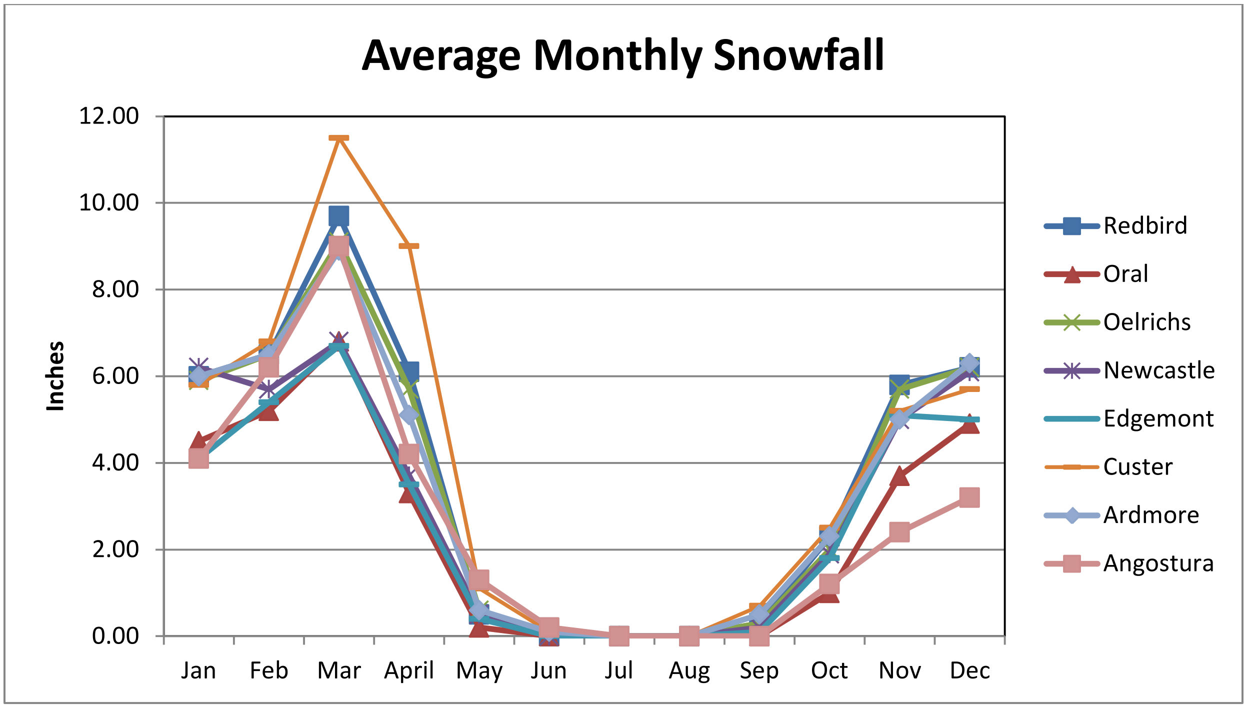
Source: Western Regional Climate Center, 2011

Figure 2.5-10a: Average Monthly Precipitation for Newcastle



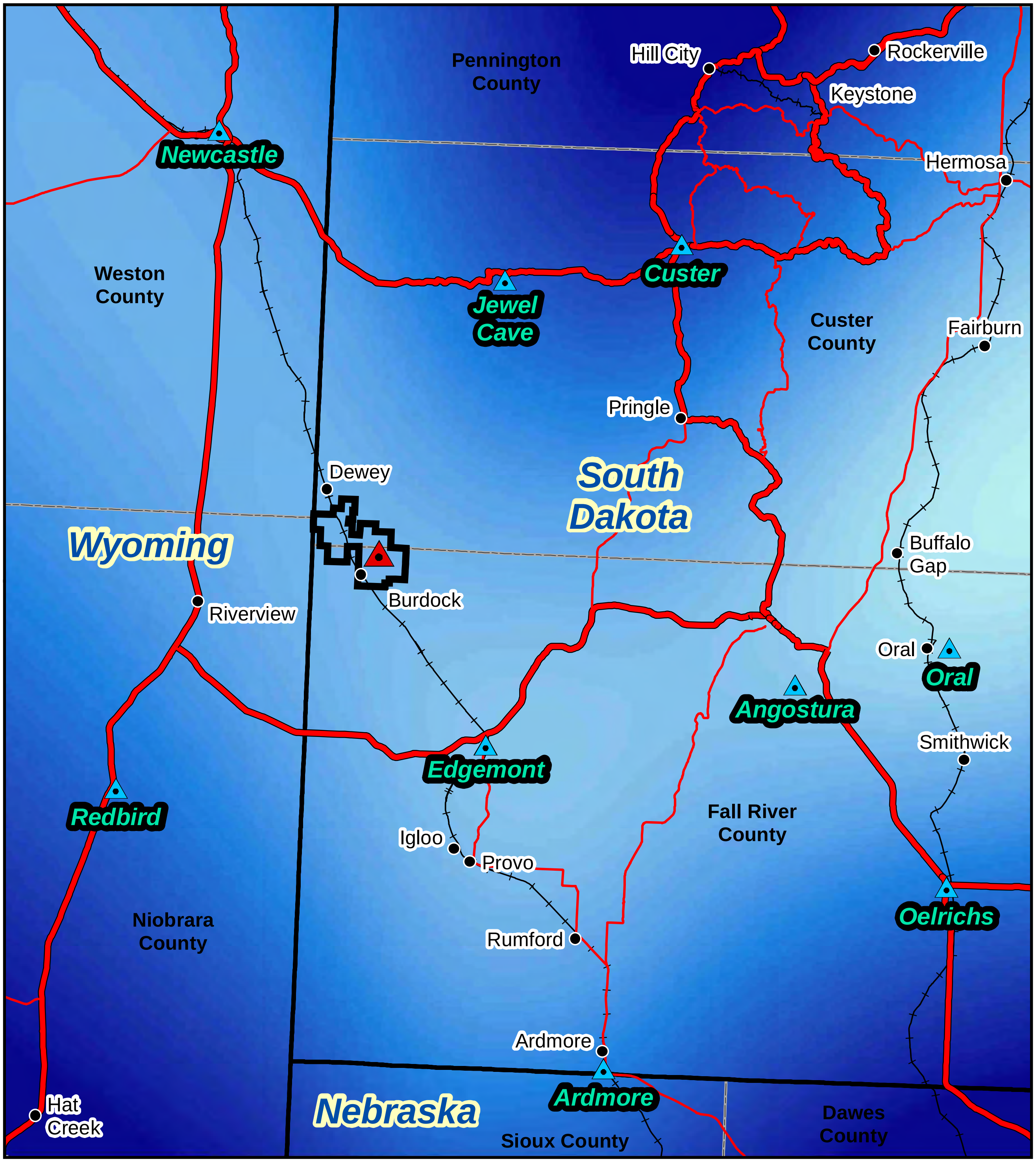
Source: Western Regional Climate Center, 2011

Figure 2.5-10b: Baseline Year Monthly Precipitation for Newcastle



Source: South Dakota State University, 2008

Figure 2.5-11: Average Monthly Snowfall at Regional Sites



Source: High Plains Regional Climate Center, 2008, South Dakota State University, 2008

Miles: 0, 5, 10, 20
Kilometers: 0, 10, 20, 30

N

Legend

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

Transportation

- US Highway
- State Highway
- Railroad

Snowfall (Inches)

High : 61.0755

Low : 27.3016

Figure 2.5-12

Average Annual Snowfall

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	17-Jun-2013
FILENAME	AnnualSnowfall.mxd

POWERTECH (USA) INC.

2.5.2.4 Wind Patterns

As described in Section 2.5.2, Powertech determined that the Newcastle WRC site is more representative of the project area than the Chadron NWS site. Although the Chadron NWS site represents the closest NWS station with hourly wind data, it was eliminated from consideration since it is more than 60 miles from the project area and the wind patterns are substantially different (refer to Figure 2.5-20), which shows comparative wind roses for the Newcastle, Dewey-Burdock, and Chadron weather stations. Instead, the Newcastle WRC site was chosen due to its proximity (approximately 30 miles away) and similar elevation, surrounding topography and proximity to the southwestern flank of the Black Hills. The meteorological instruments at the Newcastle WRC site meet or exceed both NWS and NRC standards (refer to Table 2.5-1a).

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 MILDOS-AREA modeling as well as air quality monitoring locations. While the Newcastle WRC site is not strictly representative of the Dewey-Burdock project area, 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.

Figure 2.5-13 shows wind roses at the Newcastle WRC site for the nine full years of monitoring and for the one year corresponding to the Dewey-Burdock baseline monitoring period. Figure 2.5-14 presents a graphical comparison of short and long-term wind direction distributions. Both figures demonstrate qualitatively that the period from 7/18/2007 to 7/17/2008 is representative of the longer term.

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 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 (Appendix 2.5-E).

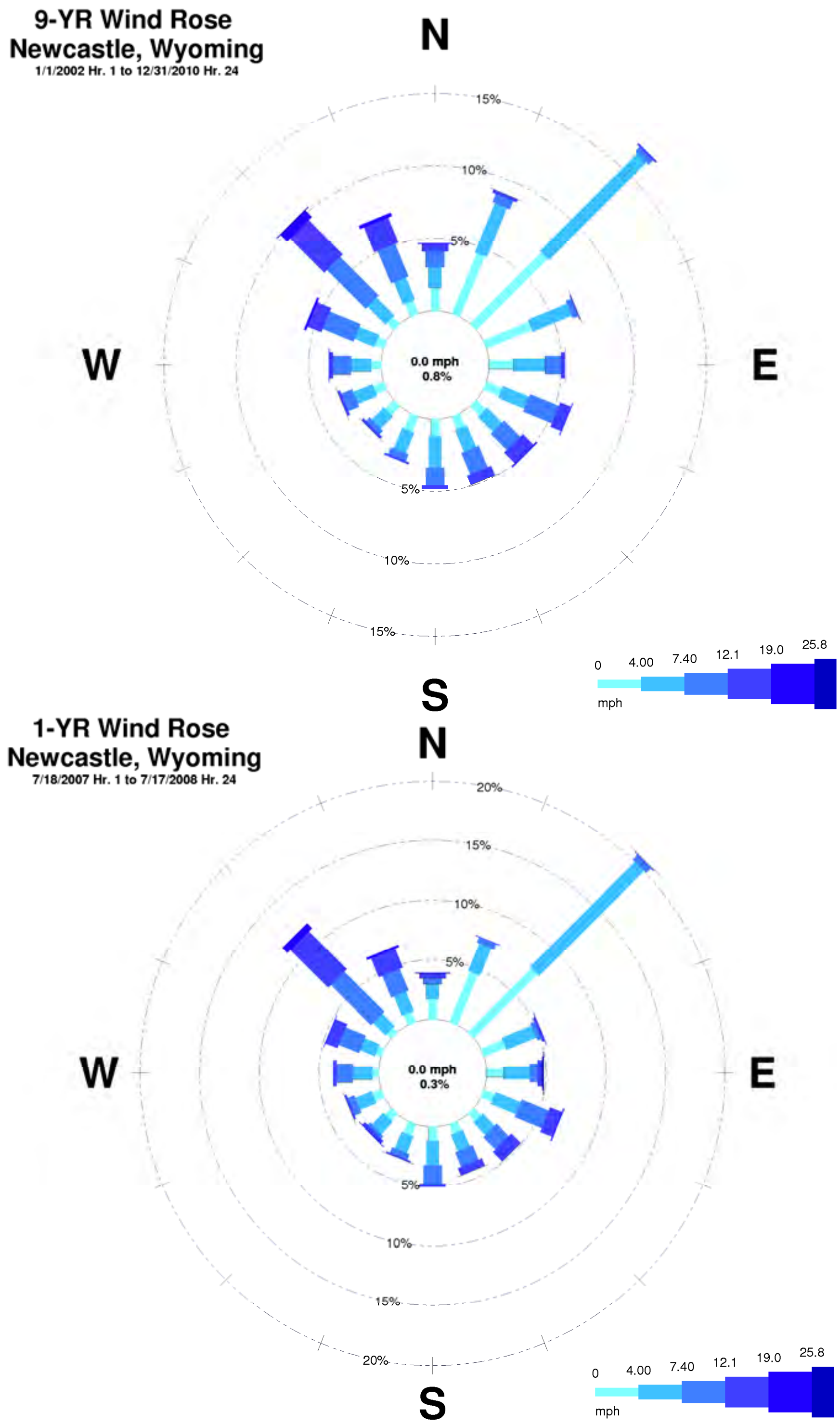


Figure 2.5-13: Newcastle WRC Site 9-Year and 1-Year Wind Roses

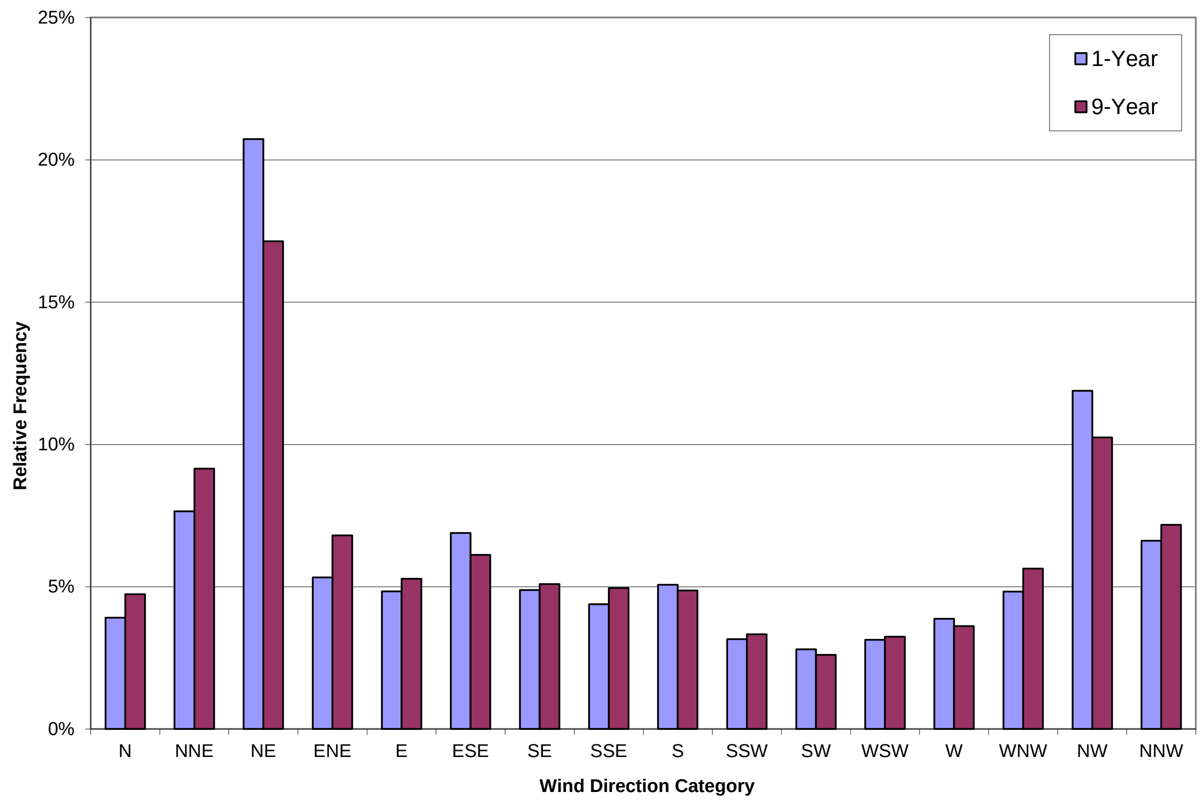
For the joint frequency wind distribution used in the MILDOS-AREA model, wind speeds are divided into six classifications ranging from mild (0 – 3 mph) to strong (> 24 mph). Likewise, wind directions are divided into 16 categories corresponding to the compass directions illustrated in Figure 2.5-14.

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 one-year and nine-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 2.5-15 presents the correlation for the wind speed distributions at the Newcastle WRC site. Each point represents one of the six wind speed classes. The x-coordinate corresponds to the percent of the one-year period during which the wind speed fell in a given class, while the y-coordinate corresponds to the percent of the nine-year period during which the wind speed fell in that same class.

The regression line (red) in Figure 2.5-15 represents the least-squares fit to the six data points. The corresponding R^2 value of 0.994 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 2.5-16 presents this correlation at the Newcastle WRC site. Each point represents one of the 16 wind direction categories. The x-coordinate corresponds to the percent of the one-year period during which the wind blew from a given direction, while the y-coordinate corresponds to the percent of the nine-year period during which the wind blew from that same direction.



Source: IML, 2011

Figure 2.5-14: Newcastle WRC Site Short vs. Long-Term Wind Direction Distribution

The regression line (red) in Figure 2.5-16 represents the least-squares fit to the 16 data points. The corresponding R^2 value of 0.954 implies very strong linear correlation. The linear slope of 0.78 further implies that short and long-term wind direction frequencies are similar.

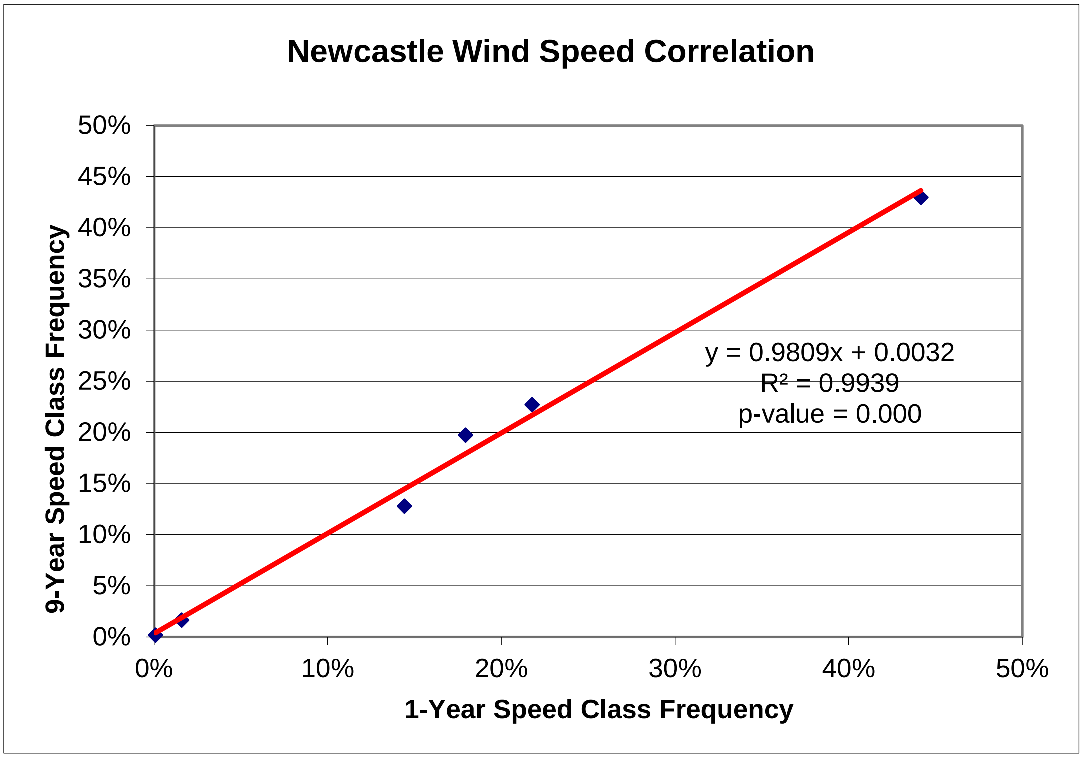
Figures 2.5-15 through 2.5-16 offer conclusive evidence that the 2007-2008 baseline monitoring year adequately represents the last nine years at the Newcastle WRC site. Since the one-year wind data serve as reliable predictors of the long-term wind conditions at the Newcastle WRC site, and since the Dewey-Burdock project area experiences similar regional weather patterns, it is concluded that the one-year baseline monitoring represents long-term meteorological conditions at the Dewey-Burdock project area.

This same methodology can be used to determine whether or not the Newcastle WRC site weather data are strictly representative of the Dewey-Burdock project area. Figure 2.5-17 compares the wind direction distributions for the baseline monitoring year at the two sites.

With an R^2 of 0.052, Figure 2.5-17 indicates little or no correlation of wind direction frequencies 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 Dewey-Burdock and 20.7% of the winds at the Newcastle WRC site. This difference may stem from local topographic effects. The Newcastle WRC site 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 2.5-18 shows the long-term wind rose for the Newcastle WRC site 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 2.5-13, presumably due to the absence of down-slope convection breezes. It is reasonable to assume that the Dewey-Burdock project area, situated several miles farther from the mountains than Newcastle, would not experience the same degree of diurnal convection breezes.

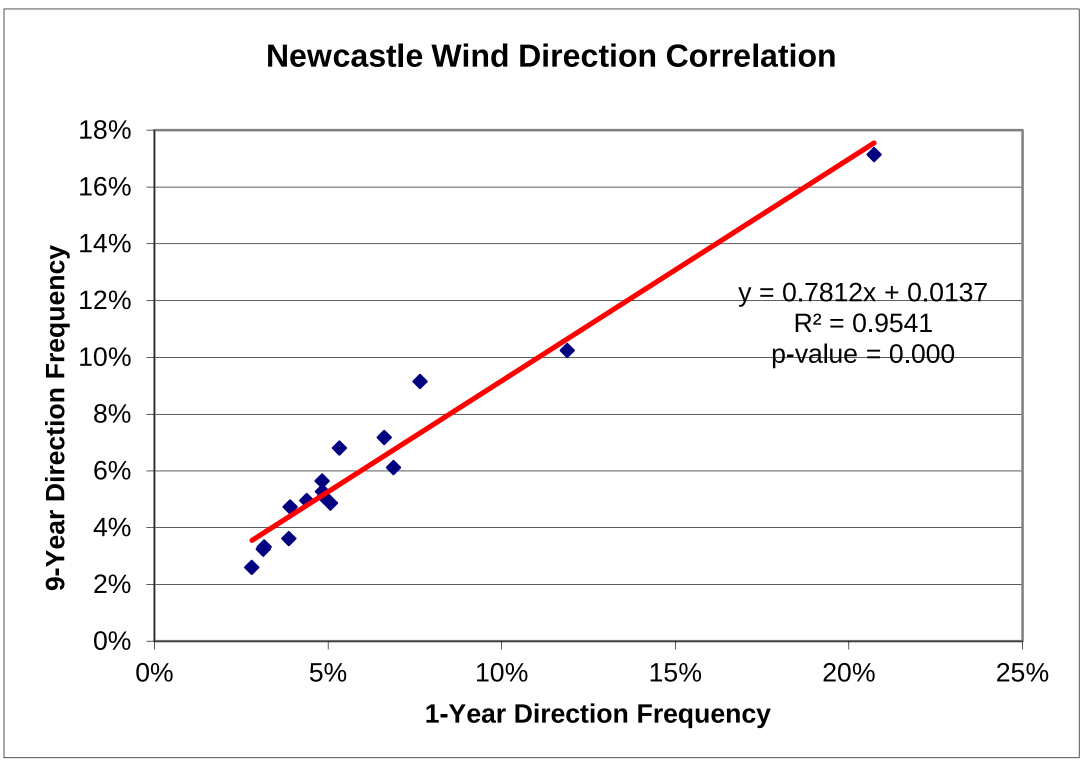
If the NE component is removed from each frequency distribution, a mild correlation between the two sites emerges. Figure 2.5-19 presents the same regression analysis as Figure 2.5-17, except with the NE outlier removed. While the much higher R^2 value of 0.60 still suggests no more than a weak correlation, it supports the premise that both sites are influenced by similar regional weather patterns. Appendix 2.5-E presents the results of another study showing that in northeastern Wyoming, spatial variations in wind patterns (attributable to local topography) far exceed temporal variations (attributable to synoptic weather systems from year to year). Hence, the conclusion that using the baseline year to represent long-term conditions is valid at either the Newcastle or the Dewey-Burdock project area, but not between the two sites.

Figure 2.5-20 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.



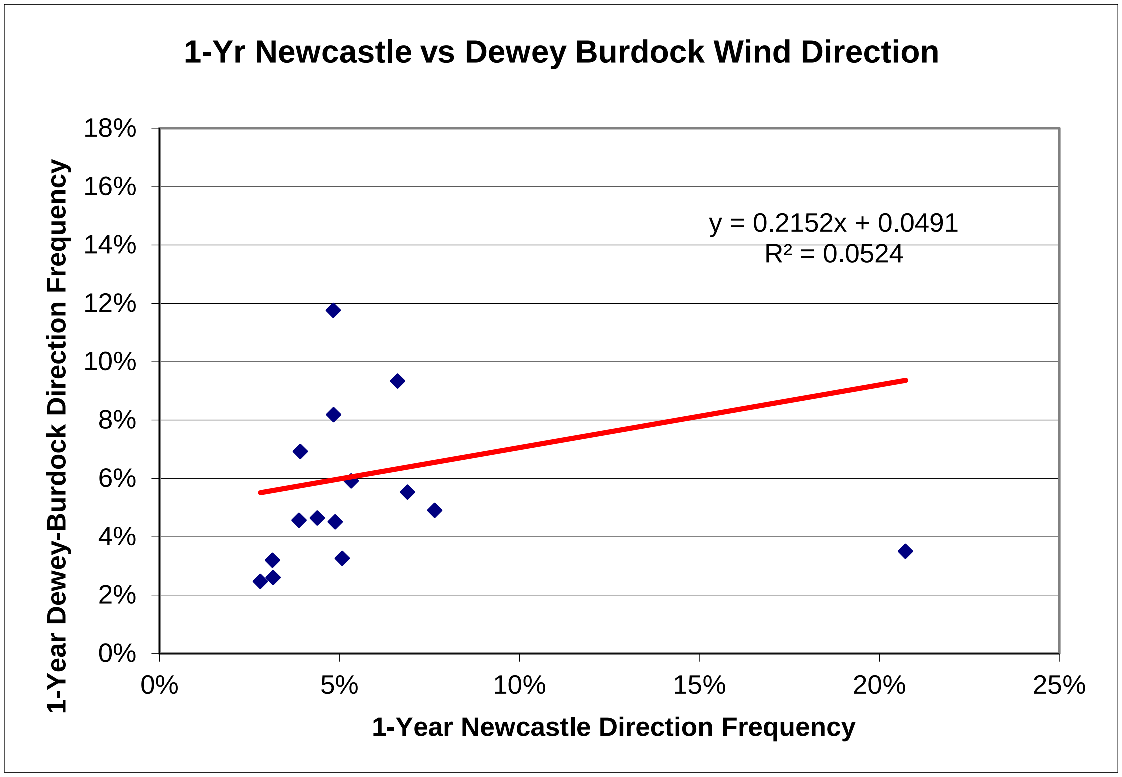
Source: IML, 2011

Figure 2.5-15: Newcastle WRC Site Wind Speed Correlation



Source: IML, 2011

Figure 2.5-16: Newcastle WRC Site Wind Direction Correlation



Source: IML, 2011

Figure 2.5-17: 1-Year Newcastle vs. Dewey-Burdock Wind Direction

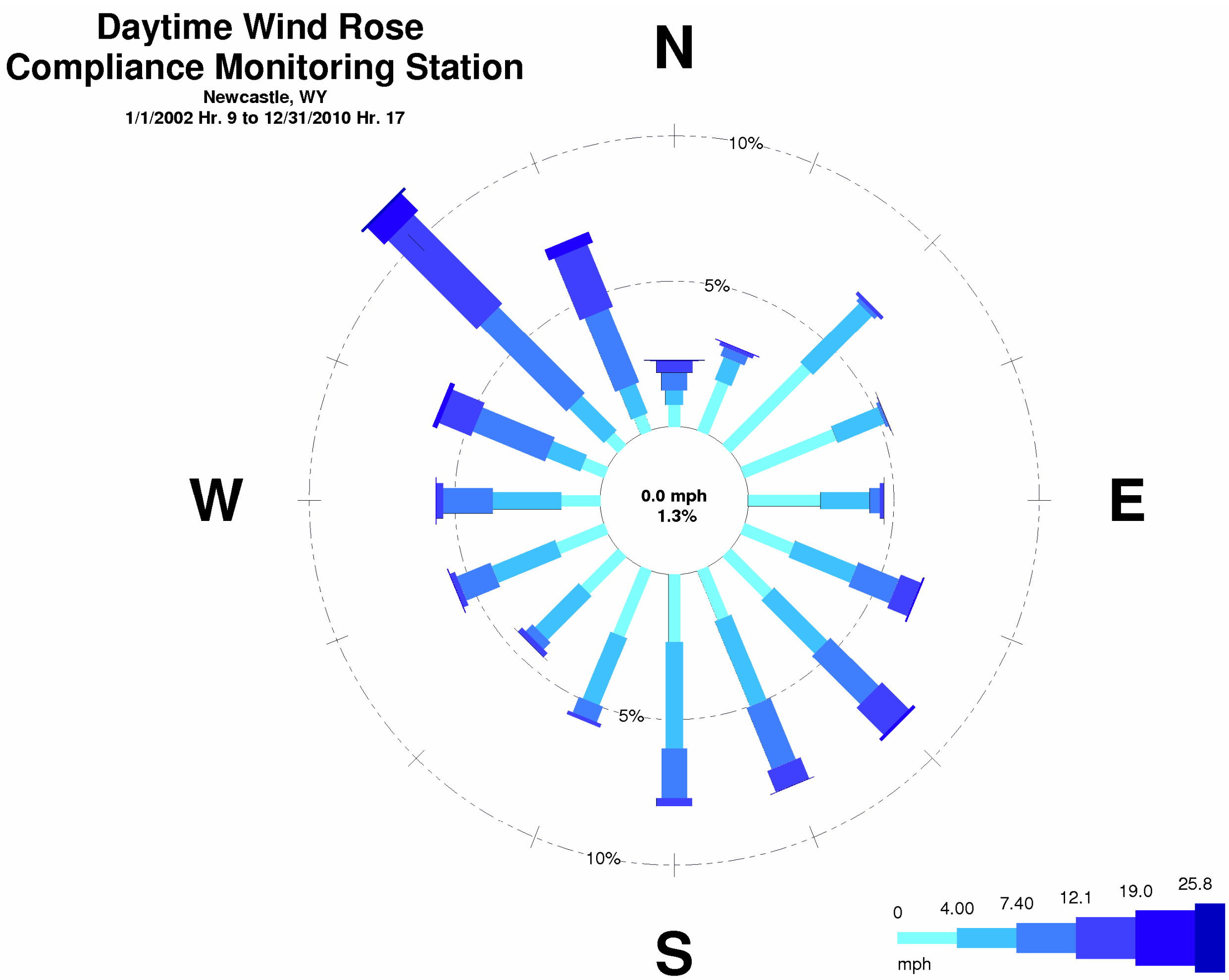
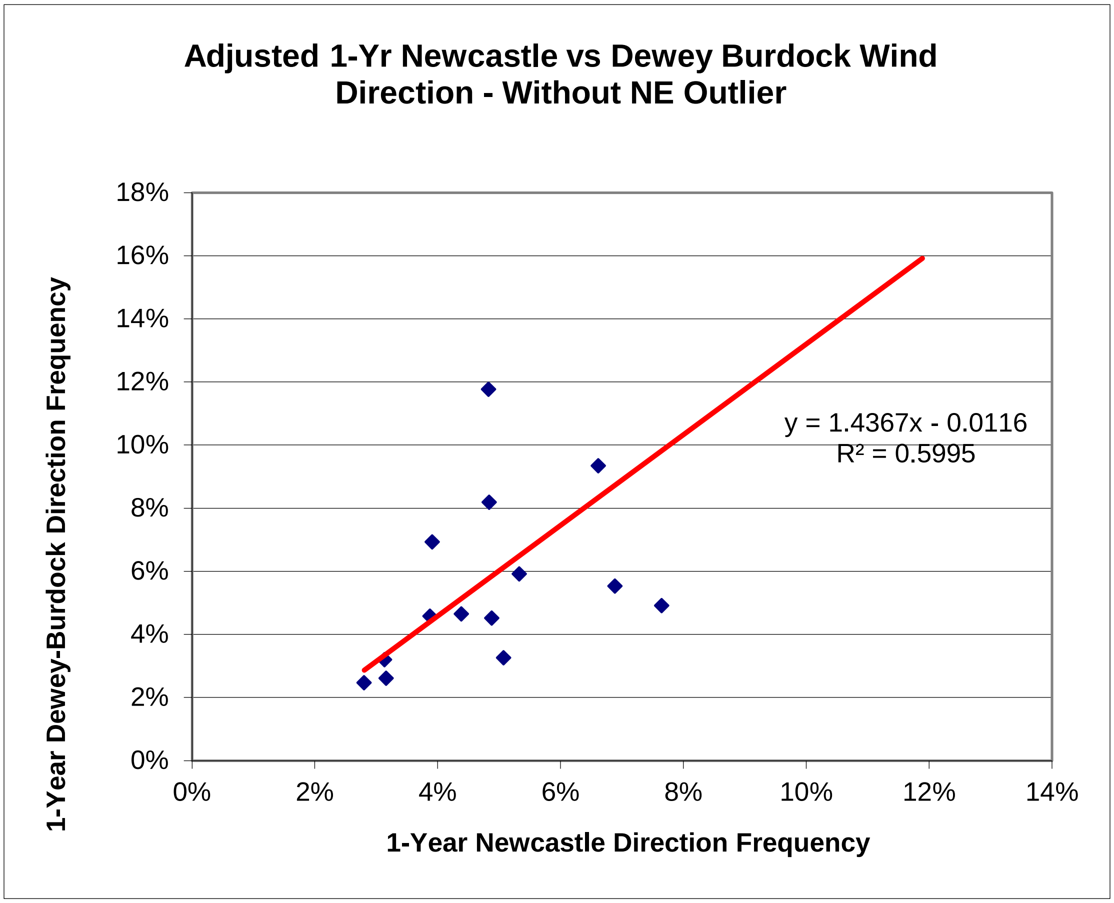


Figure 2.5-18: Daytime Wind Rose at the Newcastle WRC Site



Source: IML, 2011

Figure 2.5-19: Adjusted 1-Year Newcastle WRC Site vs. Dewey-Burdock Wind Direction – Without NE Outlier

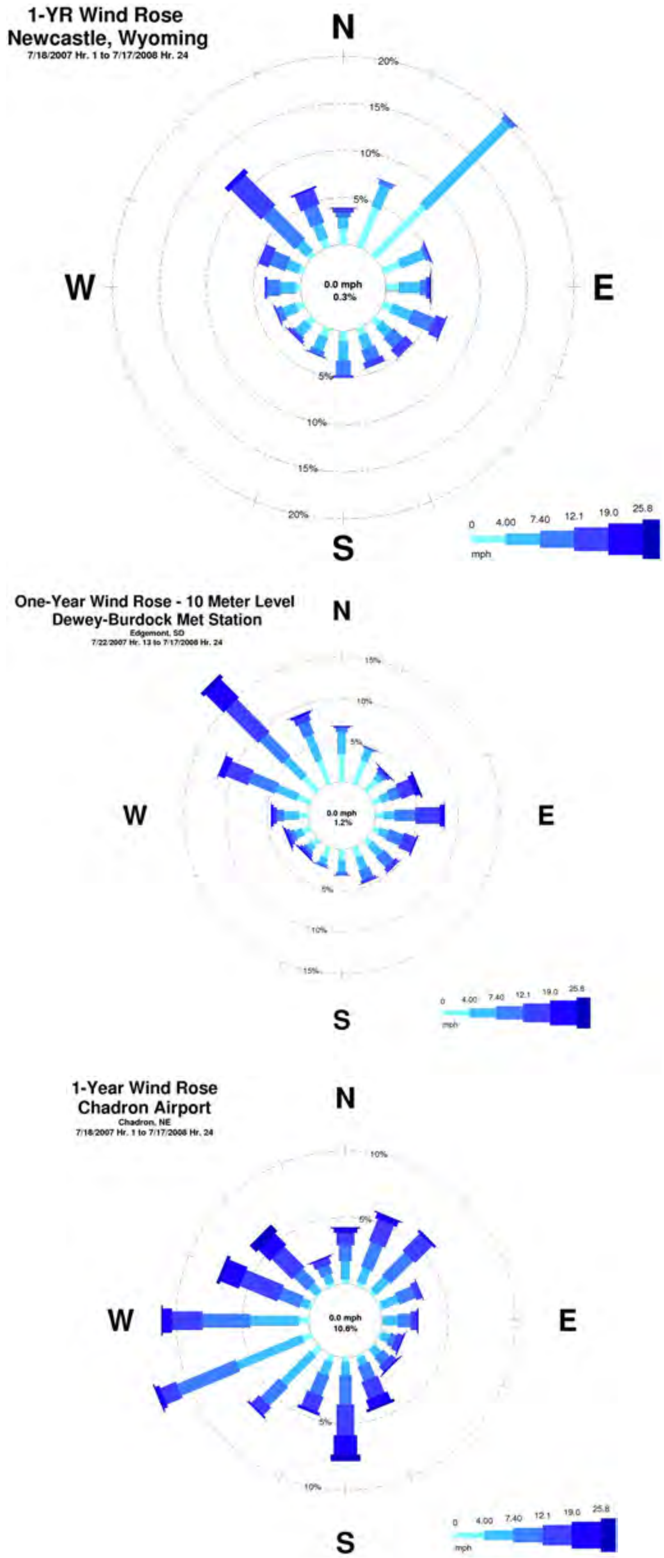
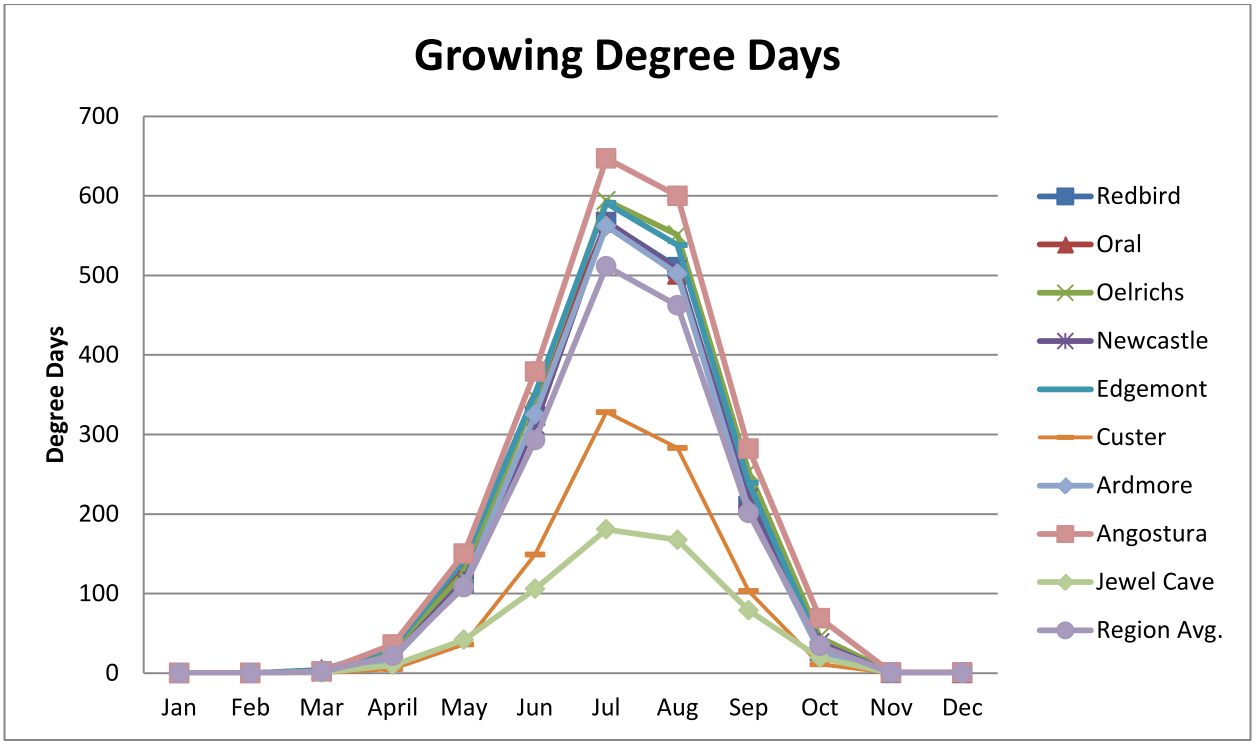


Figure 2.5-20: Comparative 1-Year Wind Roses

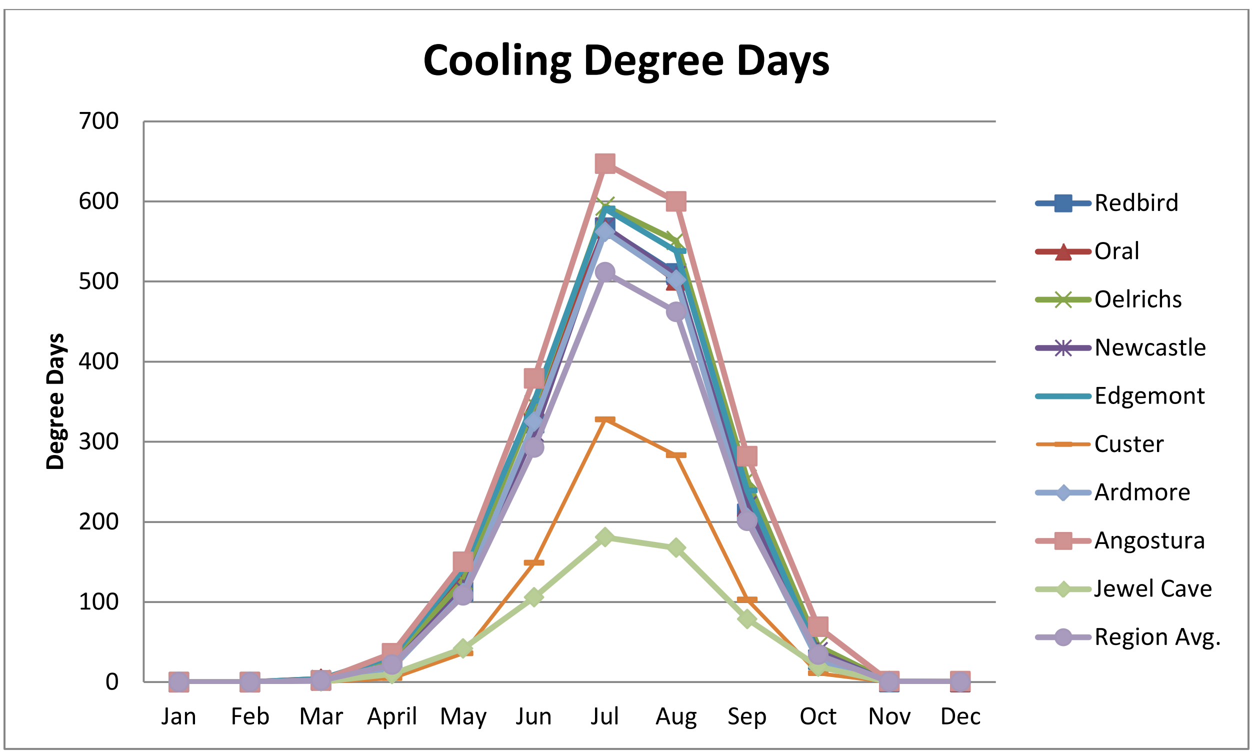
2.5.2.5 Cooling, Heating and Growing Degree Days

The graphs shown in Figures 2.5-21, 2.5-22, and 2.5-23 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, which is likely caused by the higher relative elevation of these two sites.



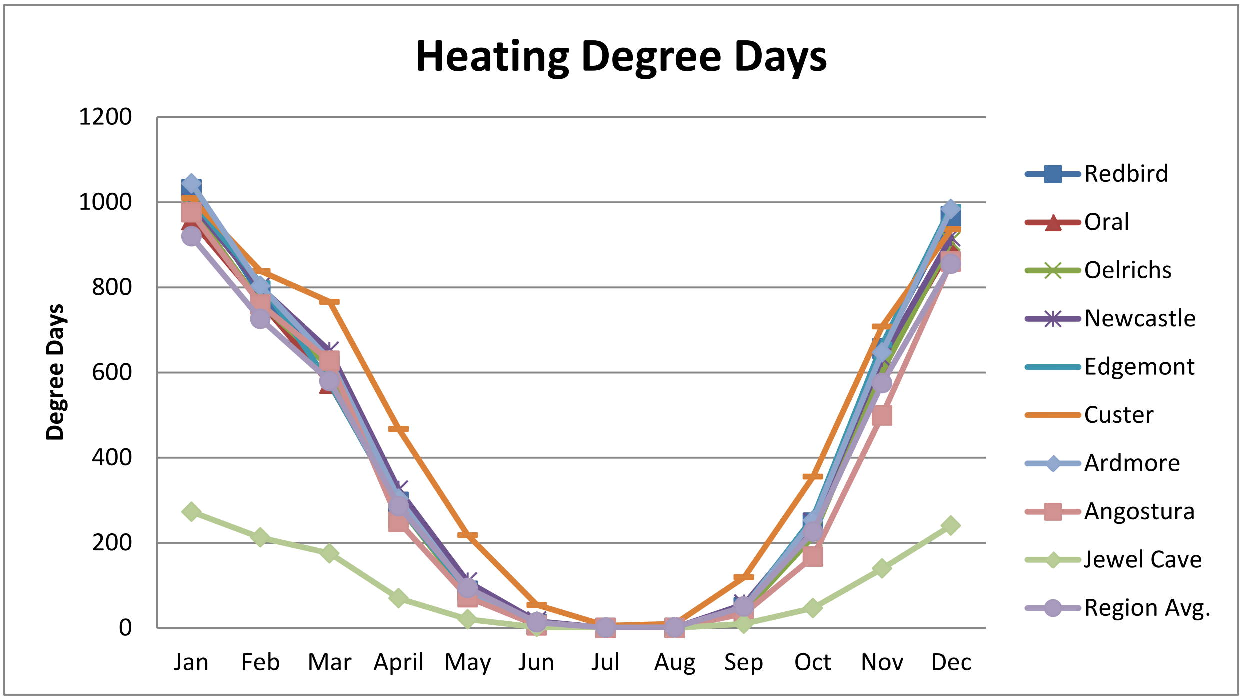
Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

Figure 2.5-21: Growing Degree Days for Regional Sites



Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

Figure 2.5-22: Cooling Degree Days for Regional Sites



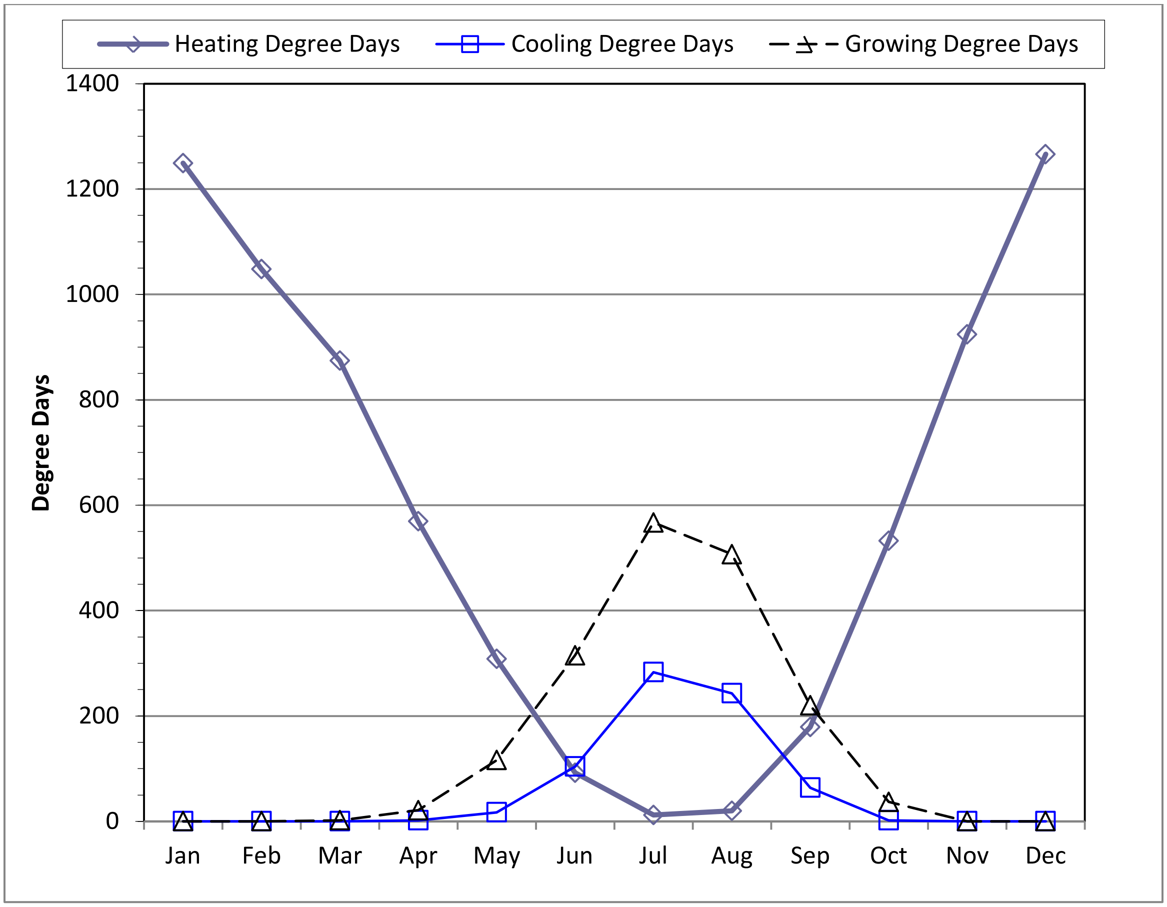
Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

Figure 2.5-23: Heating Degree Days for Regional Sites

Figure 2.5-24 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.

2.5.2.6 Evapotranspiration

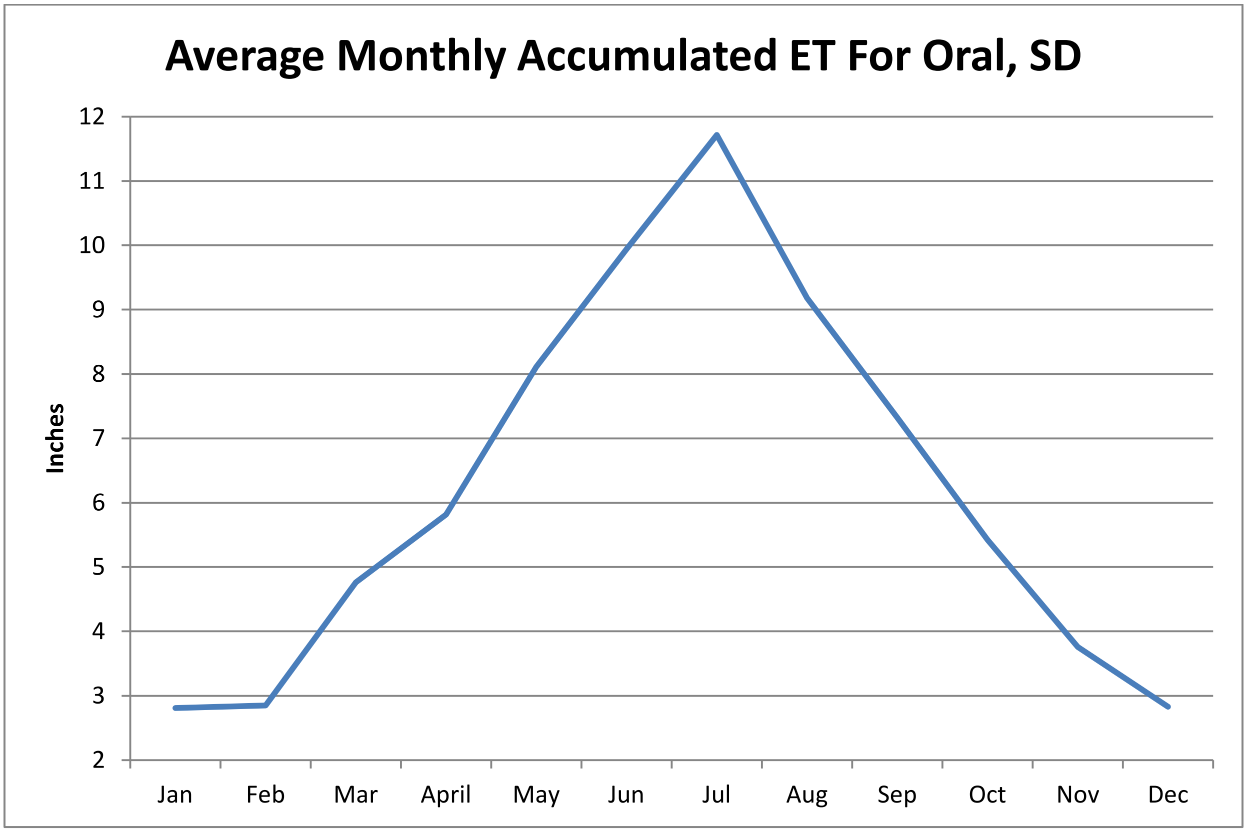
The American Society of Civil Engineers (ASCE) Standardized Reference Evapotranspiration Equation was used to calculate daily evapotranspiration (ET) using a tall reference crop coefficient. The weather parameters needed to calculate ET using this method are daily maximum and minimum temperature, maximum 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 2.5-25 displays a graph of the



Source: WRCC, 2011

Figure 2.5-24: Degree Days for Newcastle

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

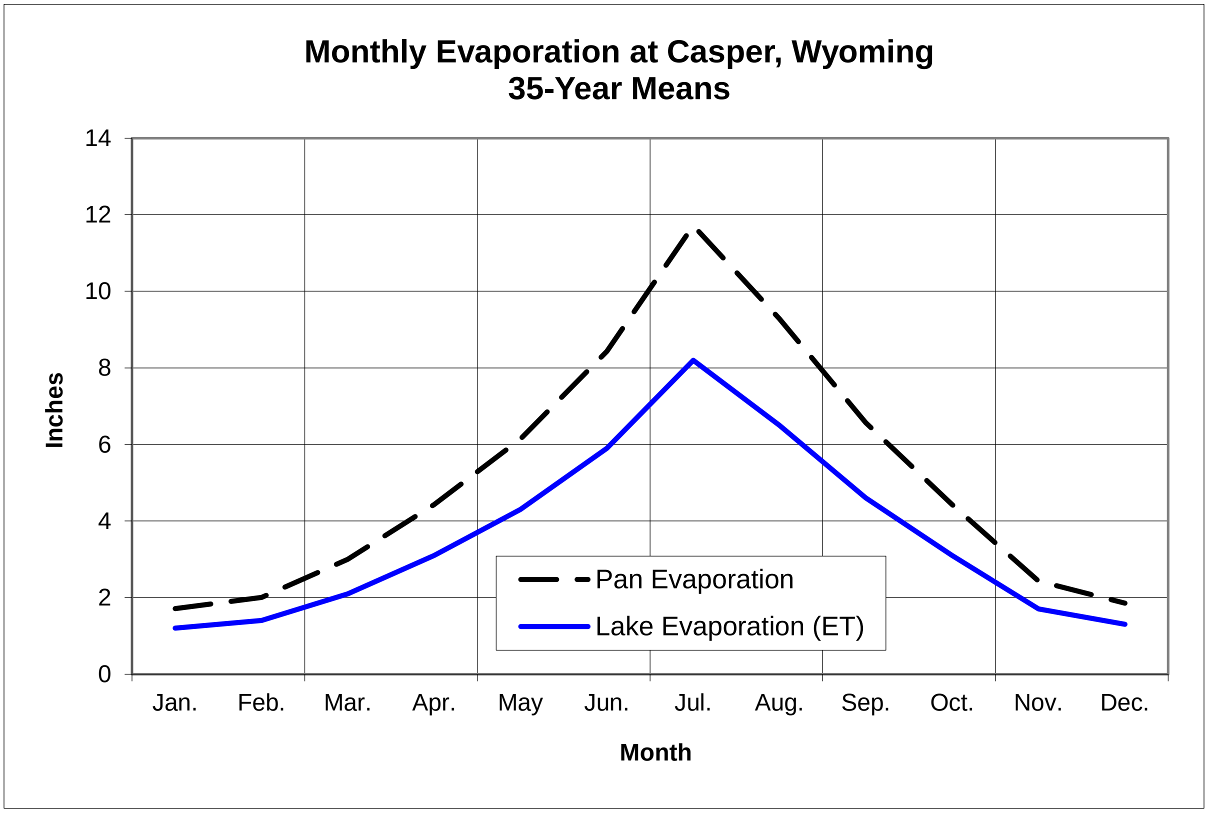


Source: High Plains Regional Climate Center, 2008; South Dakota State University, 2008

Figure 2.5-25: Average Monthly Accumulated Evapotranspiration for Oral, South Dakota

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. 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 2.5-26 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.



Source: Wyoming Water Research Center, 1985

Figure 2.5-26: Average Monthly Evaporation for Casper, Wyoming

It will be noted by comparing Figures 2.5-25 and 2.5-26 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.

2.5.3 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 configured and installed by the South Dakota Office of Climatology at South Dakota State University. Parameters monitored include wind speed/direction at both 3- and 10-meter heights (9.8 and 32.8 feet), ambient temperature, relative humidity and solar radiation. Section 2.5.3.2 provides a discussion on how the data were used to determine atmospheric stability classes and resulting joint frequency distributions, thus meeting the goals of Regulatory Guide 3.63. The hourly average wind speed and wind direction reported at the site represent averages of twelve 5-minute data points for each hour. Table 2.5-6 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 2.5-B.

All instruments were factory-calibrated prior to installation. Both the Met-One wind speed sensor and the Met-One wind direction sensor have an operating threshold of 1.0 mph (0.45 m/sec). No instrument audits or re-calibrations were performed at the Dewey-Burdock weather station during the baseline monitoring year. Data quality control during the baseline monitoring period was conducted by comparing hourly averages to nearby stations. In a letter from the State Climatologist, Dr. Todey, to Powertech (USA), included in Appendix 2.5-F, it was reported that no data quality issues were detected that would have required a special site visit.

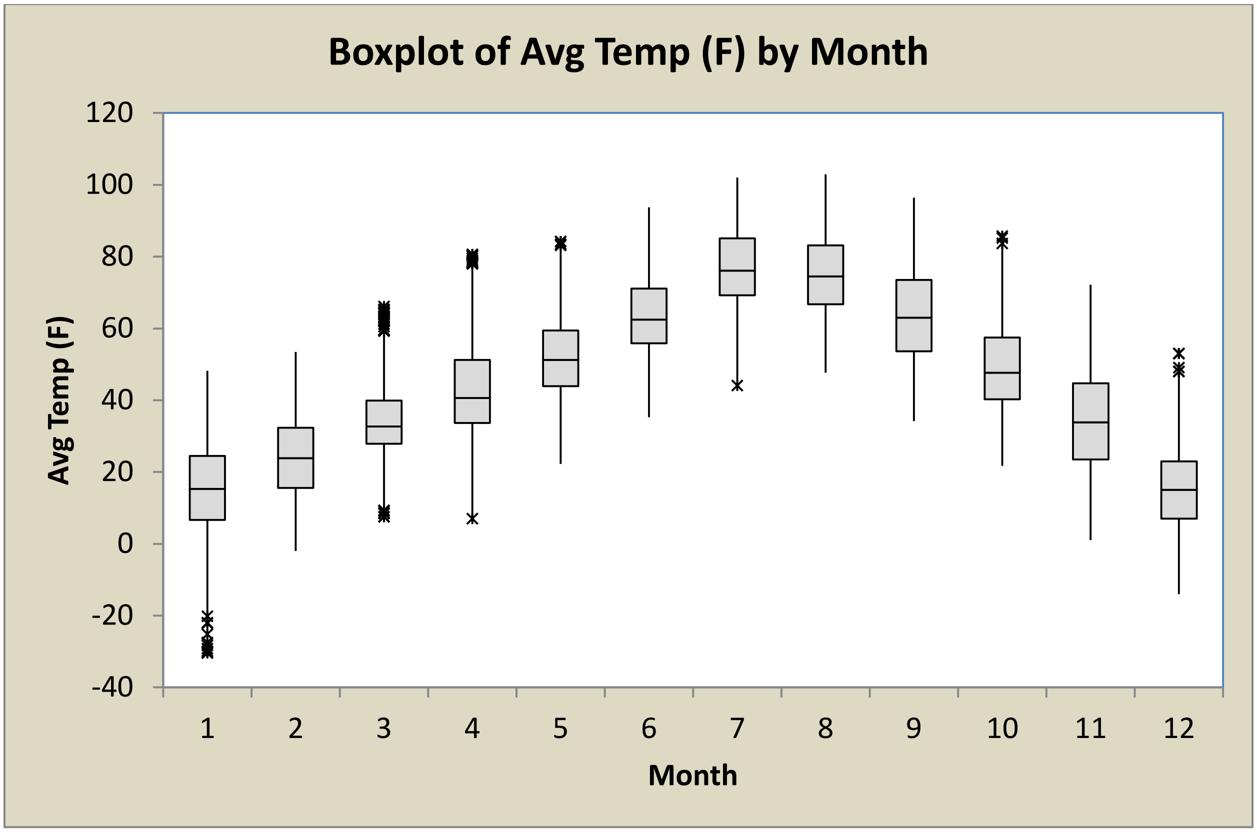
During the baseline year, wind data recovery was 87% at the 10-meter level and 99.7% at the 3-meter level. Temperature data recovery was 97.5%, relative humidity data recovery was 100%, and solar radiation data recovery was 99.8%.

Table 2.5-6: 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/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	-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

2.5.3.1 Temperature

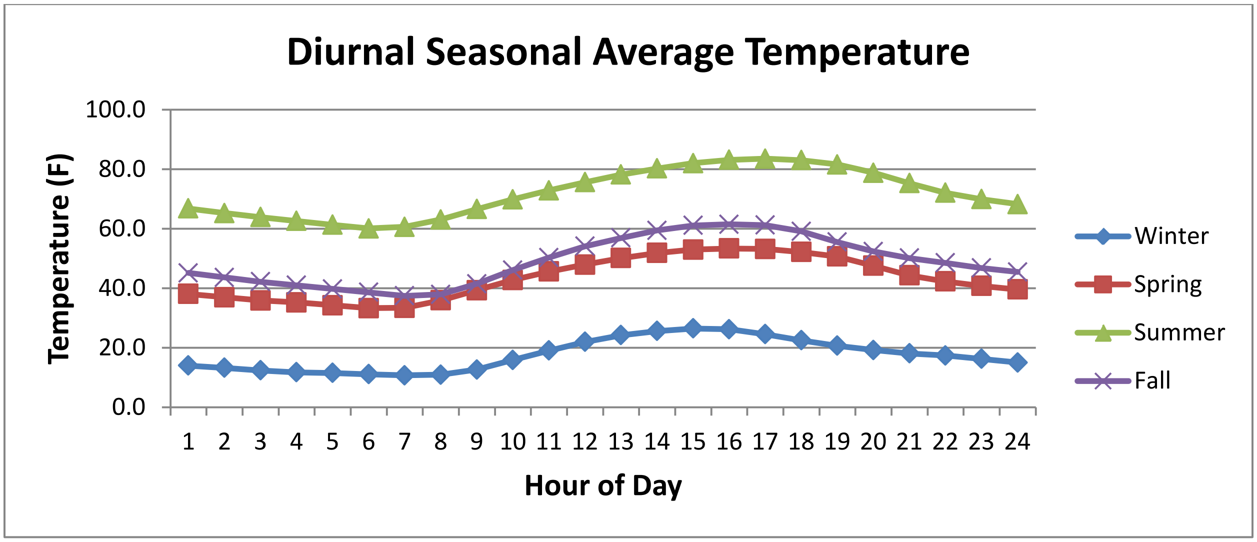
The average hourly temperature over the year for the site was 45.5°F. A maximum temperature of 104°F was reached on both July 21, 2007 and August 13, 2007, while the minimum temperature for the period of record was –28°F on January 22, 2008. A boxplot of the average temperature by month is shown in Figure 2.5-27. 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.



Source: South Dakota State University, 2008

Figure 2.5-27: Average Temperature (Degrees Fahrenheit) by Month from the Project Meteorological Site

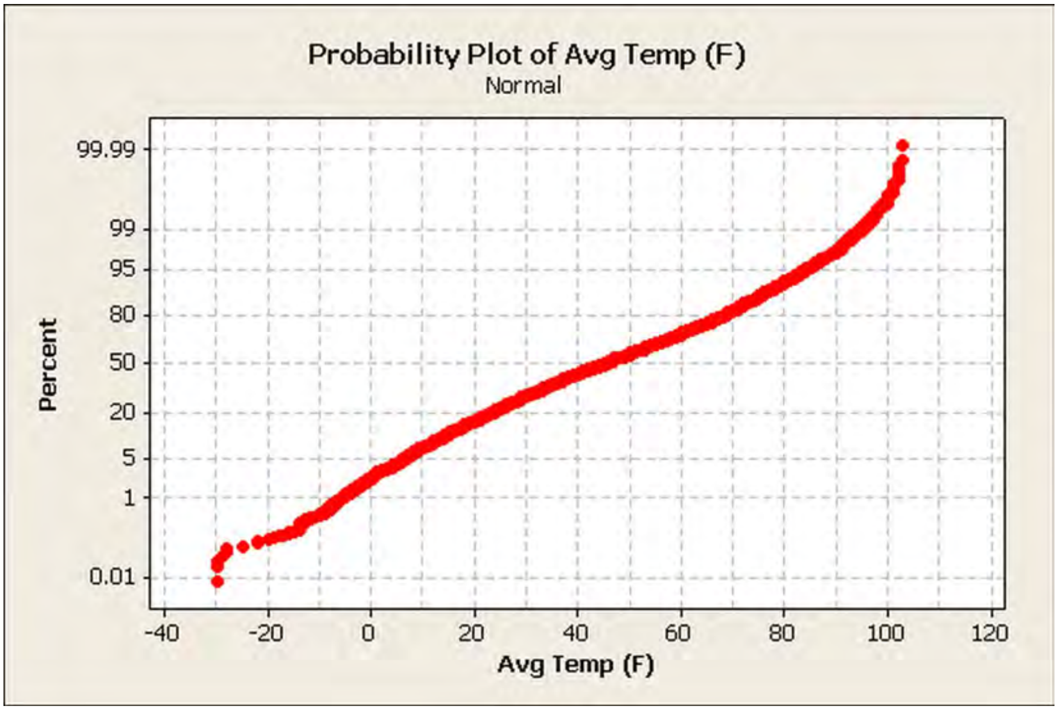
There were large variations in seasonal and diurnal temperature (Figure 2.5-28). In the summer season, average temperatures were as low as 60°F at 6 a.m. to 83.6°F at 5 p.m. In the winter season, temperatures varied from an average of 11°F between 7 a.m. and 8 a.m. and rose to nearly 27°F at 4 p.m. The 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.



Source: South Dakota State University, 2008

Figure 2.5-28: Diurnal Average Temperature for the Project Meteorological Site by Season

Figure 2.5-29 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.



Source: South Dakota State University, 2008

Figure 2.5-29: Probability Plot of Average Temperature from the Project Meteorological Site

2.5.3.2 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 2.5-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 2.5-7, 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-southeasterly winds were prevalent in summer months. Figures 2.5-30 and 2.5-31 show the quarterly wind roses for the Dewey-Burdock project area at the 10-meter height. 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 2.5-32 shows the annual wind rose for the project area, with northwesterly and west-northwesterly winds dominating. Figure 2.5-33 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.

Joint wind data recovery at the Dewey-Burdock 10-meter height was approximately 87% for the baseline monitoring year, compared to the Regulatory Guide 3.63 recommendation of 75% for joint data recovery. Most of the invalid records occurred in the six weeks after the station began operating (late July and August 2007). Data recovery at the 3-meter height was over 99% for the year. To verify that the missing data at 10 meters did not significantly skew the wind analysis, an annual and a summer wind rose were generated for the 3-meter level. Figure 2.5-34 compares the annual wind roses at 3 and 10 meters, while Figure 2.5-35 compares the summer wind roses. For each period, the wind directions are distributed similarly at both heights. The principal differences can be explained by the normal increase in wind speeds with height, and by the greater frequency of winds from the regionally dominant (northwesterly) direction at 10 meters.

The joint frequency distribution provides more detail on wind speed distribution by wind direction and atmospheric stability class. Appendix 2.5-C presents the stability classes and joint frequently distribution for the Dewey-Burdock project area and describes the methodology used for calculations.

Table 2.5-7: 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: South Dakota State University, 2008

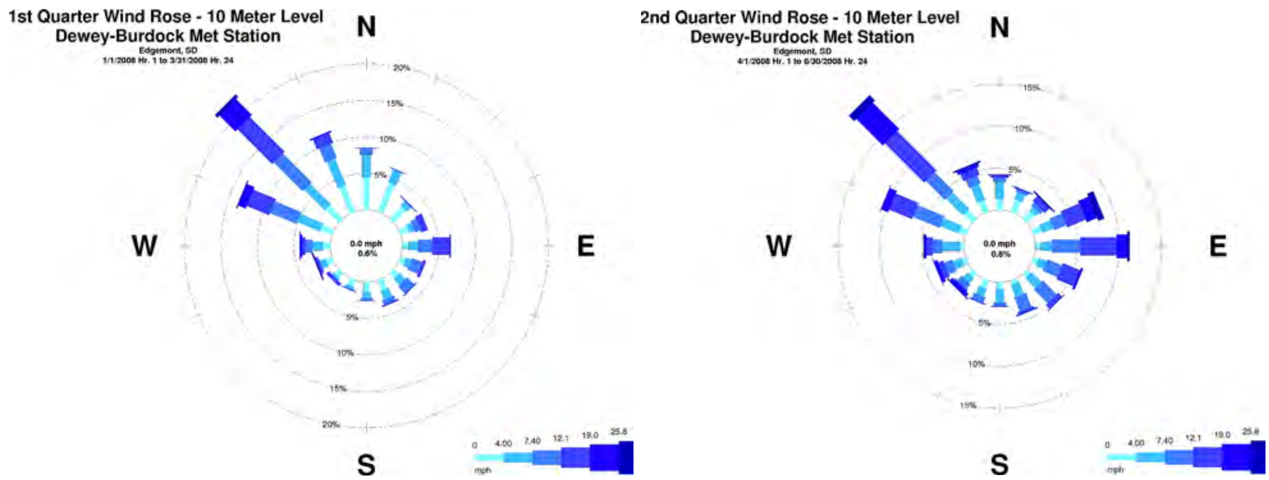


Figure 2.5-30: First and Second Quarter Wind Roses

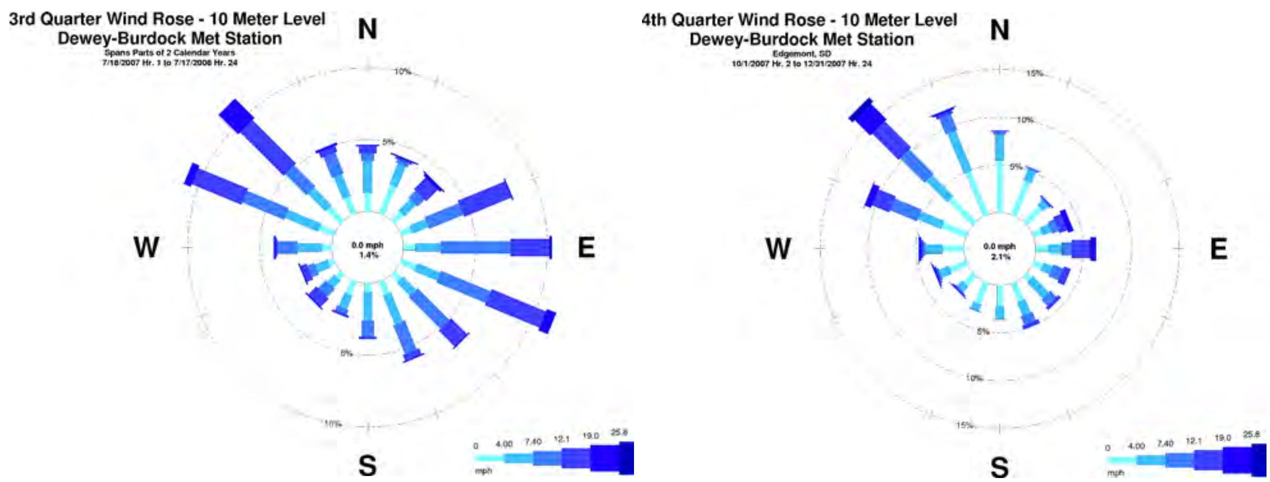


Figure 2.5-31: Third and Fourth Quarter Wind Roses

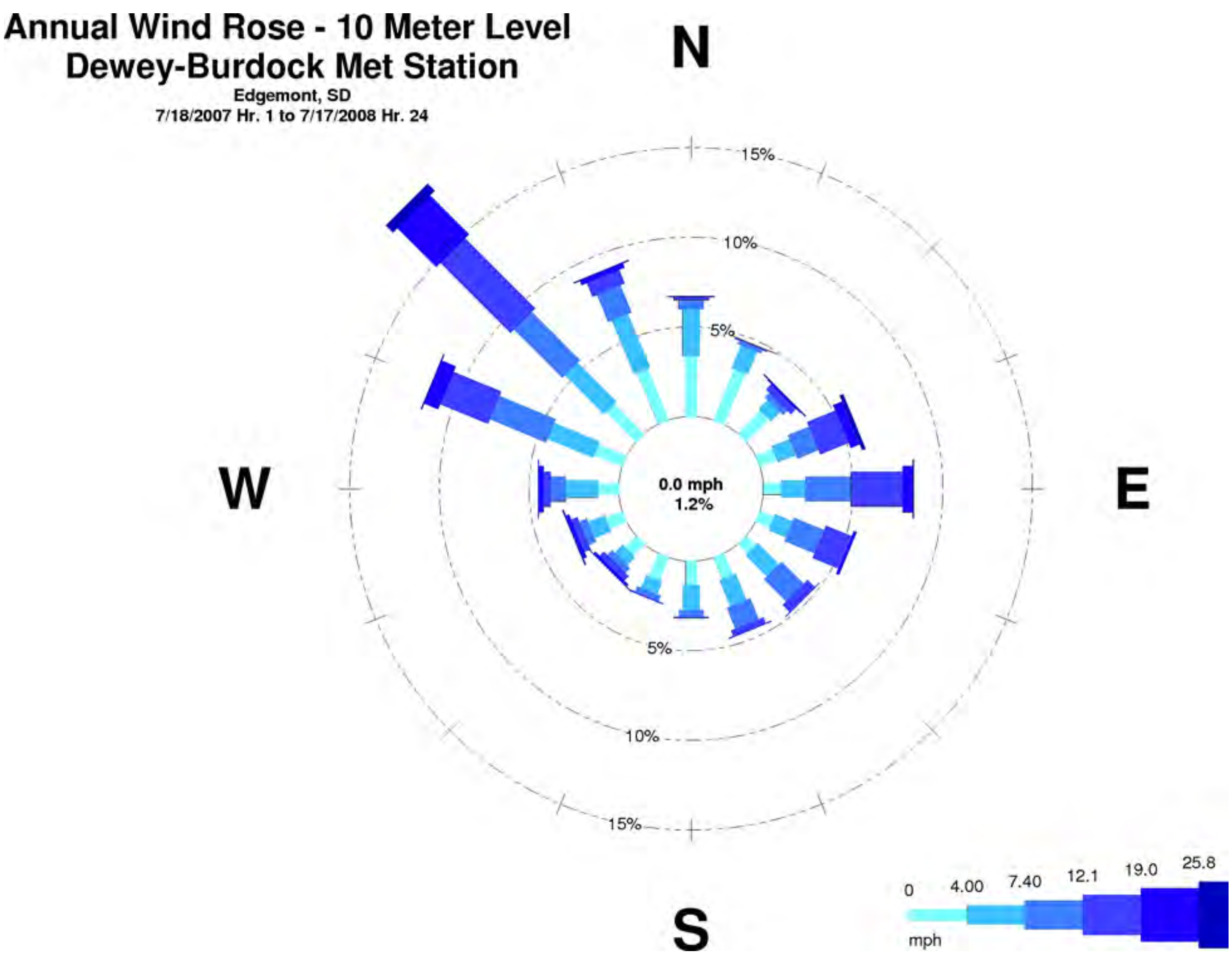


Figure 2.5-32: Annual Wind Rose

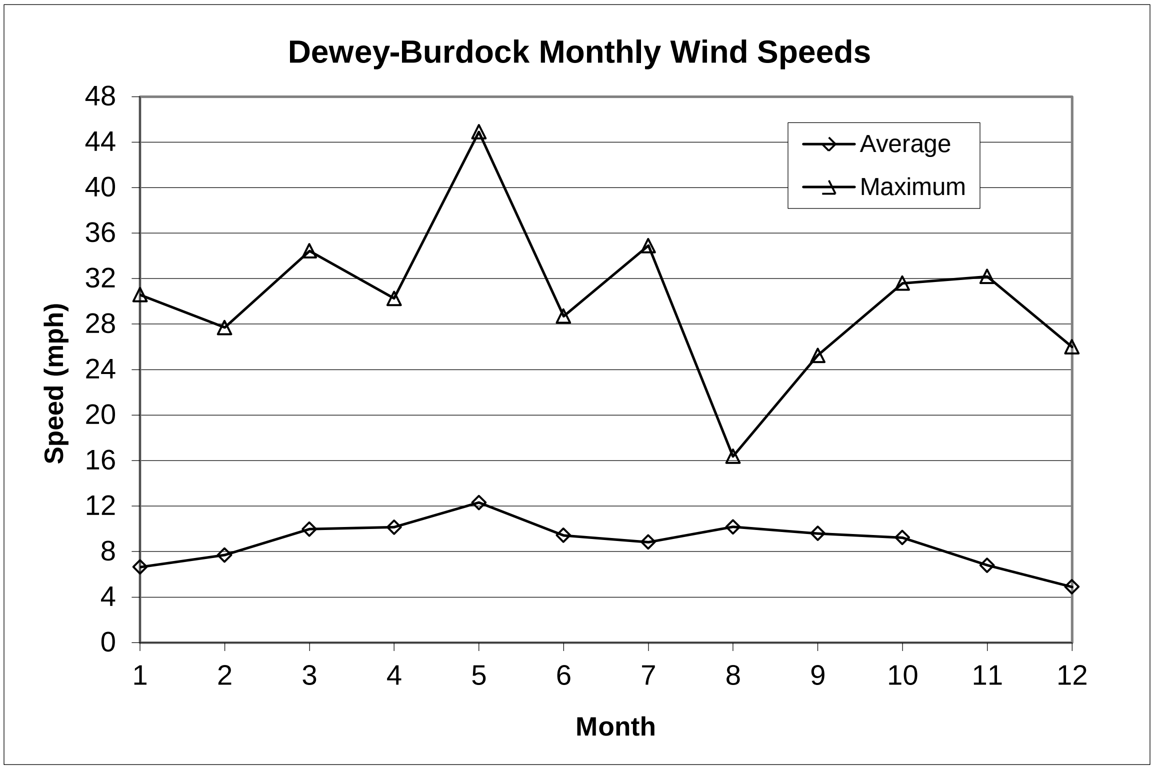


Figure 2.5-33: Dewey-Burdock Monthly Wind Speeds

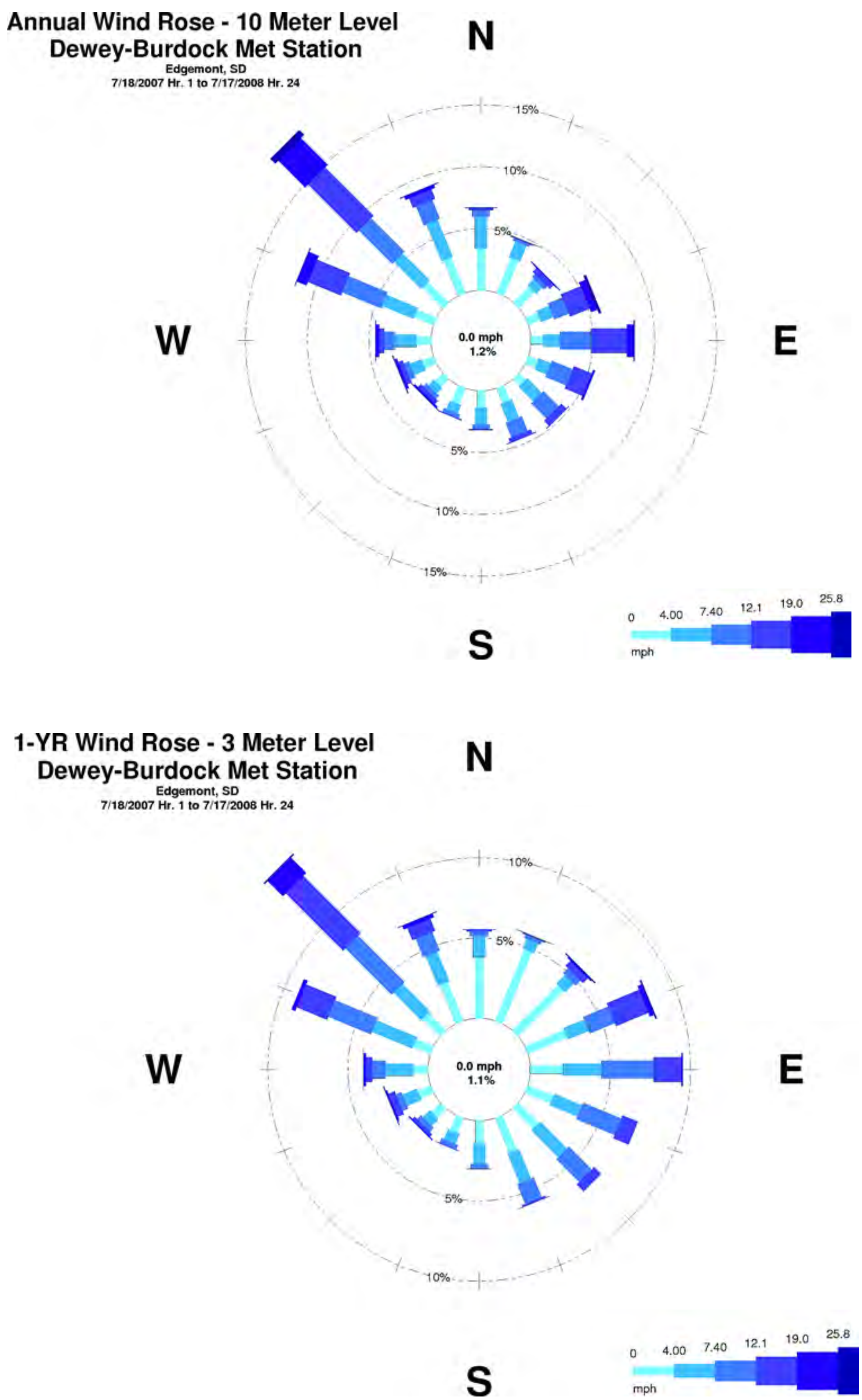
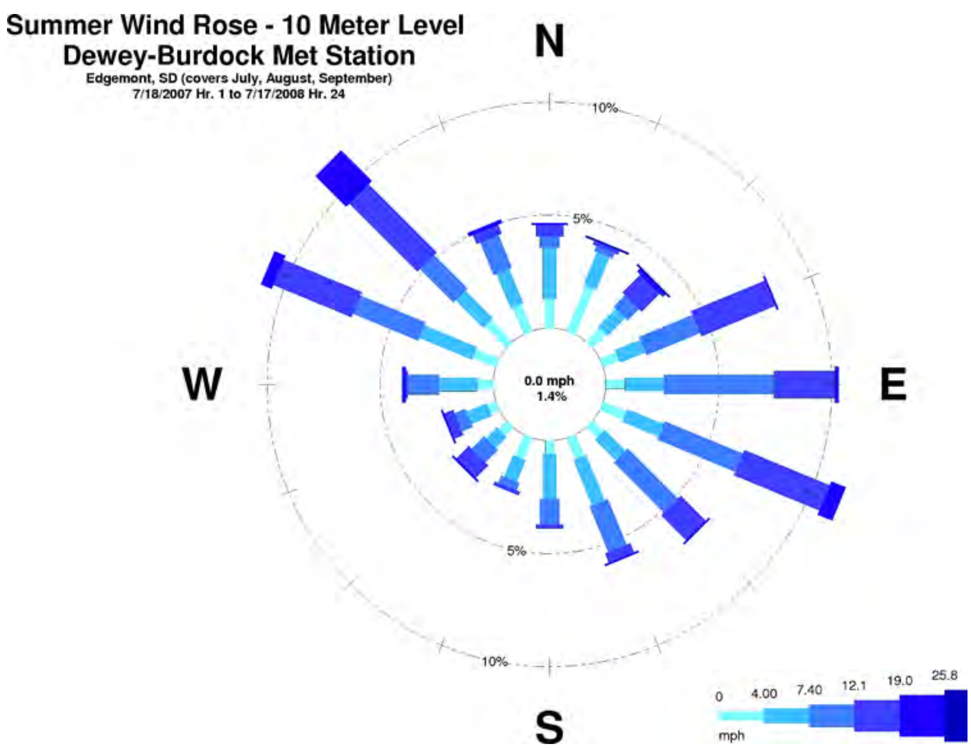


Figure 2.5-34: Dewey-Burdock Annual Wind Rose Comparison: 10m vs. 3m



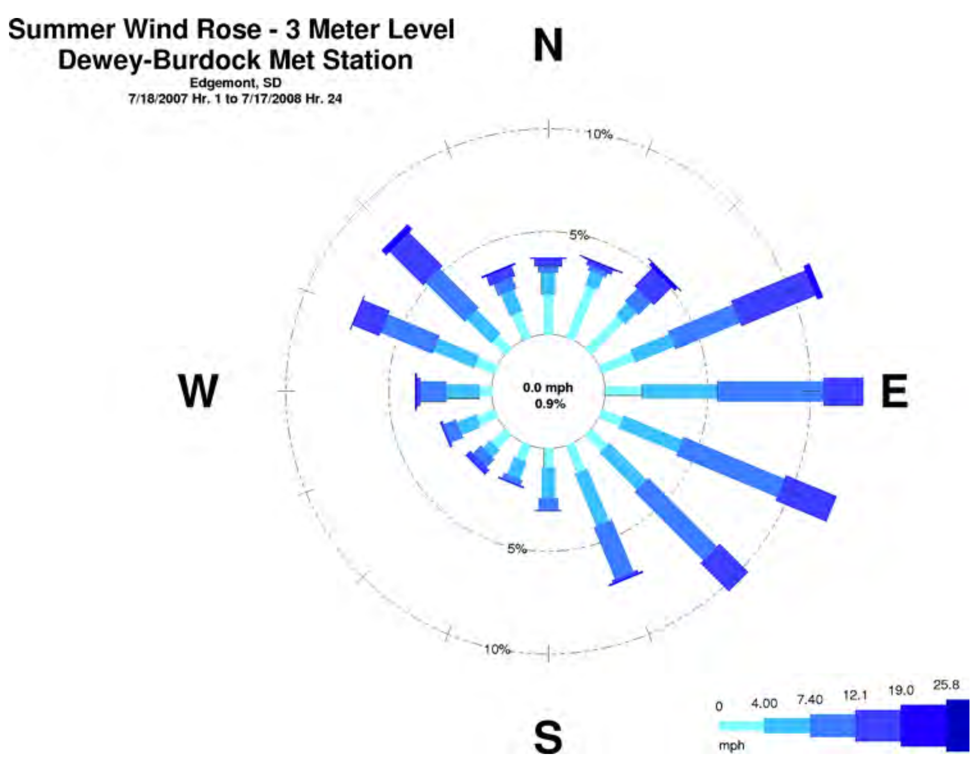
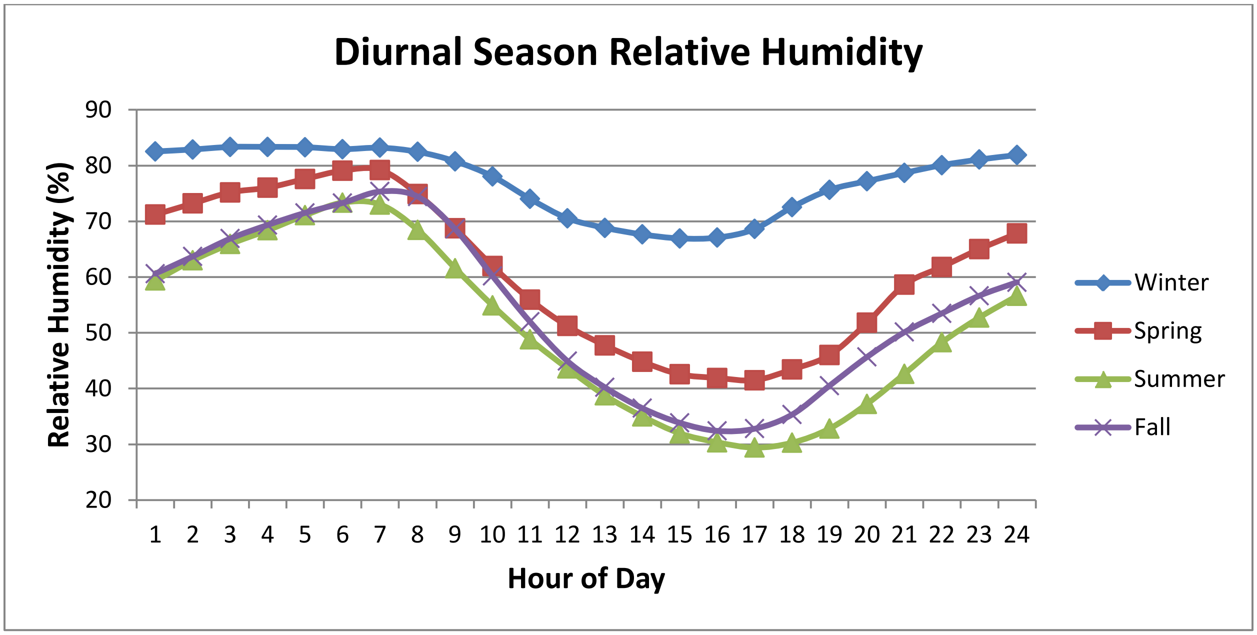


Figure 2.5-35: Dewey-Burdock Summer Wind Rose Comparison: 10m vs. 3m

2.5.3.3 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 compared 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 2.5-36). During the winter months, the diurnal relative humidity range was much less because of less intense and shorter duration solar radiation.

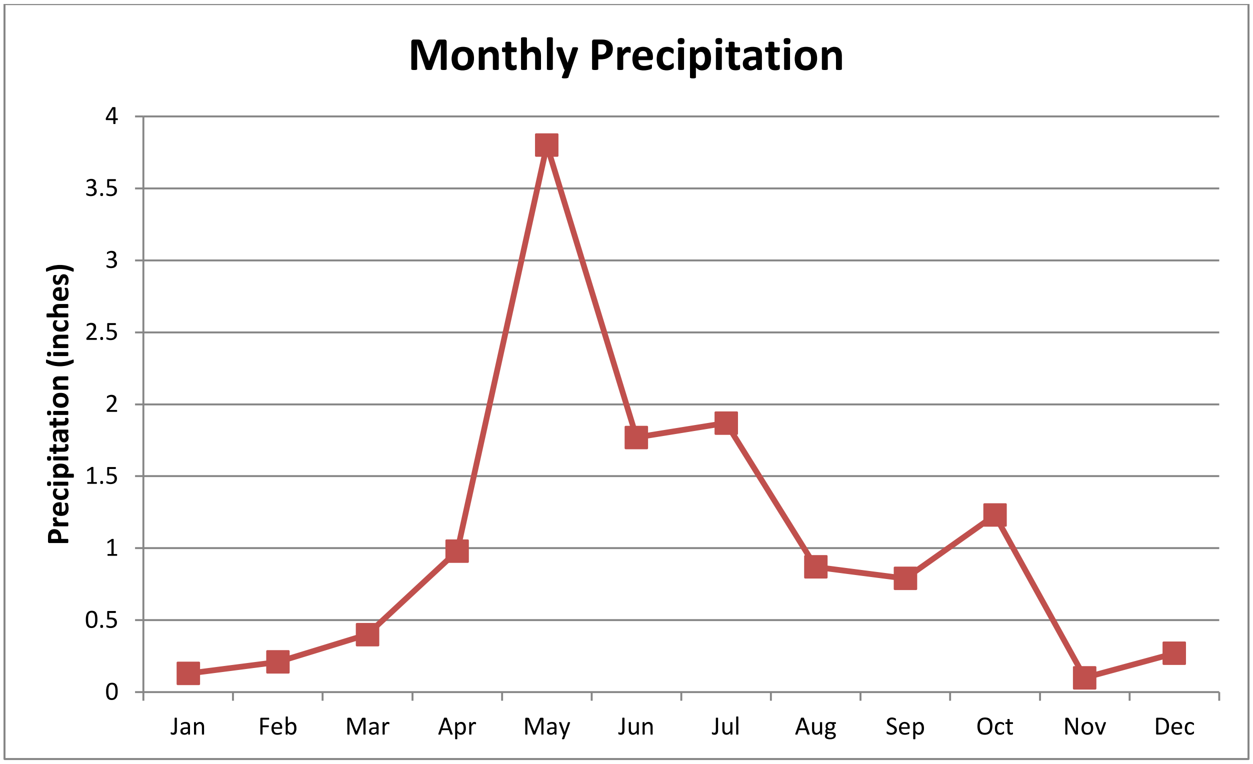


Source: South Dakota State University, 2008

Figure 2.5-36: Diurnal Relative Humidity by Season from Project Meteorological Site

2.5.3.4 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 2.5-37 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 inches). 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.

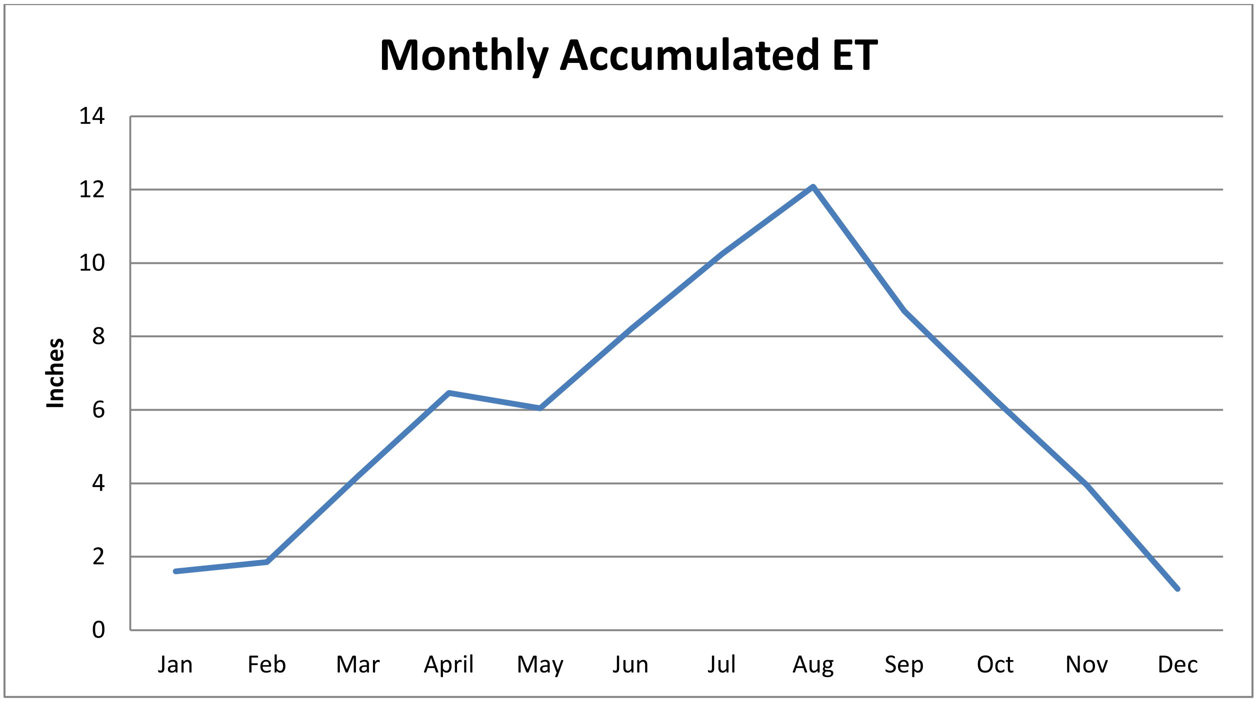


Source: South Dakota State University, 2008

Figure 2.5-37: Monthly Precipitation from the Project Meteorological Site

2.5.3.5 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 2.5-38) 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.



Source: South Dakota State University, 2008

Figure 2.5-38: Estimated Evapotranspiration Calculated Using Weather Data Collected at the Project Meteorological Site

2.5.3.6 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. The MILDOS-AREA model uses mixing height, along with other wind parameters, to predict pollutant dispersion. Unstable air leads to more dispersion, which leads to lower predicted impacts on ambient air quality.

The default mixing height of 100 meters was used for Dewey-Burdock MILDOS-AREA modeling. This is very conservative given that both morning and afternoon mixing heights at Rapid City, SD averaged much higher. Table 2.5-8 provides these average mixing heights, computed from upper air and surface data, at the Rapid City Airport, which is the closest site to the project 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 2.5-9. The annual average mixing height is 1,110 meters, an order of magnitude higher than the default used for modeling.

Table 2.5-8: Rapid City Mixing Height Averages, 1984-1991

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

Table 2.5-9: Quarterly Mixing Height Averages

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

2.5.4 References

High Plains Regional Climate Center, 2008**,** "*Historical Climate Data Summaries*", retrieved August 2008 from High Plains Regional Climate Center Web Site: http://www.hprcc.unl.edu/ data/historical/

Inter-Mountain Laboratories, (IML), 2011, Compliance Monitoring Results from the Wyoming Refining Company Meteorological Monitoring Station, Newcastle, Wyoming, 2002-2011.

South Dakota State University, 2008**,** "*South Dakota Climate and Weather,*" retrieved August 2008 from South Dakota State University Web Site: http://www.climate.sdstate.edu/ climate_site/climate_page.htm

Western Regional Climate Center, 2011**,** "*Historical Climate Data Summaries,*" retrieved September 2011 from Western Regional Climate Center Web Site: http://www.wrcc.dri.edu/ data

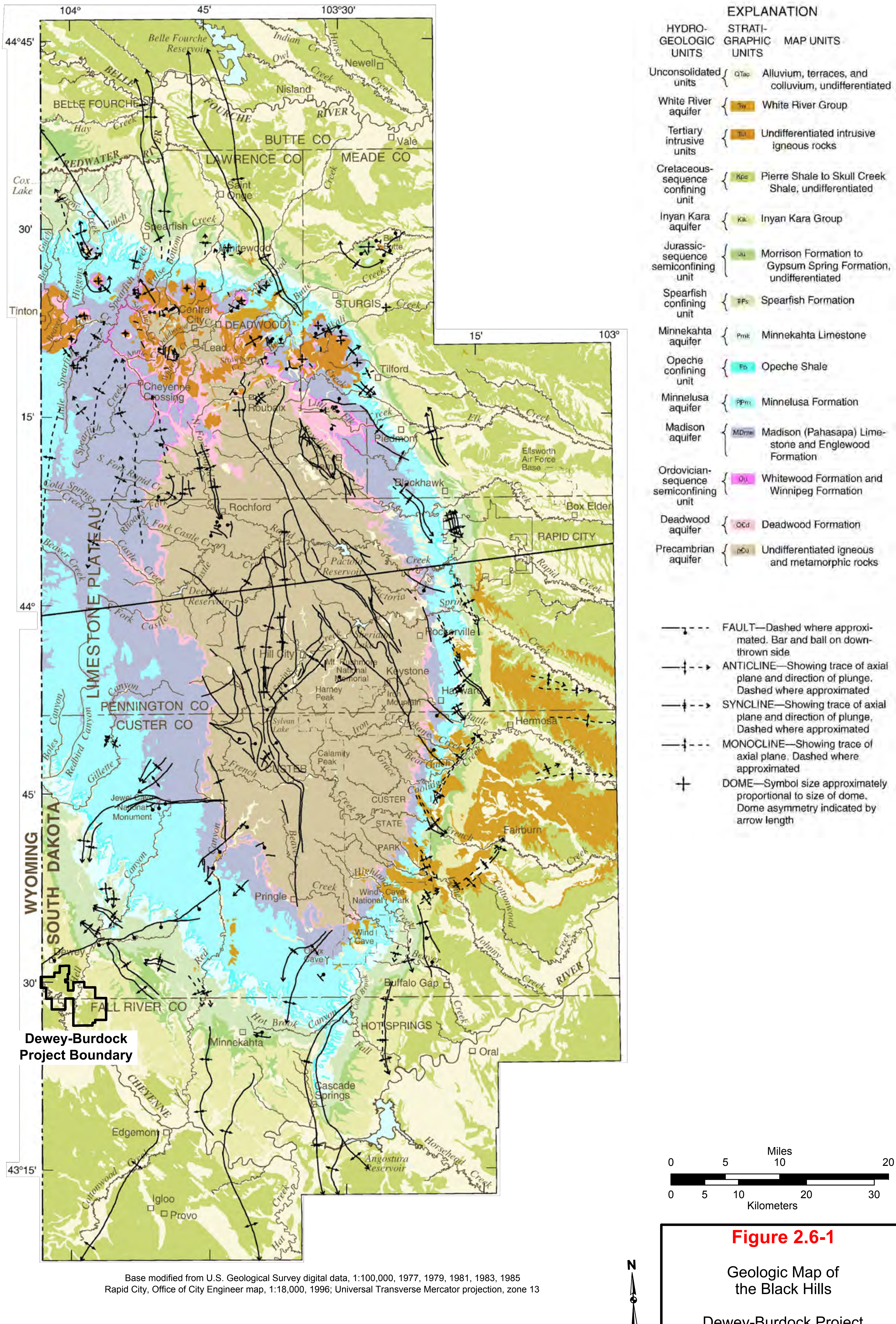
Wyoming Water Research Center, 1985**,** "*Design Information for Evaporation Ponds in Wyoming,*" by L. Pochop, K. Warnaka, J. Borrelli and V. Hasfuther, retrieved September 2011 from Wyoming Water Research Center Web Site: http://library.wrds.uwyo.edu/wrp/85-21/85-21.html

United States Environmental Protection Agency (EPA), 1987, "Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD)." EPA-450/4-87-007.

2.6 Geology

2.6.1 Regional Geology

The project 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 PAA is the Powder River Basin of Wyoming. The regional geologic map of this region is shown in Figure 2.6-1.



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

Source: Ground-Water Resources in the Black Hills Area, South Dakota. Water-Resources Investigations Report 03-4049, by J. M. Carter, D. G. Driscoll and J. F. Sawyer, Rapid City, South Dakota, 2003, p. 5.

Figure 2.6-1

Geologic Map of the Black Hills

Dewey-Burdock Project

DRAWN BY Bonner, Hetrick	
DATE 19-Jun-2013	
FILENAME BlackHillsGeoMap.dwg	POWERTECH (USA) INC.

2.6.1.1 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 rock 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. In early Cretaceous time minor deformation along concealed northeast trending 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.

2.6.1.2 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 surfaced of this structural feature. Overlying these crystalline rocks are 2000-3000 feet of Paleozoic sediments. This sedimentary sequence contains several regional aquifers, to include 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. The Sundance Formation is a minor aquifer in the southern Black Hills region. A thick sequence of Cretaceous age sediments completes the Mesozoic section.

The Early Cretaceous sediments of the Inyan Kara Group consist of the Lakota Formation and the Fall River Formation and 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 as the Cretaceous Seaway inundated a stable land surface. Basal units of the Lakota Formation scour into clays of the 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 flood plain 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 3000-5000 feet of 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) tuffaceous White River Formation. This thick, tuffaceous sequence was the result of volcanic eruptions to the west and was rich in volcanic fragments. The White River sediments have primarily been removed by erosion and can be found only 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.

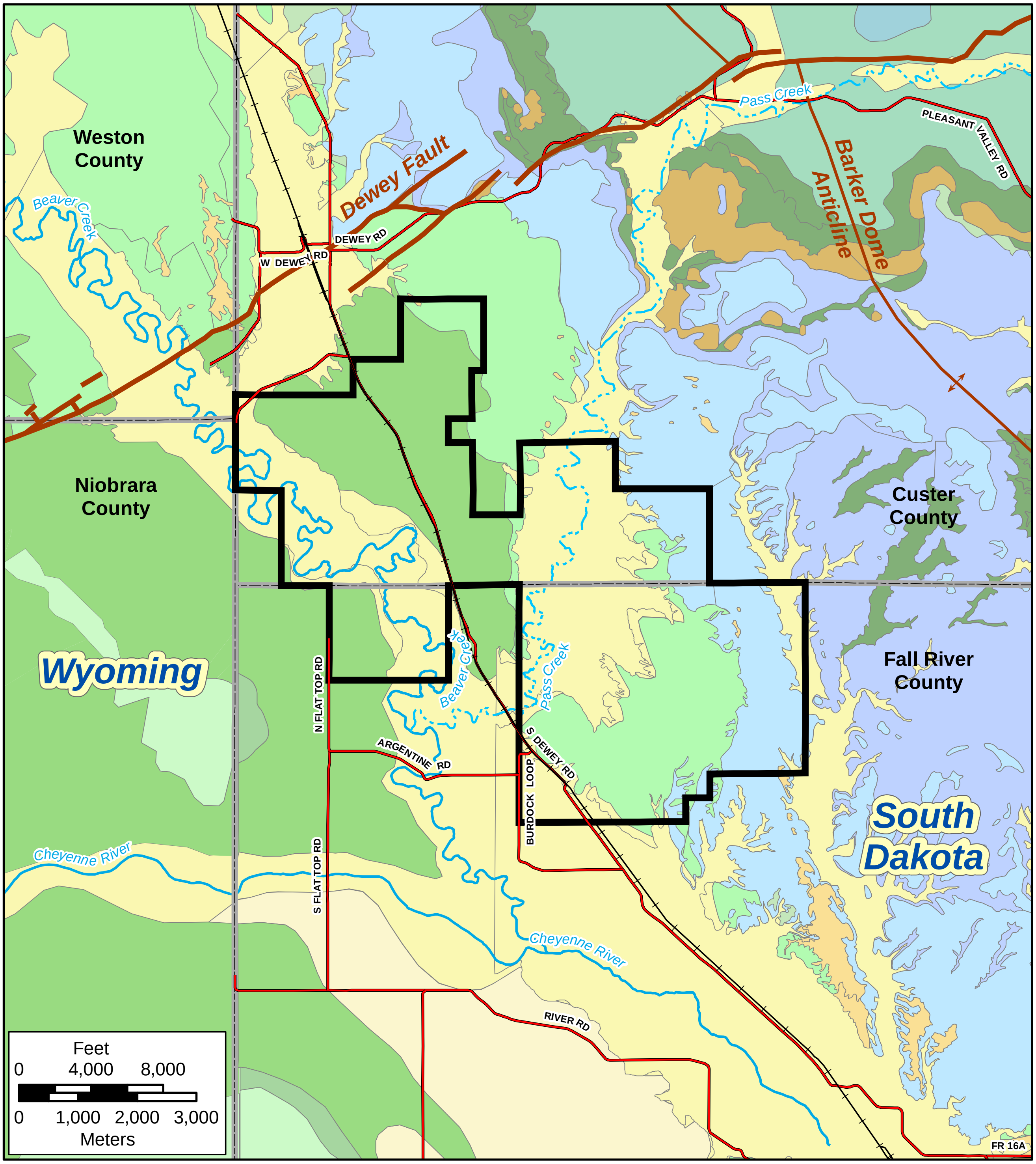
The most recent sediments in the region are Quaternary-age deposits consisting of local material derived as a result of post-Laramide-uplift erosion. Recent deposits include alluvium and floodplain terrace deposits.

Refer back to Figure 2.2-3 for a stratigraphic column of the Black Hills.

2.6.2 Site Geology

The site surface geology is shown in Figure 2.6-2. The Fall River Formation outcrops across the eastern part of the project and the Skull Creek Shale, Mowry Shale, and Belle Fourche Shale (collectively referred to as the Graneros Group) outcrop across the western part of the project. The formations dip west and southwest at 2 to 6 degrees.

The geology of the project 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 electric logs run to characterize natural radioactivity and the lithology (rock type) of the sediments in the subsurface. Resistivity and Self Potential provide 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 2.6-2a is an example of a "type log" from the project.



- 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

Legend

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

N

Figure 2.6-2

Site Surface Geology

Dewey-Burdock Project

DRAWN BY	F. Lichnovsky
DATE	17-Jun-2013
FILENAME	SurfaceGeology.mxd

POWERTECH (USA) INC.

This log is a single, good quality drill hole log, with the purpose of presenting the overall, general stratigraphy and the relative position of stacked ore bodies (roll fronts) within the entire Dewey-Burdock project area. This log does not precisely represent the stratigraphy within all potential well fields across the project. The three major confining units (Graneros Group, or upper confining layer, Fuson Member, and Morrison Formaiton, or lower confining layer) are depicted on the log in their typical relationship to the host sands which are in the Fall River and Lakota Formations. Figure 2.6-2a clearly shows that there are no ore bodies within the Fuson Shale. The Fuson Shale is a confining unit, and uranium recovery will not and cannot occur within this unit.

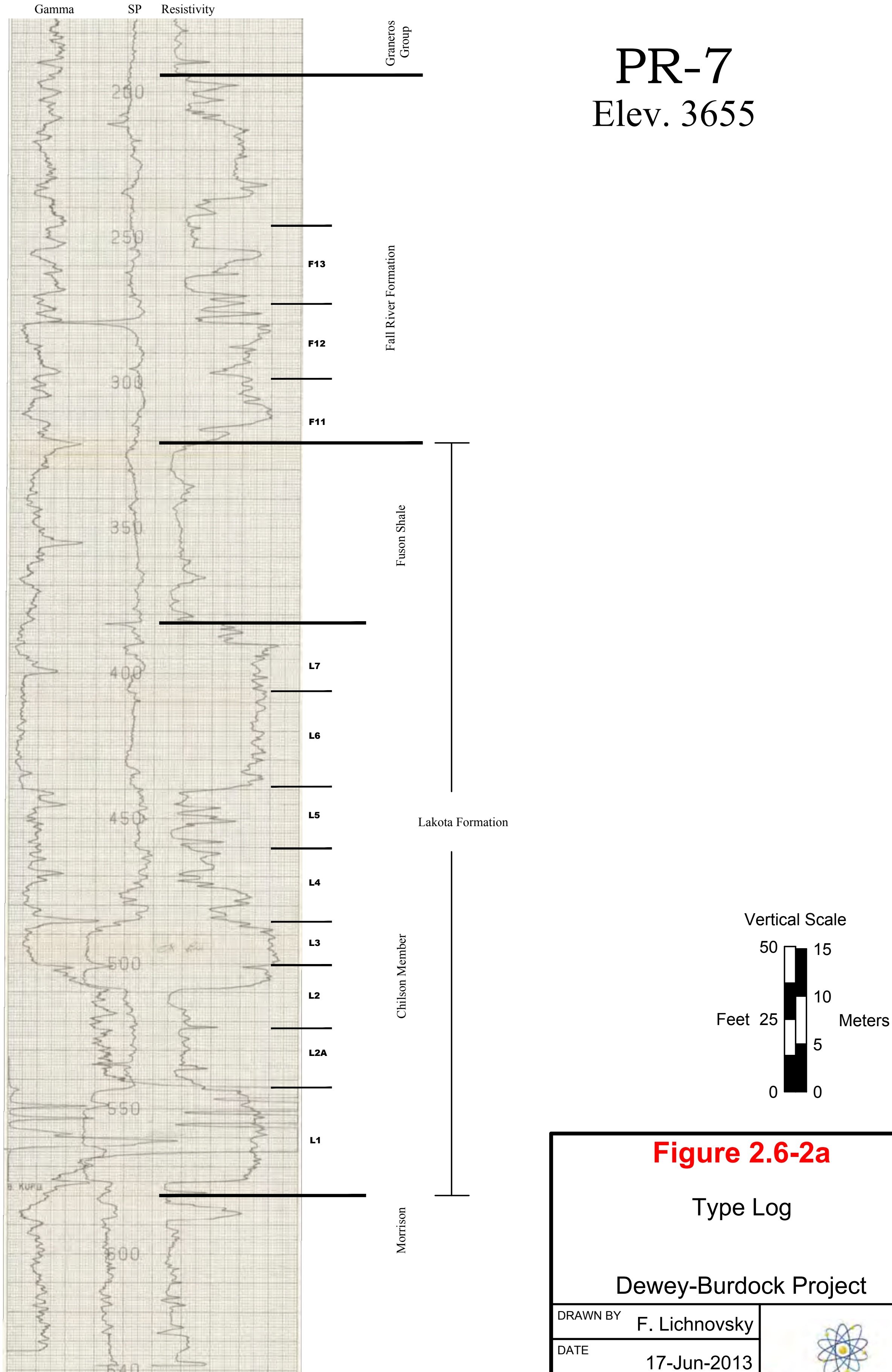


Figure 2.6-2a

Type Log

Dewey-Burdock Project

DRAWN BY	F. Lichnovsky
DATE	17-Jun-2013
FILENAME	TypTypeLog.dwg

POWERTECH (USA) INC.

2.6.2.1 Site Structure

The structure across the project 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 2.6-1), the Morrison Formation (Plates 2.6-2 and 2.6-2a), the Chilson Member of the Lakota Formation (Plates 2.6-3, 2.6-3a and 2.6-3b), the Fuson Shale (Plates 2.6-4 and 2.6-4a), and the Fall River Formation (Plate 2.6-5). Isopach maps are also provided for the Morrison Formation (Plates 2.6-6), Chilson Member (Plate 2.6-7 and 2.6-7a), Fuson Shale (Plate 2.6-8), Fall River Formation (Plates 2.6-9 and 2.6-9a), Graneros Group (Plate 2.6-10) and Alluvium (Plate 2.6-11).

The Dewey Fault, a northeast to southwest trending fault zone, is present approximately one mile north of the north and northwest parts of the PAA. 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 USGS considers an area 7 miles southeast of the project as the Long Mountain Structural Zone. This northeast – southwest trend contains several small shallow surface faults in the Inyan Kara. No faults show up along this trend on subsurface structure maps of the underlying Madison Formation, Minnelusa Formation or the Deadwood Formation. Despite the presence of faulting north and south of the site, there are no identified faults within the Dewy-Burdock PAA.

There is some folding in the areas surrounding the project. East of the project 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 and the Powder River Basin.

2.6.2.2 Site Stratigraphy

The sedimentary rocks of primary interest that underlie the project range in age from Upper Jurassic to Early Cretaceous. The Upper Jurassic Morrison Formation is considered to be the Lowermost Confining Unit for the project. The uranium mineralization is contained within the Inyan Kara Group (specifically within the Fall River Formation and Chilson Member of the Lakota Formation). The Graneros Group is the Uppermost Confining Unit. Figure 2.6-2a is a type log for the PAA, illustrating the relationship between these sedimentary units. Figure 2.2-3 demonstrates the relationship between these sedimentary units and underlying rocks, ranging in age from Jurassic to Precambrian.

The following is a brief description of the formations of interest at the project site:

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 project site. Where present, the Unkpapa Sandstone is 50 to 80 feet of well sorted, fine-grained, eolian sandstone.

Morrison Formation - The Upper Jurassic Morrison Formation was deposited as flood plain deposits. It is composed of waxy, unctuous, calcareous, noncarbonaceous massive shale with numerous limestone lenses and a few thin fine grained sandstones. Below the site, this formation has an average thickness of approximately 100 feet and is the Lower Confining Unit for the project. 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. Further, analyses of Morrison Formation core by Powertech (USA) indicate very small vertical permeabilities ranging from 0.012 to 0.043 millidarcies. The continuity, thickness, and lithology of the Morrison Formation ensure hydraulic isolation of the overlying Chilson sandstones.

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 project area are also available to assist with evaluation of the Morrison Formation. Table 2.6-1a provides a listing of these 26 identified Morrison Formation penetrations.

Plate 2.6-2 is a structure contour map of the top of the Morrison Formation. This map was developed in response to an NRC staff request for information on holes that penetrated into the Morrison Formation. This structure map shows the Morrison Formation generally dipping 2½ degrees to the southwest – away from the southwestern flank of the Black Hills Uplift. As shown on this plate, the irregular contour lines in the Dewey and Burdock areas 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 2.6-6 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 project area. Also shown on this isopach map is the location of cross section A-A'-A".

Plate 2.6-13 shows geologic cross section A-A'-A", which 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 consistent thick sequence of Morrison clays across the project area. Copies of all electric logs from test holes that penetrate the Morrison Formation are contained in Appendix 2.6-H. The A–A' portion of the cross section traverses the project 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 to outcrop along the eastern edge of the project 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 project area to over 550 feet in the southwestern portion of the project area. The Fuson Shale ranges from 20 to 80 feet thick throughout the project 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.

Table 2.6-1a: 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

Although present regionally, the Minnewaste Limestone Member of the Lakota Formation is not present within the Dewey-Burdock project 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 project 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 Dewey-Burdock project area).

A review of all drill hole and geologic lithology logs shows the Minnewaste Limestone does not occur within the project area. Geologic cross section E-E' (Plate 2.6-12e), along the northeastern portion of the project area, illustrates the geologic section where, if present, the Minnewaste Limestone would occur. If present, this limestone unit would occur immediately beneath the

Powertech (USA) Inc.

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. As shown on cross section E-E' (Plate 2.6-12e), no limestone is present.

The Chilson Member (commonly referred to as the Lakota Sandstone) is composed largely of fluvial deposits. These deposits consist of sandstone, shale, siltstone, and shale. 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. Analyses of core samples of these sandstones indicate these units exhibit high horizontal permeabilities, ranging from 2.6 x 10^{-3} cm/sec to 4.1 x 10^{-3} cm/sec (2697 millidarcies to 4161 millidarcies). 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 shows the thickness of the channel sandstones and interbedded shales within the Chilson Member. Thicknesses vary from 100 to 240 feet. This isopach map may not adequately show the total thickness of the Chilson Member because drilling usually did not penetrate its entire extent. Drilling was usually stopped in the lower carbonaceous shale unit of the Chilson Member and did not reach the Morrison Formation. (Plates 2.6-7 and 2.6-7a).

The Fuson Member is the upper most member of the Lakota Formation and the shale-siltstone portion of the Fuson 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 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 2.6-8). 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 and anisotropic. Due to the highly stratified nature of the interbedded shales and mudstones, the vertical permeability is estimated to be several orders of magnitude smaller than the horizontal permeability. Estimates of vertical hydraulic conductivity of the Fuson Shale developed from pumping tests conducted in the Fall River and Chilson near Burdock in 1979 range from 1×10^{-7} to 4.6×10^{-8} cm/s (Boggs and Jenkins, 1980). Further, analyses of core samples of these lithologies demonstrate low vertical permeabilities, ranging from 7.8×10^{-9} cm/sec to 2.2×10^{-7} cm/sec (0.008 millidarcies to 0.228 millidarcies). Detailed pump tests to be conducted after license issuance as a part of the well field hydrogeologic packages will provide additional quantification of the low hydraulic conductivity of the confining units (see Section 3.1.3.2).

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 project area, across Bennett Canyon, in the E/2

Section 30, T6S, R2E, where the Fuson Member pinches out. However, based on Powertech (USA)'s borehole logs no evidence of Fuson Shale pinch-out locations has been identified within the project area. The Fuson Shale is clearly continuous with a thickness of more than 20 feet across the entire project area.

Based on Powertech (USA)'s borehole and geophysical logs for more than 3,000 exploratory holes, the Fuson Shale is continuous and no less than 20 feet thick throughout the entire project area. A database providing the information to generate the Fuson Shale isopach (Plate 2.6-8) was provided to the NRC staff on November 4, 2010 in response to a request for clarification by NRC staff. The pervasive occurrence and continuity of the Fuson Shale throughout the project area is shown on the revised geologic cross sections (Plates 2.6-12a through 12h and 12j).

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 project and generally contain the uranium deposits. Overlying the channel sandstones is another sequence of alternating sandstone and shales. The sandstones are cross-bedded to massive, fine to medium-grained, and well-sorted.

The isopach map of the Fall River Formation 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 PAA, this formation is exposed on the surface and erosion has taken place (Plate 2.6-9).

Skull Creek Shale - The Skull Creek Shale directly overlies the Fall River Formation and consists of dark-grey to black shale, organic material, and some silt sized quartz grains. The Skull Creek Shale has a thickness of approximately 200 feet and is part of the Graneros Group, which is the Uppermost Confining Unit for the project. Analyses of core samples demonstrate that the Skull Creek clays have extremely low vertical permeabilities, in the range of 6.8×10^{-9} cm/sec (0.007 millidarcies). The Skull Creek Shale is eroded from the eastern parts of the project.

Mowry Shale – At the project the Skull Creek Shale is directly overlain by the Mowry shale, also considered to be part of the Graneros Group, which is the Uppermost Confining Unit. When

present the Newcastle Sandstone is stratigraphically located between the Skull Creek Shale and the Mowry Shale. There is no Newcastle Sandstone on the surface or in the subsurface within the Dewey-Burdock project area. Figure 2.2-3 shows the regional presence of this unit. While the Newcastle Sandstone is present within the Graneros Group regionally, there are areas, including the Dewey-Burdock project area, where it is absent. As shown on Figure 2.2-3, the Newcastle Sandstone is equivalent to the Muddy Sandstone, which is a prolific oil producer in much of Wyoming and Colorado. Because the Muddy Sandstone (or its equivalent) has been the target of extensive oil & gas exploratory drilling, its regional presence (or absence) in the subsurface has been well delineated. Drilling on the Dewey-Burdock project area has encountered no Newcastle Sandstone. Geologic cross sections H-H' and J-J' (Plates 2.6-12h and 2.6-12j) illustrate the geologic sections where, if present, the Newcastle Sandstone would occur. On these sections, a 400-foot thickness of low-permeability Graneros Group shale is shown overlying the Fall River Formation. The lower 200 feet of the Graneros Group is made up of the Skull Creek Shale. If present, the Newcastle Sandstone would immediately overlie this shale unit. However, as shown on the cross sections, there is no sandstone in this interval; instead, the Mowry Shale overlies the Skull Creek 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 combined Graneros Group (Skull Creek, Mowry and Belle Fourche shales) reaches a thickness of over 500 feet in the western part of the project area. Plate 2.6-10 is an isopach map showing the combined thickness of the Graneros Group. In the northeastern portion of the PAA, these units crop out and have been eroded.

Terrace Deposits - Along the sides of drainages are relatively flat 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 PAA 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 2.6-11.

2.6.2.2.1 Site Stratigraphy of the Initial Dewey and Burdock Well Fields

Following is a description of the geologic and hydrologic characterization of the initial Dewey and Burdock well fields. It should be noted that much more detailed geologic and hydrologic characterization and well field design will be included in well field hydrogeologic data packages after license issuance but prior to commencement of any ISR operations. As described in Section 3.1.3.1.1, delineation drilling will be undertaken to further characterize the zones of mineralization and to identify the interbedded sand and clay intervals. Design of the injection and recovery well pattern for each well field, and associated monitoring system(s), will take into account the hydrogeology to ensure that production fluids can be contained within the production zone and adequately monitored. As detailed in Section 3.1.3.1.2, ISR operations will be monitored by perimeter monitor wells screened over the entire thickness of the production zone.

In addition to delineation drilling, well field scale pumping tests will be conducted prior to development of each well field to further evaluate the hydraulic characteristics within the production zone and to demonstrate continuity between the production zone and perimeter monitor well ring. Results of any hydrogeologic testing will also be included in the well field data package prior to commencement of any ISR operation.

The Fall River Formation and the Fuson Shale and Chilson Member of the Lakota Formation are of fluvial depositional origin and consist of interbedded channel and overbank deposits. The uranium deposits are associated with channel deposits very similar to those in many other states including Nebraska, Texas, and Wyoming that have been successfully developed for ISR operations.

Geologically, the Fall River Formation is physically and hydraulically separated from the underlying Chilson Member by the Fuson Shale. Similarly, the Chilson Member is physically and hydraulically isolated from the underlying regional aquifers by the Morrison Formation. A structural contour map for the top of the Fuson Shale in the vicinity of Dewey Well Field 1 is provided as Plate 2.6-4a, and a structural contour map of the top of the Morrison Formation is presented in Plate 2.6-2a. These maps are equivalent to structural contour maps for the base of the Fall River and base of the Chilson, respectively. A structure contour map of the Morrison Formation throughout the project area is provided as Plate 2.6-2.

These structure contour maps reflect the attitude and topography of the confining units underlying the Fall River Formation in the Dewey area and the Chilson Member in the Burdock area. In both areas, the confining units are shown to dip gently to the west and southwest, away

from the core of the Black Hills Uplift. In the Dewey area, the structure contour map also may reflect some minor scouring, but cross sections in the area show a consistent 50-foot thickness of Fuson Shale. In the Burdock area, there is a depression on the Morrison structure contour map, but this appears to be related to depositional environment of the Morrison Formation as opposed to later scouring. Cross sections in this area show a consistent 80-foot thickness of Morrison shales.

Plate 2.6-12 is a cross section index map for nine geologic cross sections (Plates 2.6-12a through 2.6-12h and 2.6-12j) covering the project 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 project 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 project area. The Graneros Group is composed of several geologic formations including the Skull Creek, Newcastle (not present in the project 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 project area and crops out east of the project 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 project area crops out east of the project boundary.

The nine cross sections of Plates 2.6-12a through 2.6-12h and 2.6-12j 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.). It appears that 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 packages prepared for each well field.

Cross section A-A’ (Plate 2.6-12a) illustrates the proposed Burdock Well Field 1. While uranium mineralization can be seen in all three Chilson sand units, this well field is planned to be recovering uranium from the Lower Chilson sand. Exploration hole DB08-11-18 penetrates a 72-foot thick sequence of the Morrison Formation and the entire thickness of the Unkpapa Sandstone and bottoms in the Sundance Formation. The thickness of the Fuson Shale ranges from 30 to 60 feet, and the thickness of the uppermost confining unit (the Graneros Group) varies from 30 to 200 feet along this cross section.

Cross sections C-C’ (Plate 2.6-12c) and D-D’ (Plate 2.6-12d) depict subsurface conditions at potential well fields in the Burdock area immediately east of B-WF1. There are no Fall River ore bodies within this portion of the project area; only Chilson sandstones are targeted. Cross section C-C’ (Exhibit 2.7-1c) illustrates the subsurface beneath B-WF2 and B-WF4, which are proposed to target ore bodies within the Middle Chilson sandstone. Although there also is uranium mineralization present in the Upper and Lower Chilson sandstones, to date no ore bodies have been identified in these sand units in this area. The Fuson Shale, which overlies and confines the Chilson sandstones, maintains a thickness of 50 to 60 feet along this cross section.

Cross section D-D’ (Plate 2.6-12d) is drawn through the vicinity of potential Burdock well fields B-WF2 and B-WF4. Both well fields target the Middle Chilson sandstone. Also shown is Burdock well field B-WF3 that targets ore bodies within the Upper Chilson sandstone. Overlying the Chilson sandstones in this area is a 50-foot thickness of Fuson Shale. As shown on the cross section, exploration hole RONA-81 fully penetrates the Morrison Formation, which is 85 feet thick at this locale and demonstrates the integrity of the lowermost confining unit in this portion of the project area.

Cross section H-H’ (Plate 2.6-12h) is drawn through proposed Dewey Well Field 1. Exploration hole DB08-32-11 penetrates a 97-foot thick sequence of the Morrison Formation and the entire thickness of the Unkpapa Sandstone and bottoms in the Sundance Formation. This provides a cross-sectional view of the lowermost confining unit (the Morrison Formation) as well as deeper stratigraphy below the project area. As shown in this cross section, all uranium ore bodies are contained in the Lower Fall River Sand in the F13, F12 and F11 roll fronts. There are over 400 feet of Graneros Group clays overlying the Fall River Formation, and the Fuson Shale maintains an average thickness of 50 feet along the cross section.

Cross section J-J’ (Plate 2.6-12j) is drawn through potential Dewey Well Fields 2, 3 & 4. As shown on the cross section, exploration hole DB08-32-11 penetrates a 97-foot thick sequence of

the Morrison Formation, the entire thickness of the Unkpapa Sandstone and bottoms in the Sundance Formation. The log for this exploration hole provides an excellent cross sectional view of the lowermost confining unit (Morrison Formation) as well as deeper stratigraphy below the Dewey-Burdock site. As shown in this cross section, proposed D-WF2 targets ore bodies in the Middle Chilson sandstone, proposed D-WF3 addresses resources in the Lower Fall River sandstone and proposed D-WF4 targets ore bodies in the Upper Chilson sandstone. There is not a high density of exploratory drilling in these potential well field areas, and a future delineation drilling program will be implemented to thoroughly delineate resources and to accurately define well field limits. However, this conceptual approach to identifying potential well fields is an important step in visualizing the spatial relationships of host formations and ore bodies to be developed in the future.

These cross sections show that the major geologic units are continuous throughout the project area, with consistent upper and lower confinement zones. These are virtually ideal conditions for a successful ISR operation, providing optimal control of fluids and minimal opportunity for vertical excursions.

The extent of current potential well fields is based on available drill hole data. Further delineation will take place after license issuance and will be used to prepare detailed well field hydrogeologic data packages for each potential well field.

As described in Section 3.1.3, detailed delineation drilling will be conducted to map smaller changes in the depositional environment which may have a potential to change flow on a smaller scale. Design of the pattern areas for each well field and the associated monitoring system will account for any of these potential flow features to ensure that lixiviant can be contained within the production zone and adequately monitored. Well field pump tests will also be conducted in order to demonstrate communication between production zones and perimeter monitor well rings. All of this mapping, design, and testing information will be included in the well field hydrogeologic packages (see Section 3.1.3.3), which will be prepared for each well field prior to operation.

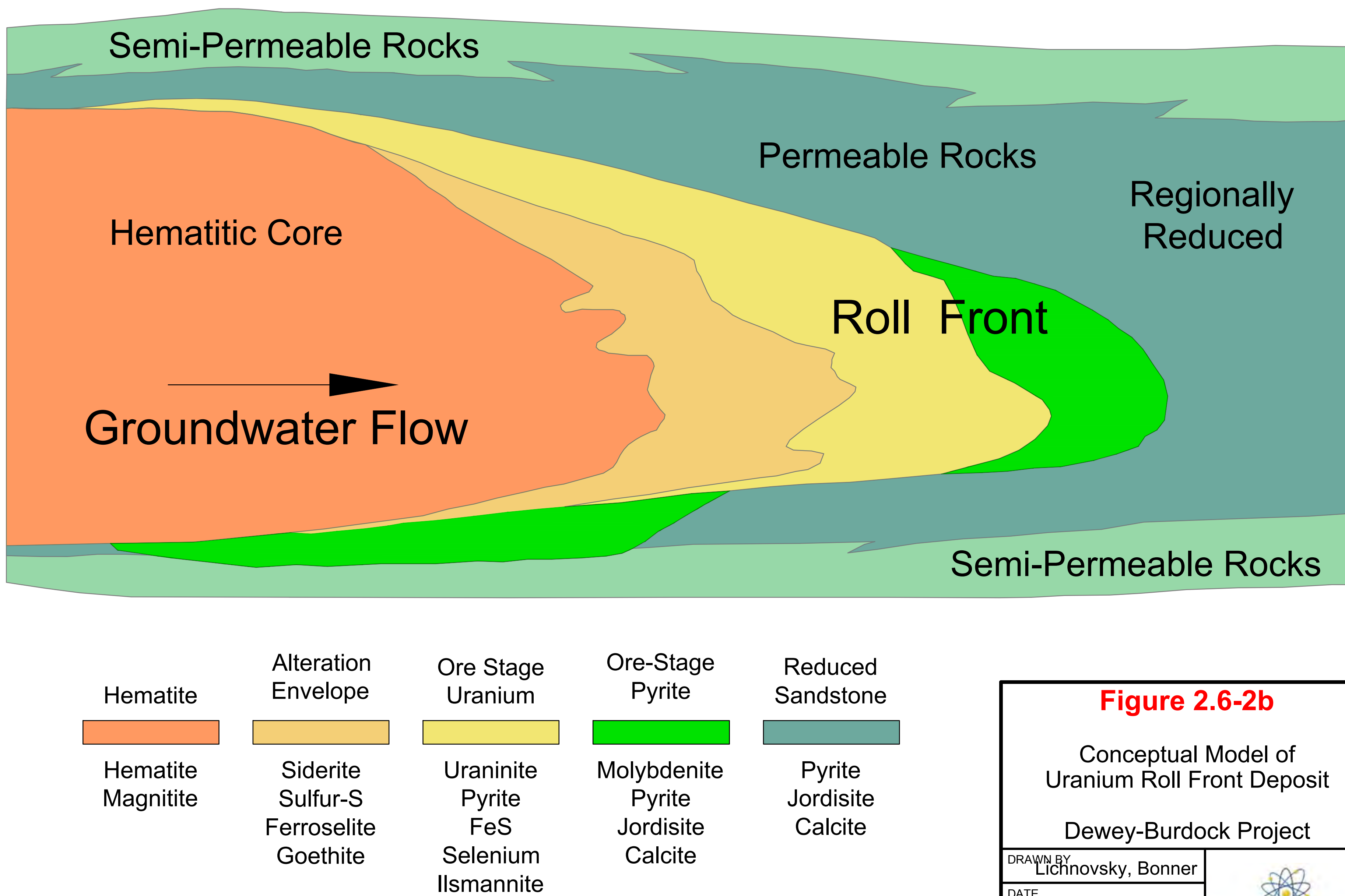
2.6.3 Ore Mineralogy and Geochemistry

Uranium deposits within the project 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 extending up-dip, 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 these epigenetic uranium deposits are the result of uranium minerals leached from the surface environment, transported down-gradient 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 2.6-2b). Roll-front deposits similar to those in the Dewey-Burdock project area are generally described in the ISR GEIS, NUREG-1910, Section 2.1.2.

Within the project area, roll-front deposits occur at depths of less than 100 feet in the outcrop area of the Fall River Formation and at depths of up to 800 feet in sands of the Chilson Member of the Lakota Formation in the northwestern part of the project area. The mineralized sandstones are typically fine to medium grained quartz sands that are moderately to very well sorted and show subangular to subrounded 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. The average thickness of this mineralization is 4.6 feet and the average grade is 0.21 percent U_3O_8 in the project area.

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 Dewey-Burdock project area. Information included in this description was obtained from a 1971 petrographic study of core from the Dewey portion of the project area by Homestake-Wyoming Partners utilizing microscopic, thin section, polished section, X-ray powder diffraction and spectrographic analyses (Honea, 1971).



Source: DeVoto (1978).

Figure 2.6-2b

Conceptual Model of Uranium Roll Front Deposit

Dewey-Burdock Project

DRAWN BY Lichnovsky, Bonner

DATE 30-Oct-2013

FILENAME DeVotoRollFrontConcept.dwg

POWERTECH (USA) INC.

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 grey 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. 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. Within 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. Within the project 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 grey 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.

2.6.4 Historic Oil and Gas and Uranium Exploration Activities

2.6.4.1 Historic Oil and Gas Exploration Activities

No former or actively producing oil and gas wells exist within the project boundary or within two kilometers 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 project area. The locations of these abandoned test wells are depicted on Figure 2.6-2c.

2.6.4.2 Historic Uranium Exploration Activities

Uranium was first discovered in the Edgemont District in 1952 by professors from the SDSMT. They mined about 500 pounds of ore and hauled it to Grand Junction, Colorado. The Atomic Energy Commission (AEC) announcement of a new district at Edgemont led to a boom of stacking, mining, and dealing in the summer of 1952. By 1953 the AEC had built a buying station in Edgemont. In July 1956 a 250-ton per-day mill went on stream and soon expanded to a 500-ton-per-day. In 1960 a vanadium circuit was added. Production from the Edgemont District (open pits in the Fall River), some mines in the Powder River basin and several mines in the Northern Black Hills continued until 1972. Susquehanna Western Inc. (SWI) bought the Edgemont mill and took control of the mines in the Edgemont District. Until the late 1960's early 1970's they were the only company active in the Edgemont District.

In 1967, Homestake Mining Company began exploration in the Dewey area. In 1974, Wyoming Mineral Corporation (Westinghouse) acquired the Dewey properties from Homestake. In 1974, TVA bought out the mill and mines from SWI. The mill was shut down, but exploration continued. Besides WMC and TVA, other companies exploring in the district were Union Carbide, Federal Resources, and Kerr McGee. TVA acquired the Dewey Project from WMC in 1978 and continued exploration until 1986. In total, over 4000 exploration drill holes were completed on this project.

In 1981 TVA completed a mine feasibility study on the project deposits. A DES was prepared by TVA to address the potential impacts of a proposed underground mine in the PAA, but the NEPA process was never completed by TVA. Due to falling uranium prices the project leases were allowed to expire. In 1994 EFN acquired the mineral interests within the PAA. Their intention was to mine the uranium deposits by ISL. EFN did no additional exploration drilling on the project. In 2000 the leases were dropped.

In 2005, Powertech (USA) acquired the property, consisting of approximately 10,580 acres. Since the spring of 2007, Powertech (USA) has drilled approximately 115 exploration holes, including 20 monitoring wells on the project. Both the historic and recent drill holes have helped to generate the geologic model and delineate the extent of the mineralized sands. Figure 2.6-3 is

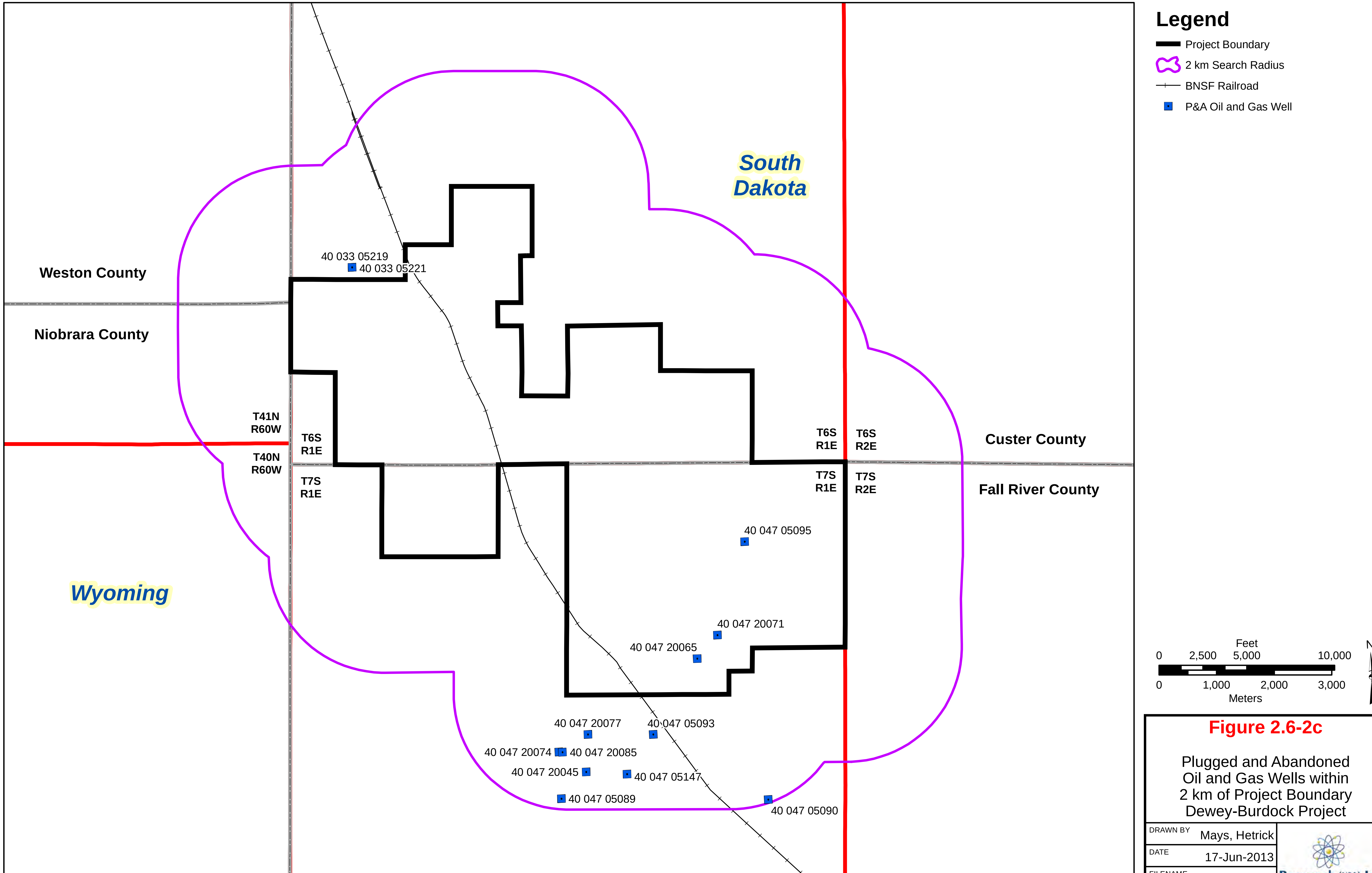


Figure 2.6-2c

Plugged and Abandoned Oil and Gas Wells within 2 km of Project Boundary Dewey-Burdock Project

DRAWN BY	Mays, Hetrick
DATE	17-Jun-2013
FILENAME	Wells-OilGas-PA2km.mxd

POWERTECH (USA) INC.

a map showing the location of all known drill holes. Appendix 2.6-A includes a table summarizing all historical exploration drilling.

There are underground mine workings along the eastern portion of the project area associated with four former, shallow underground uranium mines and two open pit adits. These are depicted on Figure 2.6-3a. All of the underground workings are associated with existing open-pit remnants that are clearly visible in the project area or, in the case of the Triangle mine, have been backfilled and reclaimed. There are no underground mines within the project 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 historic 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. 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 project area (refer to Section 3.1.1.1.1) and the Fuson Shale confining unit is intact and undisturbed. The following discussion provides detailed information on these underground workings.

The first uranium mines in the Edgemont Mining 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 late 1950s and operated both underground and surface mines. The locations of historic surface mining operations in the Triangle Mine area and the Darrow Mine area are depicted on Figure 2.6-3a. Susquehanna-Western often drove adits short distances into open pit walls to recover additional uranium ore that was adjacent to but not within the pit boundary. These types of underground workings were common at historic surface mines and were considered to be extensions of the open pit mining operations.

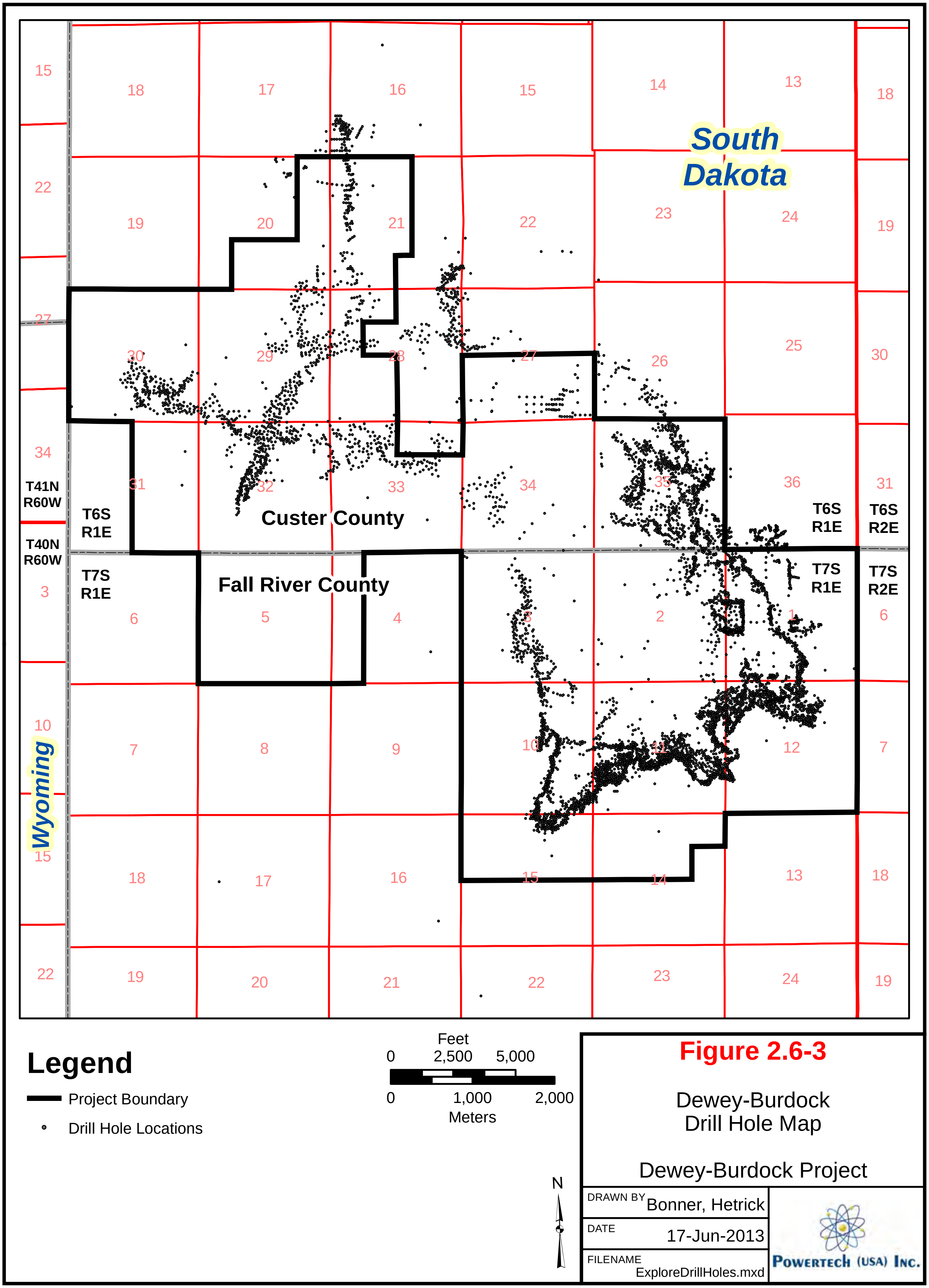


Figure 2.6-3

Dewey-Burdock Drill Hole Map

Dewey-Burdock Project

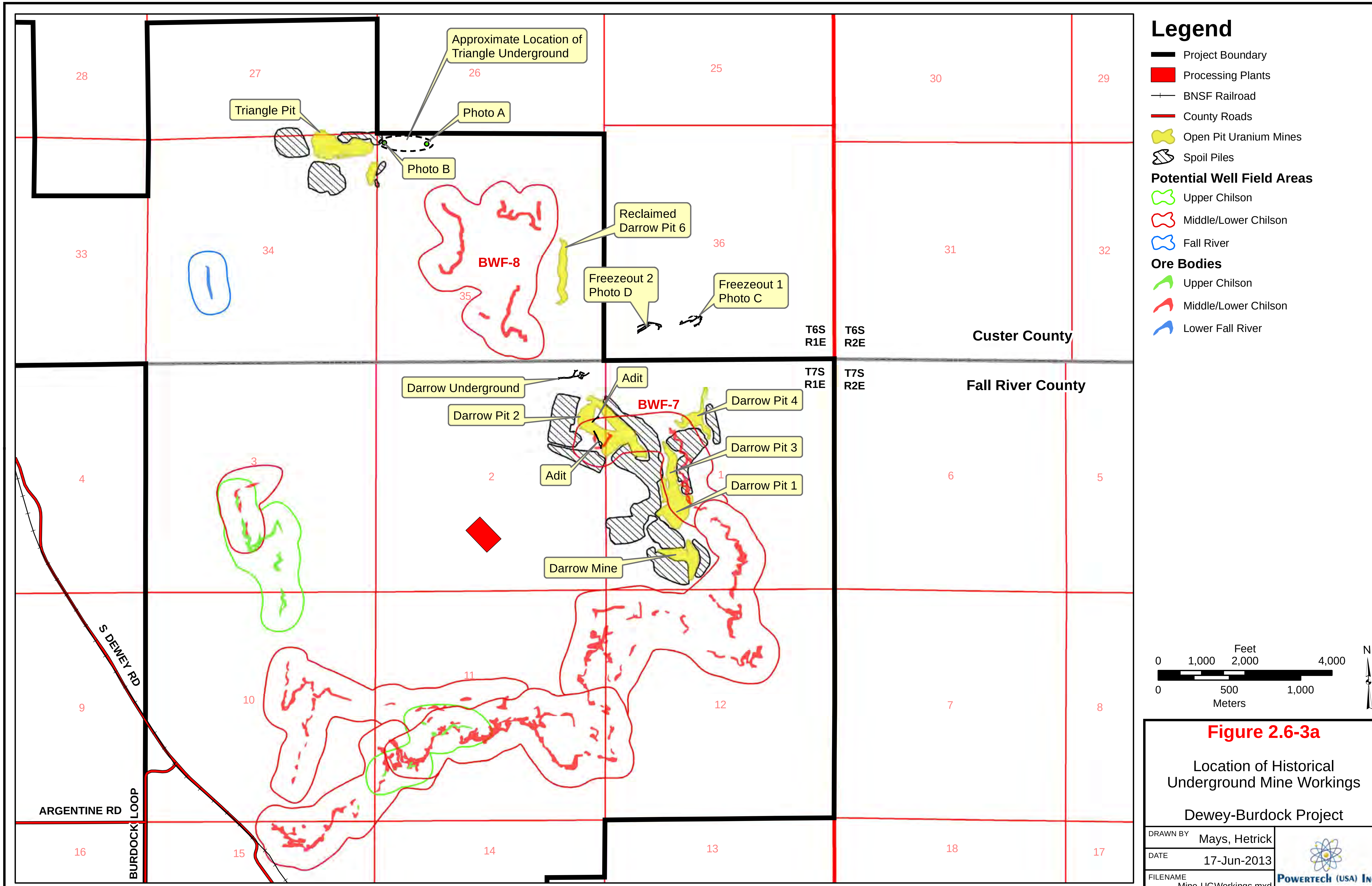


Figure 2.6-3a

Location of Historical Underground Mine Workings

Dewey-Burdock Project

Triangle Mine Area

As shown on Figure 2.6-3a, the Triangle Mine was an open pit mining operation along the northeastern border of the project area in the SE/4 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 NE/4 Section 35, T6S, R1E (see Photo 2.6-1). All photo locations are depicted on Figure 2.6-3a. 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 2.6-2). Powertech (USA) measured the depth to the bottom of this vent shaft 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 which recovered additional ore from the mineralized trend. This adit connected the open pit with the abandoned underground workings.

In 1960, Susquehanna-Western 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 geologist who directed the delineation drilling for this mine. He 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.

Photo 2.6-1: Former Triangle Underground Mine Decline (Photo A on Figure 2.6-3a)

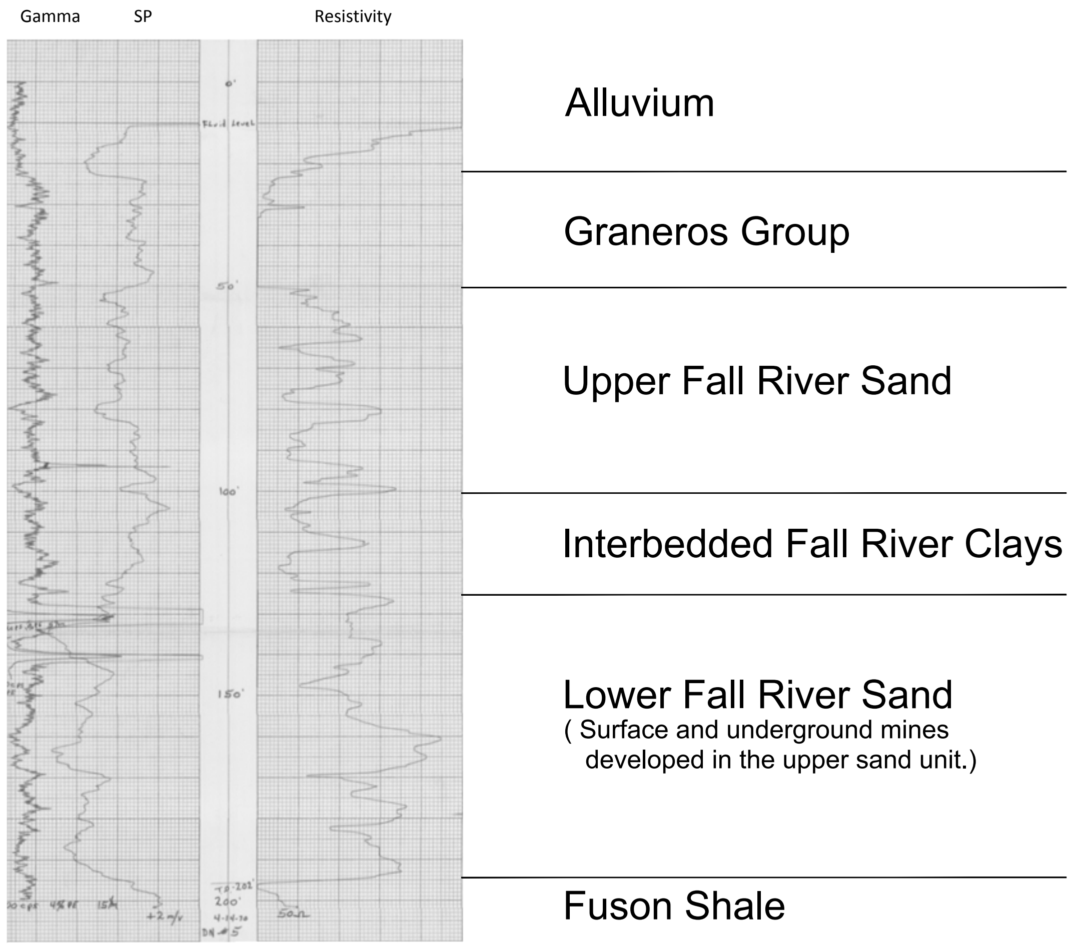
Photo 2.6-2: Triangle Underground Mine Vent Shaft (Photo B on Figure 2.6-3a)

Figure 2.6-3b 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 historic mining operations did nothing to compromise the integrity of the Fuson Shale confining unit.

<u>Darrow Mines Area</u>

Figure 2.6-3a depicts the location of the Darrow Mine surface pits in the eastern portion of the project 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 2.6-3a, the Freezeout underground mines were located approximately ½ mile north of the Darrow surface mines. These historic underground mines are outside of the project area in the SW/4 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 2.6-3 and 2.6-4 show the current condition of 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 2.6-3c 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 2.6-3a shows the location of the Darrow underground mine, approximately 500 feet northwest of Darrow Pit No. 2, in the NE/4 of Section 2. According to personal communication with Donald Spencer (2011), this underground mining consisted of approximately 1,200 feet of workings within a 250-foot x 700-foot area, which was also accessed by declines. The surface in this area has been reclaimed and all evidence of mining operations has been removed. Figure 2.6-3d 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 drill holes and air vents for



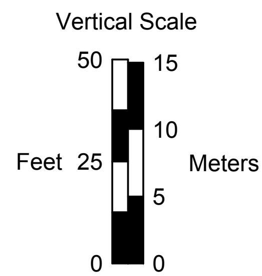


Figure 2.6-3b

Type Log
Triangle Mine Area

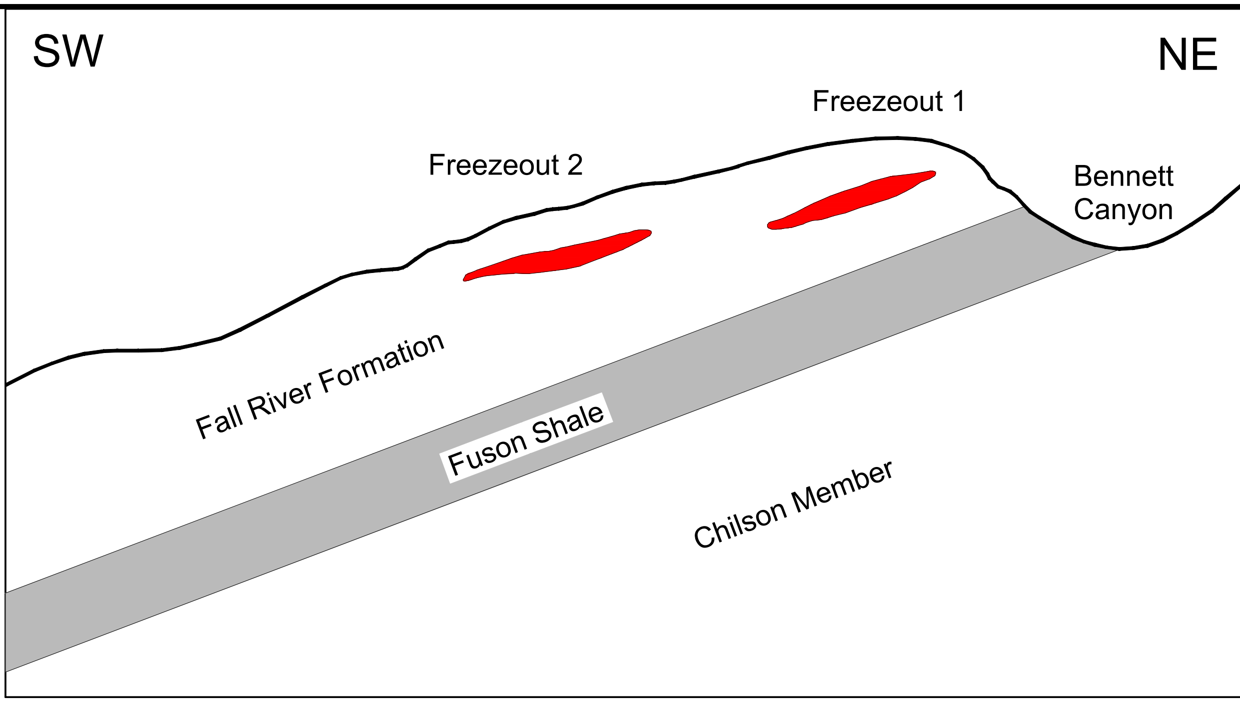
Dewey-Burdock Project

DRAWN BY	F. Lichnovsky
DATE	14-Jun-2013
FILENAME	Mine-TriangleTypeLog.dwg

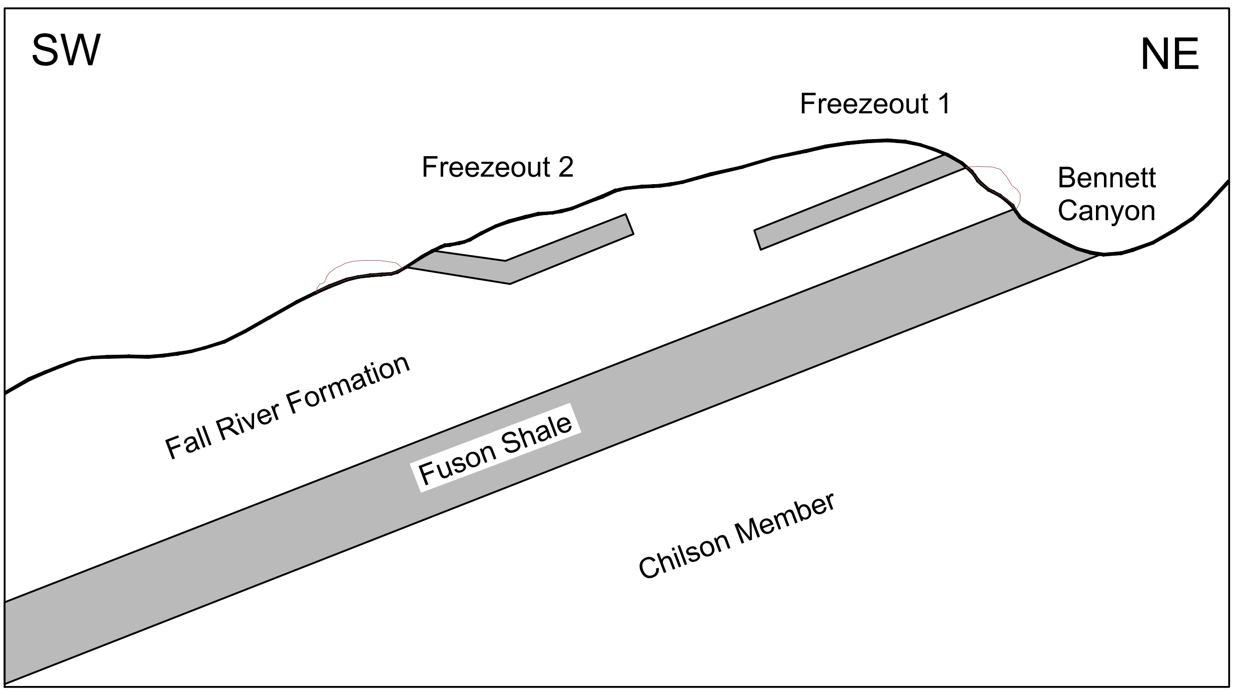
POWERTECH (USA) INC.

Photo 2.6-3: Former Freezeout Mine Decline (Photo C on Figure 2.6-3a)

Photo 2.6-4: Former Freezeout Mine Decline (Photo D on Figure 2.6-3a)



A. Shallow ore bodies in Fall River



B. Declines developed to access Fall River ore bodies.

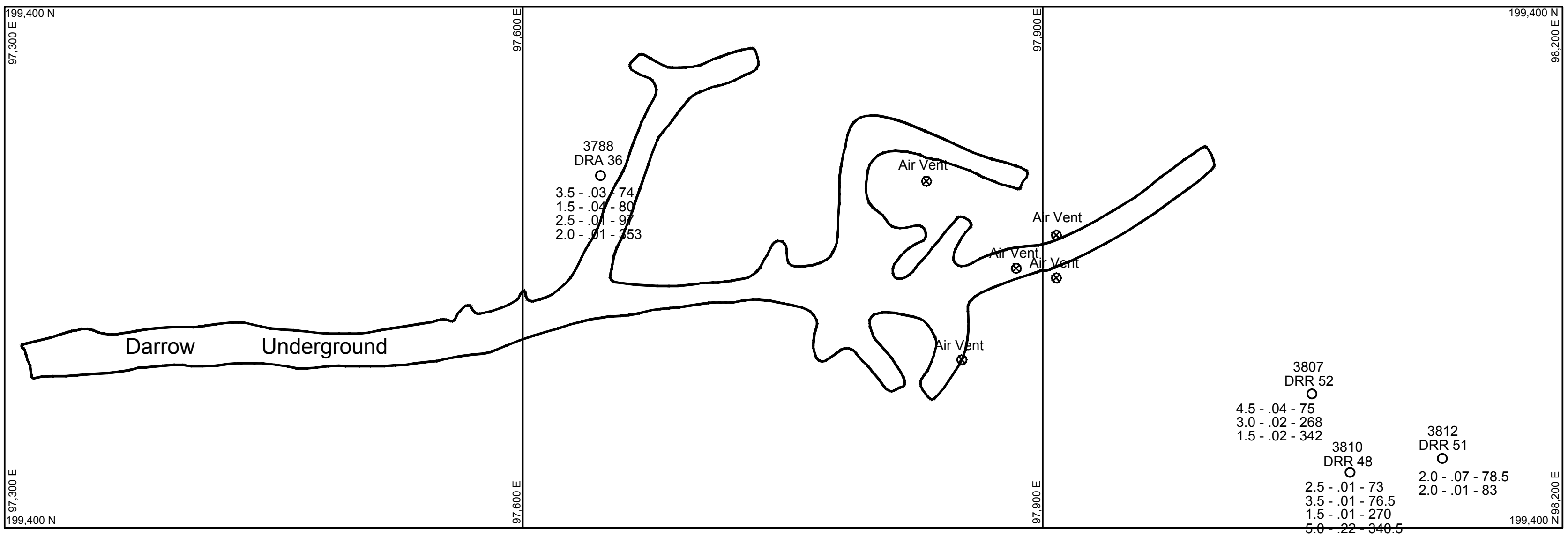
Figure 2.6-3c

Schematic - Underground Workings - Freezeout Mines

Dewey-Burdock Project

DRAWN BY	F. Lichnovsky
DATE	14-Jun-2013
FILENAME	Mine-FreezeoutUGWork.dwg

Powertech (USA) Inc.



N

Feet: 0 50 100 200

Meters: 0 10 20 40 60

Legend

DRR 52 ○ Boreholes

Source: TVA drill hole map

Figure 2.6-3d

Plan View - Darrow Underground Mine

Dewey-Burdock Project

DRAWN BY	F. Lichnovsky
DATE	14-Jun-2013
FILENAME	Mine-DarrowPlanView.dwg

Powertech (USA) Inc.

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 2.6-3e. 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 NE/4 Section 2, T7S, R1E (Figure 2.6-3a). 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. The underground workings are also shown on cross section F-F1 (Plate 2.6-12f).

Figure 2.6-3f 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 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 2.6-12f) illustrates the continuous Fuson Shale confining unit throughout this area. In addition, outcrop examinations of the Fuson Shale in Bennett Canyon, ½-mile up-dip from the Darrow Mine area, reveal the presence of continuous, low-permeability mudstones and shales.

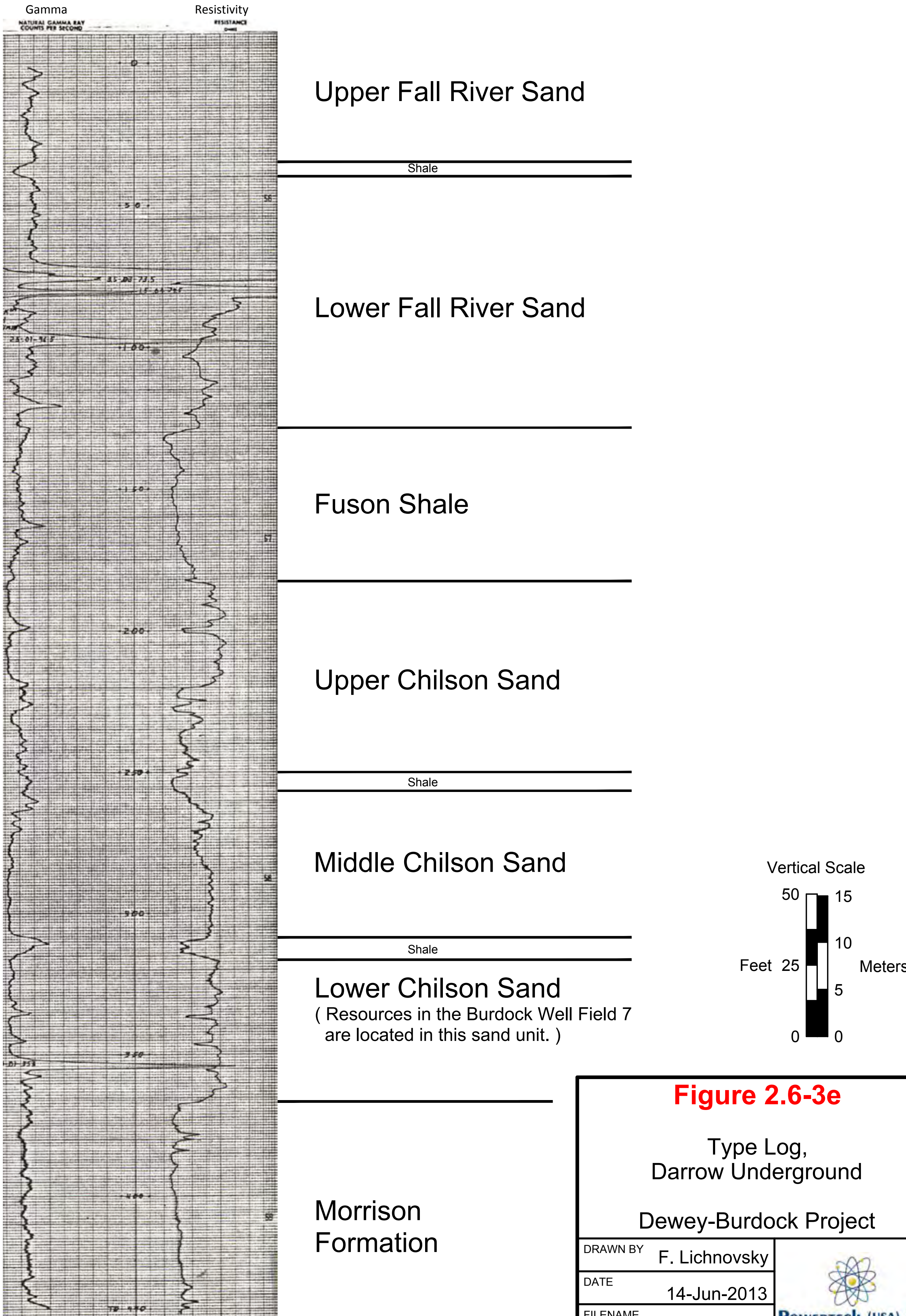


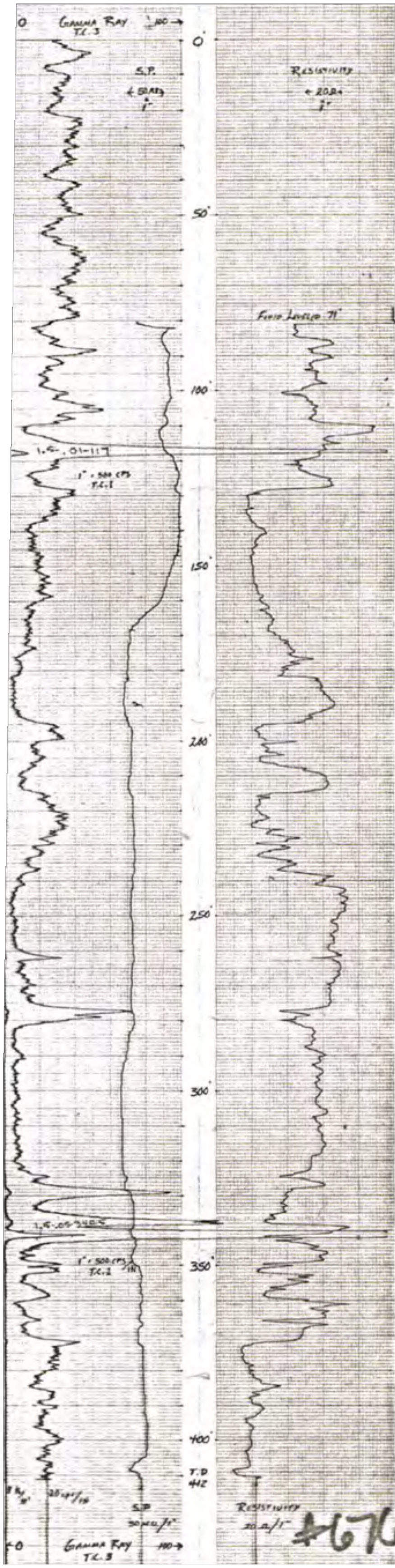
Figure 2.6-3e

Type Log,
Darrow Underground

Dewey-Burdock Project

DRAWN BY	F. Lichnovsky
DATE	14-Jun-2013
FILENAME	Mine-DarrowUGTypeLog.dwg

POWERTECH (USA) INC.



Upper Fall River Sand

Top estimated pick from structure map

Lower Fall River Sand
(surface mines and shallow underground workings located within this unit.)

Fuson Shale

Upper Chilson Sand
(Sand with interbedded Clays.)

Interbedded Chilson Clays

Middle Chilson Sand

Lower Chilson Sand
(Host sand for resources in Burdock Well field 7.)

Morrison Formation

Figure 2.6-3f

Type Log
Darrow Mine Area

Dewey-Burdock Project

DRAWN BY	R. Patton
DATE	14-Jun-2013
FILENAME	Mine-DarrowTypeLog.dwg

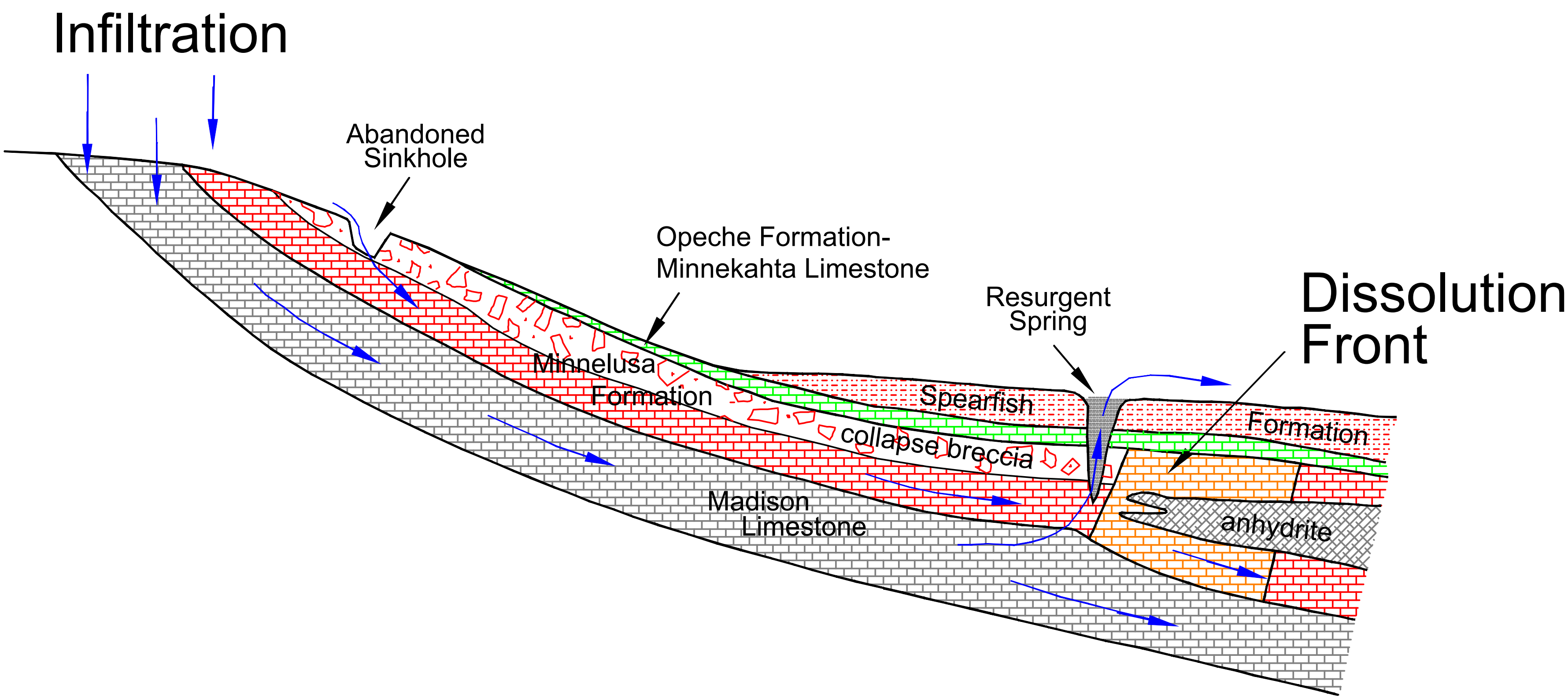
POWERTECH (USA) INC.

2.6.5 Clarification of Breccia Pipes

USGS Professional Paper 763 (Gott et al., 1974) describes the stratigraphy of the Inyan Kara Group along the southern flank of the Black Hills Uplift and presents a working theory on the localization of uranium deposits. The geologic mapping and stratigraphic descriptions contained in that report are comprehensive and provided an important source of information on the stratigraphy and depositional environment of Inyan Kara sediments in this region. However, theories presented in that report on uranium mineralization emplacement that are centered on and related to the presence of breccia pipes penetrating the Inyan Kara Group have not been proven and have been replaced by the classic "roll front" theory of uranium emplacement. Moreover, there appears to be no credible basis to support the theory that collapse features are acting as "conduits" for large volumes of ascending water to recharge the Inyan Kara Group.

Breccia pipes and collapse breccias were mapped in the southern Black Hills by Darton (1909). Gott et al. (1974) state that these collapse features originate in anhydrite and gypsum sequences within the upper portion of the Minnelusa Formation of Pennsylvanian age. Dissolution of these evaporite sequences by underlying Minnelusa and/or Madison artesian water created solution cavities into which overlying Permian sediments collapsed. On Plate 4 of Gott et al. (1974), locations of classic Black Hills collapse breccias occurring within Paleozoic sediments were identified. In addition, many other more speculative features occurring higher in the stratigraphic column were mapped. All breccia pipes or collapse structures located by Gott et al. (1974) and labeled as occurring in the Minnelusa Formation, Opeche Shale, Minnekahta Limestone or basal Spearfish Formation may be considered to be "documented" breccia pipe locations. All of these Paleozoic breccias pipes are located 8-25 miles north and east of the Dewey-Burdock project area, and none occur within the project area.

Geologic mapping and water resource reports have set limits on the expected areal extent of Minnelusa-based collapse breccias. As an example, Figure 2.6-3g, is based on an illustration in an article by Jack B. Epstein published in USGS Water-Resource Investigation Report 01-4011 (2001) and describes the maximum downdip limit of a dissolution front within the evaporite sequence of the upper Minnelusa Formation. In the Black Hills region, extensive dissolution of gypsum and anhydrite beds of the upper Minnelusa has taken place in the surface or near-surface environment. Up to 150 feet of these highly soluble sediments have been removed from the upper Minnelusa through a dissolution process. As illustrated in Photo 2.6-5, behind (up-gradient of) the dissolution front the upper Minnelusa has a distinctive appearance at the outcrop. In addition to an obvious lack of anhydrite and gypsum, its appearance indicates oxidation and



Source: USGS Water-Resources Report 01-401, 2001, Jack B. Epstein, pp. 30-37

Figure 2.6-3g

Minnelusa Dissolution Front

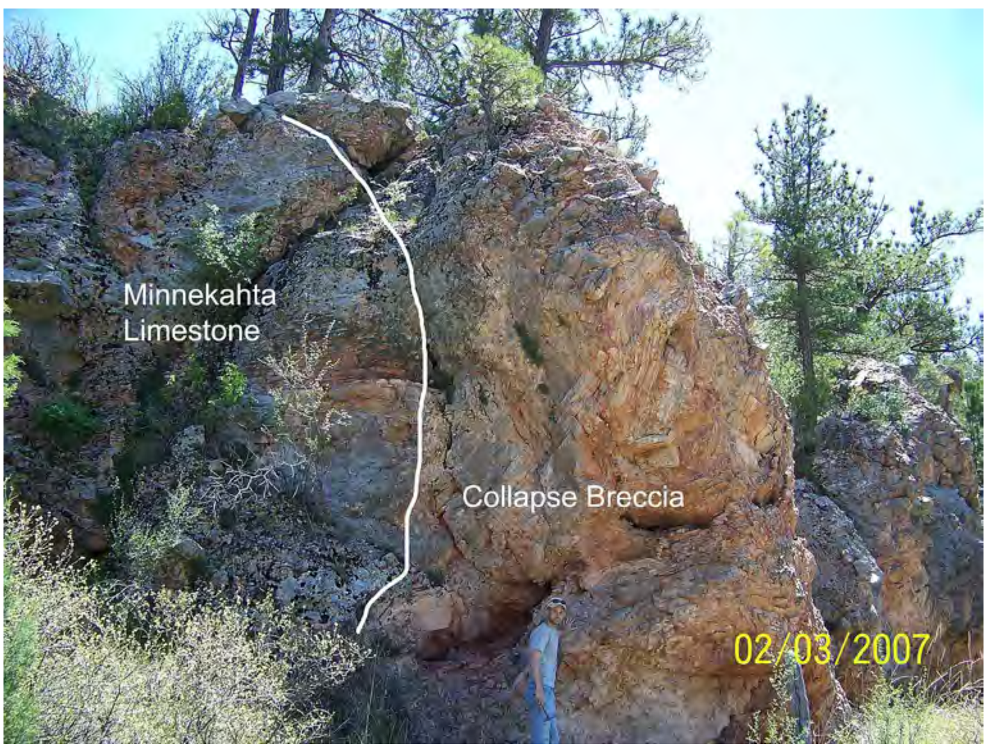
Dewey-Burdock Project

DRAWN BY	J. Bonner
DATE	14-Jun-2013
FILENAME	MinnDissFront.dwg

Powertech (USA) Inc.

Photo 2.6-5: Upper Minnelusa Outcrop (Outside Project Area)
(Photo A on Plate 2.6-15)

Photo 2.6-6: Minnekahta Collapse Breccia (Outside Project Area)
(Photo B on Plate 2.6-15)



weathering. The remaining sediments are extremely distorted, cavernous, brecciated and exhibit numerous flow features. The subsidence within this unit, due to the dissolution process, results in down-dropping of, and collapse breccias within, overlying sediments. Epstein shows that this dissolution extends only a few miles down-gradient in the subsurface, where he shows it stopping at a dissolution front. Down-dip from this front, no dissolution occurs and the evaporite sequences within the upper Minnelusa are intact. With no dissolution, no subsidence, collapse or brecciation can take place.

The presence of a dissolution front within the upper Minnelusa has been recognized for more than a half century. In 1955-56, the USGS mapping team of Braddock, Carter and Bridge compiled the geologic mapping for the Jewel Cave SW 7 ½ minute quadrangle map (Plate 2.6-14). This mapping included the upper Minnelusa Formation in the area of Hell Canyon, in which extensive dissolution has taken place. Within the sediments overlying the upper Minnelusa in this area, there are many collapse breccia features. In fact, this area of lower Hell Canyon (not within the project area) is one of the best locations to view classic Black Hills breccia pipes. Photo 2.6-6 shows a small collapse breccia developed in the Minnekahta Limestone within Hell Canyon. Disoriented blocks of Minnekahta Limestone and smaller breccia material can be seen in this collapse structure. Less than 2 miles down-gradient from the location of this breccia pipe, the USGS mapping team annotated on the geologic map "Probable limit of collapse breccias in Minnelusa Formation" – showing the down-dip extent of the dissolution front. This boundary for Minnelusa breccia pipes is some 6 miles northeast of the Dewey-Burdock project area.

Plate 2.6-15 is based on Plate 4 of Gott et al. (1974) and shows all suggested locations for the three categories of collapse features (using the terminology of Gott et al., 1974): 1) "breccia pipes or collapse features," 2) "structures of possible solution origin," and 3) "topographic depressions." It also illustrates the outcrop areas of the Minnelusa Formation and the Inyan Kara Group. The "red line" on this exhibit corresponds to locations where the downdip limit of the dissolution front in the upper Minnelusa has been mapped or projected. North of this line classic Black Hills breccia pipes have been mapped and identified. South of this line suggested locations of collapse features are more speculative and many features are identified as "structures of possible solution origin" and "topographic depressions." The identification and mapping of a solution front within the upper Minnelusa is critical to confirming the absence of breccia pipes at the Dewey-Burdock project area. As previously described, dissolution of the anhydrites and gypsum within the upper Minnelusa is essential for subsequent collapse brecciation and breccia pipe formation in overlying sediments. In areas where there has been no dissolution, there is no

geologic foundation for the creation of breccia pipes in overlying sediments. Also shown on Plate 2.6-15 is the outline of the Jewel Cave SW 7½ minute quadrangle map (Plate 2.6-14) and the locations of all photographs.

Figure 2.6-3h shows the Mesozoic and a portion of the Paleozoic stratigraphy below the project site. This electric log is from an abandoned oil & gas test well (the Darrow well) in Section 2, T7S, R1E that penetrated the Minnelusa Formation. The character of the upper Minnelusa Formation under the project area is extremely important because all Black Hills breccia pipes are "rooted" in this unit. Three observations from Figure 2.6-3h are of major significance to this matter.

1) As discussed above, the dissolution front in the upper Minnelusa has been mapped north of the project area. This test well is located approximately 7 miles further down-gradient from and beyond the dissolution front. The electric log signature shows thick sequences of evaporites. There has been no dissolution within the upper Minnelusa under the project area.
2) The thickness of the upper Minnelusa in the Darrow test well also supports the fact that this test hole is located well in advance of a dissolution front. Hayes (1999) discusses the collapse brecciation at Cascade Springs and provides stratigraphic descriptions of the upper Minnelusa. He describes this interval as beginning at a red, mudstone-rich marker bed, locally known as the Red Marker and continuing upward to the Opeche Shale. He states that a 300-foot thickness of the upper Minnelusa is common in areas where anhydrite has been removed by solution and breccia pipes occur. Basinward (downdip), the upper Minnelusa is 150 feet thicker in the subsurface where dissolution of anhydrite beds has not taken place. The thickness of the upper Minnelusa in the Darrow test well is 442 feet, again indicating that there has been no dissolution under the project area.
3) As shown in the left margin of Figure 2.6-3h, the stratigraphic horizons that host classic Black Hills breccia pipes are the upper Minnelusa Formation, Opeche Shale, Minnekahta Limestone and the lower 200 feet of the Spearfish Formation. These geologic units are fully intact and over 1,000 feet below the ground surface at the Dewey-Burdock project area.

The following Powertech (USA) geological evaluations and environmental baseline analyses present additional evidence demonstrating that breccia pipes are not present at the Dewey-Burdock site.

1) Exploration Drilling - The large number of exploration drill holes (more than 4,000) completed within the project area without any indication of solution collapses bolsters the hypothesis that no breccia pipes have penetrated the Inyan Kara Group (Figure 2.6-3). If such an event had occurred, evidence of solution collapses would be observed in the

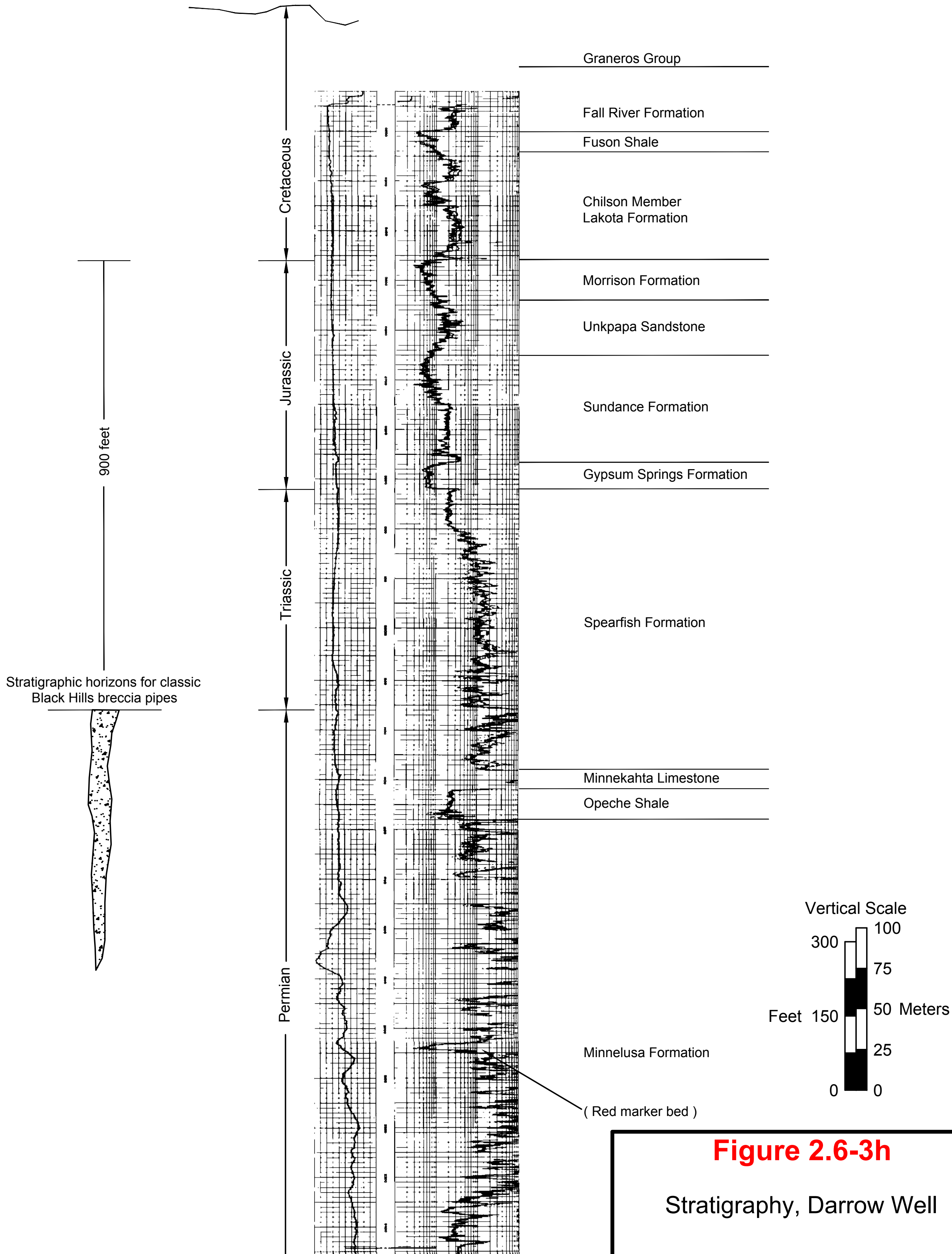


Figure 2.6-3h

Stratigraphy, Darrow Well

Dewey-Burdock Project

DRAWN BY	J. Bonner
DATE	14-Jun-2013
FILENAME	Mine-DarrowWellStratig.dwg

POWERTECH (USA) INC.

correlation of the electric logs or from the structure maps developed on top of the Morrison Formation, Chilson Member, Fuson Shale or Fall River Formation. Any subsidence, collapse features or down-dropped sediments would have been evident while preparing cross sections or structure contour maps.

2) Field Investigations for Breccia Pipes - In Professional Paper 763, Gott et al. presented the theory that breccia pipes may extend upward into the Inyan Kara sediments. While there were no features identified within the project boundary, Powertech (USA)'s field investigation focused on "proposed" collapse features within Jurassic and Cretaceous sediments northeast of the project. Due to the high-grade uranium deposits that have been mined within breccia pipes in the Arizona Strip of northwest Arizona, the uranium industry has extensive experience in surface exploration techniques for these features (Figure 2.6-3i). As a comparison, Arizona Strip evaluation criteria were applied to the proposed Black Hills features. These criteria consisted of displaced sediments, brecciation, dip changes of surface beds, fracture patterns and alteration patterns. In addition, due to the Gott et al. theory that breccia pipes were conduits for high volumes of ascending groundwater as recharge to the Inyan Kara aquifer, the Powertech (USA) geologic team specifically searched for evidence of solution movement at these sites. Investigation sites correspond to photo locations shown on Plate 2.6-15.

   A. The first site examined was Cascade Springs, a classic Black Hills breccia pipe located south of Hot Springs, South Dakota. This breccia pipe area was the subject of the previously mentioned USGS Water-Resource Investigation Report 99-4168 (Hayes, 1999). Powertech (USA) staff believed it was important to examine a verified collapse breccia feature and collect "ground truth" before investigating other sites. At the subject site, the surface Minnekahta Limestone met several of the Arizona Strip evaluation criteria, including major fracture patterns, brecciation within the limestone, dip changes of surface beds in the fractured areas and obvious evidence of solution movement. Also of major importance, this feature is located upgradient or updip of the mapped upper Minnelusa dissolution front. Photos 2.6-7 and 2.6-8 illustrate some of these observed evaluation criteria.

   B. The second site focused on "breccia pipes" mapped by Gott et al. within Jurassic sediments approximately 2 miles north of the project area. This area is located 2 miles down-gradient from the mapped downdip limit of the dissolution front and no evidence of collapse or brecciation was observed. Instead, these features were found to be small normal faults within the Dewey Fault Zone. As shown in Photos 2.6-9 and 2.6-10, the sediments were subject to high compressional forces within the fault zone, resulting in folding and normal faulting. The area met none of the Arizona Strip evaluation criteria.

   C. The third and fourth sites examined were areas where Gott et al. mapped "breccia pipes" within Inyan Kara sediments approximately 2-3 miles northeast of the project area. These features were of primary interest because they had purportedly penetrated the Morrison Formation and Inyan Kara sediments. Powertech (USA) geologists spent two days investigating these features. These

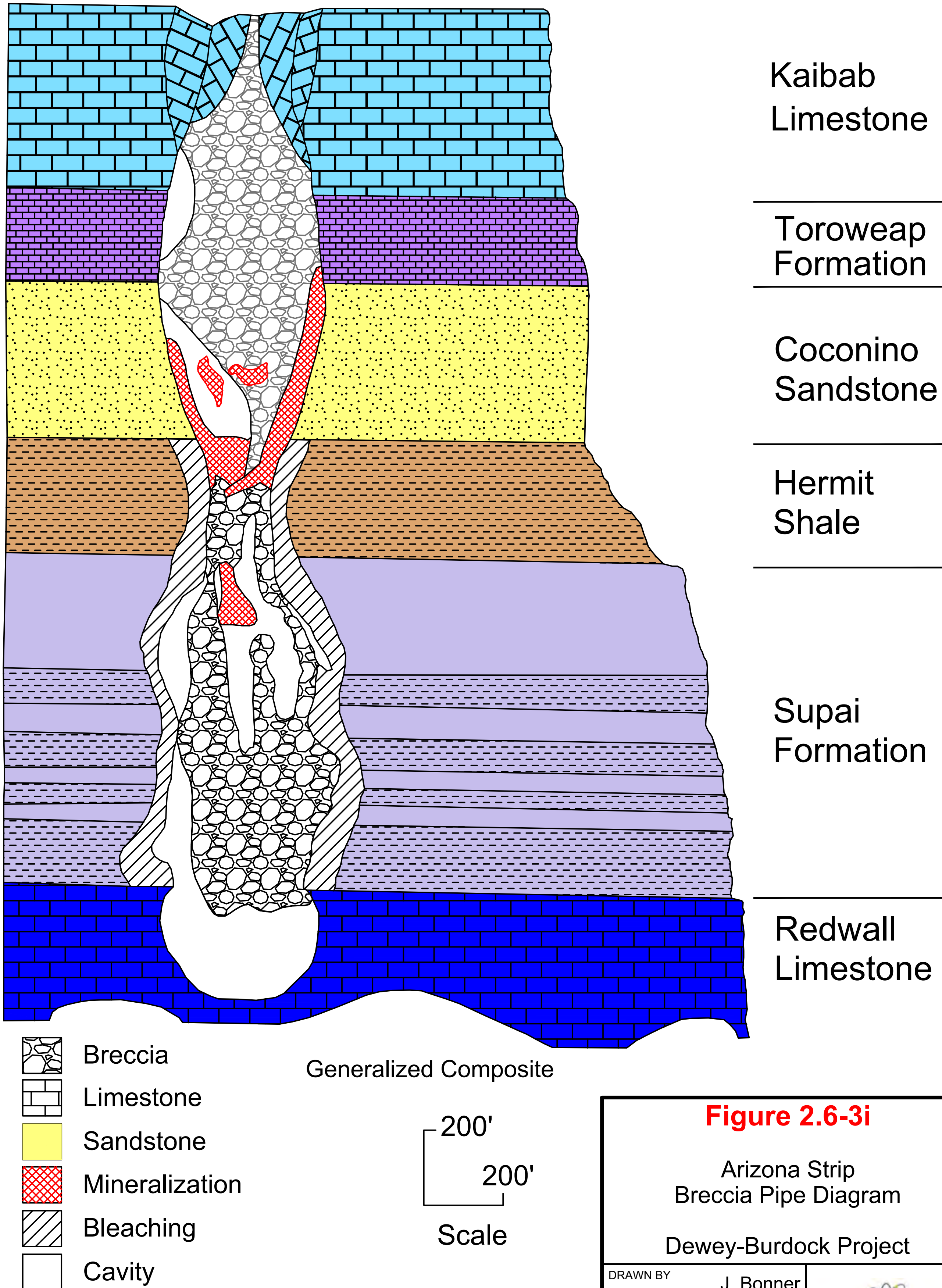


Figure 2.6-3i

Arizona Strip
Breccia Pipe Diagram

Dewey-Burdock Project

DRAWN BY	J. Bonner
DATE	14-Jun-2013
FILENAME	ZAStripBrecciaPipe.dwg

Powertech (USA) Inc.

Photo 2.6-7: Cascade Springs Breccia Pipe (Outside Project Area) (Photo C on Plate 2.6-15)

Photo 2.6-8: Cascade Springs Breccia Pipe (Outside Project Area) (Photo D on Plate 2.6-15)

Photo 2.6-9: Sundance Formation Fault (Outside Project Area)
(Photo E on Plate 2.6-15)

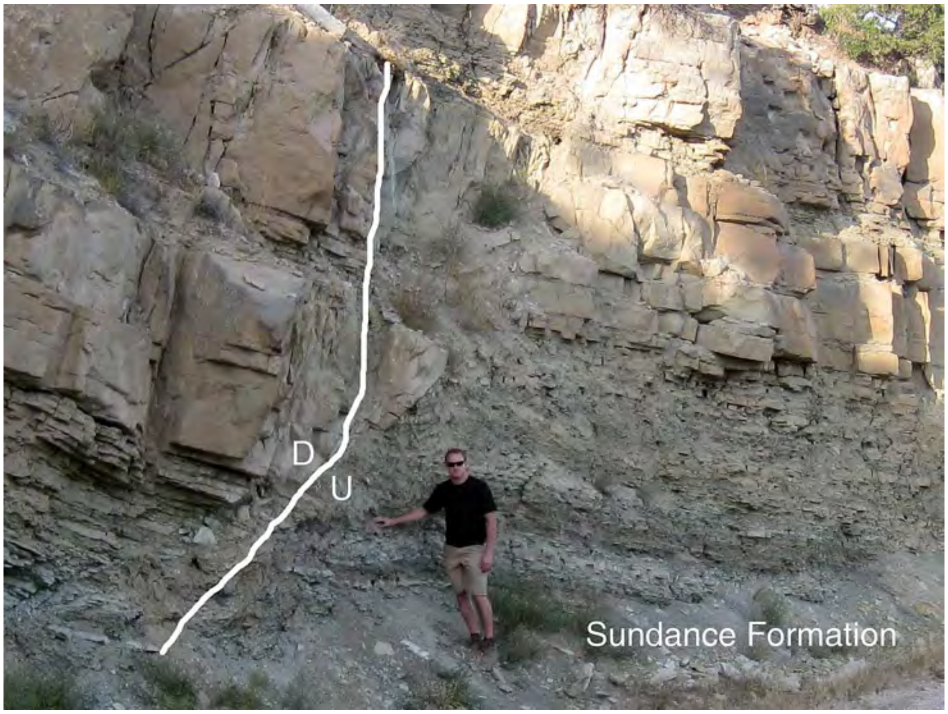


Photo 2.6-10: Sundance Formation Fault (Outside Project Area)
(Photo F on Plate 2.6-15)

features were located in Sections 21 and 24, T6S, R2E and were 2 miles down-gradient from the mapped dissolution front. These features were found in the bottoms of deep canyons with Chilson Member sandstones forming steep cliffs along the canyon walls. There was no evidence of collapse or brecciation and, as shown in Photos 2.6-11 and 2.6-12, it appears the features were the result of surface erosion and slump blocks caving off the steep canyon walls. The area met none of the Arizona Strip evaluation criteria.

In addition to the above sites, other "structures of possible solution origin" were investigated. All of these sites were located down-gradient of the mapped downdip limit of the dissolution front and met none of the Arizona Strip criteria. Further, there was no evidence of springs to indicate flow of ascending groundwater into the Inyan Kara aquifer. The signature surface expressions for breccia pipes are lacking in all areas examined; no surface geologic evidence could be found to support the presence of breccia pipes on or adjacent to the project area.

3) Inyan Kara Water Temperatures - Gott et al. also theorized that the rapidly ascending groundwater from the deeper Minnelusa Formation would have a higher temperature than the water in the Inyan Kara aquifer. This theory proposes that "water probably has been heated in deeper aquifers and then has ascended to the Inyan Kara Group" through breccia pipes. As supporting evidence of this theory, Gott et al. cite the presence of high geothermal gradients within Inyan Kara wells averaging 1.5º C per 100 feet, as opposed to an average geothermal gradient of 0.9º C per 100 feet for pre-Cretaceous rocks in the Black Hills area.

   As part of Powertech (USA)'s environmental baseline analyses, field parameters (including groundwater temperature) were collected at each sampled well (Appendix 2.7-G). Water temperature measurements from 16 wells completed within the Inyan Kara aquifer were used to estimate geothermal gradients within the Inyan Kara aquifer at the Dewey-Burdock Project. In addition to these field measurements, Powertech (USA) also has accurate information on the screened interval for each of these wells, which provides reliable depths to groundwater (top of screened intervals).

   Depths to groundwater in the 16 Inyan Kara wells ranged from 30 to 715 feet below ground surface. Water temperatures ranged from 11.55º C (in the shallowest well) to 15.39º C (in the deepest well). The average geothermal gradient of these 16 wells was calculated to be 0.42º C per 100 feet – well below one-half the gradient cited by Gott et al. for the Inyan Kara aquifer. Based on Powertech (USA)'s more accurate and concentrated water sampling results within the Dewey-Burdock project area, all evidence indicates the presence of a normal geothermal gradient within the Inyan Kara aquifer – not an elevated gradient due to rapidly ascending, heated groundwater from underlying aquifers as theorized by Gott et al.

4) Regional Pumping Tests - As described in Section 2.7.2, the pumping tests conducted by TVA in the early 1980s (Appendix 2.7-K) and by Powertech (USA) in 2008 (Appendix 2.7-B) were "regional tests" aimed specifically at evaluating hydraulic transmission and storage characteristics of the mineralized zones within the Fall River

Photo 2.6-11: Mapped "Breccia Pipes" (Outside Project Area) (Photo G on Plate 2.6-15)

Photo 2.6-12: Mapped "Breccia Pipes" (Outside Project Area) (Photo H on Plate 2.6-15)

Formation and the Chilson Member of the Lakota Formation and the intervening Fuson Shale confining unit. Based on the results of the regional pumping tests that have been conducted within the project area, the Fuson Shale, which is the confining unit between the overlying Fall River Formation and the underlying Chilson Member, may locally be “leaky”; that is, the observed aquifer response in the Fall River and Chilson suggests possible hydraulic communication between these units. In none of the aquifer tests that have been conducted to date, however, has a “recharge boundary” been observed which would suggest the existence of a significant source of water such as postulated by Gott et al. (1974). In other areas of the Black Hills, the surface discharge through breccia pipes is on the order of several cubic feet per second.

As described in Section 3.1.3.2, delineation drilling and “well field scale” pumping tests will be undertaken prior to the development of each well field. These well field scale pumping tests will specifically address potential leakage through confining beds, through improperly-sealed or unplugged exploration boreholes, or associated with naturally-occurring geologic features such as faulting, breccia pipes, etc.

5) Color Infrared (CIR) Imagery - 2010 CIR satellite imagery was obtained for an approximately 10-square-mile area, including the project area and surrounding vicinity. The imagery obtained through the National Agriculture Imagery Program (NAIP) of the USDA Farm Services Agency has a resolution of one meter.

The imagery was examined visually for any anomalies that may suggest groundwater discharge at or near surface, such as from upward flow through a breccia pipe, an open borehole or a natural spring. Using a combination of CIR and field investigations, all surface water features within the project area were identified and no surface water features or groundwater flow sources were found within the project area indicative of a breccia pipe flowing to the surface.

6) Numerical Groundwater Modeling - An integral component of the groundwater modeling efforts was to simulate the aquifer response to “point-source recharge” such as might occur as a result of upward leakage through improperly-plugged or unplugged boreholes or a breccia pipe. These simulations included an evaluation of how leakage would be manifested in the observed aquifer response to pumping and during ISR operations.

The results of the groundwater modeling are provided in Appendix 6.1-A.

2.6.6 Soils

Powertech (USA) conducted baseline soil sampling and mapping covering an estimated 7,964.26 acres as shown on Plate 2.6-16 in accordance with NUREG-1569 and RG-4.14.

Stripping depths for the PAA 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 are based on laboratory data of the samples found within the borders of the area, as well as field observations and knowledge of the soils in Custer and Fall River Counties, South Dakota.

Soils in the PAA 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.

Almost all soils have some suitable topsoil. The primary limiting factors within the PAA are electrical conductivity (EC), sodium adsorption ratio (SAR), calcium carbonates, and texture (clay percentage).

Refer to Appendix 2.6-B for the Soil Mapping Unit Descriptions. Refer to Appendix 2.6-C for the Soil Series Descriptions. Refer to Appendix 2.6-D for the Original Laboratory Data Sheets. Refer to Appendix 2.6-E for the Prime Farmland Designation. Refer to Appendix 2.6-F for the Site Photographs.

2.6.6.1 Methodology

2.6.6.1.1 Review of Existing Literature

The soils in this portion of Custer and Fall River Counties were studied and mapped to an Order 2 scale by the USDA, NRCS in 1982 and 1990. Information for Custer and Fall River Counties is available electronically as well as hard copy. The NRCS has also centralized dissemination of typical soil series descriptions; general information is available on the internet at www.nrcs.usda.gov.

2.6.6.1.2 Project Participants

BKS performed the 2007 soil survey field work and compiled the resulting report. All soil analysis was handled by Energy Labs in Gillette, Wyoming.

2.6.6.1.3 Soil Survey

Construction of the PAA soil map was completed according to techniques and procedures of the National Cooperative Soil Survey. Guideline No. 1 (August, 1994 Revision) of the WDEQ-LQD was followed during all phases of the work.

A total of 7,960.77 acres were included in the final soil mapping of the PAA, in which 3,065.74 of those acres were located in disturbance areas. Note that the reference to disturbance area in terms of baseline soil sampling and mapping does not reflect the actual area proposed for disturbance by Powertech (USA). When the soil mapping was completed, Powertech (USA) had not yet designed proposed facilities and potential well field areas to the level of detail presented in this application. The 3,065.74 acres of disturbance area discussed in this section are based on an initial estimate of the orebody and monitoring ring extents. Refer to Table 2.6-1 for soil mapping unit designations and associated acreage within the PAA. Table 2.6-1 also describes the soil map units in terms of actual map designations and slope percentages.

Table 2.6-1: Proposed Action Area Soil Mapping Unit Acreages

Map Symbol	Map Unit Description	Permit Acreage	Disturbance Areas[1]	% Total PAA
Aa	Alice, 0 to 6 percent slopes	36.99	0	0
Ar	Arvada, 0 to 6 percent slopes	258.3	121.78	3.97
As	Ascalon, 0 to 6 percent slopes	27.42	41.22	1.35
Bc	Barnum, 0 to 6 percent slopes	484.09	13.01	0.42
Bo	Boneek, 0 to 6 percent slopes	51.53	0	0
Br	Broadhurst, 6 to 15 percent slopes	60.22	190.74	6.22
Bw	Butche, 6 to 40 percent slopes	234.53	25.42	0.83
Cn	Colby, 6 to 15 percent slopes	72.2	0	0
Cy	Cushman, 6 to 15 percent slopes	110.06	12.26	0.40
Dg	Demar, 0 to 6 percent slopes	509.39	134.26	4.38
DA	Disturbed-Ag	196.05	41.36	1.35
GrA	Grummit, 0 to 6 percent slopes	250.81	37.85	1.24
GrB	Grummit, 6 to 15 percent slopes	632.43	369.1	12.04
GrC	Grummit, 15 to 60 percent slopes	550.67	48.43	1.58
Ha	Haverson, 0 to 6 percent slopes	233.1	0	0
He	Hisle, 0 to 6 percent slopes	307.65	54.52	1.78
Ky	Kyle, 0 to 6 percent slopes	471.39	333.96	10.89
Lo	Lohmiller, 0 to 6 percent slopes	38.06	5.66	0.19
Mm	Mathias, 15 to 40 percent slopes	331.62	34.08	1.11
MP	Mine Pit	340.48	18.31	0.60
Nf	Nihill, 15 to 50 percent slopes	11.36	25.61	0.84
No	Norka, 0 to 6 percent slopes	85.07	0	0
NuA	Nunn, 0 to 6 percent slopes	28.54	41.22	1.35
NuB	Nunn, 6 to 15 percent slopes	17.45	0	0
Pa	Paunsaugunt, 6 to 15 percent slopes	0.86	0	0
Pg	Penrose, 15 to 40 percent slopes	210.76	231.08	7.54
PeA	Pierre, 0 to 6 percent slopes	479.11	216.03	7.05
PeB	Pierre, 6 to 15 percent slopes	470.36	157.99	5.15
RO	Rock Outcrop	126.91	17.42	0.57
Sa	Samsil, 15 to 40 percent slopes	249.01	515.29	16.81
Sc	Satanta, 0 to 6 percent slopes	32.28	0	0
Sn	Shingle, 15 to 40 percent slopes	86.75	11.66	0.38
SS	Slickspots	536.39	148.77	4.85
Gs	Snomo, 6 to 15 percent slopes	179.92	106.06	3.46
Ta	Tillford, 0 to 6 percent slopes	171.69	7.84	0.26
W	Water	32.77	72.5	2.37
Wt	Winetti, 0 to 6 percent slopes	7.73	6.92	0.23
202	Worfka, 15 to 40 percent slopes	3.04	0	0
ZnB	Zigweid, 6 to 15 percent slopes	11.35	25.39	0.83
ZnC	Zigweid, 6 to 40 percent slopes	22.43	0	0
Total		**7,960.77**	3,065.74	**100**

[1] Note: The reference to disturbance area in terms of baseline soil sampling and mapping is based on an initial estimate of the orebody and monitoring ring extents and does not reflect the actual area proposed for disturbance. Refer to Section 6.2.2 for planned surface disturbance.

2.6.6.1.4 Field Sampling

Soil series were sampled to reflect recommended sample numbers in WDEQ Guideline 1 (August 1994 Revision) based on mapping acreage. Most samples were taken either in or near disturbed areas. Additional sampling of soils in the permit area will occur as the operation is expanded outside the current disturbed areas.

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. A total of 33 sites on the PAA were sampled for analysis; all had corresponding soil profile descriptions written. Refer to Table 2.6-2 Soils Series Sample Summary and Table 2.6-3 Soil Sample Locations.

Table 2.6-2: Soil Series Sample Summary for the Proposed Action Area[1]

Soil Series	Number of Profiles Sampled for Chemical Analysis
Broadhurst	1
Kyle	3
Hisle	2
Nevee	1
Barnum	1
Ascalon	1
Cushman	1
Zigweid	1
Butche	1
Samsil	3
Paunsaugunt	1
Boneek	4
Arvada	1
Lohmiller	2
Pierre	2
Haverson	1
Demar	2
Penrose	1
Satanta	1
Snomo	1
Grummit	1
Shingle	1
Total	**33**

[1]Samples were taken within proposed disturbed area as defined by initial estimates of the orebody.

Table 2.6-3: Proposed Action Area[1] Soil Sample Locations

Soil Sample Number	Map Unit Designation	Soil Series
17	Broadhurst silty clay, 6 to 15 percent slopes	Broadhurst
27	Kyle noncalcareous variant, 0 to 6 percent slopes	Kyle
36	Kyle noncalcareous variant, 0 to 6 percent slopes	Kyle
39	Hisle silt loam, 0 to 6 percent slopes	Hisle
40	Hisle noncalcareous variant, 0 to 6 percent slopes	Hisle
41	Nevee silt loam, 6 to 15 percent slopes	Nevee
42	Barnum silt loam, 0 to 6 percent slopes	Barnum
43	Ascalon clay loam, 0 to 6 percent slopes	Ascalon
50	Cushman loam, 6 to 15 percent slopes	Cushman
56	Zigweid loam, 0 to 6 percent slopes	Zigweid
57	Butche clay loam, 3 to 15 percent slopes	Butche
60	Samsil clay loam, 15 to 40 percent slopes	Samsil
63	Paunsaugunt loam, 6 to 15 percent slopes	Paunsaugunt
64	Boneek silty clay loam, 0 to 6 percent slopes	Boneek
72	Arvada silty clay loam, 0 to 6 percent slopes	Arvada
73	Lohmiller loam, 0 to 6 percent slopes	Lohmiller
74	Pierre sandy clay loam, 0 to 15 percent slopes	Pierre
75	Haverson clay loam, 0 to 6 percent slopes	Haverson
76	Demar loam, 0 to 6 percent slopes	Demar
77	Penrose clay loam, 0 to 6 percent slopes	Penrose
79	Demar silty clay loam, 0 to 6 percent slopes	Demar
82	Satanta loam, 0 to 6 percent slopes	Satanta
83	Snomo silty clay loam, 0 to 6 percent slopes	Snomo
84	Lohmiller silty clay loam, 0 to 6 percent slopes	Lohmiller
85	Kyle loam, 0 to 6 percent slopes	Kyle
88	Samsil noncalcareous variant, 15 to 40 percent slopes	Samsil
89	Pierre silty clay loam, 0 to 15 percent slopes	Pierre
90	Grummit silty clay, 0 to 6 percent slopes	Grummit
91	Boneek clay loam, 0 to 6 percent slopes	Boneek
92	Samsil silty clay loam, 15 to 40 percent slopes	Samsil
93	Shingle loam, 15 to 40 percent slopes	Shingle
94	Boneek noncalcareous variant, 0 to 6 percent slopes	Boneek
95	Boneek loam, 0 to 6 percent slopes	Boneek

[1]Samples were taken within proposed disturbed area as defined by initial estimates of the orebody.

2.6.6.1.5 Laboratory Analysis

Samples were individually placed into lined aluminum pans to air dry. Coarse fragments were measured with a 10 mesh screen prior to grinding; the entire sample was then hand ground to pass 10 mesh. An approximate 20 ounce subsample was obtained through splitting with a series

of riffle splitters and subsequently analyzed. A second subsample was maintained in storage at Energy Labs. Approximately 10 percent of the samples are run for duplicate analysis. Actual laboratory analysis follows the methodology outlined in WDEQ-LQD Guideline 1 (August 1994 Revision). In general, samples were analyzed within 45 days of receipt of the samples at the laboratory. All analytical data is presented in Appendix 2.6-D, Original Laboratory Data Sheets.

2.6.6.2 Results and Discussion

2.6.6.2.1 Soil Survey - General

General topography of the area ranged from nearly level uplands to very steep hills, ridges and breaks of dissected shale plains. The soils occurring on the PAA 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 PAA contained deep soils on level upland areas with shallow and very shallow soils located on hills, ridges and breaks.

2.6.6.2.2 Soil Mapping Unit Interpretation

The primary purpose of the 2007 fieldwork was to characterize the soils within the PAA in terms of topsoil salvage depths and related physical and chemical properties. The total number of samples per series was established in line with WDEQ Guideline 1 (August 1994 Revision) recommendations based on estimated acreage of soil series known within the PAA. Refer to Appendix 2.6-B and Appendix 2.6-C for soil mapping unit descriptions and soil series descriptions, respectively.

2.6.6.2.3 Analytical Results

Analyzed parameters, as defined in WDEQ Guideline 1 (August 1994 Revision), are in Appendix 2.6-D, Original Laboratory Data Sheets. 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. Where applicable, field observation of fine sands is also included in the textures found in the soil series descriptions in Appendix 2.6-C. In several of the pedestal sampling locations, laboratory analysis yielded finer than expected textures (based upon field observations). Where textures are finer than typical for the series, it is noted in the Range of Characteristics (according to field observations, lab analysis) in the soil series descriptions.

2.6.6.2.4 Evaluation of Soil Suitability as a Plant Growth Medium

Approximate salvage depths of each map unit series are presented in Table 2.6-4 and ranged from 0.0 to 5.0 feet. Within the PAA, 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 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. Marginal or unsuitable parameter information for sampled profiles is identified in Table 2.6-5. A summary of trends in marginal or unsuitable parameters as it relates to soil series is found in Table 2.6-6. Based on laboratory analysis and field observations, marginal material parameters primarily consisted of texture (clay percentage), calcium carbonates, EC, and SAR.

Table 2.6-4: Proposed Action Area Summary of Approximate Soil Salvage Depths

Map Symbol	Mapping Unit Description	Disturbance Areas[1]	Salvage Depth (feet)	Total Volume (Acre feet)
Ar	Arvada	121.78	1.5	182.67
As	Ascalon	41.22	1.17	48.23
Bc	Barnum	13.01	0.5	6.51
Br	Broadhurst	190.74	0.67	127.80
Bw	Butche	25.42	0.67	17.03
Cy	Cushman	12.26	2.08	25.50
Dg	Demar	134.26	0.21	28.20
DA	Disturbed-Ag	41.36	-	-
GrA	Grummit, 0 to 6 percent slopes	37.85	1.67	63.21
GrB	Grummit, 6 to 15 percent slopes	369.1	1.67	616.40
GrC	Grummit, 15 to 60 percent slopes	48.43	1.67	80.88
He	Hisle Noncalc. Variant Average	54.52	5 5 5	272.60
Ky	Kyle Noncalc. Variant Average	333.96	2.5 0.80 1.65	551.03
Lo	Lohmiller	5.66	0.34	1.92
Mm	Mathias	34.08	0	0
MP	Mine Pit	18.31	-	-
Nf	Nihill	25.61	0.42	10.76
Nu	Nunn	41.22	2	82.44
Pg	Penrose	231.08	3	693.24
PeA	Pierre, 0 to 6 percent slopes	216.03	0.71	153.38
PeB	Pierre, 6 to 15 percent slopes	157.99	0.71	112.17
RO	Rock Outcrop	17.42	-	-
Sa	Samsil Noncalc. Variant Average	515.29	0.42 1.5 0.96	494.68
Sn	Shingle	11.66	0.67	7.81
SS	Slickspots	148.77	-	-
Gs	Snomo	106.06	0	0
Ta	Tilford	7.84	3.33	26.11
W	Water	72.5	-	-
Wt	Winetti	6.92	0.33	2.28
Zn	Zigweid	25.39	5	126.95
Average Salvage Depth of Study Area			**1.44**	
Total		**3,065.74**		**3,731.80**

[1] Note: The reference to disturbance area in terms of baseline soil sampling and mapping is based on an initial estimate of the orebody and monitoring ring extents and does not reflect the actual area proposed for disturbance. Refer to Section 6.2.2 for planned surface disturbance.

Table 2.6-5: Proposed Action Area Summary of Marginal and Unsuitable Parameters within Sampled Profiles

Series	Sample Point	Depth (in)	Parameter
Broadhurst	17	0-3 3-8 8-24 24-40 40-54 54-60	Marginal clay %
Broadhurst	17	8-24	Marginal saturation %
Broadhurst	17	40-54	Marginal pH (Low)
Broadhurst	17	54-60	Unsuitable pH (Low)
Kyle	27	2-17 17-24 24-39 39-60	Marginal clay %
Kyle	27	24-39	Marginal saturation %
Kyle	27	17-24 24-39 39-60	Marginal SAR
Kyle	36	2-15 15-26 26-36 36-60	Marginal clay %
Kyle	36	2-15 26-36	Marginal saturation %
Kyle	36	15-26 26-36	Marginal SAR
Hisle	40	27-38 38-60	Marginal clay %
Nevee	41	21-36 36-45 45-60	Unsuitable EC (Conductivity) Unsuitable SAR Marginal Selenium
Nevee	41	21-36	Unsuitable Boron
Barnum	42	6-17 17-39	Unsuitable EC (Conductivity) Unsuitable SAR
Barnum	42	39-60	Marginal EC (Conductivity) Marginal SAR
Barnum	42	6-17	Marginal Selenium
Ascalon	43	2-14	Marginal clay %
Ascalon	43	38-60	Unsuitable SAR
Samsil	60	3-10	Marginal clay %
Samsil	60	10-18	Marginal EC (Conductivity) Marginal Selenium
Samsil	60	3-10 10-18	Marginal SAR
Boneek	64	17-33	Marginal pH (High)
Boneek	64	33-42	Marginal EC (Conductivity) Marginal Selenium
Arvada	72	18-28	Marginal clay %
Arvada	72	28-43 43-60	Marginal EC (Conductivity)

Table 2.6-5: Proposed Action Area Summary of Marginal and Unsuitable Parameters within Sampled Profiles

Series	Sample Point	Depth (in)	Parameter
Arvada	72	28-43	Marginal SAR
Arvada	72	43-60	Unsuitable SAR
Arvada	72	18-28 28-43 43-60	Marginal Selenium
Lohmiller	73	3-15 15-23 23-34 34-38 38-60	Marginal clay % Unsuitable SAR
Lohmiller	73	15-23 23-34 38-60	Marginal saturation %
Lohmiller	73	15-23	Marginal EC (Conductivity)
Lohmiller	73	23-34 34-38 38-60	Unsuitable EC (Conductivity)
Lohmiller	73	15-23 23-34 34-38 38-60	Marginal Selenium
Pierre	74	15-27 27-38	Marginal pH (High)
Pierre	74	27-38 38-51 51-60	Unsuitable EC (Conductivity) Marginal Selenium
Pierre	74	15-27 27-38 38-51 51-60	Unsuitable SAR
Haverson	75	15-35	Marginal SAR
Haverson	75	35-46 46-60	Unsuitable SAR
Demar	76	2-21 21-29	Marginal clay % Marginal SAR
Demar	76	29-46 46-60	Unsuitable SAR
Demar	76	46-60	Marginal Selenium
Penrose	77	36-48	Unsuitable Boron
Demar	79	3-17 17-30 30-42 42-60	Marginal clay % Unsuitable pH (Low)
Satanta	82	0-4	Marginal pH (Low)
Snomo	83	3-17 17-33	Marginal clay % Marginal texture
Snomo	83	42-52	Marginal saturation %

Table 2.6-5: Proposed Action Area Summary of Marginal and Unsuitable Parameters within Sampled Profiles

Series	Sample Point	Depth (in)	Parameter
Snomo	83	0-3 3-17	Unsuitable pH (Low)
Snomo	83	33-42 42-52 52-60	Unsuitable Boron
Lohmiller	84	18-37	Marginal clay % Marginal texture Unsuitable EC (Conductivity) Unsuitable SAR
Lohmiller	84	0-5 5-18	Marginal saturation %
Lohmiller	84	5-18 37-47 47-60	Marginal EC (Conductivity)
Lohmiller	84	5-18 37-47	Marginal SAR
Kyle	85	2-7	Marginal saturation %
Samsil	88	2-9	Marginal clay % Marginal texture
Pierre	89	0-2	Marginal pH (Low)
Pierre	89	2-18 18-31 31-37	Marginal clay % Marginal texture Marginal saturation %
Grummit	90	0-2 2-8 8-20	Marginal clay % Marginal texture Marginal saturation %
Boneek	91	4-19 40-48 48-60	Marginal saturation %
Boneek	91	19-40 40-48 48-60	Unsuitable EC (Conductivity) Unsuitable SAR
Boneek	91	48-60	Marginal Selenium
Samsil	92	7-19	Marginal clay % Marginal texture Marginal saturation %
Boneek	94	0-2 2-8 8-20 32-44 44-60	Marginal clay % Marginal texture Marginal saturation %
Boneek	94	20-32	Marginal saturation %
Boneek	95	24-38	Marginal Selenium

Table 2.6-6: Proposed Action Area Summary of Trends in Marginal and Unsuitable Parameters for Soil Series

Series	Unsuitable/Marginal Parameter
Arvada	Sodium/Salts, Selenium/Boron
Ascalon	Sodium/Salts
Barnum	Sodium/Salts, Selenium/Boron
Boneek	Texture, Sodium/Salts, Selenium/Boron
Broadhurst	Texture, pH
Demar	Sodium/Salts
Grummit	Texture
Haverson	Sodium/Salts
Hisle	Texture
Kyle	Texture
Lohmiller	Texture, Sodium/Salts
Nevee	Sodium/Salts, Selenium/Boron
Penrose	Selenium/Boron
Pierre	pH
Samsil	Texture
Satanta	pH
Snomo	Texture, pH, Selenium/Boron

2.6.6.2.5 Topsoil Volume Calculations

Based on the 2007 fieldwork with associated field observations and subsequent chemical analysis, the recommended topsoil average salvage depth over the PAA was determined to be 1.43 feet. Refer to Table 2.6-4, Approximate Soil Salvage Depths.

2.6.6.2.6 Soil Erosion Properties and Impacts

Based on the soil mapping unit descriptions, the hazard for wind and water erosion within the PAA 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 PAA, the soils are more susceptible to erosion from water than wind. See Table 2.6-7 for a summary of wind and water erosion hazards within the PAA.

Table 2.6-7: Proposed Action Area Summary of Wind and Water Erosion Hazards[1]

Soil Sample Number	Map Unit Description	Water Erosion Hazard	Wind Erosion Hazard
17	Broadhurst silty clay, 6 to 15 percent slopes	slight	very slight
27	Kyle noncalcareous variant, 0 to 6 percent slopes	moderate	very slight
36	Kyle noncalcareous variant, 0 to 6 percent slopes	moderate	very slight
39	Hisle silt loam, 0 to 6 percent slopes	moderate	slight
40	Hisle noncalcareous variant, 0 to 6 percent slopes	slight	very slight
41	Nevee silt loam, 6 to 15 percent slopes	moderate	slight
42	Barnum silt loam, 0 to 6 percent slopes	moderate	slight
43	Ascalon clay loam, 0 to 6 percent slopes	slight	slight
50	Cushman loam, 6 to 15 percent slopes	slight	moderate
56	Zigweid silty clay loam, 0 to 6 percent slopes	moderate	very slight
57	Butche clay loam, 3 to 15 percent slopes	slight	slight
60	Samsil clay loam, 15 to 40 percent slopes	slight	slight
63	Paunsaugunt loam, 6 to 15 percent slopes	slight	moderate
64	Boneek silty clay loam, 0 to 6 percent slopes	moderate	very slight
72	Arvada silty clay loam, 0 to 6 percent slopes	moderate	slight
73	Lohmiller loam, 0 to 6 percent slopes	very slight	slight
74	Pierre sandy clay loam, 0 to 15 percent slopes	negligible	severe
75	Haverson clay loam, 0 to 6 percent slopes	slight	slight
76	Demar loam, 0 to 6 percent slopes	slight	moderate
77	Penrose clay loam, 0 to 6 percent slopes	slight	slight
79	Demar silty clay loam, 0 to 6 percent slopes	slight	slight
82	Satanta loam, 0 to 6 percent slopes	very slight	severe
83	Snomo silty clay loam, 0 to 6 percent slopes	moderate	very slight
84	Lohmiller silty clay loam, 0 to 6 percent slopes	moderate	very slight
85	Kyle loam, 0 to 6 percent slopes	slight	slight
88	Samsil noncalcareous variant, 15 to 40 percent slopes	slight	slight
89	Pierre silty clay loam, 0 to 15 percent slopes	moderate	very slight
90	Grummit silty clay, 0 to 6 percent slopes	slight	negligible
91	Boneek clay loam, 0 to 6 percent slopes	slight	slight
92	Samsil silty clay loam, 15 to 40 percent slopes	slight	slight
93	Shingle loam, 15 to 40 percent slopes	slight	severe
94	Boneek noncalcareous variant, 0 to 6 percent slopes	slight	very slight
95	Boneek loam, 0 to 6 percent slopes	slight	moderate

[1]Based on lab analysis.

2.6.6.2.7 Prime Farmland Assessment

Prime farmland was assessed by Dan Shurtliff, the Acting State Soil Scientist out of Huron, South Dakota. The following sections in T6S R1E contain Prime farmland if irrigated: Sections 27, 30, 31, 32, 34, and 35. The following sections in T7S R1E contain Prime farmland if irrigated: Sections 1, 3, 4, 5, 10, 12, 14, and 15. The following sections in T7S R1E contain Farmland of statewide importance: Sections 2, 3, 4, 5, 10, 11, 12, 14, and 15. See Appendix 2.6-E for prime farmland designation. The following soil series have been listed as Prime farmland if irrigated: Alice, Ascalon, Barnum, Boneek, Haverson, Norka, Nunn, Satanta, and Tilford. The following soil series have been listed as Farmland of statewide importance: Kyle, Lohmiller, Nunn, Pierre, Satanta, and Stetter.

2.6.7 Seismology

2.6.7.1 Seismic Hazard Review

The seismic hazard review was based on analysis of available literature and historical seismicity for the PAA. 10 CFR Part 40, Appendix A Criterion 4(e) states:

"The impoundment may not be located near a capable fault that could cause a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand. As used in this criterion, the term "capable fault" has the same meaning as defined in section III(g) of Appendix A of 10 CFR Part 100. The term "maximum credible earthquake" means that earthquake which would cause the maximum vibratory ground motion based upon an evaluation

of earthquake potential considering the regional and local geology and seismology and specific characteristics of local subsurface material."

There are no capable faults (i.e. active faults) with surface expression mapped within a radius of 100 kilometers (62 miles) from the center of the PAA, according to the 2002 U.S. Geological Survey's Quaternary Fault and Fold Database. In addition, there are no capable faults mapped in the entire state of South Dakota. The closest capable faults to the site are located in central Wyoming, nearly 345 km (200 miles) to the west-southwest.

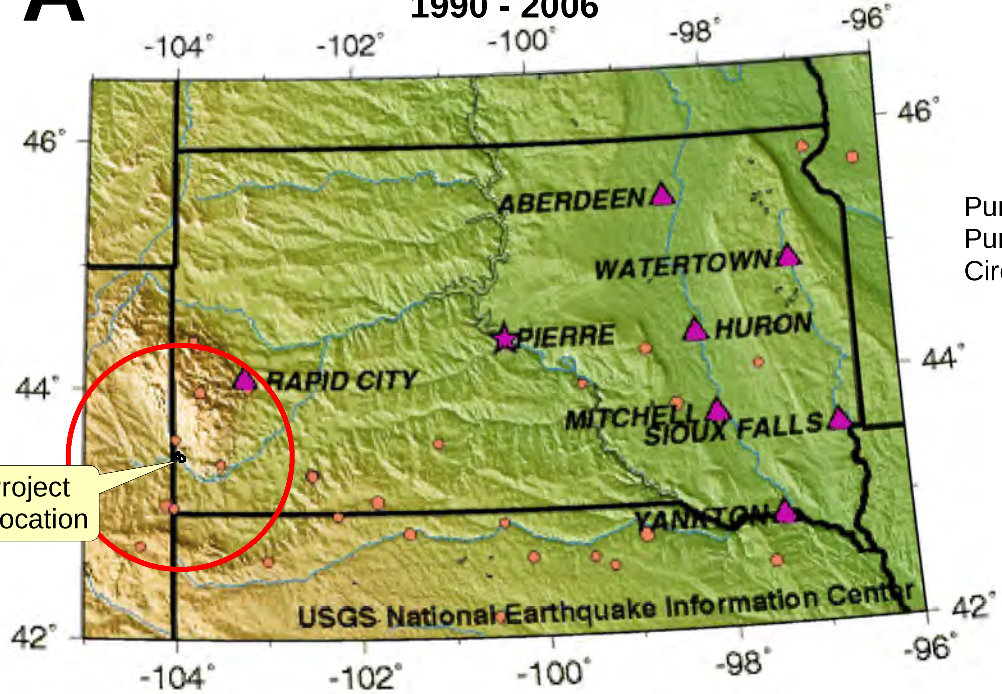
2.6.7.1.1 Seismicity

South Dakota has a comparatively higher rate of seismicity than other areas in the northern plains states, although earthquakes in the area tend to be relatively rare and of low to moderate magnitude, and no active faults have been mapped in the vicinity. It is unclear which earthquakes, if any, in the PAA vicinity are associated with known faults. Since the Midwestern states are relatively stable in terms of earthquake activity, only a small number of seismograph stations are located in the region. South Dakota has one station located in Rapid City, which began operation in 1991. Two nearby stations are located in Golden, Colorado and French Village, Missouri.

Since 1872, a minimum of 65 earthquake epicenters have been identified in South Dakota (Hammond, 1992). These have mainly been concentrated in the southern and eastern regions of the state and are generally of low to moderate modified Mercalli intensity, with a maximum recorded intensity reaching VI. In general, the majority of the epicenters in the proximity of the project (see Figure 2.6-4) exhibit modified Mercalli intensities from III to V (corresponding to Richter magnitudes ranging from 2.2 to 4.1). However, a 1966 earthquake with intensity VI (approximate Richter magnitude 4.4) was recorded approximately 63 miles northeast of the project (17 miles northwest of Rapid City).

A

Seismicity of South Dakota
1990 - 2006

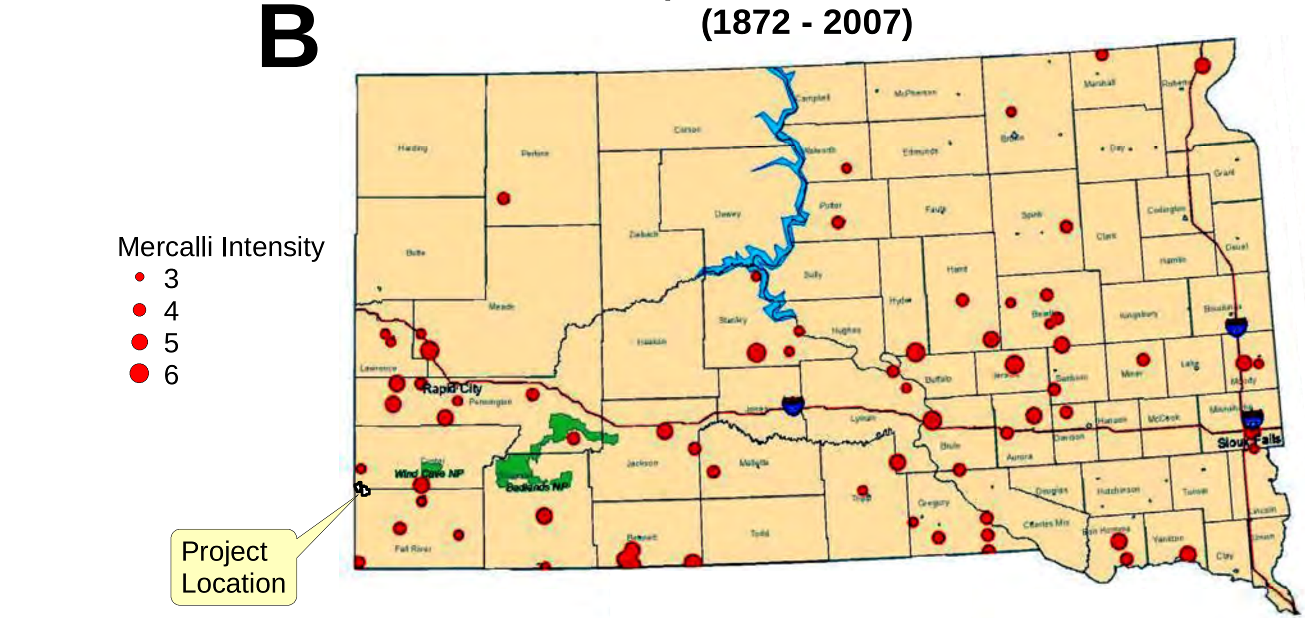


Purple Triangle: Cities
Purple Star: Capital City
Circles: Earthquakes

100 km Radius

B

Earthquakes in South Dakota
(1872 - 2007)



Mercalli Intensity
- 3
- 4
- 5
- 6

Source: USGS/DEIC PDE Catalog
Map A: USGS website:
http://earthquake.usgs.gov/regional/states/south_dakota/seismicity.php
Map B: USGS website:
http://www.sdgs.usd.edu/digitalpubmaps/quakemap.html

Figure 2.6-4
Seismicity of South Dakota
1990 - 2006
and Earthquakes in South Dakota
1872 - 2007
Dewey-Burdock Project

DRAWN BY	Mays, Hetrick
DATE	17-Jun-2013
FILENAME	SDQuakesSeismic.mxd

POWERTECH (USA) INC.

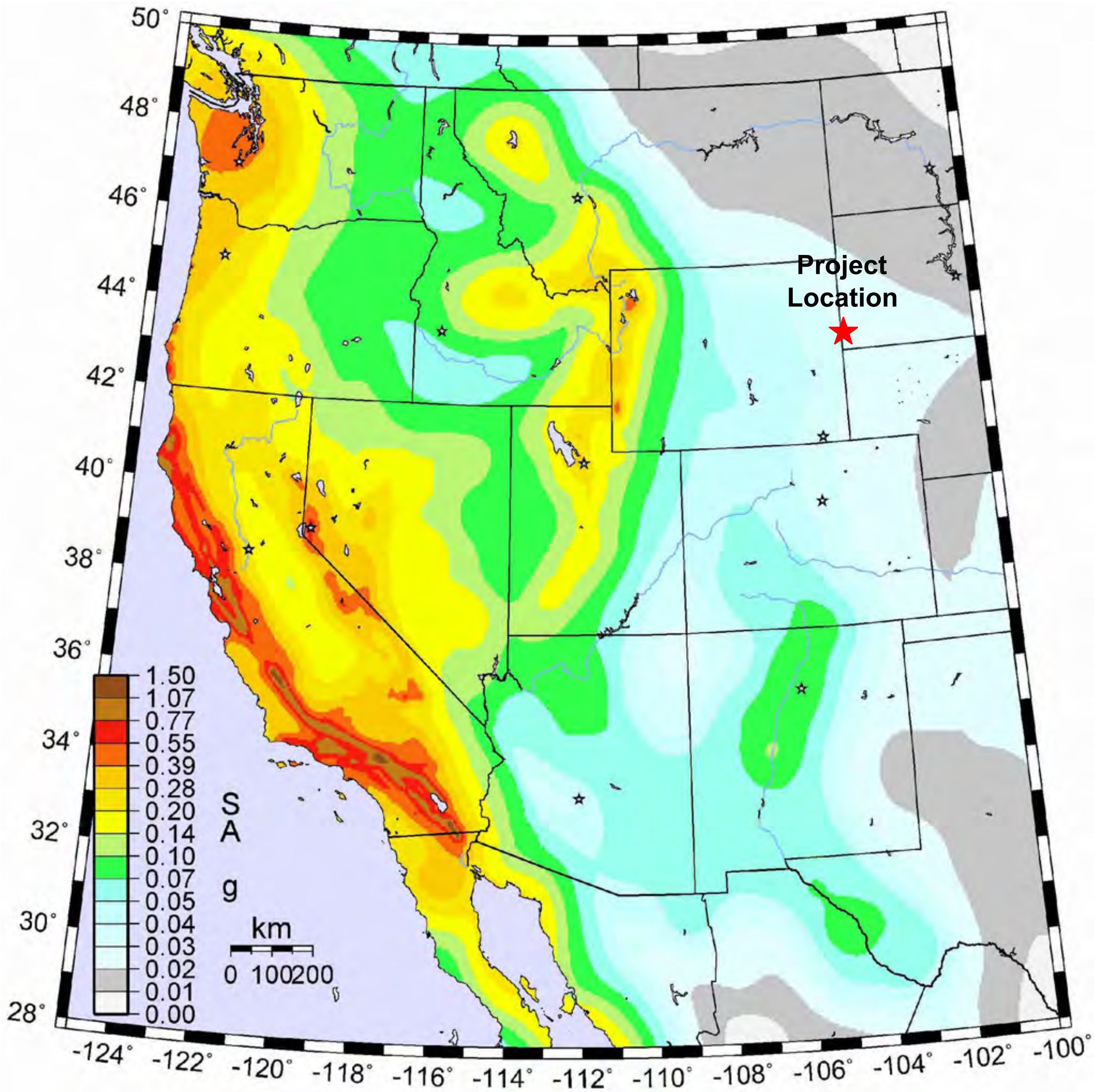
The U.S. Geological Survey Earthquake Database reports locations, times, and magnitudes for epicenters recorded since 1973. The database reports a total of 12 earthquakes with Richter magnitudes ranging from 2.3 to 3.7 within 100 km radius of the site (Appendix 2.6-G). This list includes epicenters in Wyoming and Nebraska. The most recent earthquake recorded in the entire state of South Dakota took place on February 7, 2007, 35 miles east of Rapid City (approximately 80 miles northeast of the project site) and displayed a magnitude of 3.1. The closest historical earthquake to the project site (magnitude 2.8) was recorded on January 5, 2004 approximately 13 km (8 miles) north of the center of the project area. The magnitude of the event was reported to be 2.8 on the Richter Scale, which is approximately equivalent to a modified Mercalli intensity of III (Burchett, 1979). This magnitude is near the low end of the range of 2.3 to 3.7 (Richter Scale) reported for seismic events within a 100-km radius of the project area (Appendix 2.6-G). Other information included in Appendix 2.6-G specific to this event includes the origin time, depth, and latitude and longitude.

According to Burchett (1979), a magnitude 2.8 earthquake (Richter Scale) would not result in people feeling any earth movement, nor would there be any structural damage. 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 3.1-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."

According to the U.S. Geological Survey Earthquake Database (Appendix 2.6-G), two historical earthquakes, each exhibiting a magnitude of 3.7, represent the largest historical events recorded within 100 km (62 miles) of the project. These events occurred on February 6, 1996, and April 9, 1996, and were located 59 km (37 miles) to the northeast and 46 km (28 miles) to the southwest of the site, respectively. If the search radius was expanded to 200 km (124 miles), an earthquake with magnitude 5.50 occurring on October 18, 1984 approximately 187 km (116 miles) to the southwest of the site is the largest magnitude event near the site.

A zone of higher earthquake frequency is recorded along the eastern flank of the Black Hills (structural deformation also seems to be concentrated on the eastern flank; Geological Survey of South Dakota, 2004) and in the southwest corner of South Dakota (Figure 2.6-4). In addition, the PGA maps (USGS, 2002) of the area display an increase in ground motion to the west and southwest part of the state (Figures 2.6-5 and 2.6-6). Earthquakes may be concentrating along or near the boundaries of structural provinces (e.g. Black Hills and Missouri Plateau, or Missouri Plateau and High Plains) in the Precambrian, crystalline basement. Two possible faulting mechanisms may be at work: 1) initiation of movement along preexisting fractures due to crustal plate movements; or 2) fault movement and fracturing due to glacial rebound (South Dakota Department of Emergency Management website).

According to the U.S. Geological Survey's 2002 Seismic Hazard Mapping Program, the peak ground acceleration (PGA) derived from the probabilistic maximum bedrock acceleration with a 10 percent exceedance in 50 years (475-year return period) is 0.03g (Figure 2.6-5) for the southwestern part of South Dakota. The probabilistic maximum bedrock acceleration with a 2 percent chance of exceedance in 50 years (2,475-year return period) is 0.09g for the region (Figure 2.6-6).

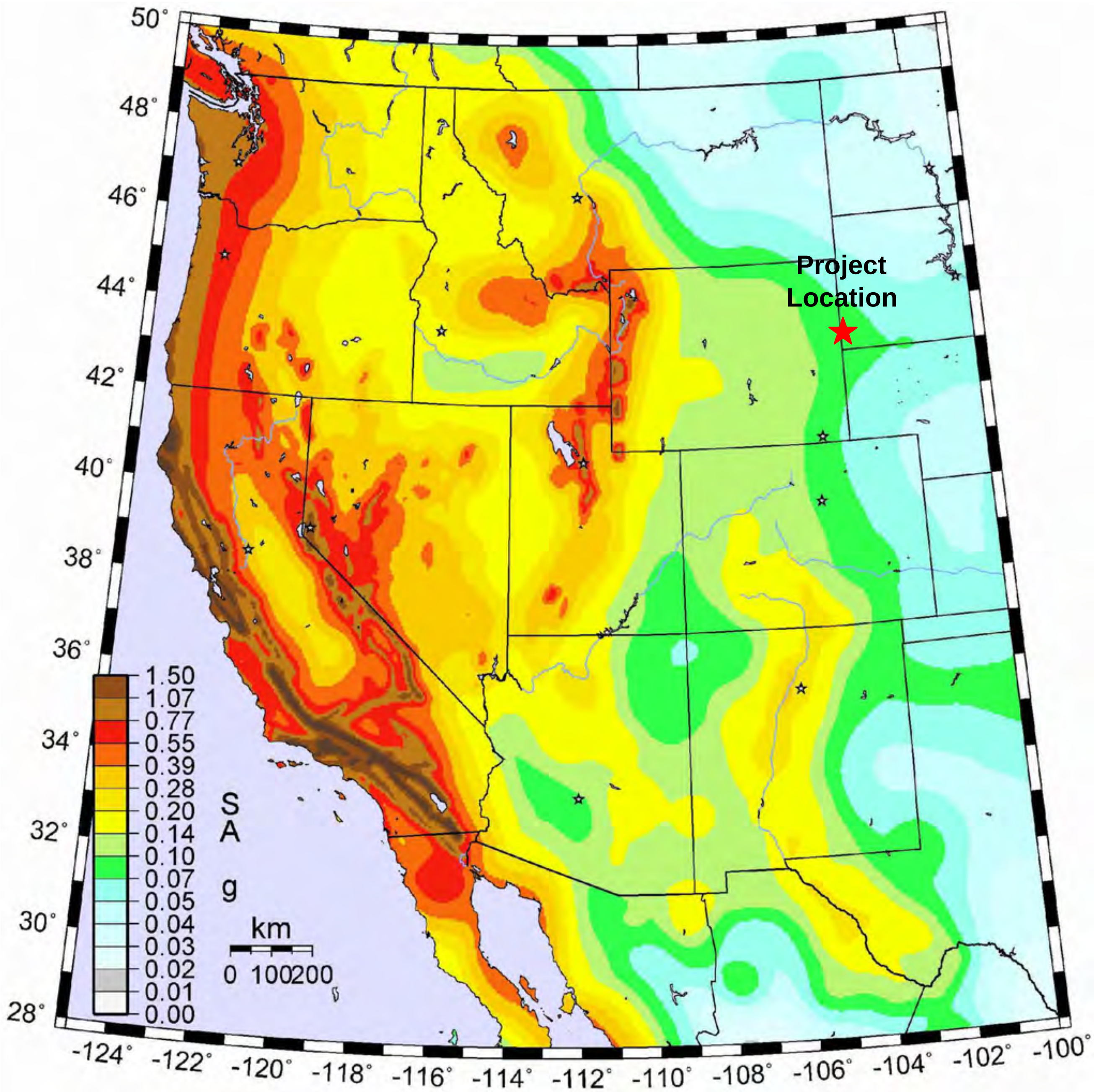


Source: USGS (2008)

Figure 2.6-5
Peak Ground Acceleration (PGA), Illustrating 10 Percent Probability of Exceedance in the Next 50 Years
Dewey-Burdock Project

DRAWN BY	S. Hetrick
DATE	14-Jun-2013
FILENAME	PGA10Pct50Yr.dwg

POWERTECH (USA) INC.



Source: USGS (2008)

Figure 2.6-6
Peak Ground Acceleration (PGA), Illustrating 2 Percent Probability of Exceedance in the Next 50 Years
Dewey-Burdock Project

DRAWN BY	S. Hetrick
DATE	14-Jun-2013
FILENAME	PGA2Pct50Yr.dwg

POWERTECH (USA) INC.

2.6.7.1.2 Seismic Sources

Assessment of seismic hazards requires consideration of potential earthquake source zones, either identifiable faults or larger areas with common seismic characteristics. Once potential source zones have been identified, design earthquakes can be assigned based on a synthesis of geological and seismological data.

2.6.7.1.3 Capable Faults

The proposed project is located in an area of historically low seismic potential. There are no known capable faults within 100 kilometers of the site and a relatively low number of historical earthquakes (Figure 2.6-4; Appendix 2.6-G). The closest capable fault zone to the project is located nearly 345 km (200 miles) west of the site in central Wyoming. Therefore, the randomly occurring 'floating' earthquake is considered to be the most significant seismic hazard for the PAA (discussed below), the same as the maximum credible earthquake as defined in 10 CFR Part 40, Appendix A Criterion 4(e), quoted above.

2.6.7.1.4 The Randomly Occurring 'Floating' Earthquake

Industry standards and federal regulations require an analysis of the earthquake potential in regions where the surface expression of active faults is not mapped or exposed, and where earthquake epicenters are associated with buried faults with no associated surface rupture. Earthquakes associated with buried faults are assumed to occur randomly and can occur anywhere within that area of uniform earthquake potential. In reality, random earthquake distribution may not be the case, since all earthquakes are associated with specific faults. However, since all buried faults in the PAA have not been identified, it is reasonable to consider the distribution to be random. A 'floating' earthquake is an earthquake that is considered to occur randomly within a tectonic province.

The U.S. Geological Survey identified tectonic provinces for the contiguous United States (Algermissen et al., 1982). The project site is located in a source zone with a uniformly distributed seismicity which generally encompasses the Black Hills and surrounding environs. The zone is characterized by an earthquake with maximum magnitude M_{max}=6.1. This magnitude is used as the best estimate for the floating earthquake.

2.6.7.2 Conclusion

Seismic hazards at the project site include low to moderate ground shaking associated with regional and local earthquake sources. Figures 2.6-4 through 2.6-6 illustrate seismicity and PGA maps for the PAA, and Appendix 2.6-G is a summary of the USGS database results for historical earthquakes recorded within 100 and 200 km from the site since 1973.

There are no capable faults (as defined in section III(g) of Appendix A of 10 CFR Part 100) known to be present within 100 km of the project site. The closest capable fault zone to the project is located nearly 345 kilometers (200 miles) west of the site in central Wyoming. Therefore, the most significant seismic hazard is considered to be the randomly occurring, or 'floating', earthquake for the PAA. This is the maximum credible earthquake estimated for the project based on available literature, geologic information of the surrounding area, and historical data. A magnitude M_{max}=6.1 is estimated for this event.

According to the U.S. Geological Survey's 2002 Seismic Hazard Mapping Program, PGA derived from the probabilistic maximum bedrock acceleration with a 10 percent exceedance in 50 years (475-year return period) is 0.03g (Figure 2.6-5) for the southwestern part of South Dakota. The probabilistic maximum bedrock acceleration with a 2 percent chance of exceedance in 50 years (2,475-year return period) is 0.09g for the region (Figure 2.6-6). Both of these estimates are considered to reflect a relatively low ground motion hazard.

2.6.8 References

Algermissen, S.T., Perkins, D.M., Thenhaus, P.C., Hanson, S.L., and Bender, B.L., 1982, "*Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States*", U.S. Geological Survey, Open-File Report 82-1033.

Boggs, J.M and A.M. Jenkins, 1980, Analysis of Aquifer Tests Conducted at the Proposed Burdock Uranium Mine Site, Burdock, South Dakota, Tennessee Valley Authority, Office of Natural Resources, Division of Water Resources, Water Systems Development Branch, Report No. WR28-1-520-109, May 1980.

Burchett, R.R., 1979, Earthquakes in Nebraska. University of Nebraska Conservation and Survey Division, Education Circular No. 4 in *Recorded Earthquakes in South Dakota*, 1872-1992, R.H. Hammond, 1993.

Darton, N.H., 1909, Geology and Water Resources of the Northern Portion of the Black Hills and Adjoining Regions in South Dakota and Wyoming, USGS Professional Paper 65, 105 pp.

Davis, 2011, personal communication between James F. Davis, former Susquehanna Western geologist, and Jim Bonner, Powertech (USA) Inc., April 15, 2011.

DeVoto, R.H., 1978, Uranium Geology and Exploration, Colorado School of Mines Press, Golden Colorado.

Energy Metals Corporation. 2007. Technical Report for the Moore Ranch Uranium Project, Campbell County, Wyoming. Docket No. 40-9073. September, 2007

Epstein, J.B., 2001, Hydrology, Hazards, and Geomorphic Development of Gypsum Karst in the Northern Black Hills, South Dakota and Wyoming, USGS Water-Resource Investigation Report 01-4011, p. 30-37.

Gott, G.B., D.E. Wilcott and C.G. Bowles, 1974, Stratigraphy of the Inyan Kara Group and Localization of Uranium Deposits, Southern Black Hills, South Dakota and Wyoming, USGS Professional Paper 763, prepared on behalf of the U.S. Atomic Energy Commission.

Hammond, R.H,. 1992, "*Recorded Earthquakes in South Dakota, 1872-1991*", South Dakota Geological Survey map.

Hayes, T.S., 1999, Episodic Sediment-Discharge Events in Cascade Springs, Southern Black Hills, South Dakota, USGS Water-Resources Investigation Report 99-4168, 34 p.

Honea, R.M., 1971, Detailed Study of the Dewey Ore Trend, Custer County, South Dakota, Homestake–Wyoming Partners, February 1971.

Martin, J.E., Sawyer, J.C., Fahrenbach, M.D., Tomhave, D.W., and Schulz, L.D., 2004, "*Geologic Map of South Dakota*", South Dakota Geological Survey, General Map 10.

Northern State University website: http://www.northern.edu/natsource/index.htm

Schnabel, R.W., and L.J. Charlesworth, Jr., 1963, Geology of the Burdock Quadrangle, South Dakota, USGS Survey Bulletin 1063-F, Plate 17.

South Dakota Department of Public Safety, Office of Emergency Management, Accessed April 15, 2008 http://www.oem.sd.gov/Mitigation/hmgp/vulnerability.htm

Spencer, 2011, personal communication between Donald Spencer and Jim Bonner, Powertech (USA) Inc., April 28, 2011.

Tank, R. W., 1956, Clay Mineralogy of the Morrison Formation, Black Hills Area Wyoming and South Dakota, Bulletin of the American Association of Petroleum Geologists, Vol. 40, No. 5, p. 871-878.

U.S. Geological Survey, _____, Earthquake Hazards Program, Accessed _______, from the USGS website http://earthquake.usgs.gov/regional/states/south-dakota/seismicity.php

U.S. Geological Survey, _____, Earthquake Hazards Program, Accessed ______, from the USGS website http://www.sdgs.usd.edu/digialpubmaps/quakemap.html.

U.S. Geological Survey, 2006, "*Quaternary Fault and Fold Database for the United States*", Accessed April 2008, from the USGS website http://earthquake.usgs.gov/regional/qfaults/

U.S. Geological Survey, 2002, "*Earthquake Hazards Program, Preliminary Conterminous States Probabilistic Maps & Data*", Accessed April 2008 <http://earthquake.usgs.gov/research/hazmaps/products_data/48_States/index.php

Wyoming Department of Environmental Quality, Land Quality Division, 1994, "*Guideline 1, Topsoil and Overburden Including Selenium Update*".

2.7 Hydrology

Powertech (USA) conducted baseline surface water and groundwater quality monitoring in accordance with NRC Regulatory Guide 4.14 and NUREG-1569. The following sections describe the hydrology baseline assessment program and results.

2.7.1 Surface Water

2.7.1.1 Regional Hydrology

The PAA is approximately 16.5 mi^2 and lies in southwestern Custer County and northwestern Fall River County in South Dakota (Figure 2.7-1). 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 and others, 2002).

The PAA 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 and others, 2002).

The Great Plains physiographic 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 primarily flow from west to east (Driscoll and others, 2002).

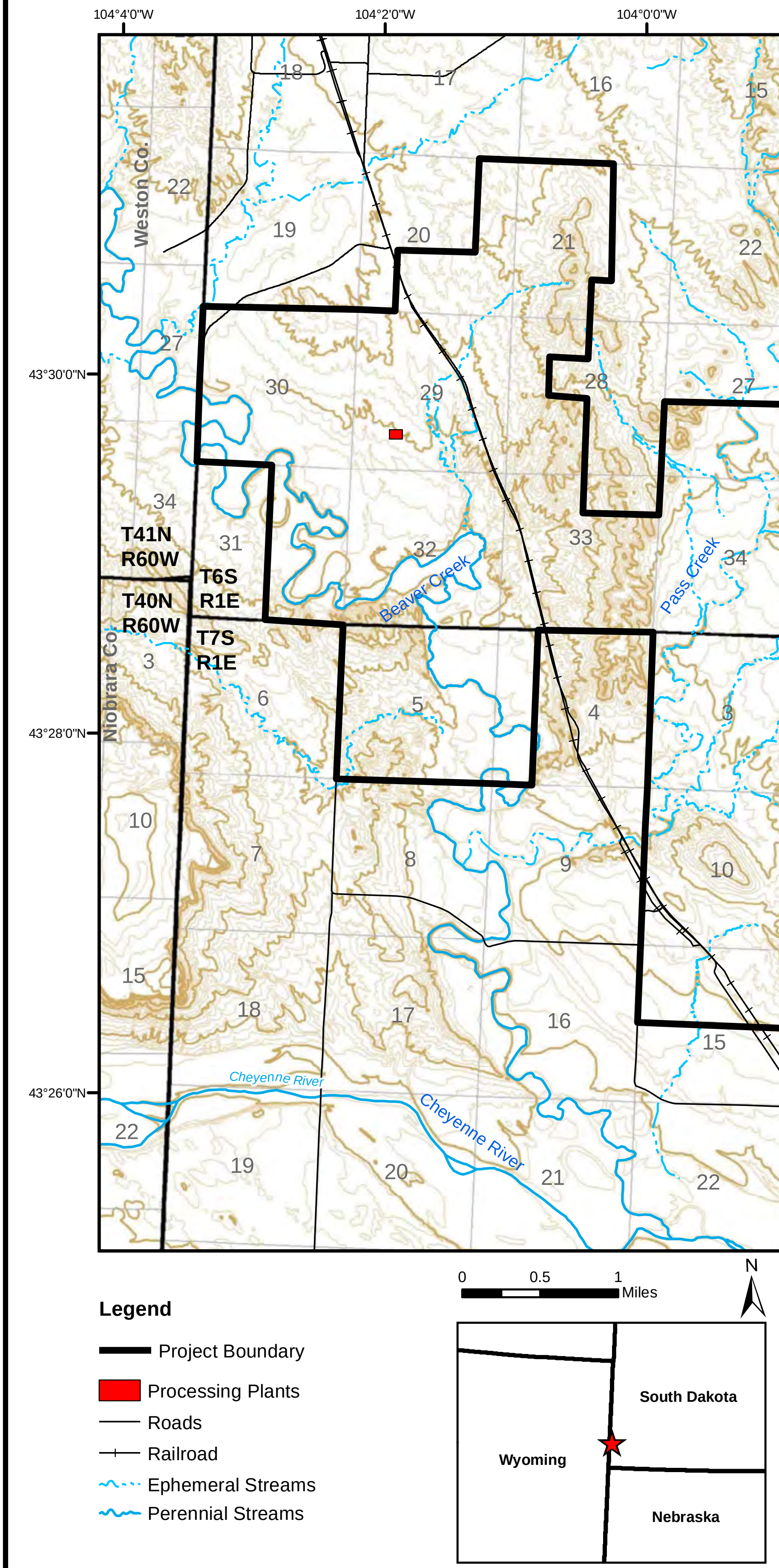


Figure 2.7-1

Site Drainage Systems

Dewey-Burdock Project

DRAWN BY RESPEC, WWC

DATE 15-Nov-2013

FILENAME Fig 2.7-1 SiteDrainageSystems.mxd

POWERTECH (USA) INC.

2.7.1.2 Site Hydrology

The local hydrology and surface water resources are described for the PAA and for the two main drainage systems that pass through the site (Beaver Creek and Pass Creek) (Figure 2.2-1).

2.7.1.2.1 Topography

The PAA is characterized by low to moderately sloping brush land with areas of moderately steep ridges. The elevation ranges from approximately 3,600 feet to about 3,900 feet within the site. The slopes within the site range from 0 percent to 92 percent, with an average slope of nearly 6 percent. Two primary facility zones exist within the PAA. Both the eastern and western facility zones have an average slope of nearly 3 percent.

2.7.1.3 Drainage Basins

The PAA lies primarily within the Beaver Creek Basin and is drained by both Beaver Creek and Pass Creek. The Pass Creek watershed is a sub-basin 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 PAA from the northwest to the southeast. The Pass Creek system flows south through the central portion of the PAA and joins Beaver Creek southwest of the PAA. Three miles south of this confluence, Beaver Creek converges with the Cheyenne River (Figure 2.7-1) which eventually flows into the Missouri River.

The nearest discharge gage on the Cheyenne River upstream of its confluence with Beaver Creek is USGS gage 06386500 near Spencer, WY. The nearest discharge gage downstream of the confluence of Beaver Creek and the Cheyenne River is USGS gage 06395000 at Edgemont, SD. This gage captures the contribution of flow to the Cheyenne River from Beaver Creek and Pass Creek between Spencer, WY and Edgemont, SD. Figure 2.7-2 shows an annual hydrograph for gage 06386500 from 1948 to 2008, and Figure 2.7-3 shows an annual hydrograph for gage 06395000 from 1903 to 2008. The lines in Figures 2.7-2 and 2.7-3 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 2.7-3), 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 graph indicates 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).

Powertech (USA) Inc.

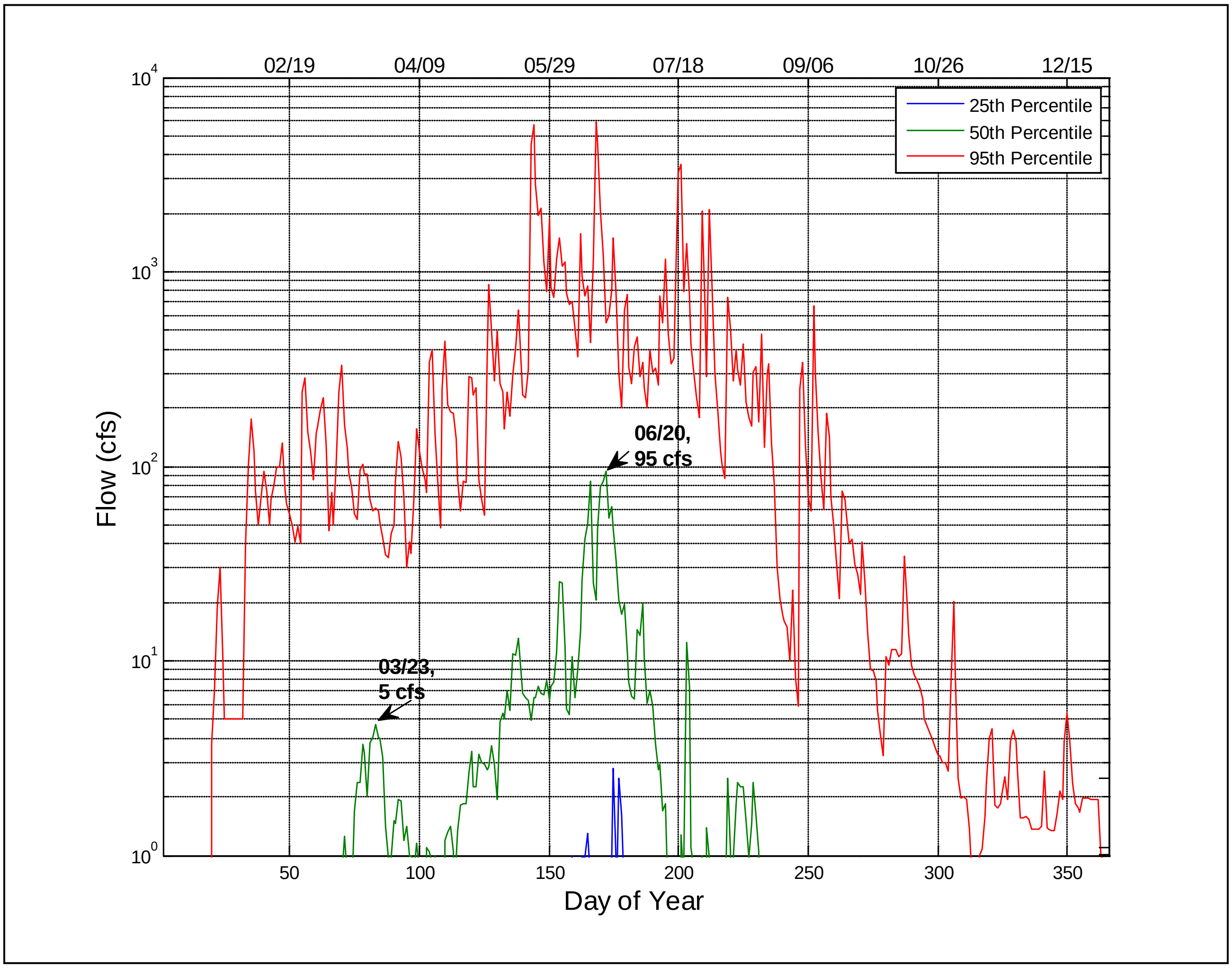


Figure 2.7-2: Annual Hydrograph for USGS Gage 06386500 on the Cheyenne River near Spencer, WY from 1948 to 2008

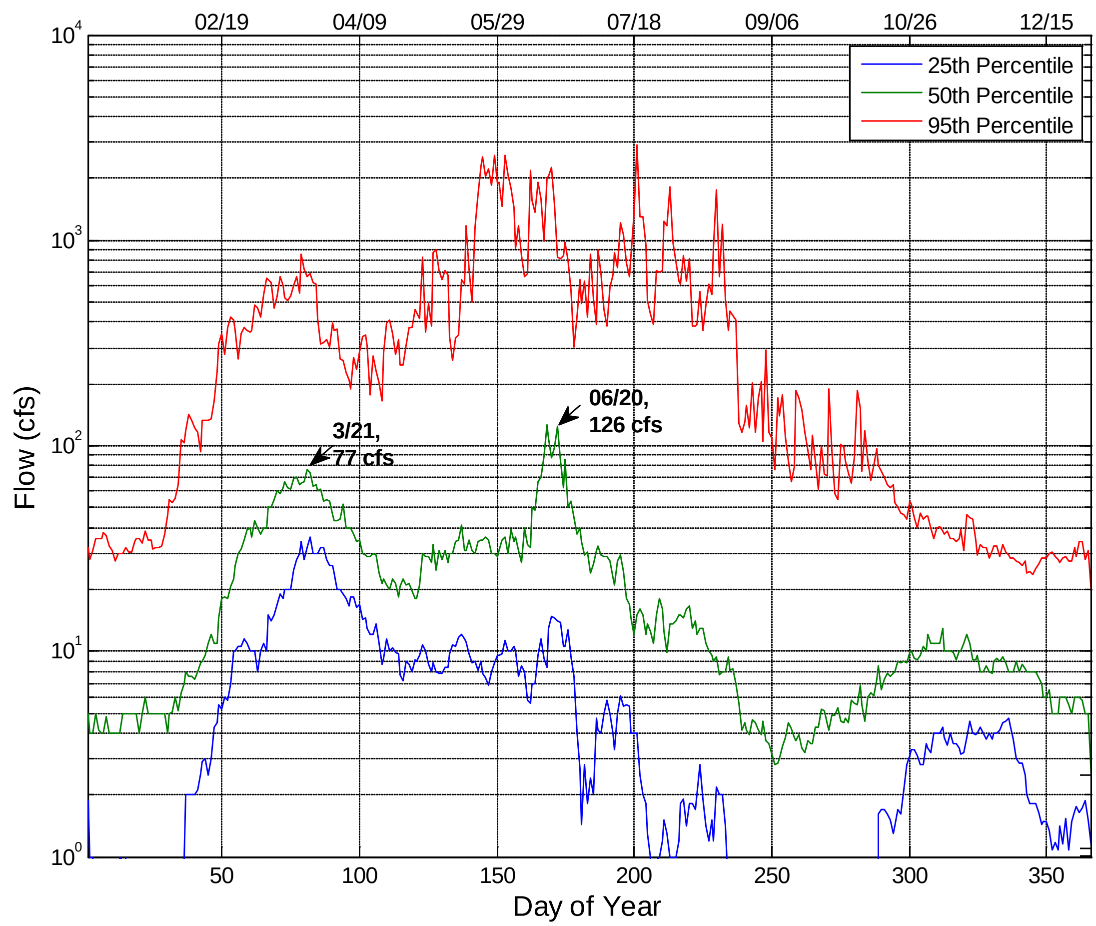


Figure 2.7-3: Annual Hydrograph for USGS Gage 06395000 on the Cheyenne River at Edgemont, SD from 1903 to 2008

2.7.1.3.1 Beaver Creek Basin

The Beaver Creek Basin is 1360 mi^2, excluding the Pass Creek sub-basin. It extends from a few miles northwest of Upton, WY to about eight 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 is collected at USGS gage 06394000 near Newcastle, WY (Figure 2.2-1). Figure 2.7-4 shows an annual hydrograph with the 25th, 50th and 95th flow percentiles for this gage from 1944 to 1998. Figure 2.7-5 shows monthly average flow data for this gage from 1944 to 1998.

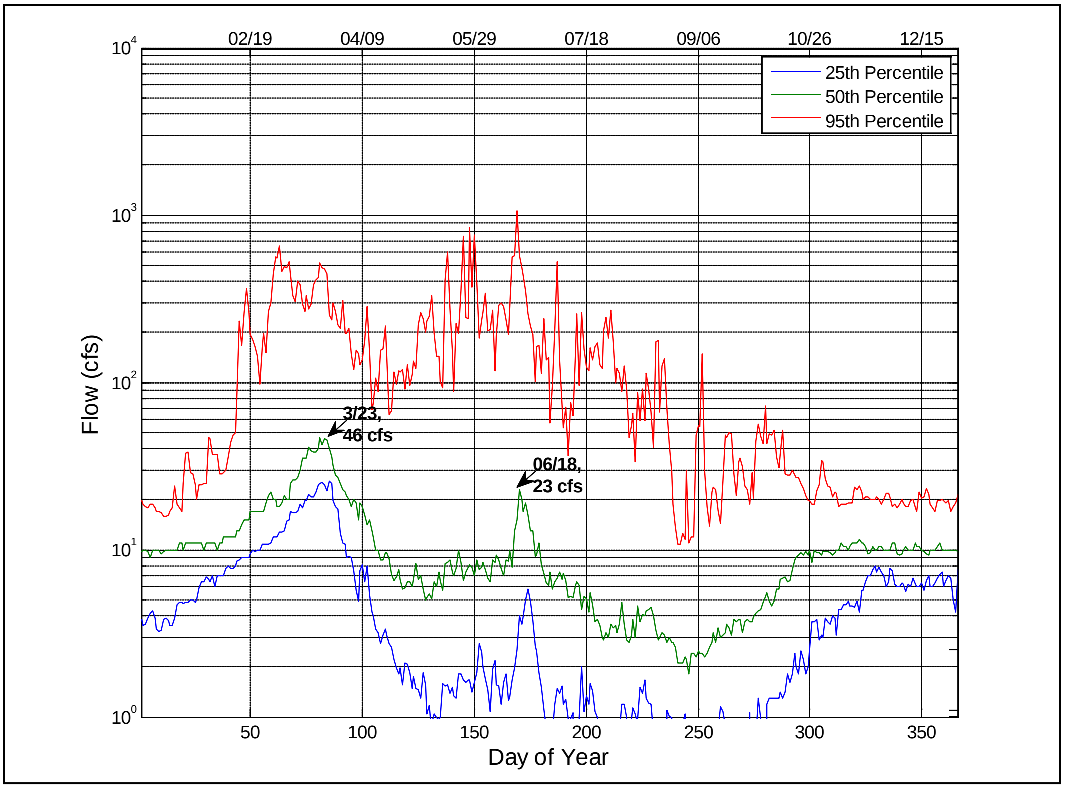


Figure 2.7-4: Annual Hydrograph for USGS Gage 06394000 on Beaver Creek near Newcastle, WY from 1944 to 1998

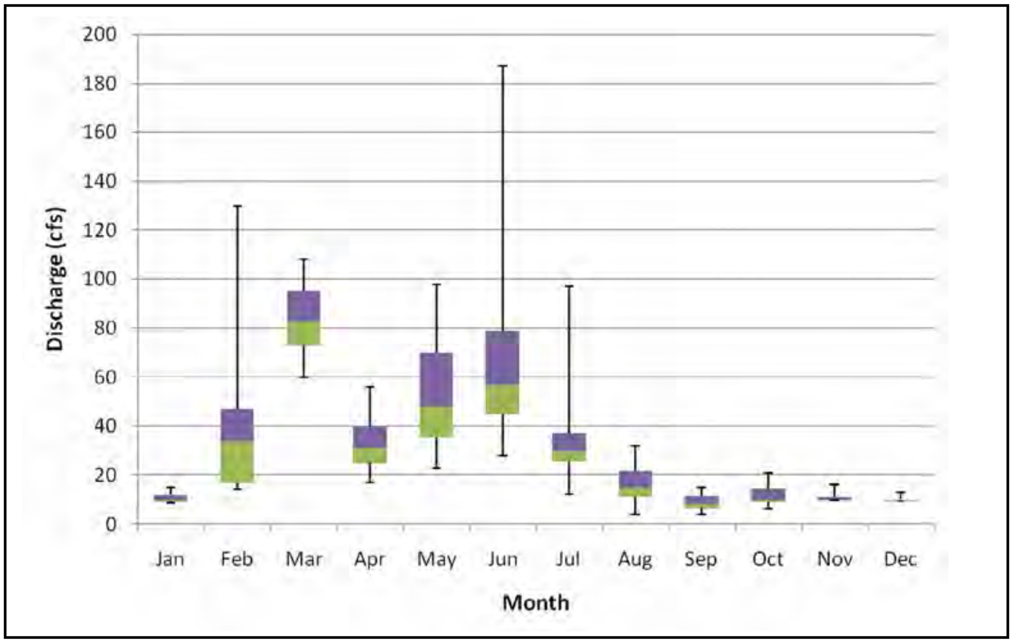


Figure 2.7-5: Monthly Average Flows at USGS Gage 06394000 on Beaver Creek near Newcastle, WY from 1944 to 1998

2.7.1.3.2 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 mi^2 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.

2.7.1.3.3 Project Boundary

The northwestern section of the PAA drains to Beaver Creek and ephemeral tributaries. The north-central and east-central section of the PAA is drained via Pass Creek and smaller, ephemeral tributaries. The southeast portion of the PAA is also part of the Cheyenne River Basin that drains into the Cheyenne River through East Bennett Canyon. The PAA contains many intermittent streams and drainage channels, particularly in the eastern extent, that are consistently dry throughout the year. Stream flow only occurs in these channels after significant precipitation or snowmelt events and even then may not be of considerable amounts. Three small ephemeral stream channels cut through the primary facility zone in the eastern section of the PAA. Most of the small impoundments that exist within the PAA are dry during most of the year (Plate 5.7-1). Many of these existing impoundments are found along ephemeral streams and tributaries, particularly in the eastern section of the PAA.

2.7.1.3.4 Proximity of Surface Water Features to Proposed ISL Facilities

Beaver Creek is the primary surface water resource in the PAA. Pass Creek is a secondary surface water resource in the PAA, although the ephemeral channel is dry except during infrequent runoff or snow melt events. The remaining surface water resources in the PAA are small, ephemeral stream channels and small impoundments.

Section 3.1.7 describes the construction of ISL facilities in relation to surface water features. Plate 2.7-1 depicts the location of proposed facilities and potential well field areas in relation to the 100-year flood inundation areas for surface water features. Where possible, facilities will be located out of the 100-year flood inundation boundary. 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.

2.7.1.4 Surface Water Run Off

2.7.1.4.1 General Approach

The potential for flood or erosion damage in the PAA was evaluated by developing a design flood using statistical methods and a computer model for watershed hydrology in accordance with NUREG-1569. 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 PAA 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 PAA 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.

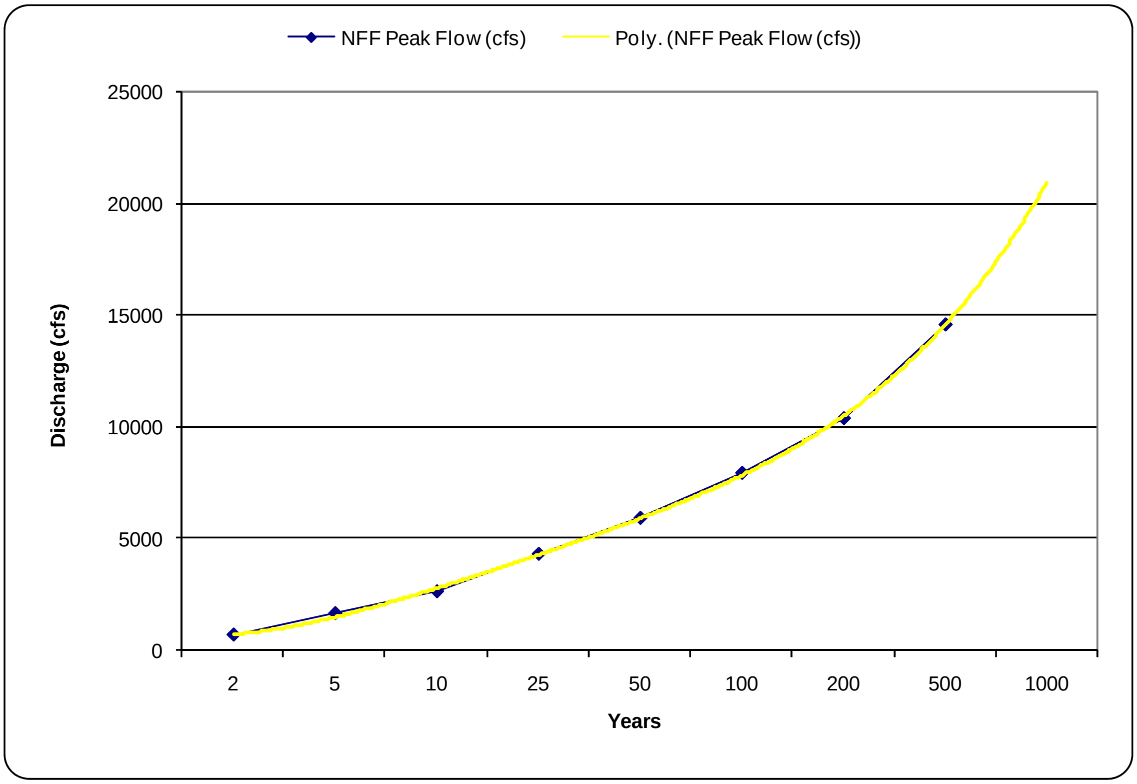
The 100-year flows were developed using hydrologic analyses for Beaver Creek, Pass Creek and ephemeral tributaries. These flows are then transformed to maximum water levels using a stream channel hydraulic model. Upper-bound flows, or extreme flows, were developed for Beaver Creek and Pass Creek and 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.

2.7.1.4.2 Hydrologic Analysis – Beaver Creek

USGS gage number 06394000 is located along Beaver Creek near Newcastle, WY (Figure 2.2-1). 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 and others, 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 PKFQW in 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 1500 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 mi^2 and 387 mi^2, 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 2.7-6. 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 2.7-1.



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

Figure 2.7-6: Beaver Creek Flood Estimates

Table 2.7-1: 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

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 2.7-2.

Table 2.7-2: Matlab Flood Estimate Results for Beaver Creek

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

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 2.7-3.

Table 2.7-3: 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

The flood estimates for Beaver Creek are summarized in Table 2.7-4. 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.

Table 2.7-4: 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

2.7.1.4.3 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 PAA, 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.

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 the ArcView Geographic Information System (GIS). 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 U.S. Geological Survey 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 two 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 (US Department of Commerce) (Table 2.7-5). The PMP estimate was obtained from HMR-51 depth-area-duration maps (Schreiner and Riedel, 1978) (Table 2.7-6). 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 2.7-7 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 2.7-7.

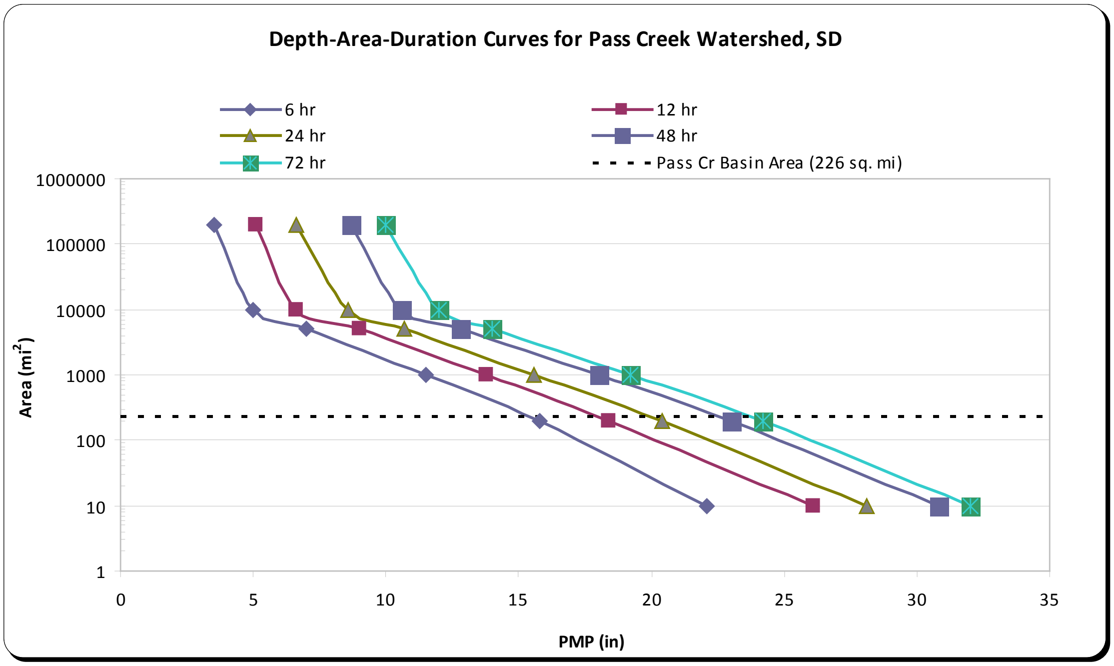
Table 2.7-5: Depth-Duration Data for the 100-Year Storm Event

100-year Storm	
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 2.7-6: Probable Maximum Precipitation (PMP)

	Duration (hr)				
Area (mi^2)	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
1000	11.5	13.8	15.6	18	19.2
5000	7	9	10.7	12.8	14
10000	5	6.6	8.6	10.6	12
200000	3.5	5.1	6.6	8.7	10

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



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

Figure 2.7-7: Depth-Area-Duration Curves for the Pass Creek Watershed in SD

Table 2.7-7: Interpolated Estimates for the Probable Maximum Precipitation (PMP) for the Pass Creek Watershed in SD

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

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 four-day duration with 15-minute time intervals for the 100-year/24-hour storm, and the second used a seven day duration with six 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

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 five percent was also 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 value is 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 2.7-8. 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.

Table 2.7-8: Discharge Results for the Single Basin Model of the Pass Creek Watershed

Event	Peak Discharge (cfs)
100yr	5620
Estimated PMF	65600
50% Estimated PMF	32800

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 sub-basins with routing. This combination results in a larger instantaneous peak flow entering the stream channel of Pass Creek within the PAA. The extreme condition flood is only included to illustrate the extent of the flood plain 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 1569 for in situ leach extraction operations.

2.7.1.4.4 Floodplain Analysis – Beaver Creek and Pass Creek

The stream channels of both Beaver Creek and Pass Creek within the PAA were each 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 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.

The Geospatial River Analysis Extension (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 PAA. 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 PAA. 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 PAA on May 21, 2008 (Table 2.7-9). Figures 2.7-8 and 2.7-9 are photos of the Beaver Creek and Pass Creek stream channels along with their floodplains taken during the site inspection.

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.

Table 2.7-9: Manning's n Values for the Beaver Creek and Pass Creek Channels

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

Note: based on field observations

Two steady flow profiles were created for each creek: the 100-year flood and the extreme condition flood (a 500-year – 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 for each profile of Beaver Creek and Pass Creek, respectively. Downstream boundary conditions used normal depth with updated slopes of the energy grade lines.

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

Figure 2.7-8: The Beaver Creek Stream Channel and Floodplain

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

Figure 2.7-9: The Pass Creek Stream Channel and Floodplain

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 PAA are shown in Figures 2.7-10 and 2.7-11, respectively. These figures also depict the modeled 100-year flood inundation areas for ephemeral tributaries within the project area as described in Section 2.7.1.4.5. Plate 2.7-1 depicts the location of proposed facilities and potential well field areas in relation to the modeled 100-year flood inundation areas. The horizontal and vertical distances separating the primary facility zones and known ore bodies from the 100-year floodplain for each creek are shown in Table 2.7-10.

Table 2.7-10: Proximity Data for the 100 Year Floods of Beaver Creek and Pass Creek

Creek	Concern	Horizontal Distance (ft)	Vertical Distance (ft)
Beaver			
	Facilities	3,140	30
	Ore Bodies	300	5
Pass			
	Facilities	5,470	80
	Ore Bodies	210	5

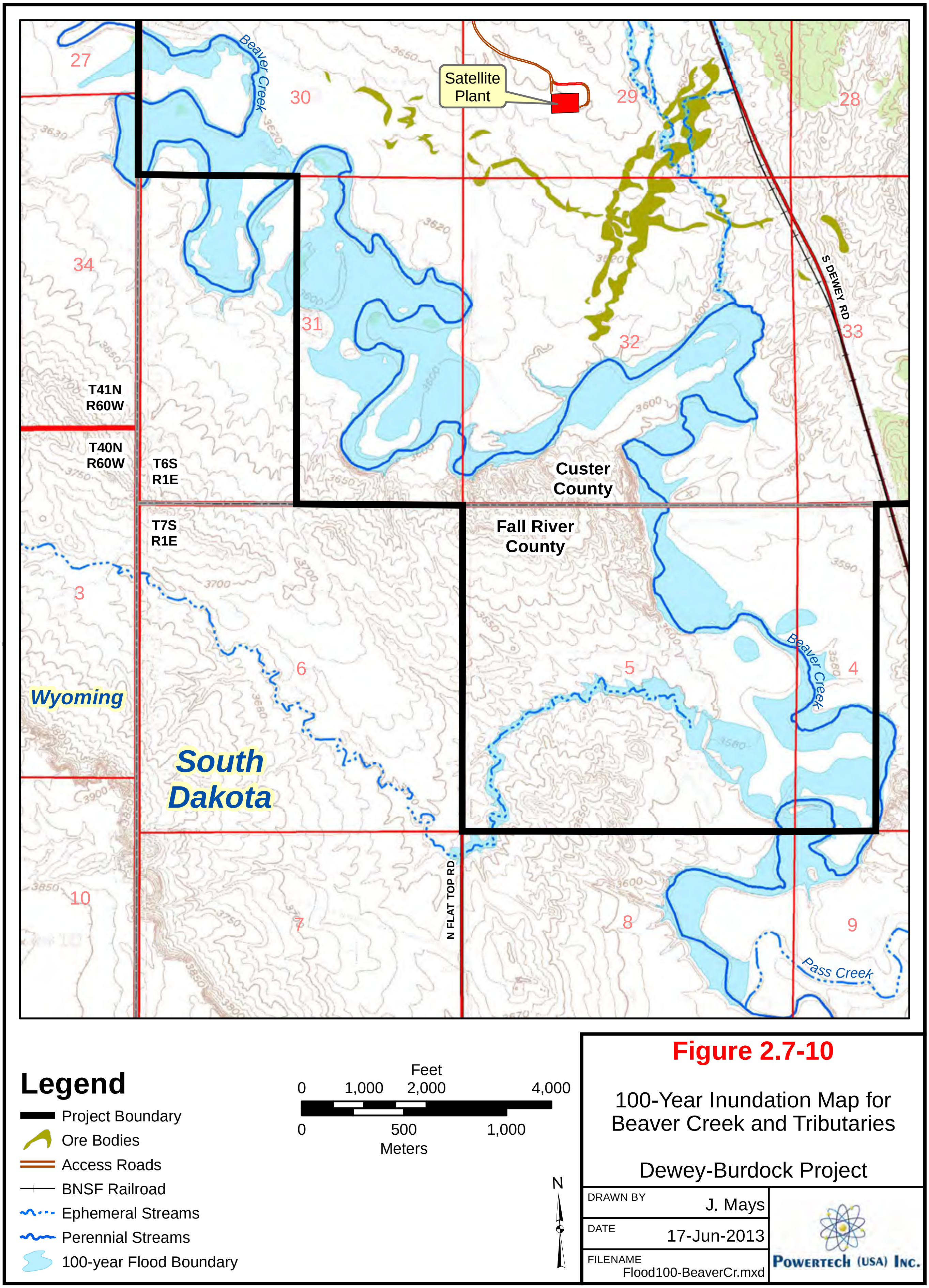


Figure 2.7-10

100-Year Inundation Map for Beaver Creek and Tributaries

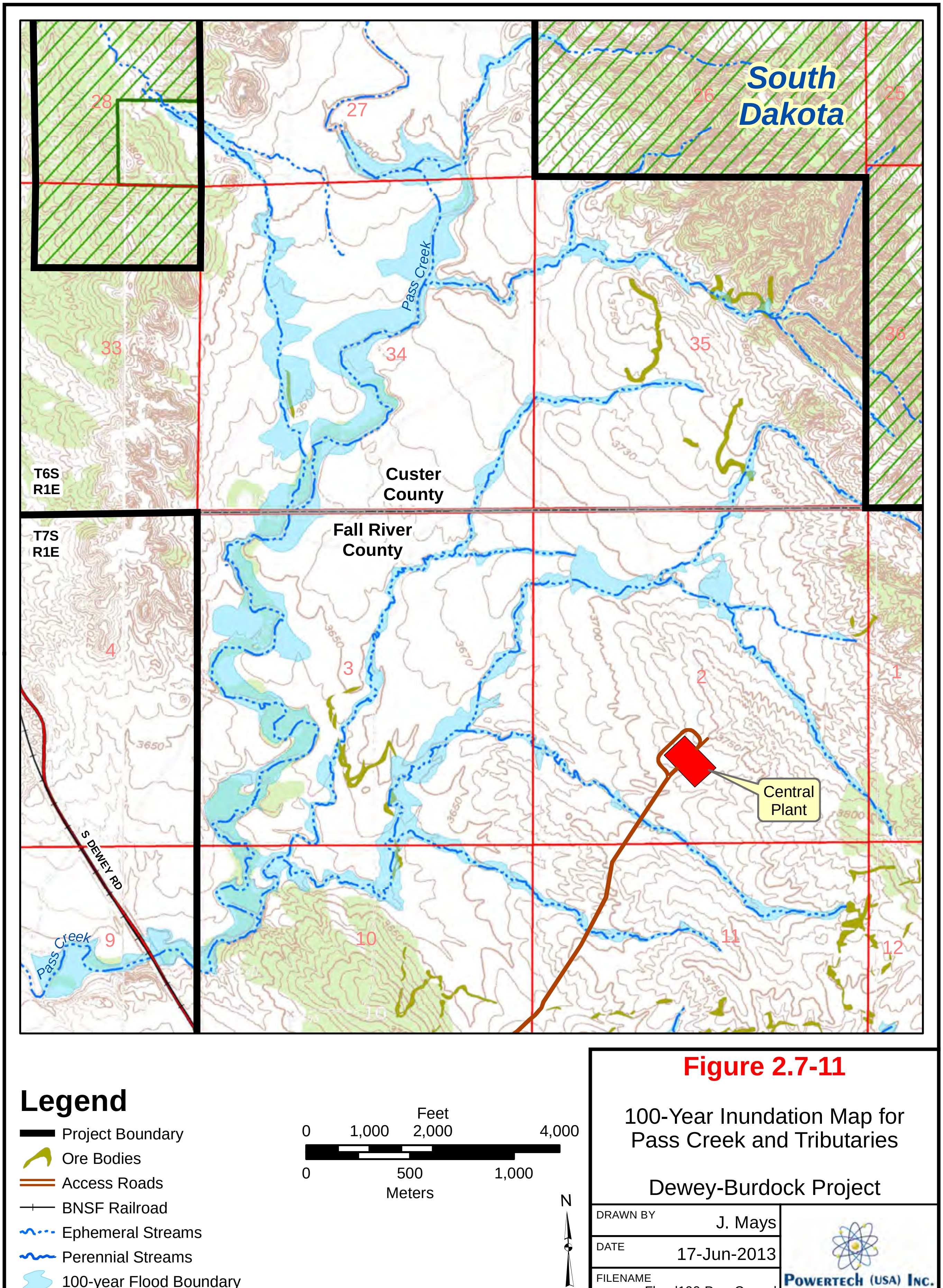


Figure 2.7-11

100-Year Inundation Map for Pass Creek and Tributaries

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	17-Jun-2013
FILENAME	Flood100-PassCr.mxd

POWERTECH (USA) INC.

The final model results for the spatial representation of the extreme condition floodplains for Beaver Creek and Pass Creek within the PAA are shown in Figures 2.7-12 and 2.7-13, 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 horizontal and vertical distances separating the primary facility zones and known ore bodies from the extreme condition floodplain for each creek are shown in Table 2.7-11. 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 than by the 100-year floods. The risk of flood or erosion damage to the PAA facilities from Beaver and Pass Creeks is extremely low.

The inundation maps of Pass Creek indicate that known ore bodies in the upstream section of the creek would become inundated. It is estimated that the water depths would be 15 feet for the 100-year flood and approximately 25 feet for the extreme condition flood.

Table 2.7-11: Proximity Data for the Extreme Condition Floods of Beaver Creek and Pass Creek

Creek	Concern	Horizontal Distance (ft)	Vertical Distance (ft)
Beaver			
	Facilities	3,090	30
	Ore Bodies	80	5
Pass			
	Facilities	5,100	80
	Ore Bodies	70	5

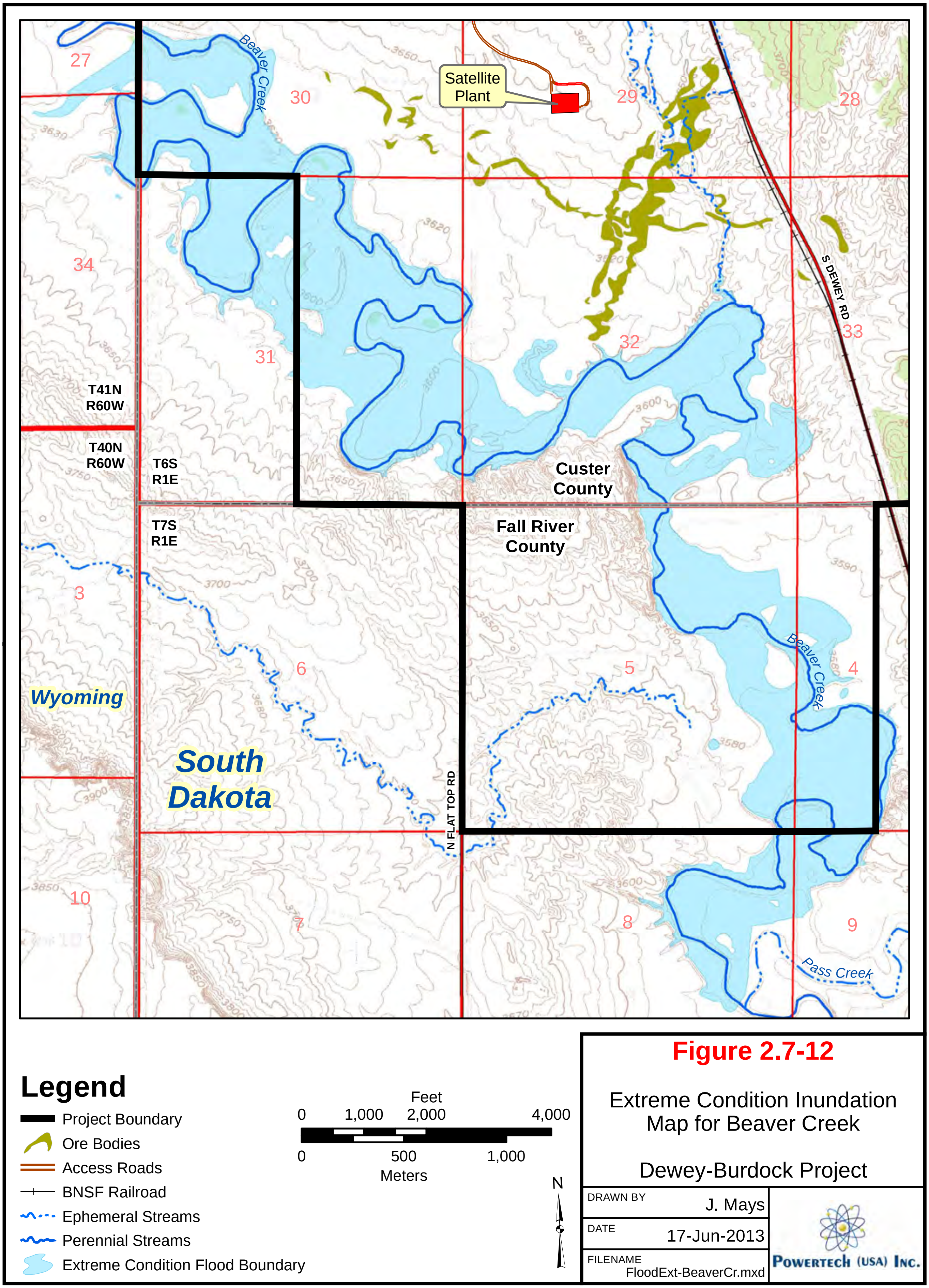


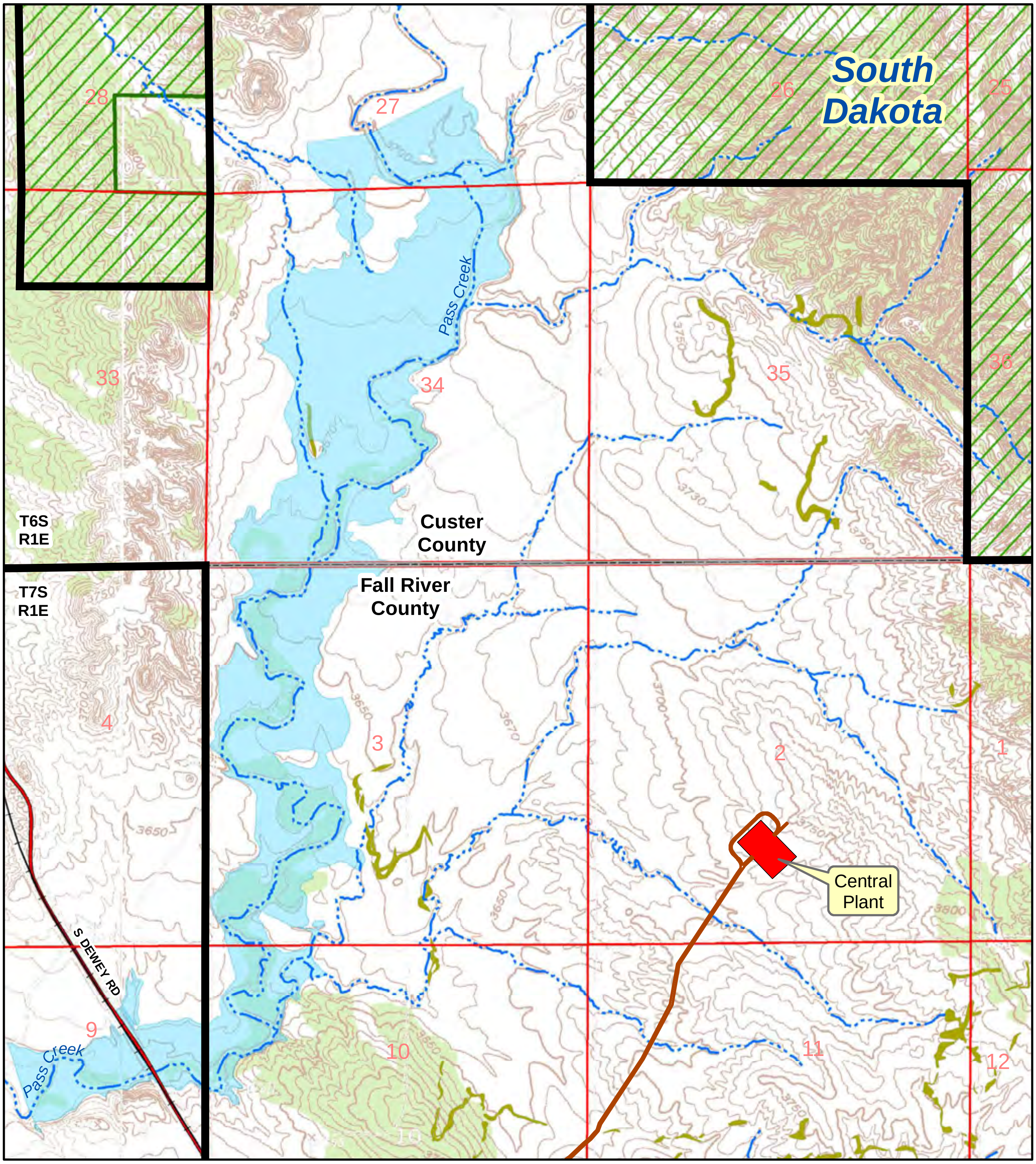
Figure 2.7-12

Extreme Condition Inundation Map for Beaver Creek

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	17-Jun-2013
FILENAME	FloodExt-BeaverCr.mxd

POWERTECH (USA) INC.



Legend

- Project 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 2.7-13

Extreme Condition Inundation Map for Pass Creek

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	17-Jun-2013
FILENAME	FloodExt-PassCr.mxd

POWERTECH (USA) INC.

2.7.1.4.5 Flooding and Erosion in Local Drainages

Smaller ephemeral drainages within the project area were modeled to evaluate potential for flooding. Results of the model are included in Appendix 2.7-M. As described in Appendix 2.7-M, HEC-HMS models were used to calculate peak discharges for various storm events for the drainages within the project area, and HEC-RAS models were used to predict the 100-year flood inundation boundary for the channels within the project area. The inundation boundaries are depicted on Plate 2.7-1.

Where possible, facilities will be located out of the 100-year flood inundation boundary. Facilities which must be located within the 100-year inundation boundary will be protected from damage by a system of structures such as straw bales, collector ditches, engineered diversion structures and/or berms. Additional information on facility construction in relation to flood inundation areas is found in Section 3.1.7.

2.7.1.4.6 Assessment of Levels of Surface Water Bodies

The purpose of the assessment is to characterize the typical seasonal ranges and averages as well as the historical extremes of levels of surface water bodies within the PAA. Surface water bodies within the PAA are surface impoundments such as ponds and old 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 16 sites from October 2, 2007 to July 18, 2008. A summary of this data is shown in Table 2.7-12 which was populated according to site location (Feature ID). Stage data at three of the 16 sites was collected only once while every other site had at least two records with one site having five records. Two of the

13 sites with at least two records had data recorded within three months of each record which would not capture the potential seasonal range of the water level for those two sites. The largest positive and negative changes in water levels over the period of collection were 2.43 feet and -0.48 feet, respectively. The smallest change overall was 0.04 feet. The largest rate of change in water level for each site over its period of collection was 0.011 feet per day or about 0.13 inches per day. The surface water bodies with the largest change in water level are located near the Darrow Mine Pits approximately two miles northeast of Burdock (Feature IDs 10032, 10033 and 10052). Another surface water body is located approximately two miles south of the Darrow Mine which represents the smallest change in water level of any of the surface water bodies (Feature ID 10040). 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 PAA. Further discussion about the interaction between ground water and surface water bodies is provided in Section 2.7.2.

Table 2.7-12: Summary of Water Level Data Collected at Surface Water Bodies

Feature ID	Data Records	Time Interval of Greatest Stage Change (days)	Stage Change (ft)	Stage Change Rate (ft/day)
10024	2	32	0.19	0.0059
10025	2	229	-0.24	-0.0010
10027	1	*NA*		
10030	4	110	0.25	0.0023
10031	4	240	0.78	0.0033
10032	3	206	2.3	0.0112
10033	4	234	2.43	0.0104
10034	1	*NA*		
10039	2	89	0.52	0.0058
10040	2	206	0.04	0.0002
10050	2	234	1.35	0.0058
10051	3	215	0.54	0.0025
10052	3	229	-0.48	-0.0021
10054	3	229	0.75	0.0033
10059	1	*NA*		
10070	5	89	0.63	0.0071

Note: Feature ID denotes Surface Water Body

2.7.2 Groundwater

2.7.2.1 Regional Hydrogeologic Setting

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

2.7.2.1.1 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 2.2-3. Figure 2.2-2 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 2.7-13 summarizes hydraulic properties of major 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 project 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 project 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 project 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 project 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

Table 2.7-13: 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, Wyo-ming
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 2.7-13: Estimates of Hydraulic Properties of Major Aquifers from Previous Investigations (concl.)

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)

portion of the project area (Fall River) and immediately to the east and north of the project 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 project area.

2.7.2.1.1.1 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 2.6.2.2 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 2.7-13). The Inyan Kara is confined below by the Jurassic Morrison Formation and above by the Cretaceous Graneros Group.

2.7.2.1.1.2 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 2.7-13). 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 project area.

2.7.2.1.1.3 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 2.7-13. 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 2.7-13). 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 project 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 Formations are isolated beneath the project area (refer to the Class V UIC application, Appendix 2.7-L).

2.7.2.1.1.4 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 2.7-13; 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 project area.

2.7.2.1.1.5 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 project 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.

2.7.2.1.2 Regional Potentiometric Surfaces

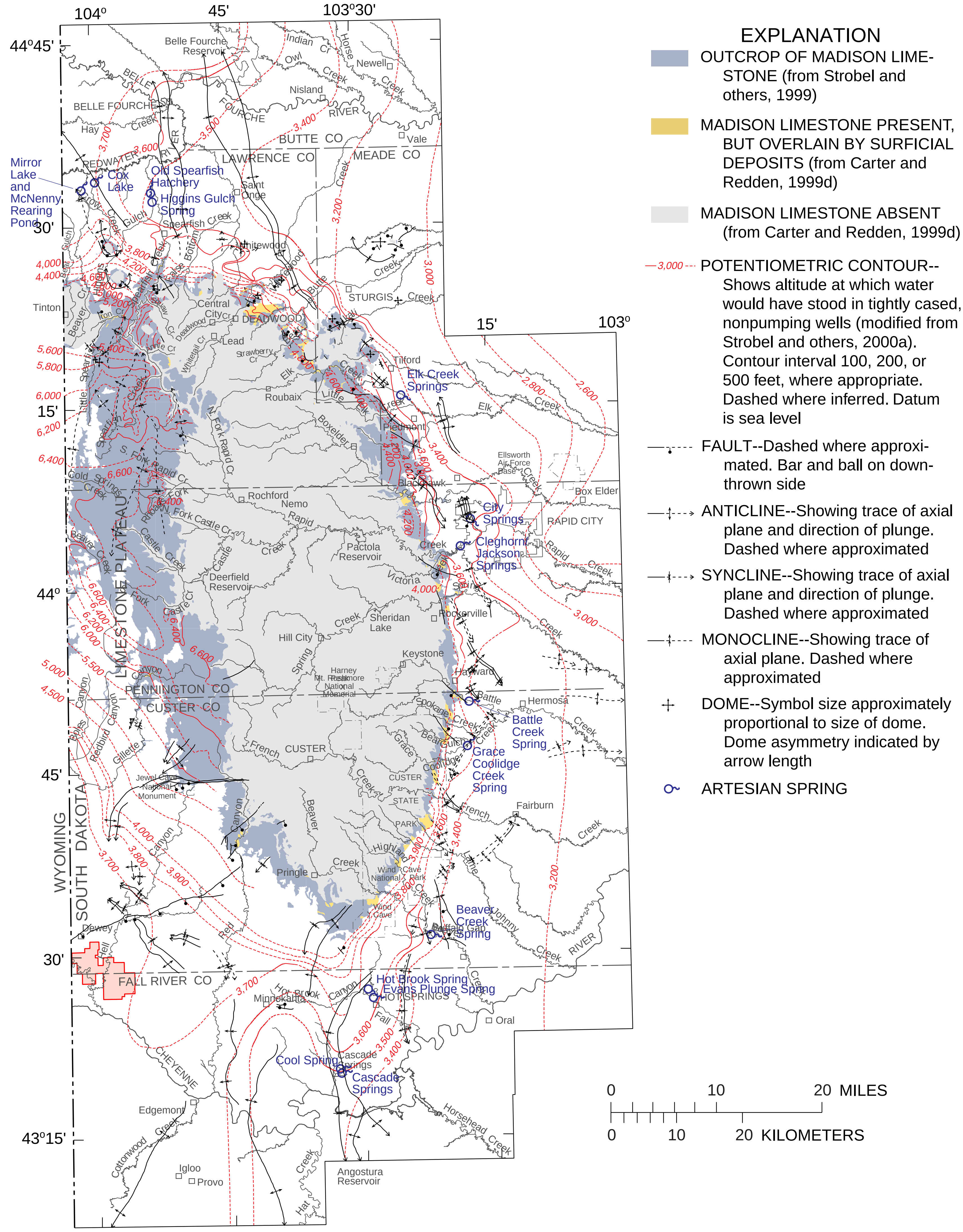
As part of its 1990s study of the hydrologic significance of selected bedrock aquifers, the USGS developed 1:100,000-scale potentiometric contour maps for the Inyan Kara, Minnekahta, Minnelusa, Madison, and the Deadwood (Strobel et al., 2000a thru 2000e). These maps provide a basis for evaluating regional groundwater flow direction and hydraulic gradients in the Black Hills. Figures 2.7-14 and 2.7-15 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 project area other than the Dewey Fault, which is located north of the project area, and the Long Mountain Structural Zone, which is located approximately 7 miles south of the project 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 project 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 project 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 project area, but no evidence of karsting has been observed in the project area. A detailed analysis of the potential occurrence of breccia pipes and karsting north and east of the project area is presented in Section 2.6.5.



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

Legend

Dewey-Burdock Project Boundary

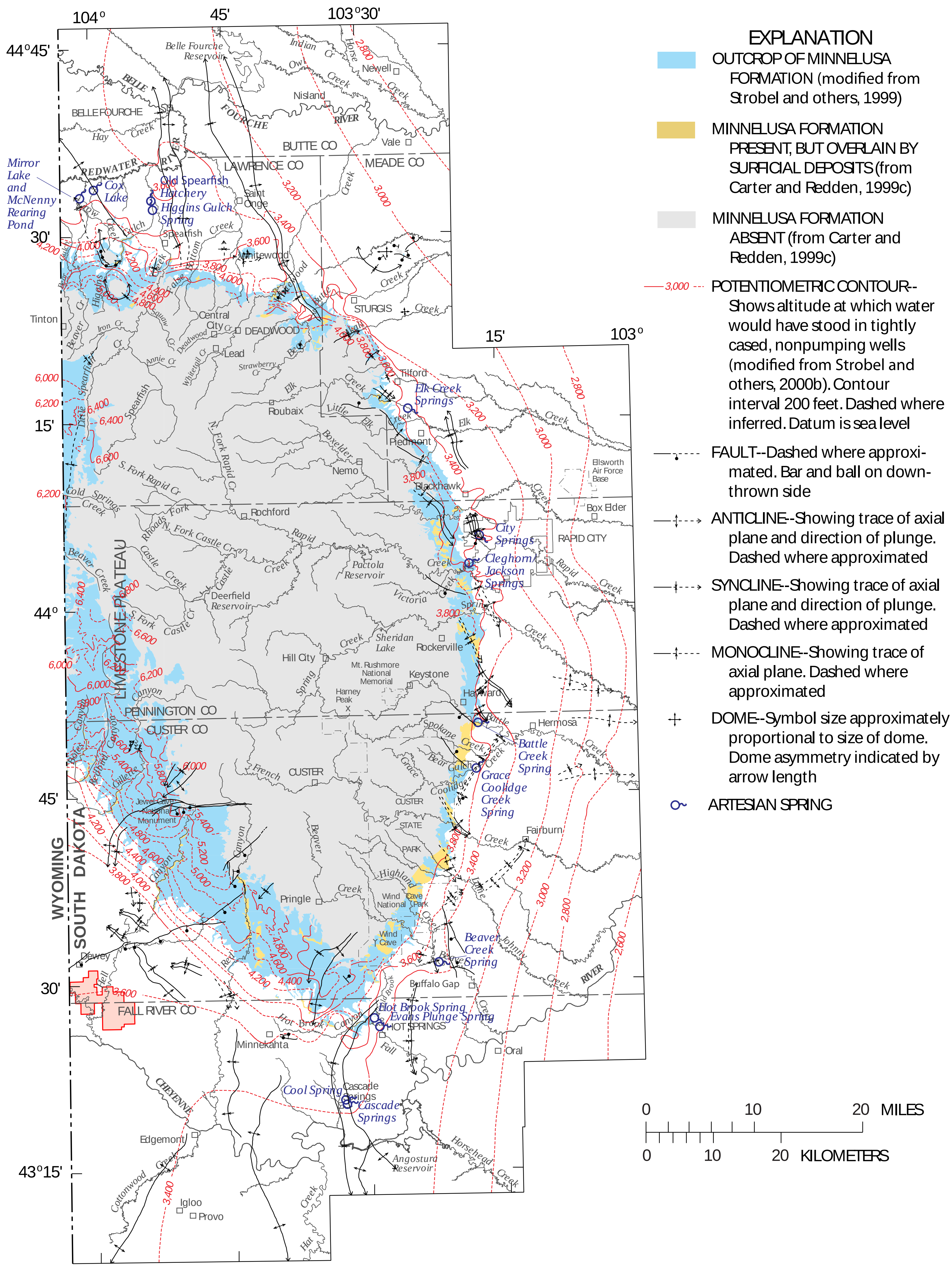
From:
Water-Resources Investigations Report 02-4094
(modified by Driscoll et al., 2002)

N

Figure 2.7-14
Regional Potentiometric Contour Map, Madison Limestone
Dewey-Burdock Project

DRAWN BY	J. Medford	
DATE	1-Nov-2011	
FILENAME	2011_Fig_2.7-14.ai	

POWERTECH (USA) INC.



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

Legend

Dewey-Burdock Project Boundary

From:
Water-Resources Investigations Report 02-4094
(modified by Driscoll et al., 2002)

N

Figure 2.7-15
Regional Potentiometric Contour Map, Minnelusa Formation
Dewey-Burdock Project

DRAWN BY	J. Medford
DATE	1-Nov-2011
FILENAME	2011_Fig_2.7-15.ai

POWERTECH (USA) INC.

2.7.2.2 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 project 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 2.6-5), Chilson Member of the Lakota (Plates 2.6-3, 2.6-3a and 2.6-3b) and Unkpapa Sandstone (Plate 2.6-1). Based on the logs for thousands of exploration holes, no major faults or other structural features have been identified within the project area.

2.7.2.2.1 Site Hydrostratigraphic Units

Refer to Figure 2.2-3 for a regional stratigraphic column and Section 2.6.2.2 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 project area for domestic, livestock, and agricultural uses. These same formations are the host rocks for the uranium mineralization within the project area. Within the project 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 project 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 project 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 2.6.2.2). Because of the low vertical permeability, thickness and continuity of the Morrison Formation across the entire project 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 from limited exploratory drilling, the Spearfish in the project 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 project 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 project area.

2.7.2.2.1.1 Morrison Formation

The Morrison Formation, because of its low permeability and continuity beneath the project 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 project area have shown the vertical permeability of the Morrison clays to be very low and to range from 9 x 10^{-9} to 3 x 10^{-8} cm/sec (0.012 to 0.043 millidarcies; see Table 2.7-16).

2.7.2.2.1.2 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 Formations 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 project 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 project 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 project 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 2.7-16).

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 2.6.2.2, 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 2.6-8).

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 project 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 2.7-16). 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 issuance and the results contained in the well field hydrogeologic data packages (refer to Section 3.1.3.3). 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 project area, to more than 500 feet in the northwestern portion of the project 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.

2.7.2.2.1.3 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 project area, the thickness of the Graneros Group ranges from zero at the outcrop of the Fall River to more than 500 feet (Plate 2.6-10). The members comprising the Graneros Group are described in Section 2.6.2.2. 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).

2.7.2.2.1.4 Terrace Deposits and Quaternary Alluvium

The most recent sedimentary units within the project 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 2.6-11.

2.7.2.2.2 Groundwater Occurrence and Flow

Potentiometric contour maps for the Fall River and the Chilson Member of the Lakota are shown on Figures 2.7-16 and 2.7-17, respectively. These maps were prepared using water level measurements taken over a 5-day period from April 25 through April 29, 2011, rather than based on "average" water levels taken over several years. The data used to generate Figures 2.7-16 and 2.7-17 are presented in Appendix 2.7-A. There are other wells within the project area listed in Appendix 2.2-A, but not used in the development of potentiometric contour maps. The reasons certain wells were not used previously in the development of the potentiometric contour maps are summarized in Table 2.7-14. Also listed are mitigative actions taken to correct problems with the use of certain wells. For well location information and completion intervals, refer Appendix 2.2-B. The procedures for measuring static water levels in and calculating the water level elevations in monitoring wells are summarized in Section 2.7.3.2.2.

The potentiometric contour maps provide a regional flow direction and hydraulic gradient in accordance with the guidance in NUREG-1569, Section 2.7.3(3). Based on pump test results showing variable transmissivity, variations in the configuration of the potentiometric surfaces for the Fall River and Chilson are acknowledged and expected.

The potentiometric surface map for the Fall River (Figure 2.7-16) shows a relatively uniform hydraulic gradient across the project area, with the potentiometric levels decreasing to the southwest. The potentiometric surface for the Chilson (Figure 2.7-17) shows a slight flattening of the hydraulic gradient across the northwestern portion of the project area but with heads also decreasing to the southwest. Many factors can influence the observed potentiometric surface; most commonly they are due to changes in hydraulic properties or changes in groundwater flux. Increasing groundwater flux through an area will actually result in a steeper hydraulic gradient, not a flattening, because more water must move through the same cross sectional area of the aquifer.

A more plausible explanation of the flattening of the Chilson potentiometric surface (and therefore the hydraulic gradient) in the northwest portion of the project area is that the transmissivity of the Chilson is higher in that area. Evidence to support this explanation can be found in the pumping tests that were conducted by TVA in 1980 in the Dewey area (Boggs, 1983). The Chilson was pumped at a rate of 495 gpm for 11 days during this test, a much greater production rate than encountered in other pumping tests within the project area in either the Fall River or Chilson. The transmissivity of the Chilson near Dewey was estimated at nearly

Table 2.7-14: Reasons Wells Not Used in Development of Potentiometric Contour Map

Hydro ID	Reason(s) Wells Not Used in Development of Potentiometric Contour Maps
1	Well cannot be shut in.
2	Well cannot be shut in.
7	Domestic water well with pump – measurement of water level requires well to be removed from service.
8	Domestic water well with pump – measurement of water level requires well to be removed from service.
13	Domestic water well with pump – measurement of water level requires well to be removed from service.
14	Well has now been accessed and included in monthly monitoring program
16	Domestic water well with pump – measurement of water level requires well to be removed from service.
17	Well currently being monitored; verification of completion interval is pending.
18	Domestic water well with pump – measurement of water level requires well to be removed from service.
20	Domestic water well with pump – measurement of water level requires well to be removed from service.
42	Domestic water well with pump – measurement of water level requires well to be removed from service.
51	Well cannot be shut in.
96	Domestic water well with pump – measurement of water level requires well to be removed from service.
115	Domestic water well with pump – measurement of water level requires well to be removed from service.
147	Well currently being monitored for water levels; survey of measurement point is pending.
510	Well currently being monitored for water levels; verification of completion interval and survey of measurement point are pending.
620	Well currently being monitored for water levels; verification of completion interval is pending.
696	Flowing artesian well; well currently being monitored for water levels.
697	Flowing artesian well; well currently being monitored for water levels.
7002	Well cannot be shut in.

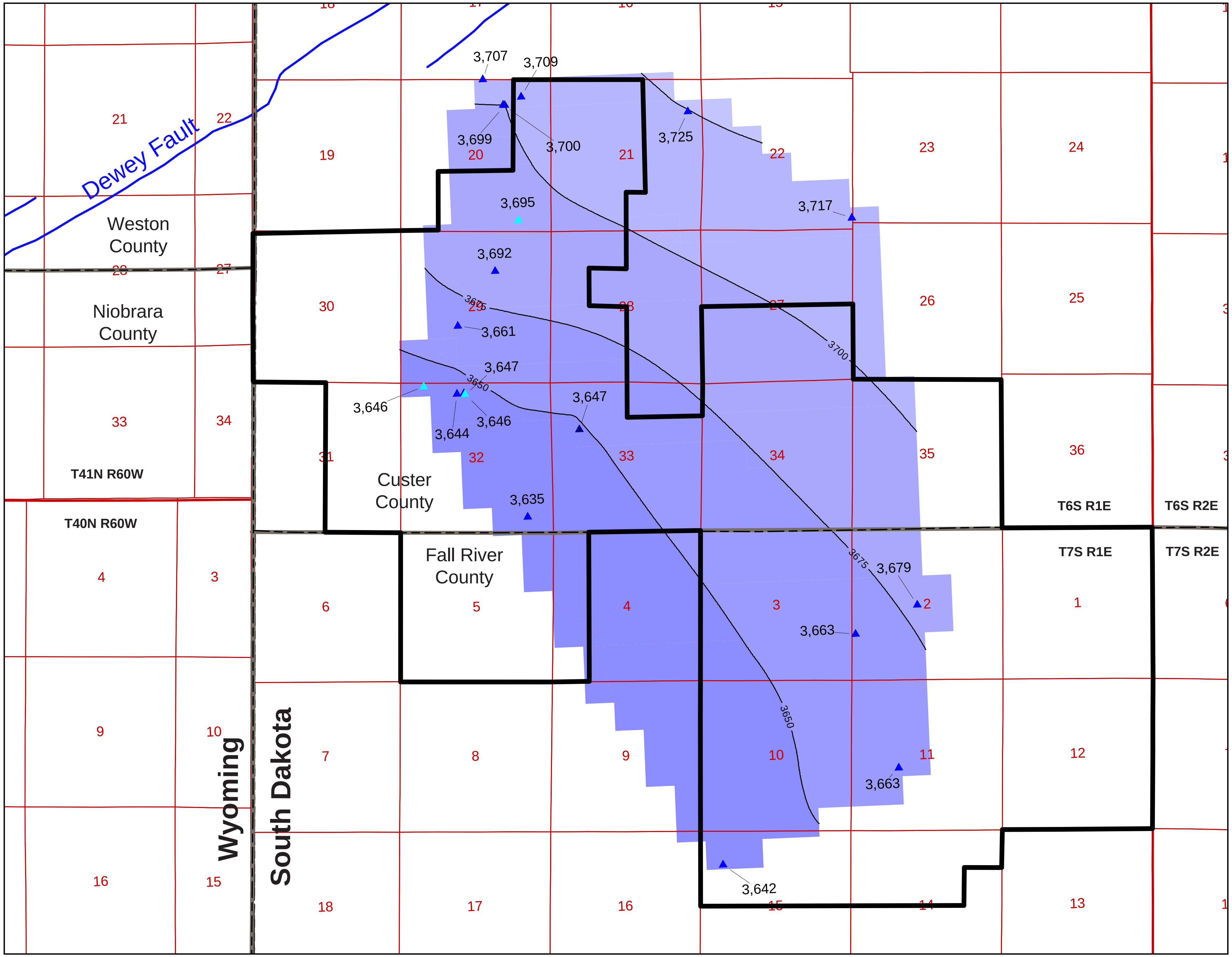


Figure 2.7-16

Potentiometric Contour Map, Fall River Formation

Dewey-Burdock Project

DRAWN BY	K. Schlieper
DATE	1-Nov-2011
FILENAME	2011_DB_Fig_2.7-16a.ai

Powertech (USA) Inc.

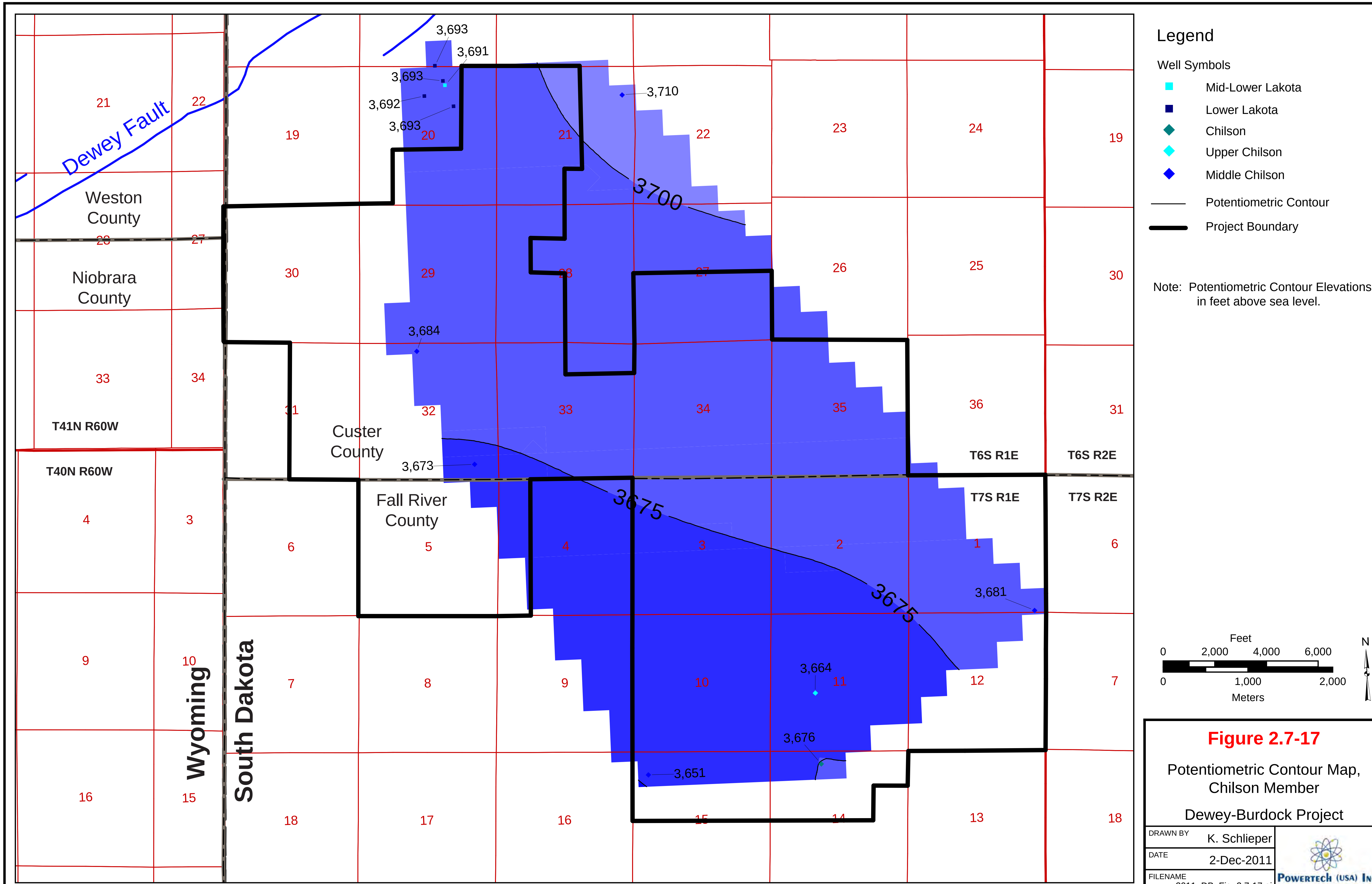


Figure 2.7-17

Potentiometric Contour Map, Chilson Member

Dewey-Burdock Project

DRAWN BY K. Schlieper

DATE 2-Dec-2011

FILENAME 2011_DB_Fig_2.7-17.ai

POWERTECH (USA) INC.

600 ft^2/day, more than twice the value determined from the Burdock area pumping tests (Boggs and Jenkins, 1980). The TVA pumping test reports are provided in Appendix 2.7-K.

2.7.2.2.2.1 Groundwater Flow Systems

Based on the regional and site-specific hydrogeological characterization, groundwater occurrence and flow in the project 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, 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 project 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 project 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 project 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 project area (Fall River) and immediately to the east and north of the project 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 project area, respectively.

Within the project 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 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).

2.7.2.2.2.2 Groundwater Recharge and Discharge

The hydrologic characterization for the project 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 Figure 2.7-16 and Figure 2.7-17, respectively. The water level data collected to date from the Unkpapa within the project 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 5.7.8.2) 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 project area, and in Bennett Canyon, which is located on and beyond the eastern edge of the project 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 project 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 2.7-18. The areas where the Fall River subcrops below the surface alluvium and crops out near the eastern edge of the project area also are recharge areas for the Fall River sands. A similar area of

recharge occurs north of the project 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.

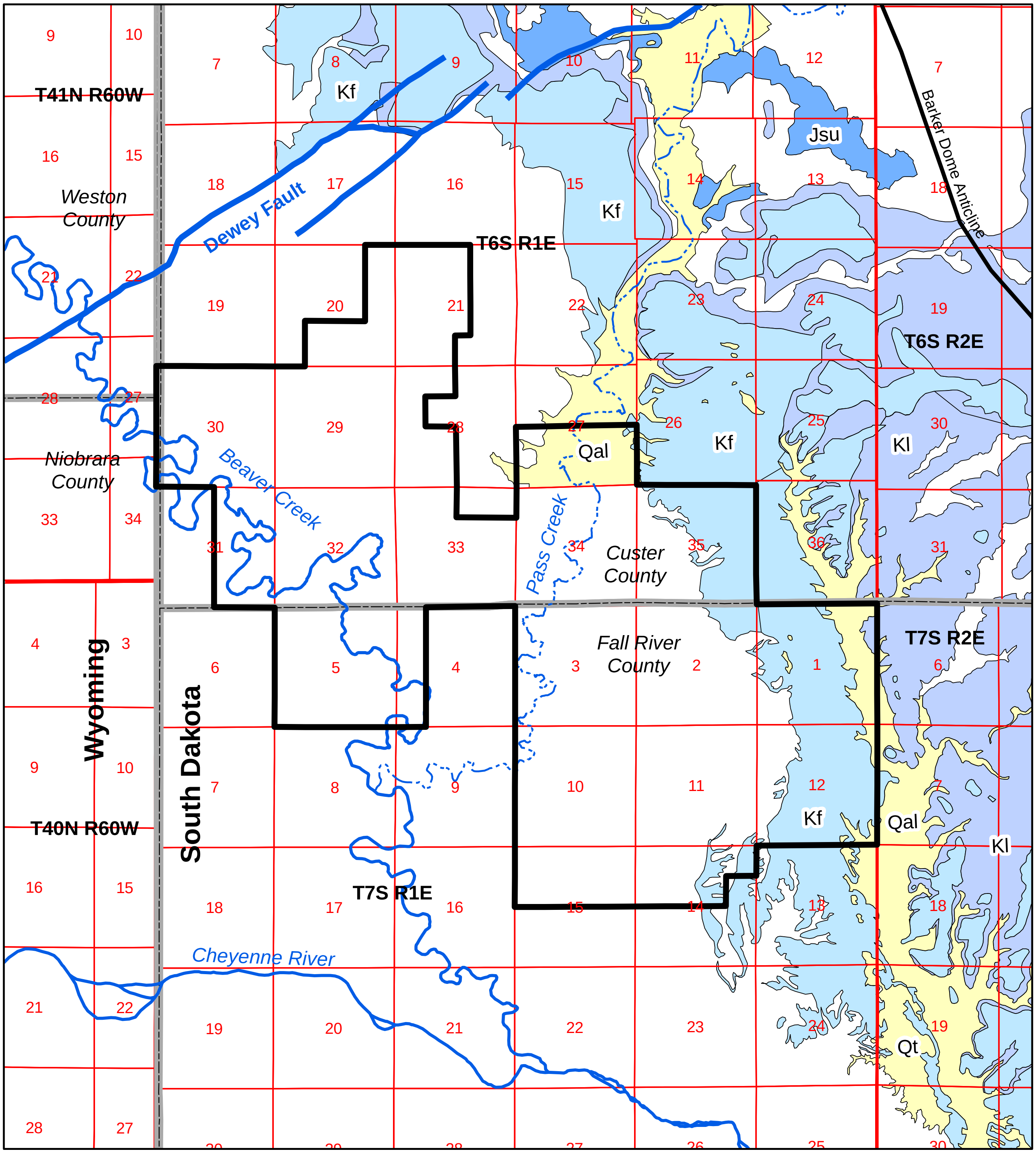
The recharge areas for the regional groundwater flow systems within the Minnelusa Formation, Madison Limestone, and Deadwood Formation are in their outcrop areas further to the east on the flanks of the Black Hills Dome. As a result of the rise in elevation, the older formations outcrop closer to the 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.

2.7.2.2.2.3 Groundwater/Surface Water Interactions

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

Extensive site investigations undertaken by Powertech (USA) and others have revealed no known natural springs within the project area. With one exception, groundwater discharging to the ground surface is limited to flowing artesian wells, which will be controlled. The only feature identified that was indicative of groundwater discharge from exploration holes at or near surface was the "alkali area" in the southwestern corner of the Burdock portion of the project 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 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.



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 2.7-18

Recharge Areas for
Fall River and Lakota Formations

Dewey-Burdock Project

DRAWN BY	J. Medford
DATE	10-Nov-2011
FILENAME	2011_DB_Fig_2.7-18.mxd

POWERTECH (USA) INC.

Potentiometric Surface Evaluation

Powertech (USA) has evaluated areas where the potentiometric surfaces of the Fall River and Chilson are above the ground surface or above the base of the alluvium in order to assess 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 2.7-19 and 2.7-20, respectively. Note that the potentiometric surfaces are anticipated to be above ground surface to the west and southwest of the areas depicted on Figures 2.7-19 and 2.7-20; 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 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 2.7-21. An isopach map for the alluvium is shown on Plate 2.6-11. 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.

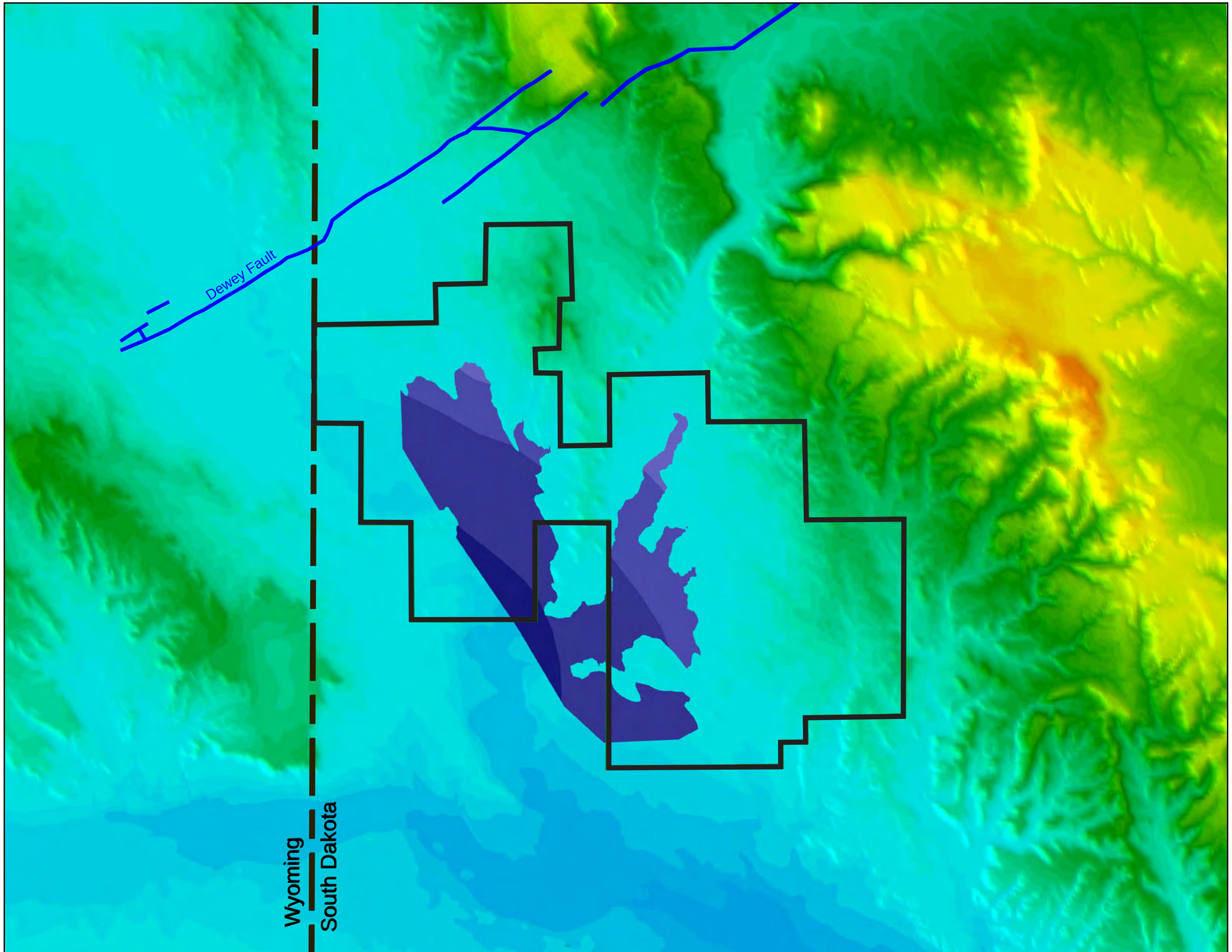


Figure 2.7-19
Area where Fall River Potentiometric Surface is above Ground Surface
Dewey-Burdock Project

DRAWN BY	K. Schlieper
DATE	1-Nov-2011
FILENAME	2011 DB_Fig_2.7-19.ai

POWERTECH (USA) INC.

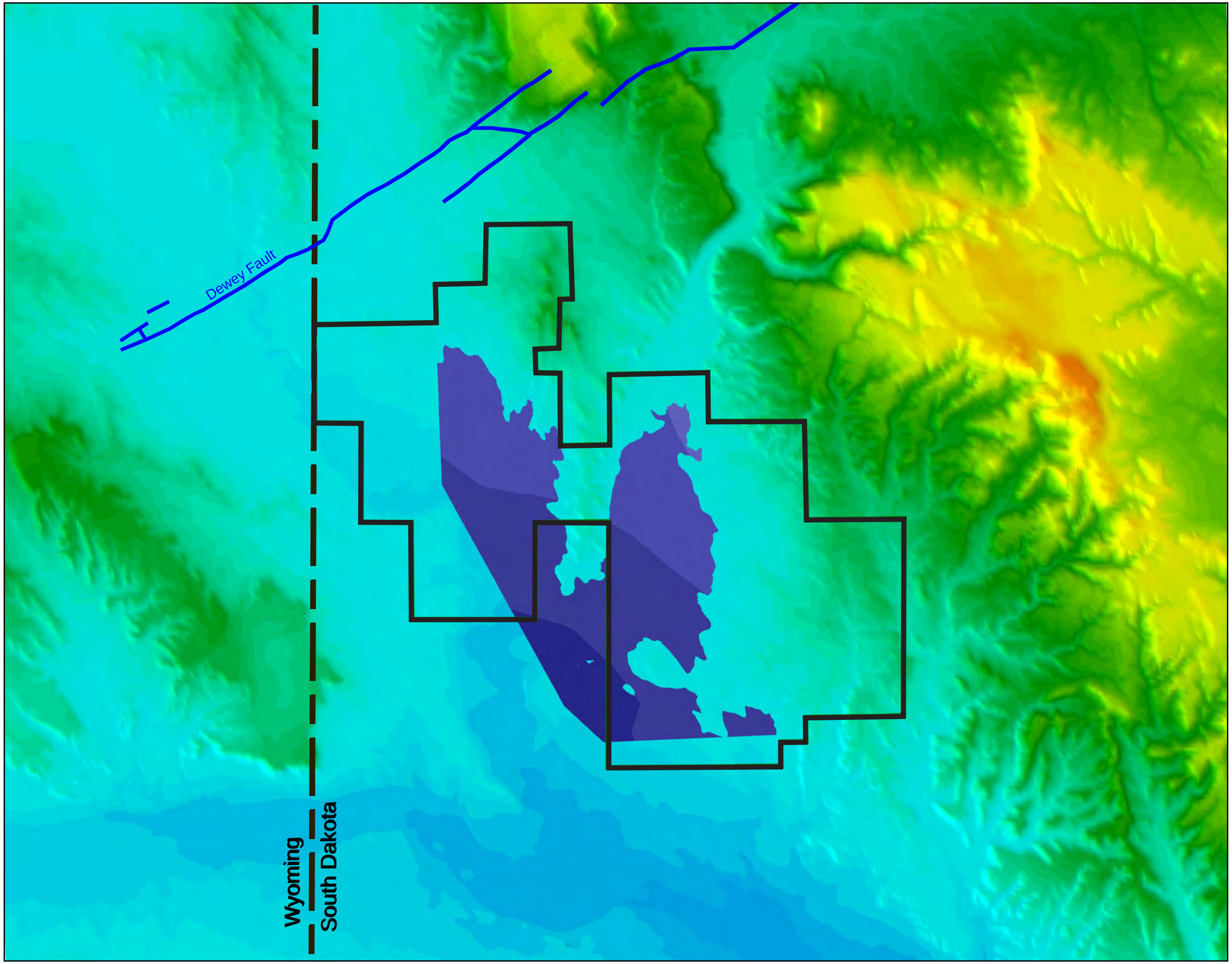


Figure 2.7-20

Area where Chilson Potentiometric Surface is above Ground Surface

Dewey-Burdock Project

DRAWN BY	K. Schlieper
DATE	1-Nov-2011
FILENAME	2011_DB_Fig_2.7-20.ai

POWERTECH (USA) INC.

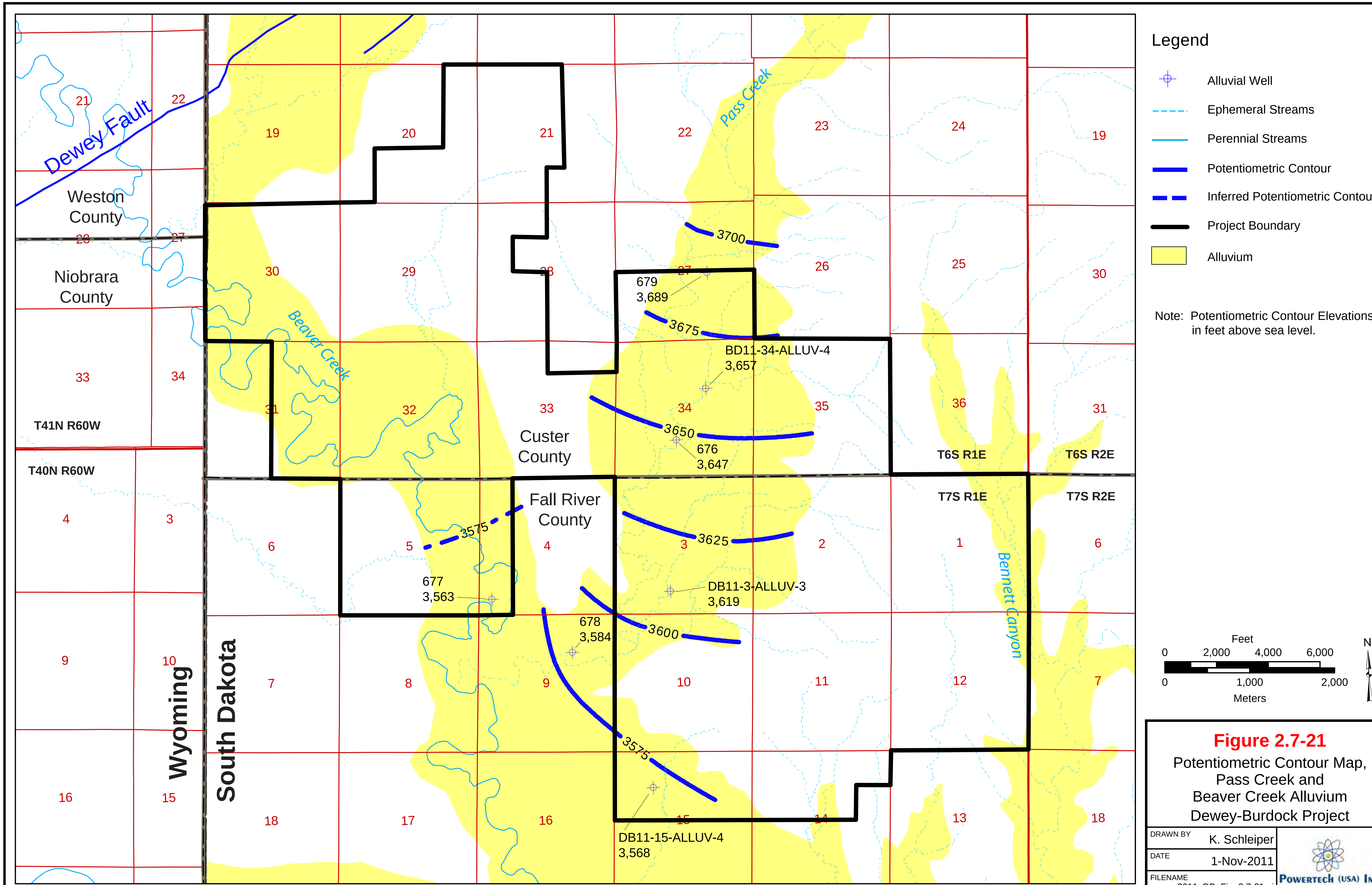


Figure 2.7-21
Potentiometric Contour Map, Pass Creek and Beaver Creek Alluvium Dewey-Burdock Project

DRAWN BY	K. Schleiper
DATE	1-Nov-2011
FILENAME	2011_DB_Fig_2.7-21.ai

Powertech (USA) Inc.

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 project 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 Image Program (NAIP) of the USDA Farm Services Agency for the project 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 project area, such areas often are indicative of enhanced water supply, such as occurs with irrigation or subirrigation.

CIR imagery for the project area and vicinity is presented in Figure 2.7-22. 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 project 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 2.7-23 and 2.7-24.

Outside the project area, the CIR imagery clearly shows two springs near the town of Dewey along the Dewey Fault (Figure 2.7-25). These locations were later verified by Powertech (USA) personnel as springs. 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 project area. Powertech (USA) will continue to use CIR imagery to assess the potential for groundwater discharge to the surface or alluvium within the project area. The obvious evidence of groundwater discharge in the “alkali area” suggests that if similar situations existed at other locations in the project area they would be readily detectable.

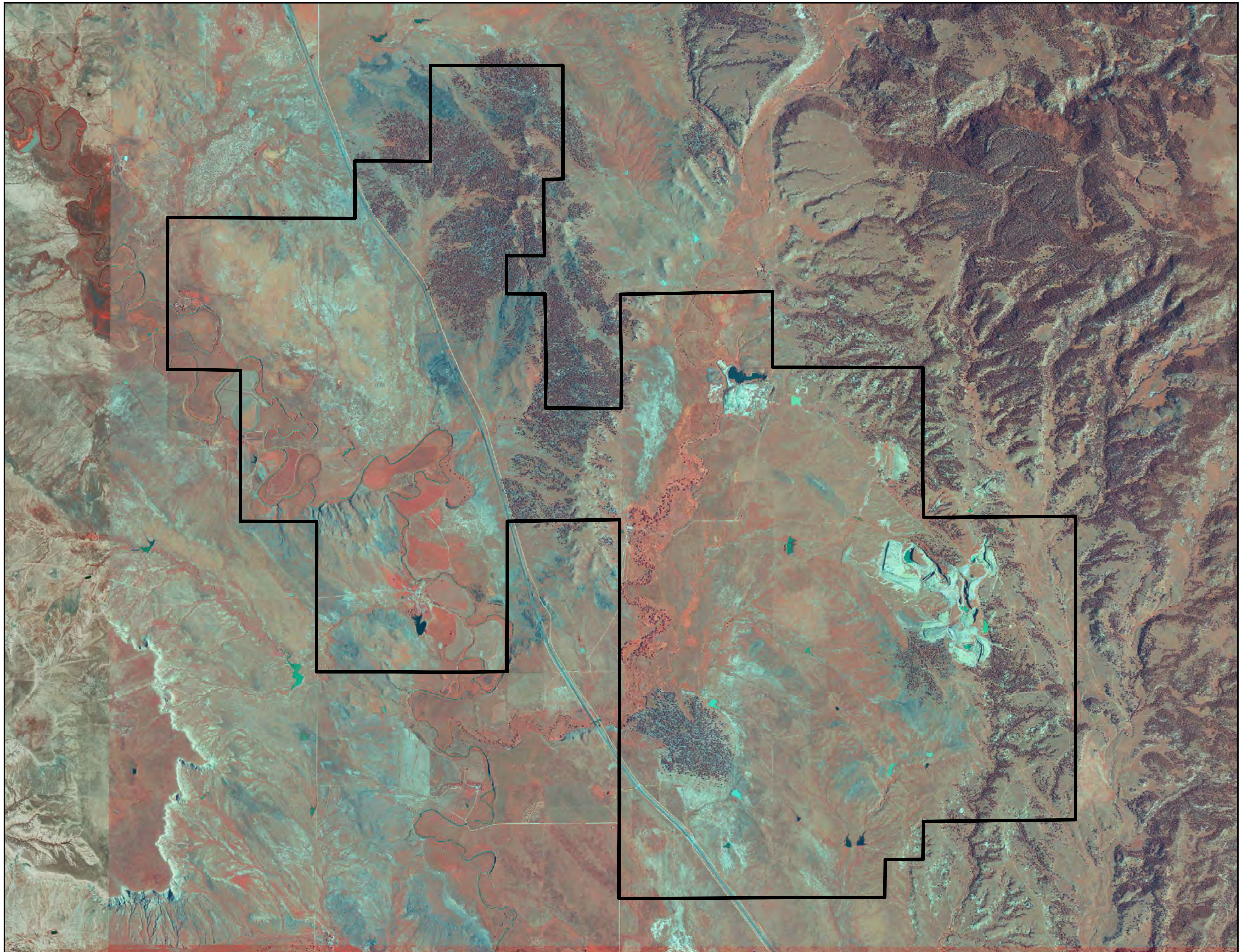


Figure 2.7-22

Color Infrared Imagery (2010 Data)

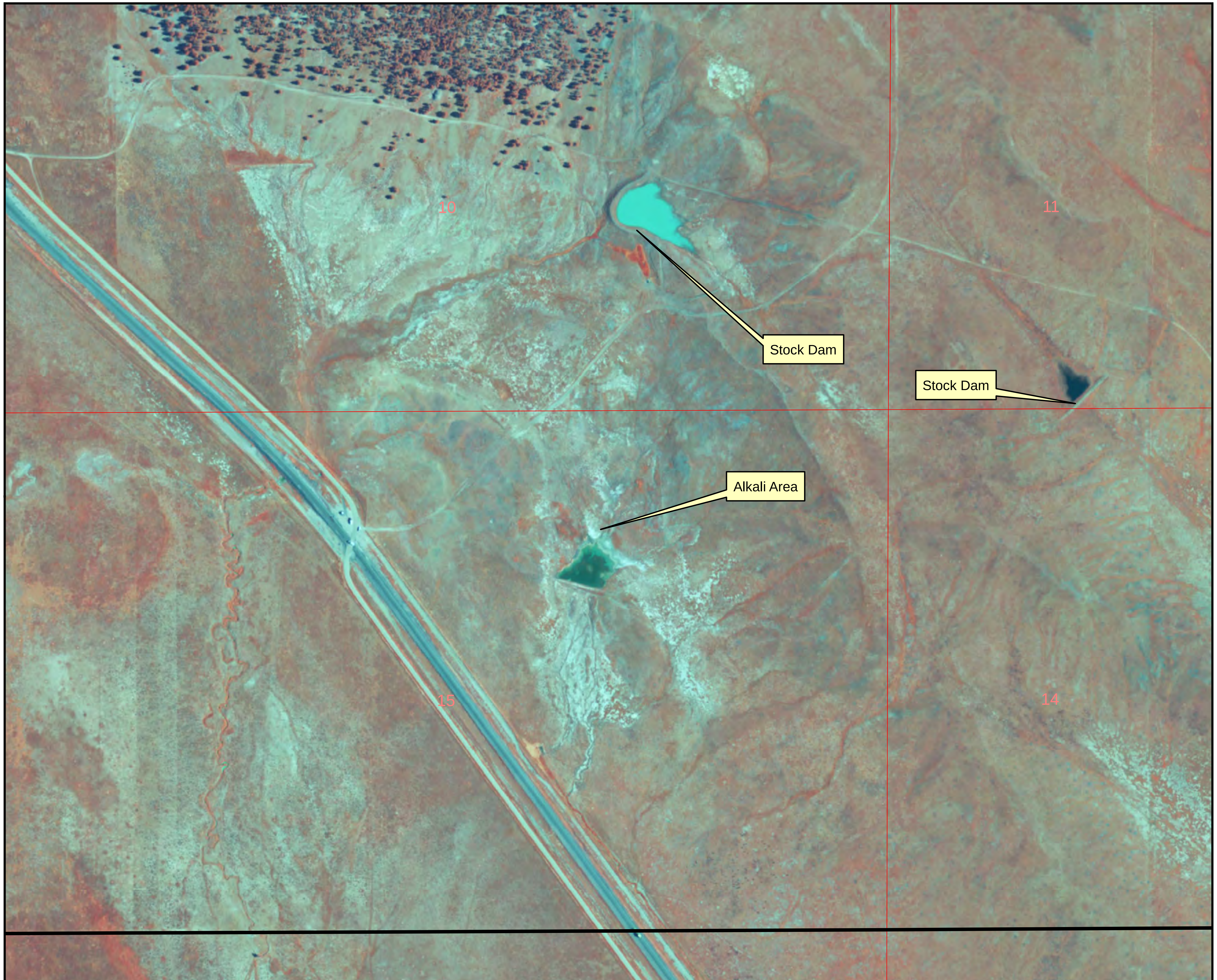
Dewey-Burdock Project

DRAWN BY J. Medford

DATE 1-Nov-2011

FILENAME 2011_DB_Fig_2.7-22.mxd

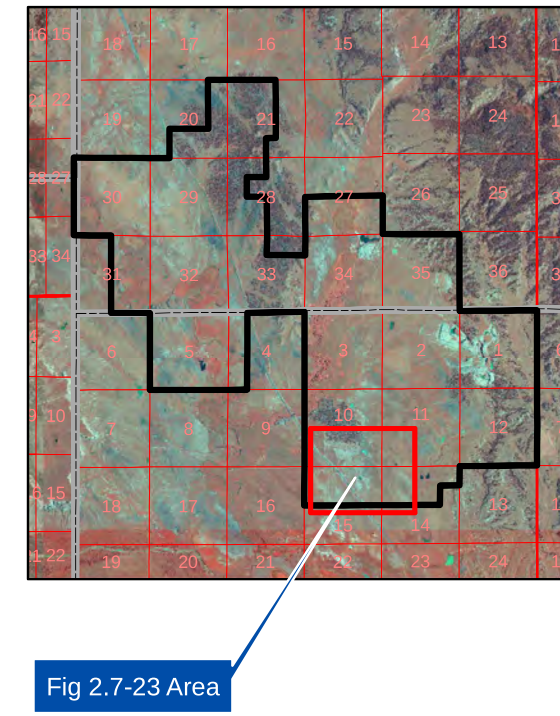
Powertech (USA) Inc.



Legend

Project Boundary

Key Map



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

Figure 2.7-23

Color Infrared Imagery (2010 Data)
Alkali Area near Burdock

Dewey-Burdock Project

DRAWN BY	J. Medford
DATE	1-Nov-2011
FILENAME	2011_DB_Fig_2.7-23.mxd

POWERTECH (USA) INC.

Legend

Project Boundary

Key Map

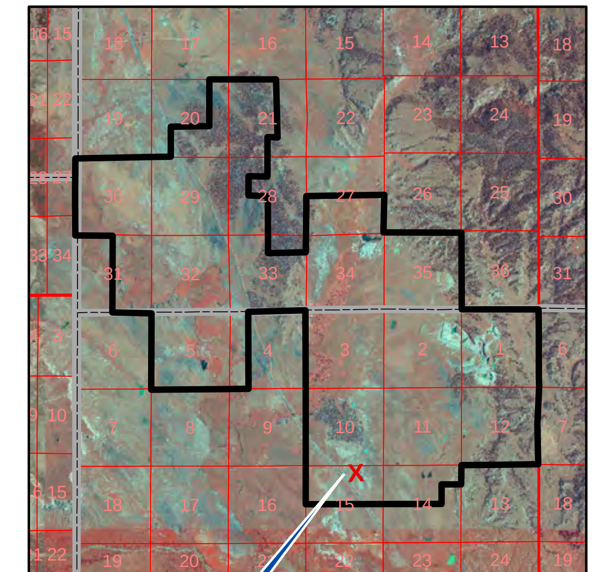


Photo taken at this location
Looking South

Scale: None

Figure 2.7-24

Photograph of Alkali Area, Looking South, near Burdock

Dewey-Burdock Project

DRAWN BY	J. Medford
DATE	1-Nov-2011
FILENAME	2011_DB_Fig_2.7-24.mxd

POWERTECH (USA) INC.

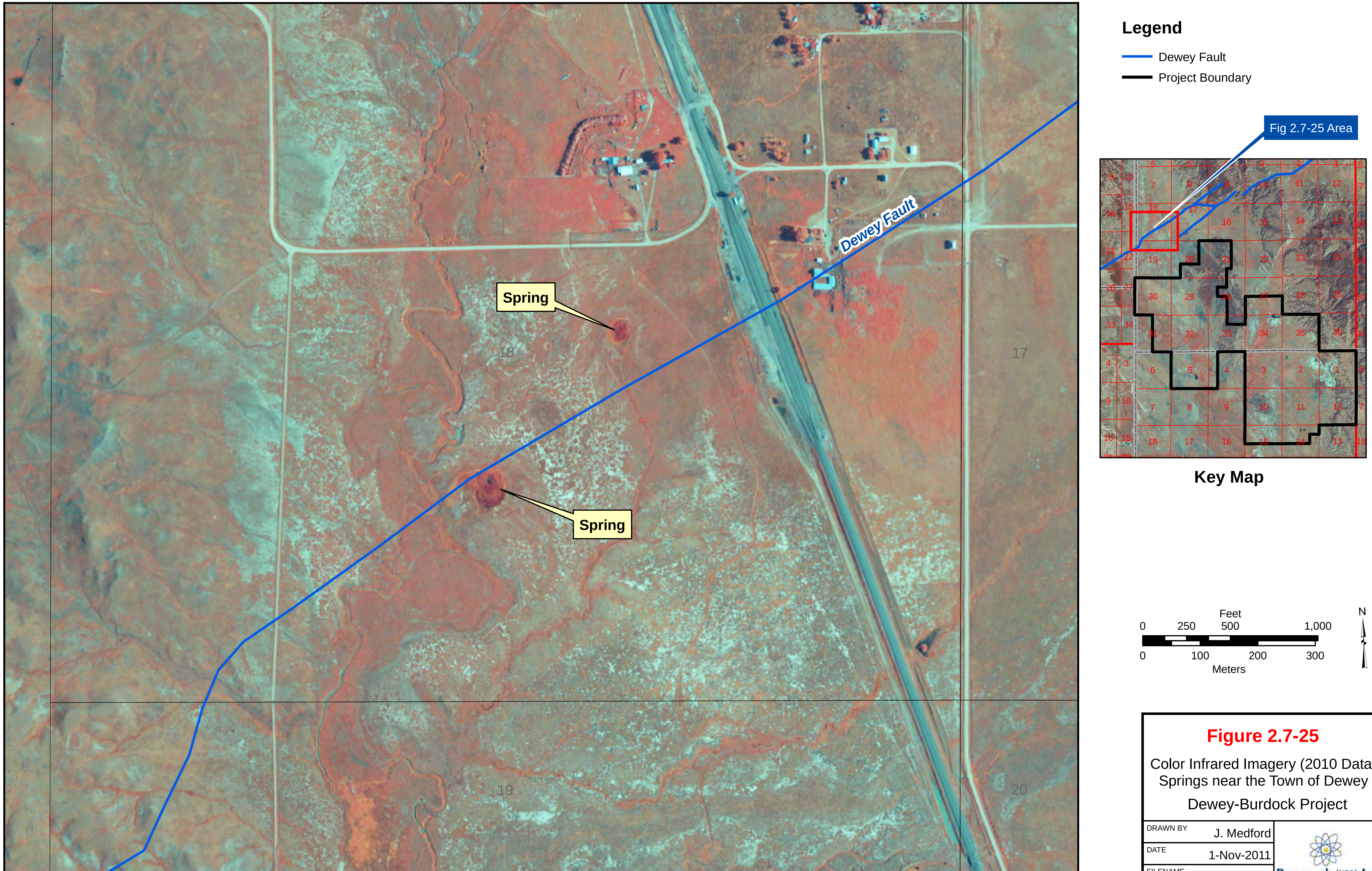


Figure 2.7-25

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

Dewey-Burdock Project

DRAWN BY	J. Medford
DATE	1-Nov-2011
FILENAME	2011_DB_Fig_2.7-25.mxd

Powertech (USA) Inc.

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 3.1.3.2).

Historical Mining Areas

As discussed in Section 2.6.4.2, historical mining operations (surface [open pit] and underground) were conducted 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 3.1.1.1.1.

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.

Partially Saturated Conditions

The uppermost portion of the Fall River Formation crops out in the eastern portion of the project 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 2.6-12a (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 2.7-26 and 2.7-27, respectively. As the Fall River dips basinward to the southwest,

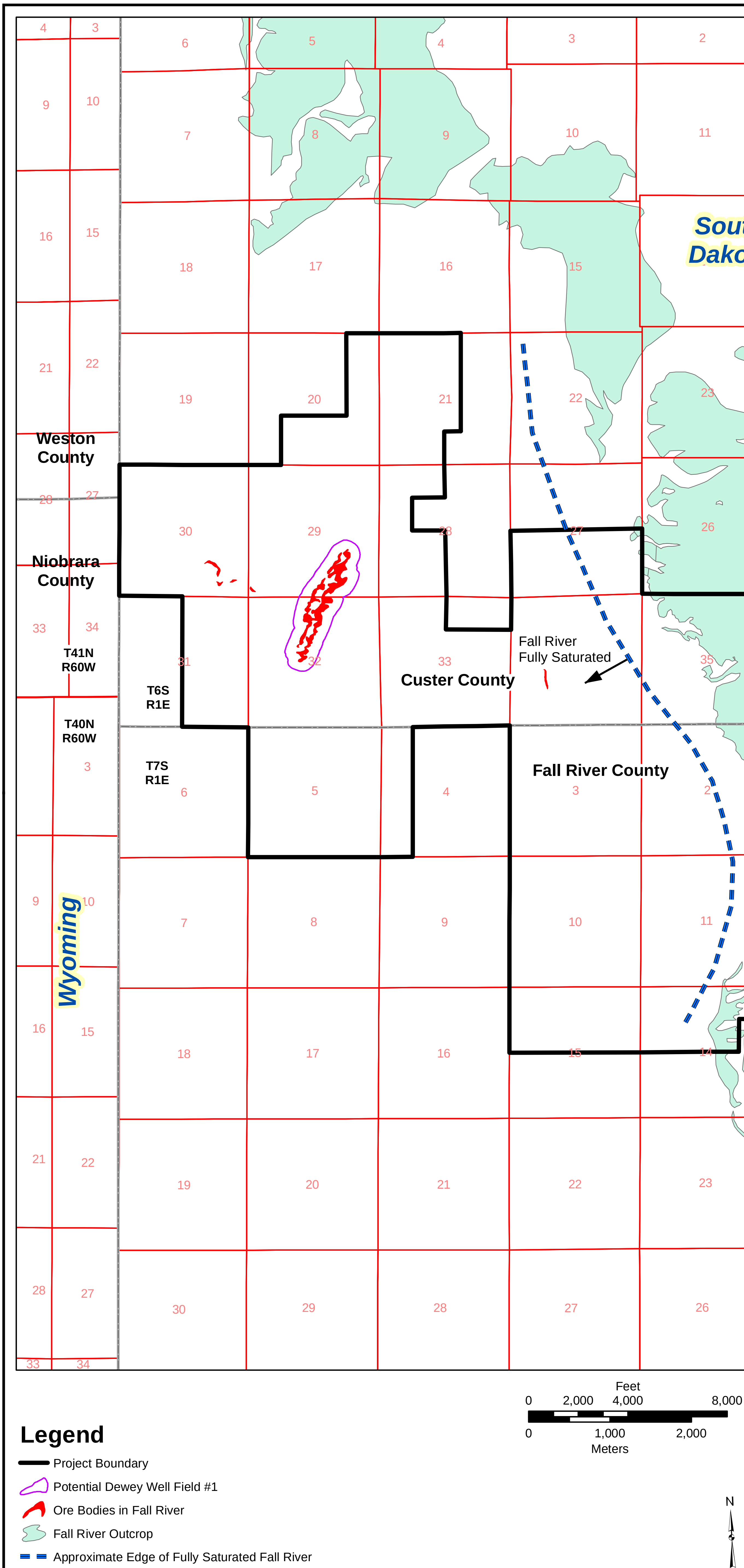


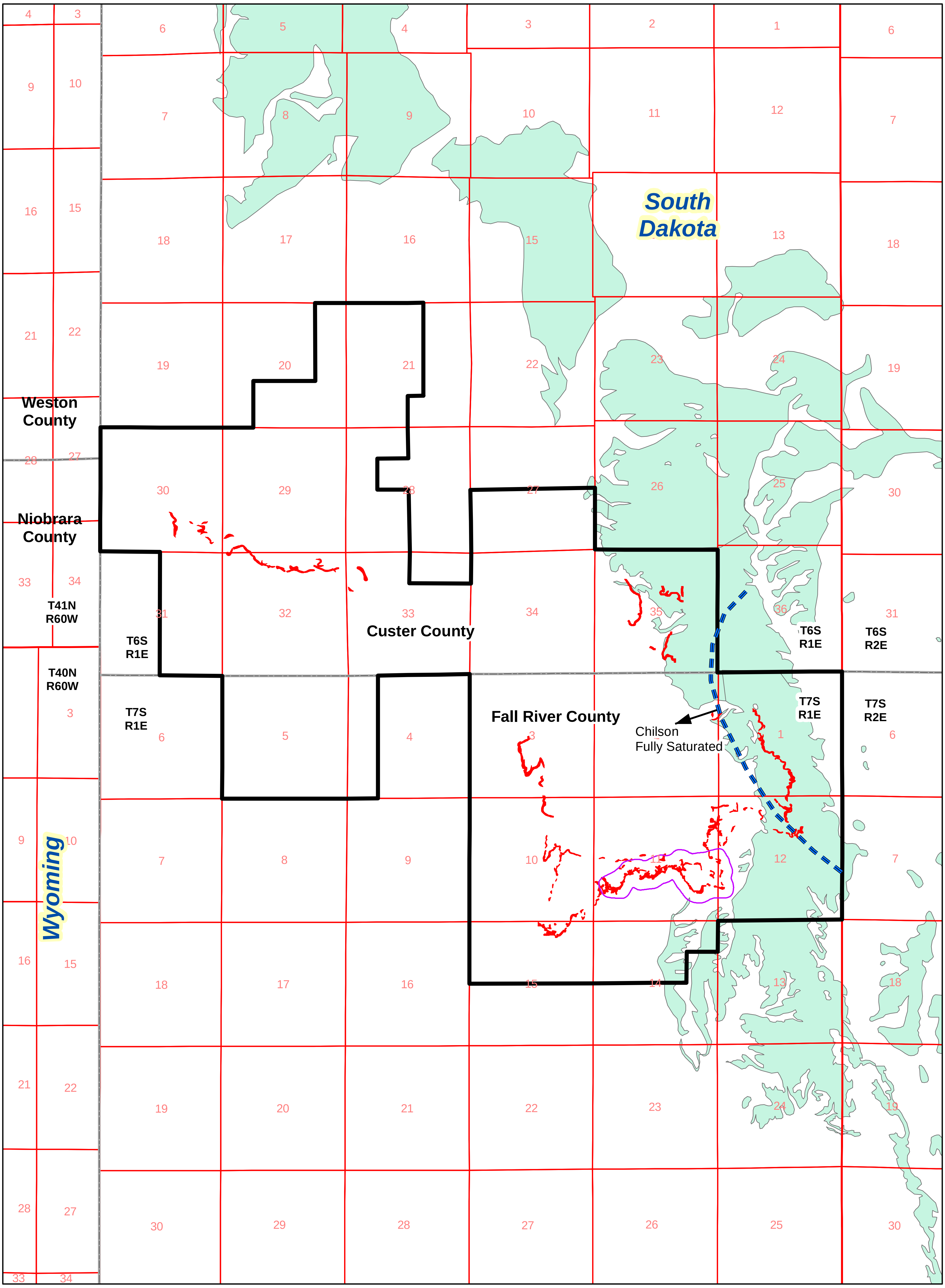
Figure 2.7-26

Location of Fully Saturated Portion of Fall River Formation

Dewey-Burdock Project

DRAWN BY	Mays, Hetrick
DATE	01-Nov-2011
FILENAME	2011_DB_Fig_2.7-26.ai

Powertech (USA) Inc.



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 2.7-27

Location of Fully Saturated Portion of Chilson

Dewey-Burdock Project

DRAWN BY	Mays, Hetrick
DATE	01-Nov-2011
FILENAME	2011_DB_Fig_2.7-27.ai

POWERTECH (USA) INC.

the potentiometric surface is above the top of the formation, as shown on Plate 2.6-12a. 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 project 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 3.1.1.1.2 for a description of well field development with respect to partially saturated conditions. After NRC license 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.

2.7.2.2.2.4 Hydraulic Isolation of Aquifers

Regionally, the Inyan Kara Group is geologically confined. In the project area, the Graneros Group shale serves as the overlying confining unit above the Fall River in the western portion of the project area. There are no major aquifers above the Inyan Kara. Below the Inyan Kara, the Morrison Formation serves as a confining unit. In the project 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 2.7.2.1.1 and 2.7.2.2.1.

As described in the previous section, the only area where the Fall River Formation is geologically unconfined is in the eastern part of the project 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 3.1.1.1.1), but does propose to conduct ISR operations in the underlying Chilson Member of the Lakota where ISR operations would not be affected by the presence of historical workings. The Chilson throughout the project area is physically and hydraulically separated from the overlying Fall River Formation by the Fuson Shale.

Based on Powertech (USA)'s borehole and geophysical logs for more than 3,000 exploratory holes, the Fuson Shale is continuous and no less than 20 feet thick throughout the entire project

area. An isopach map showing the thickness and continuity of the Fuson Shale throughout the project area is presented as Plate 2.6-8. The pervasive occurrence and continuity of the Fuson Shale throughout the project area are shown on the geologic cross sections (Plates 2.6-12a through h and j).

2.7.2.3 Summary of Previous Pumping Tests

This section describes the pumping tests previously conducted by TVA and Powertech (USA). Section 3.1.3.2 describes the pre-operational pump testing that will be conducted for each well field.

2.7.2.3.1 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 2.7-K: "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 project area and one in 1982 about 2 miles north of the Dewey portion of the project area. The results of these tests are described below.

<u>Burdock Area</u>

The Burdock tests were conducted in 1979 near S. Dewey Road at the location shown on Figure 2.7-28. 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 alternatively 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 unexpected 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:

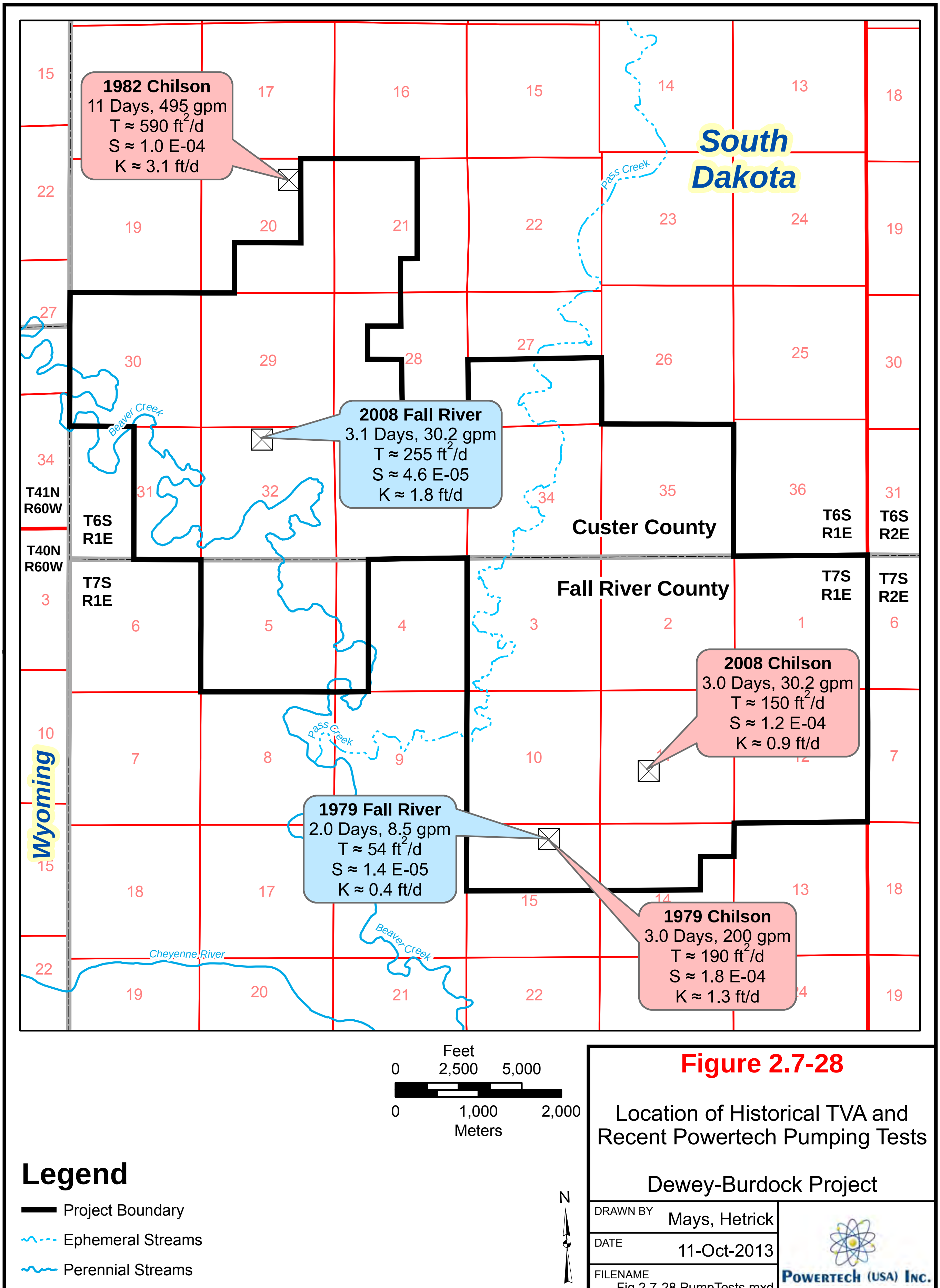


Figure 2.7-28

Location of Historical TVA and Recent Powertech Pumping Tests

Dewey-Burdock Project

DRAWN BY	Mays, Hetrick
DATE	11-Oct-2013
FILENAME	Fig 2.7-28 PumpTests.mxd

POWERTECH (USA) INC.

- 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 2.7-28. 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}.
- 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.

2.7.2.3.2 2008 Pumping Tests

In 2008 pumping tests were performed in the Dewey and Burdock portions of the project area (Figure 2.7-28), 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 2.7-B). The report results are briefly summarized in the following sections.

2.7.2.3.2.1 Burdock Area

<u>Summary of Burdock Pumping Test Results</u>

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 ft 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 is as follows:

- Nine determinations of transmissivity (Table 2.7-15) 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 ranged from 0.7 ft/day to 1.3 ft/day, with a median value of 0.9 ft/day.
- Four storativity determinations (Table 2.7-15) ranged from 6.8×10^{-5} to 1.9×10^{-4} with the median value of 1.2×10^{-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 2.7-16) 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/d, the mean value was 7.4 ft/d and the 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 2.7-16) 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 indicate vertical permeabilities of about 2×10^{-7} to 1×10^{-8} cm/sec (average 2.7×10^{-4} ft/d) for shale samples from within the Fuson Shale.
  - Morrison Shale: the laboratory core data for the shales in the underlying Morrison Formation indicate vertical permeabilities of 9×10^{-9} to 3×10^{-8} cm/sec (average 6.0×10^{-5} ft/d).

Table 2.7-15: Summary of Aquifer Hydraulic Characteristics for the Burdock Pumping Test

Well I.D.	Well Type	Radial Dist. (ft)	Interpretation Method	Transmissivity (ft²/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	-	-
11-15	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	-	-
11-02	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							
11-19	Obs	50	Theis DD(2)	260	-	1.00E-01	-
			CJ Recovery (3)	190	<0.15	-	-
Fall River (lower sandstone layer)							
11-17	Obs	50	Noordbergum Effect and response cannot be interpreted analytically				
Unkpapa Sandstone							
11-18	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.

Table 2.7-16: 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	Chilson Sand	2.4692E-03	7.0	
5V	423.35	600	30.34	1,464	2.645	Chilson Sand	1.1272E-03		3.2
6H	430.20	600	31.90	4,161	2.640	Chilson Sand	3.2037E-03	9.1	
6V	430.35	600	30.16	939	2.646	Chilson 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	Chilson Sand	2.0765E-03	5.9	
8V	420.10	600	30.17	1,750	2.651	Chilson 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 x 10^{-11} cm^2

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 2.7-28). The average transmissivity and storativity values determined from the TVA tests were 190 ft^2/d and 1.8×10^{-4} (see p. 17 in Boggs and Jenkins, 1980). Comparing the median transmissivity of 150 ft^2/d and storativity of 1.2×10^{-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, comparing the results suggests that there may be some scaling effect between the tests due to the differing 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 2.7-15).

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

The laboratory core data from samples collected within the project 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 2.7-16). 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 project 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 2.7-16). Pump test results indicate an average horizontal hydraulic conductivity of approximately 0.9 ft/d (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 project 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.

2.7.2.3.2.2 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 at 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 2.7-17) ranged from 180 to 330 ft^2/day with the 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 2.7-17) ranged from 2.3×10^{-5} to 2.0×10^{-4} with the 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 2.7-16) 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 indicates 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 Lakota Formation 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 head difference between the two units. The laboratory core data indicate a very low vertical permeability of 6.2×10^{-9} cm/sec (1.8×10^{-5} ft/day) for a shale sample from the Fuson Shale within the project area (Table 2.7-16).

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 $5.4\text{x}10^{-9}$ cm/sec ($1.5\text{x}10^{-5}$ ft/day), which is representative of an effective aquitard or aquiclude (Table 2.7-16).

For the sandstone of the Fall River Formation, the laboratory core data indicate a horizontal hydraulic conductivity of 6.1 ft/day ($2.2 \text{ x}10^{-3}$ cm/s, Table 2.7-16). Based on pump test results, the average horizontal conductivity is approximately 1.8 ft/day (6.4×10^{-4} cm/s). Within the lower Fall River Formation, the test results indicate transmissive, rapid response (2 to 3 minutes) between pumping and observations wells up to 467 feet apart with nearly 10 feet of drawdown. Response was nearly 9 feet of drawdown at 1,400-foot distance. This indicates that the aquifer was stressed to produce good quality analytical results.

Table 2.7-17: 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.

2.7.2.4 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 2.2-4. Within the project 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 of the project area and 2-km surrounding area were used to develop the well inventory. A preliminary 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 106 wells have been identified within 2 km of the project area. There are also 26 wells with historical records that currently are not present at the surface and 8 wells with historical records that have been visually confirmed as plugged and abandoned. Appendix 2.2-A contains the well inventory summary tables, and Appendix 2.2-B contains the detailed well inventory, well completion records and associated documentation. Plate 2.7-2 depicts existing wells within 2 km of the project area.

Table 1 in Appendix 2.2-A summarizes the well inventory. Those wells have one of the following uses:

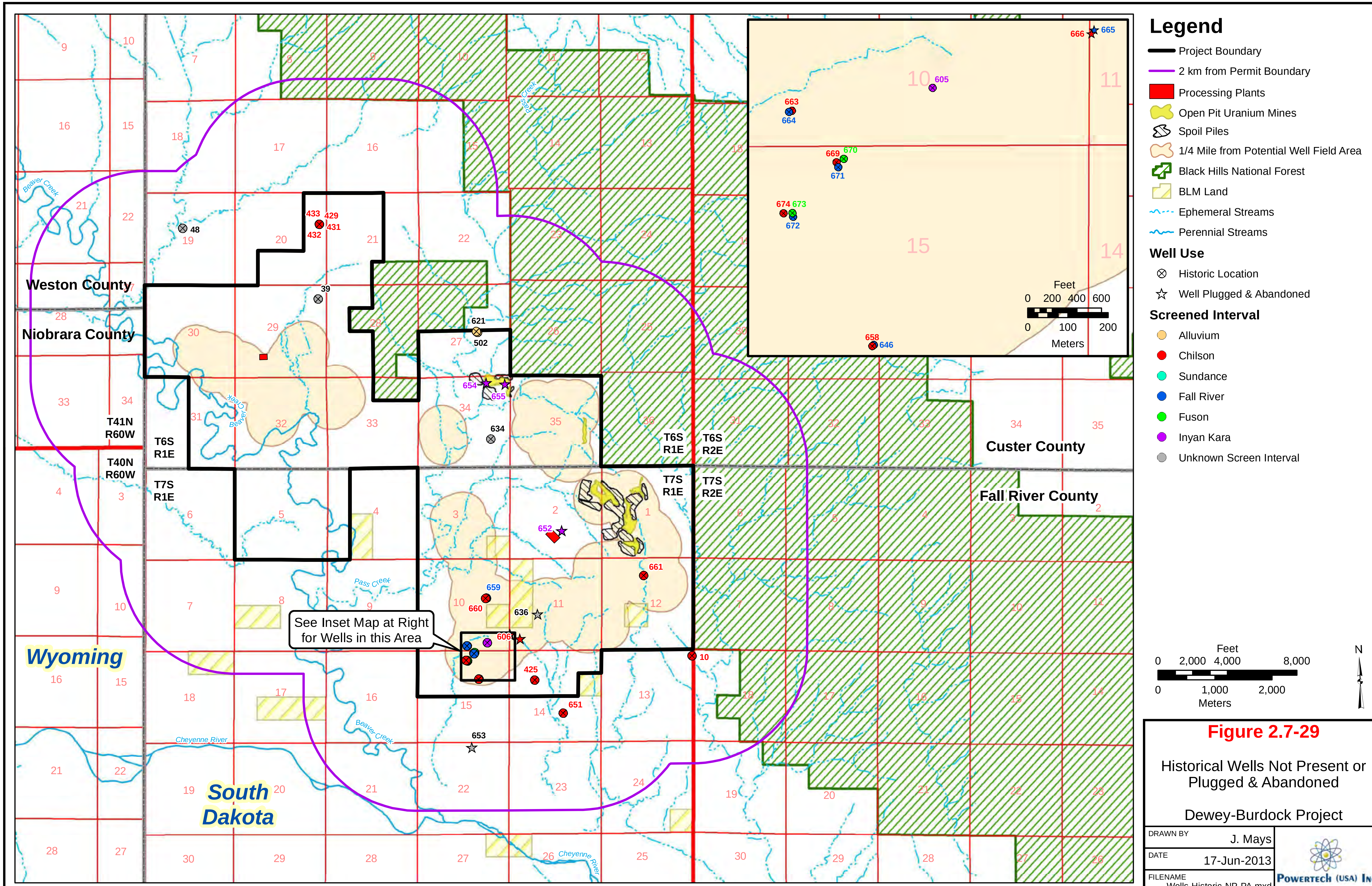
Domestic: Are currently used or reasonably can be expected to be used for domestic water use (e.g., drinking, washing, sanitary use, etc.), including wells which also are used for livestock watering. This category also includes formerly used domestic wells which through agreements with Powertech (USA) no longer will be used as drinking water wells. (19 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.). (41 wells)

Monitor: Sole use is for monitoring. (46 wells)

Table 2 in Appendix 2.2-A lists the wells identified in historical records that were not evident at the surface during the field investigations. These wells are depicted on Figure 2.7-29. 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 2.2-A lists all of the wells within 2 km of the project 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.


Legend
Project 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
T7S R1E
T6S R2E
T7S R2E
See Inset Map at Right for Wells in this Area
Feet 0 2,000 4,000 8,000
0 1,000 2,000 Meters
Figure 2.7-29
Historical Wells Not Present or Plugged & Abandoned
Dewey-Burdock Project
DRAWN BY J. Mays
DATE 17-Jun-2013
FILENAME Wells-Historic-NP-PA.mxd
Powertech (USA) Inc.

2.7.2.4.1 Operational Water Use

During ISR operations (including both production and restoration) nominal bleed rates of .5-1 percent are expected to be maintained over the life of the project. Instantaneous rates may vary in the range of 0.5 percent to 3 percent for short durations, from days to months. All effluent systems for treating bleed streams are designed for continuous operation at the maximum bleed rate of 3 percent. However, over the life of the project, a reasonable estimate of .5-1 percent, or slightly less, bleed is believed appropriate and sufficient to maintain the cone of depression necessary within any production or restoration activity. The design nominal bleed rate is 0.875 percent as described in Section 4.2.2.4.1. ISR circulates significant quantities of water through the ore zone but consumes only a small fraction of that amount because most water is reinjected into the deposit. During operations, 0.5 to 3 percent of the solution extracted from the aquifer will be "bled" from the system to ensure that a cone of depression is maintained and that no leach fluids are released from the recovery area.

It is anticipated that up to four well fields will be in production at one time, with up to two in restoration. Aquifer restoration will begin as soon as each well field has been depleted of uranium, beginning approximately two years after the start of operations. When one well field is depleted, it will be restored at the same time production continues in another well field along the ore front.

2.7.2.4.1.1 Water Requirement for the Proposed Action Facilities

The water balance is presented in Section 4.2.2.4. Water requirements of the CPP will typically be about 12 gpm. It is expected that most of this water will be derived from one or more water supply wells in the Madison formation. Some of this water may be withdrawn from the Inyan Kara aquifer, but if so, it will not occur in a fashion to affect any well field operations.

2.7.2.4.1.2 Water Usage with Reverse Osmosis and without Reverse Osmosis

Total net water use for production operations (as well field bleed) will be approximately 35 gpm from the Inyan Kara (refer to Figure 4.2-1). During aquifer restoration, the amount of water consumption from the Inyan Kara will depend on whether or not groundwater sweep is used. As described in Section 4.2.2.4.2, the restoration bleed will typically be approximately 1% of the restoration flow rate unless groundwater sweep is used, in which case it will be approximately 17%. This equates to 5 to 85 gpm during restoration without concurrent production. The typical

Inyan Kara usage during concurrent production and restoration will therefore total approximately 40 to 120 gpm.

As described in Section 4.2.2.4, water from the Madison Limestone or another suitable aquifer will be used to supply water to the CPP and as a clean water source for aquifer restoration. The quantity of Madison water used will depend on the aquifer restoration method, which in turn will depend on the liquid waste disposal option. In the deep disposal well option, RO permeate will be injected into well fields undergoing aquifer restoration, and the quantity of make-up water from the Madison Limestone or another suitable aquifer will be approximately 80 to 160 gpm. In the land application option, water from the Madison Limestone or another suitable aquifer will replace all of the water withdrawn from the well fields undergoing aquifer restoration. In this case, the usage of water from the Madison Limestone or another suitable aquifer will be about 430 to 510 gpm.

Tables 2.7-18 (without groundwater sweep) and 2.7-18a (with groundwater sweep) present the estimated Inyan Kara Group and Madison Limestone usage in the deep disposal well option. Table 2.7-19 (without groundwater sweep) and 2.7-19a (with groundwater sweep) present the estimated water usage in the land application option.

POWERTECH (USA) INC.

Table 2.7-18: Net Water Usage, Deep Disposal Well Option (without Groundwater Sweep)

	Net Water Usage at Nominal Bleed Rate (Deep Disposal Well Option)										Cumulative
INYAN KARA	Without Groundwater Sweep										Water Usage
Project Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10***	(million gallons)
Production											
Extraction composite	0	4000	4000	4000	4000	4000	4000	4000	4000	0	
Reinjection	0	3965	3965	3965	3965	3965	3965	3965	3965	0	
Well field bleed	0	35	35	35	35	35	35	35	35	0	
Bleed rate		0.875%	0.875%	0.875%	0.875%	0.875%	0.875%	0.875%	0.875%		
Aquifer Restoration**											
Extraction composite	0	0	0	500	500	500	500	500	500	500	
Reinjection	0	0	0	495	495	495	495	495	495	495	
Permeate	0	0	0	350	350	350	350	350	350	350	
Madison				145	145	145	145	145	145	145	
Well field bleed				5	5	5	5	5	5	5	
Bleed rate (%)				1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
Project Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10***	
INYAN KARA	Consumptive Usage										
Production	0	35	35	35	35	35	35	35	35	0	147
Aquifer Restoration	0	0	0	5	5	5	5	5	5	5	16
Total	0	35	35	40	40	40	40	40	40	5	163
MADISON	Consumptive Usage										
CPP water supply	0	12	12	12	12	12	12	12	12	0	50
Aquifer restoration	0	0	0	145	145	145	145	145	145	145	476
Total	0	12	12	157	157	157	157	157	157	145	526

* Aquifer restoration is only expected to last through the 1st quarter of year 10. Refer to Figure 6.1-1

**Aquifer restoration water usage estimates are conservatively high, since they are based on the peak design restoration flow rate for the entire duration of restoration. The actual water usage amount based on the required number of pore volumes to complete restoration is much lower, as shown in Appendix 6.1-A.

Table 2.7-18a: Net Water Usage, Deep Disposal Well Option (with Groundwater Sweep)

	Net Water Usage at Nominal Bleed Rate (Deep Disposal Well Option)										Cumulative
INYAN KARA	**With Groundwater Sweep**										**Water Usage**
Project Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10***	**(million gallons)**
Production											
Extraction composite	0	4000	4000	4000	4000	4000	4000	4000	4000	0	
Reinjection	0	3965	3965	3965	3965	3965	3965	3965	3965	0	
Well field bleed	0	35	35	35	35	35	35	35	35	0	
Bleed rate		0.875%	0.875%	0.875%	0.875%	0.875%	0.875%	0.875%	0.875%		
Aquifer Restoration**											
Extraction composite	0	0	0	500	500	500	500	500	500	500	
Reinjection	0	0	0	415	415	415	415	415	415	415	
Permeate	0	0	0	350	350	350	350	350	350	350	
Madison				65	65	65	65	65	65	65	
Well field bleed				85	85	85	85	85	85	85	
Bleed rate (%)				17.0%	17.0%	17.0%	17.0%	17.0%	17.0%	17.0%	
Project Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10***	
INYAN KARA	Consumptive Usage										
Production	0	35	35	35	35	35	35	35	35	0	147
Aquifer Restoration	0	0	0	85	85	85	85	85	85	85	279
Total	0	35	35	120	120	120	120	120	120	85	426
MADISON	Consumptive Usage										
CPP water supply	0	12	12	12	12	12	12	12	12	0	50
Aquifer restoration	0	0	0	65	65	65	65	65	65	65	214
Total	0	12	12	77	77	77	77	77	77	65	264

* Aquifer restoration is only expected to last through the 1st quarter of year 10. Refer to Figure 6.1-1
**Aquifer restoration water usage estimates are conservatively high, since they are based on the peak design restoration flow rate for the entire duration of restoration. The actual water usage amount based on the required number of pore volumes to complete restoration is much lower, as shown in Appendix 6.1-A.

Table 2.7-19: Net Water Usage, Land Application Option (without Groundwater Sweep)

	Net Water Usage at Nominal Bleed Rate (Land Application Option)										Cumulative Water Usage (million gallons)
INYAN KARA	**Without Groundwater Sweep**										
Project Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10***	
Production											
Extraction composite	0	4000	4000	4000	4000	4000	4000	4000	4000	0	
Reinjection	0	3965	3965	3965	3965	3965	3965	3965	3965	0	
Well field bleed	0	35	35	35	35	35	35	35	35	0	
Bleed rate		0.875%	0.875%	0.875%	0.875%	0.875%	0.875%	0.875%	0.875%		
Aquifer Restoration**											
Extraction composite	0	0	0	500	500	500	500	500	500	500	
Reinjection	0	0	0	495	495	495	495	495	495	495	
Permeate	0	0	0	0	0	0	0	0	0	0	
Madison				495	495	495	495	495	495	495	
Well field bleed				5	5	5	5	5	5	5	
Bleed rate (%)				1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
Project Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10***	
INYAN KARA	Consumptive Usage										
Production	0	35	35	35	35	35	35	35	35	0	147
Aquifer Restoration	0	0	0	5	5	5	5	5	5	5	16
Total	0	35	35	40	40	40	40	40	40	5	163
MADISON	Consumptive Usage										
CPP water supply	0	12	12	12	12	12	12	12	12	0	50
Aquifer restoration	0	0	0	495	495	495	495	495	495	495	1626
Total	0	12	12	507	507	507	507	507	507	495	1676

* Aquifer restoration is only expected to last through the 1st quarter of year 10. Refer to Figure 6.1-1

**Aquifer restoration water usage estimates are conservatively high, since they are based on the peak design restoration flow rate for the entire duration of restoration. The actual water usage amount based on the required number of pore volumes to complete restoration is much lower, as shown in Appendix 6.1-A.

Table 2.7-19a: Net Water Usage, Land Application Option (with Groundwater Sweep)

	Net Water Usage at Nominal Bleed Rate (Land Application Option)										Cumulative
INYAN KARA	**With Groundwater Sweep**										**Water Usage**
Project Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10***	**(million gallons)**
<u>Production</u>											
Extraction composite	0	4000	4000	4000	4000	4000	4000	4000	4000	0	
Reinjection	0	3965	3965	3965	3965	3965	3965	3965	3965	0	
Well field bleed	0	35	35	35	35	35	35	35	35	0	
Bleed rate		0.875%	0.875%	0.875%	0.875%	0.875%	0.875%	0.875%	0.875%		
<u>Aquifer Restoration</u>											
Extraction composite	0	0	0	500	500	500	500	500	500	500	
Reinjection	0	0	0	415	415	415	415	415	415	415	
Permeate	0	0	0	0	0	0	0	0	0	0	
Madison				415	415	415	415	415	415	415	
Well field bleed				85	85	85	85	85	85	85	
Bleed rate (%)				17.0%	17.0%	17.0%	17.0%	17.0%	17.0%	17.0%	
Project Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10***	
INYAN KARA	Consumptive Usage										
Production	0	35	35	35	35	35	35	35	35	0	147
Aquifer Restoration	0	0	0	85	85	85	85	85	85	85	279
Total	0	35	35	120	120	120	120	120	120	85	426
MADISON	Consumptive Usage										
CPP water supply	0	12	12	12	12	12	12	12	12	0	50
Aquifer restoration	0	0	0	415	415	415	415	415	415	415	1363
Total	0	12	12	427	427	427	427	427	427	415	1413

* Aquifer restoration is only expected to last through the 1st quarter of year 10. Refer to Figure 6.1-1

**Aquifer restoration water usage estimates are conservatively high, since they are based on the peak design restoration flow rate for the entire duration of restoration. The actual water usage amount based on the required number of pore volumes to complete restoration is much lower, as shown in Appendix 6.1-A.

2.7.3 Site Baseline Water Quality

2.7.3.1 Surface Water

In compliance with NRC Regulatory Guide 4.14 (RG 4.14), NUREG-1569, and South Dakota mining rules ARSD 74:29, the perennial and ephemeral streams and impoundments in the PAA were sampled upstream and downstream of the proposed permit boundary. Tables 2.7-20 and 2.7-21, respectively, list stream and impoundment water quality sampling sites within and adjacent to the PAA. Plate 2.5-1 shows the locations of the pre-operational stream and impoundment sampling sites. Stream sampling locations BVC04, CHR05, and BEN01 are not within the scale of Plate 2.5-1. Refer to Figure 2.9-11 for these pre-operational sampling locations. Following is a summary of the pre-operational surface water quality sampling program.

<u>Stream Sampling</u>

Surface water sampling locations were chosen based on the NRC Regulatory Guide 4.14 (RG 4.14) sampling requirements and the South Dakota mining rules ARSD 74:29 which require background radiological data to be collected for surface waters "that could be affected by the proposed operations."

The following eight stream sampling sites were established on Beaver Creek, Pass Creek, the Cheyenne River, Bennett Canyon, and unnamed tributaries in support of the site characterization activities:

- Two sites on Beaver Creek (BVC01 and BVC04).
- Two on Pass Creek (PSC01 and PSC02).
- Two on the Cheyenne River (CHR01 and CHR05).
- One on smaller watershed in Bennett Canyon (BEN01).
- One on an unnamed tributary within the permit boundary (UNT01).

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 project area. Table 2.7-20 provides a baseline stream sampling summary. The table includes the eight stream monitoring sites and illustrates which sites were sampled during each monthly sampling event or provides a reason why a sample could not be collected.

Section 5.7.8.1 describes how the stream sampling sites were evaluated against guidance in Regulatory Guide 4.14 to establish an operational monitoring program. A total of 10 stream sampling sites including 6 new sites are proposed for operational monitoring. After license issuance but prior to ISR operations, Powertech (USA) proposes to sample each site, monthly (including the initial samples) for 12 consecutive months in accordance with Regulatory Guide 4.14 pre-operational monitoring recommendations.

Of the original eight stream sampling sites, four will be relocated (BVC01, BVC04, PSC01 and PSC04) prior to ISR operations as described in Section 5.7.8.1. Justification for continue use of UNT01 follows. UNT01 was established for the baseline surface water monitoring program to characterize surface waters downstream from proposed activities in the eastern portion of the project area. Due to steepness of the valley walls, the site could not be located at the proposed license boundary. Instead UNT01 was installed downstream at an accessible location, which was more conducive to passive sampler installation and operation. Powertech (USA) proposes that this site is justified since it is near the proposed license boundary and there are no major intervening tributaries between the proposed license boundary and UNT01.

Impoundment Sampling

Powertech (USA) sampled surface water impoundments within the project area, including stock dams and mine pits. Surface water impoundments were originally identified 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 regional baseline surface water monitoring program is provided in Table 2.7-21a. The table includes 40 impoundments. During the regional baseline monitoring program, 11 of the 40 impoundments were visited on a quarterly basis. Table 2.7-21 illustrates which of these impoundments were sampled during each quarterly sampling event or provides a reason why a sample could not be collected. Refer to Section 2.9.8 for additional information regarding the number of samples collected and constituents analyzed during baseline impoundment monitoring.

Table 2.7-20: 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
BVC01	Beaver Creek Downstream	Grab	**X**	**X**	**X**	**X**	**X**	**X**	**X**	1	**X**	**X**	**X**	**X**
BVC04	Beaver Creek Upstream	Grab	**X**	**X**	**X**	**X**	**X**	**X**	**X**	1	**X**	**X**	**X**	**X**
CHR01	Cheyenne River Upstream	Grab	**X**	2	**X**	**X**	**X**	1	3	3	**X**	**X**	**X**	**X**
CHR05	Cheyenne River Downstream	Grab	**X**	2	**X**	**X**	**X**	**X**	1	**X**	**X**	**X**	**X**	**X**
PSC01	Pass Creek Downstream	Passive Sampler	**X**	4	4	4	4	4	4	4	4	4	4	**X**
PSC02	Pass Creek Upstream	Passive Sampler	**X**	4	4	4	4	4	4	4	4	4	4	**X**
BEN01	Bennett Canyon	Passive Sampler	3	4	4	4	4	4	4	4	4	4	4	4
UNT01	Unnamed Tributary	Passive Sampler	3	4	4	4	4	4	4	4	4	4	4	**X**

Notes:

X – sample collected
1-3 – no sample collected due to:
1 – Ice
2 – August 2007 sample collected September 5, 2007
3 – Dry
4 – Passive sampler did not indicate precipitation event

Table 2.7-21: 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

* 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

As described in Section 5.7.8, 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 5.7.8-1 and typically is due to the impoundment not being located downgradient of proposed facilities.

2.7.3.1.1 Sample Collection and Analysis Methods

A surface water quality sample constituent list was developed based on NUREG-1569 groundwater parameters (minus radon), Regulatory Guide 4.14 parameters, and added parameters from a constituent-list review with South Dakota DENR. NUREG-1569 gives no specific requirements for sampling constituents of surface water bodies. Table 2.7-22 lists constituents analyzed for in surface water samples and the analytical method for each constituent.

The following methodology was applied to collection of surface water samples:

- Field methods for sampling surface waters followed South Dakota Department of Environment and Natural Resources *Standard Operating Procedures for Field Samplers, Volume I* (SDDENR, 2003).
    - Field methods included measuring and recording field water-quality parameters dissolved oxygen, turbidity, pH, specific conductivity, and temperature with a water-quality probe.

- Sample bottles and preservative were supplied by EPA-certified Energy Laboratories in Rapid City and rinsed three times with sample water before sample collection and labeled with site ID, date, and time. Bacteriological sample bottles were not rinsed prior to filling.

- Samples were field-preserved (where required) and immediately placed on ice then 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 project boundary, the Cheyenne River was also sampled monthly upstream and downstream of confluences with streams passing through the permit boundary.

* Due to the unexpected and sudden nature of tributaries and remote locations, 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 Unnamed Tributary (UNT01).

Table 2.7-22: Surface Water and Groundwater Quality Parameter List

Constituent	Units	Analytical Method
Field Parameters		
Field Conductivity	umhos/cm	Field
Field Dissolved Oxygen	mg/L	Field
Field pH	s.u.	Field
Field Temperature	°C	Field
Field Turbidity	NTUs	Field
Water Level Elevation[1]	ft AMSL	Field
Microbiological		
Bacteria, Fecal Coliform[2]	CFU/100 mL	A9222 D
Physical Properties		
Conductivity @ 25 °C	umhos/cm	A2510 B
Oxidation-Reduction Potential[1]	mV	A2580 B
pH, Laboratory	s.u.	A4500-H B
Sodium Adsorption Ratio (SAR)	unitless	Calculated
Solids, Suspended Sediment SSC @ 105 °C[2]	mg/L	D3977
Solids, Total Dissolved TDS @ 180 °C	mg/L	A2540 C
Solids, Total Suspended TSS @ 105 °C[2]	mg/L	A2540 D
Common Elements and Ions		
Alkalinity, Total as $CaCO_3$	mg/L	A2320 B
Bicarbonate as HCO_3	mg/L	A2320 B
Calcium	mg/L	E200.7
Carbonate as CO_3	mg/L	A2320 B
Chloride	mg/L	E300.0
Fluoride	mg/L	E300.0
Magnesium	mg/L	E200.7/E200.8
Nitrogen, Ammonia as N	mg/L	A4500-NH3 G
Nitrogen, Nitrate as N	mg/L	E300.0/E353.2
Nitrogen, Nitrite as N[1]	mg/L	E300.0/E353.2
Potassium	mg/L	E200.7
Silica	mg/L	E200.7/E200.8
Sodium	mg/L	E200.7
Sulfate	mg/L	E300.0
Metals, Dissolved and Total		
Aluminum (sw - dissolved and total, gw - dissolved only)	mg/L	E200.7/E200.8
Antimony (total only)[1]	mg/L	E200.8
Arsenic	mg/L	E200.8
Barium	mg/L	E200.7/E200.8
Beryllium (total only)[1]	mg/L	E200.7/E200.8
Boron	mg/L	E200.7
Cadmium	mg/L	E200.8
Chromium	mg/L	E200.8
Chromium, hexavalent (total only)[2]	mg/L	A3500-Cr B
Chromium, trivalent (total only)[2]	mg/L	Calculated
Copper	mg/L	E200.8
Iron	mg/L	E200.7
Lead	mg/L	E200.8
Manganese	mg/L	E200.7/E200.8
Mercury	mg/L	E200.8/E245.1
Molybdenum	mg/L	E200.8

Table 2.7-22: Surface Water and Groundwater Quality Parameter List

Constituent	Units	Analytical Method
Metals, Dissolved and Total		
Nickel	mg/L	E200.8
Selenium	mg/L	A3114 B
Selenium-IV (sw - dissolved and total, gw - dissolved only)	mg/L	A3114 B
Selenium-VI (sw - dissolved and total, gw - dissolved only)	mg/L	A3114 B
Silver	mg/L	E200.8
Strontium (total only)[1]	mg/L	E200.7/E200.8
Thallium (total only)[1]	mg/L	E200.8
Thorium 232 (sw - dissolved and total, gw - dissolved only)	mg/L	E200.8
Uranium	mg/L	E200.8
Vanadium (sw - dissolved and total, gw - dissolved only)	mg/L	E200.7/E200.8
Zinc	mg/L	E200.7/E200.8
Metals, Suspended		
Thorium 232[2]	mg/L	E200.8
Uranium	mg/L	E200.8
Radionuclides, Dissolved, Suspended, and Total		
Gross Alpha (sw - total only, gw - dissolved only)	pCi/L	E900.0
Gross Beta (sw - total only, gw - dissolved only)	pCi/L	E900.0
Gross Gamma (sw - total only, gw - dissolved only)	pCi/L	E901.1
Lead 210	pCi/L	E909.0M
Polonium 210	pCi/L	RMO-3008/E912.0
Radium 226	pCi/L	E903.0
Radon 222 (total only)[1]	pCi/L	D5072-92
Thorium 230	pCi/L	E907.0
Data Quality Parameters		
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

[1] Analyzed in groundwater samples only
[2] Analyzed in surface water samples only
gw - groundwater
sw - surface water

2.7.3.1.2 Results

Tables 2.7-23, 2.7-24, 2.7-25, and 2.7-26 give results and statistical summaries for field water quality parameters collected at the Beaver Creek and Cheyenne River sites. 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 field parameters shows some exceedances of South Dakota state standards at Beaver Creek while other parameters fall into compliance range. pH was higher than 8.8 in 14 percent (3 of 21) measurements, but was not found to be lower than the 6.5 standard for coldwater marginal fish life. Dissolved oxygen measurements were in full compliance, with an average value of 10.8 mg/L (n=21) and a minimum of 6.54 mg/L. Nineteen percent (4 of 21) of temperature measurements were greater than the 75°F standard for coldwater marginal fish life, with a maximum measured temperature of 82.5°F. Krantz (2006) modeled temperatures in Beaver Creek and reports from a temperature-sensitivity analysis that air temperature is the primary controlling factor for stream temperatures in Beaver Creek. Specific conductivity values exceeded the fish, wildlife, and stock daily-maximum standard of 7,000 umhos/cm in 14 percent

(3 of 21) of measurements and exceeded the irrigation daily-maximum standard of 4,375 umhos/cm in 48 percent (10 of 21) of measurements.

Analysis of Cheyenne River field parameters also showed some exceedances of state standards. Specific conductivity values exceeded the fish, wildlife, and stock daily-maximum standard of 7,000 umhos/cm in 5 percent (1 of 20) of measurements and exceeded the irrigation daily-maximum standard of 4,375 umhos/cm in 40 percent (8 of 20) of measurements. Dissolved oxygen values were below the state standard for warm-water semi-permanent fish life of 5 mg/L in 6 percent (1 of 18) of samples. Water temperature measurements (n=20) and pH measurements (n=20) were all found to be in compliance.

Table 2.7-23: Field Data and Statistics for BVC01

BVC01					
Date	**Temp, F**	**pH**	**Dissolved Oxygen, mg/L**	**Specific Conductivity, uS/cm**	**Turbidity, NTU**
8/20/2007	81.6	8.91	12.29	1777	21.0
9/26/2007	62.1	8.87	10.95	1339	1.7
10/17/2007	53.9	8.58	11.13	5726	2.5
11/19/2007	38.4	8.20	12.20	7678	6.4
12/11/2007	31.9	7.94	11.21	4134	6.4
1/11/2008	31.9	7.67	10.07	2812	8.6
3/9/2008	32.3	8.24	13.57	1718	308
4/14/2008	60.9	8.15	9.20	5109	11.8
5/26/2008	55.1	7.95	6.86	860	1790
6/17/2008	74.9	8.13	10.39	5650	53
N	10	10	10	10	10
Mean	52.3	26	10.79	3680	221
Median	54.5	175	11.04	3473	10.2
Std Dev	18.2	0.41	1.85	2308	559
Min	31.9	7.67	6.86	860	1.7
Max	81.6	8.91	13.57	7678	1790

Table 2.7-24: Field Data and Statistics for BVC04

BVC04					
Date	**Temp, F**	**pH**	**Dissolved Oxygen, mg/L**	**Specific Conductivity, uS/cm**	**Turbidity, NTU**
8/20/2007	81.0	8.82	12.31	1450	79.5
9/28/2007	51.4	7.60	6.85	4712	
10/17/2007	50.1	8.46	10.45	7157	12.6
11/19/2007	41.2	8.18	12.39	5416	9.3
12/11/2007	31.9	7.86	11.01	4055	2.9
1/11/2008	31.8	7.74	11.37	3022	16.8
3/9/2008	31.9	8.12	13.74	2015	226
4/14/2008	62.5	8.27	12.21	7186	14.3
5/26/2008	55.5	8.09	6.54	733	1730
6/17/2008	77.3	7.52	9.55	4915	33.8
7/8/2008	82.5	8.38	12.80	6217	
N	11	11	11	11	9
Mean	54.3	8.09	10.84	4262	236
Median	51.4	8.12	11.37	4712	16.8
Std Dev	19.5	0.39	2.35	2229	565
Min	31.8	7.52	6.54	733	2.9
Max	82.5	8.82	13.74	7186	1730

Table 2.7-25: Field Data and Statistics for CHR01

CHR01					
Date	**Temp, F**	**pH**	**Dissolved Oxygen, mg/L**	**Specific Conductivity, uS/cm**	**Turbidity, NTU**
9/5/2007	79.4	8.44	13.08	4085	19.0
9/26/2007	60.8	8.02	10.48	3895	1.0
10/17/2007	55.6	8.02	5.17	6929	9.9
11/19/2007	42.2	7.47	3.74	7847	5.8
3/9/2008	45.1	8.11	12.84	3990	7.4
4/16/2008	58.9	8.32	8.13	6180	1.5
5/26/2008	56.0	8.17	7.77	350	1798
6/17/2008	80.6	8.27	7.85	2897	73.4
N	8	8	8	8	8
Mean	59.8	8.10	8.63	4522	240
Median	57.5	8.14	7.99	4038	8.7
Std Dev	14.0	0.29	3.35	2406	630
Min	42.2	7.47	3.74	350	1.0
Max	80.6	8.44	13.08	7847	1798

Table 2.7-26: Field Data and Statistics for CHR05

CHR05					
Date	**Temp, F**	**pH**	**Dissolved Oxygen, mg/L**	**Specific Conductivity, uS/cm**	**Turbidity, NTU**
9/5/2007	78.1	8.16	12.20	4570	1.0
9/26/2007	65.9	8.01		4002	2.0
10/17/2007	58.0	8.12	10.08	6986	8.3
11/19/2007	43.2	8.16	11.03	6384	13.3
12/11/2007	31.9	7.95	11.14	3888	3.8
1/11/2008	31.8	7.65	9.22	3058	2.0
2/12/2008	32.4	7.42		3353	12.3
3/9/2008	32.0	8.24	12.92	1118	177
4/14/2008	53.8	8.10	9.92	4905	12.5
4/15/2008	59.7	8.15	8.85	4970	36.0
5/26/2008	55.9	8.19	7.69	510	1790
6/17/2008	74.1	8.24	7.63	3721	59.3
N	12	12	10	12	12
Mean	51.4	8.03	10.07	3955	176
Median	54.9	8.14	10.00	3945	12.4
Std Dev	16.9	0.25	1.78	1872	511
Min	31.8	7.42	7.63	510	1.0
Max	78.1	8.24	12.92	6986	1790

Surface water quality summary tables for each sampling location are provided in Appendix 2.7-C. Consistent with Section 2.7.4 of NUREG-1569, surface water analytical data are presented in tables on a date-by-date, parameter-by-parameter, and surface water location-by-surface water location basis. The following describes the presentation of data in Appendix 2.7-C.

All field-measured parameters are presented with the corresponding laboratory data. Footnotes on each surface water quality table indicate the sampling frequency and reasons why samples were not collected during a scheduled sample event (frozen, dry, etc.). For concentrations reported as non-detect by the laboratory, the data are reported as "< RL" where RL is the laboratory reporting limit. In cases where the laboratory reported a numerical value less than the RL, the numerical results are provided along with the value of the RL, with a footnote explaining the reporting convention. 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.

Appendix 2.7-D provides the minimum and maximum result for all sampled constituents detected at or above the PQL, the sampled site and the date of sampling. Appendix 2.7-E provides a comparison between water quality constituents in impoundments and streams that

were detected at or above the PQL. Constituents in italics are those in which the absolute difference in percent detections between streams and impoundment was 30 percent or greater. Fecal coliform, alkalinity, bicarbonate, and dissolved and total boron were detected primarily in streams, while ammonia, dissolved aluminum, dissolved iron, dissolved nickel, dissolved and total zinc, and dissolved and total radium 226 were primarily detected in subimpoundments.

Analytical results are provided in Appendix 2.7-F. Duplicate sample results are not included in Appendix 2.7-F. Table 2.7-27 summarizes the results of baseline stream sampling on Beaver Creek, Pass Creek and the Cheyenne River.

2.7.3.2 Groundwater Quality

This section provides details on the monitoring network, methods, and results for the baseline groundwater quality sampling plan.

Table 2.7-27: 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 2.7-27: 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 2.7-27: 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

2.7.3.2.1 Groundwater Monitoring Network and Parameters

Baseline groundwater sampling was conducted in general accordance with NRC Regulatory Guide 4.14 (NRC, 1980) as appropriate to ISL operations. Because of the significant number of groundwater wells, their geochemical similarities, and an abundance of historical water quality data, a representative subset of the wells was selected for sampling. The wells were selected based on type of use, aquifer, and location in relation to the ore bodies. For the baseline study for the NRC permit, 19 groundwater wells (14 existing and five 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 2.7-30, Table 2.7-28). The existing wells selected for sampling include eight domestic wells, six stock watering wells, and five monitor wells. The subset includes wells within the Fall River Formation (6), Chilson Member of the Lakota Formation (7), Inyan Kara Group (Fall River and Chilson) (1), and alluvium (5). Initial baseline sampling of these wells was conducted quarterly from the 3rd quarter 2007 through the 2nd quarter 2008.

As required by the SD DENR (rule ARSD 74:29), an additional 14 wells were sampled monthly beginning in early 2008 and continuing through early 2009 (Figure 2.7-31, Table 2.7-29). Of these 14 wells, six wells are in the Dewey area, six wells are near Burdock, and two wells are north of the project area. The goal of the monthly sampling program was to select wells, upgradient, within, and downgradient of the proposed operations. In addition to the baseline sampling plan, one water quality sample was collected from each of the monitor wells used during the May 2008 aquifer pump tests (Wells 49, 682, 684-687 and 690-693 in Table 2.7-30). One sample also was collected from two new Unkpapa domestic wells (703 and 704 in Table 2.7-30). One sample also was collected from well 704 after it was completed in the Chilson.

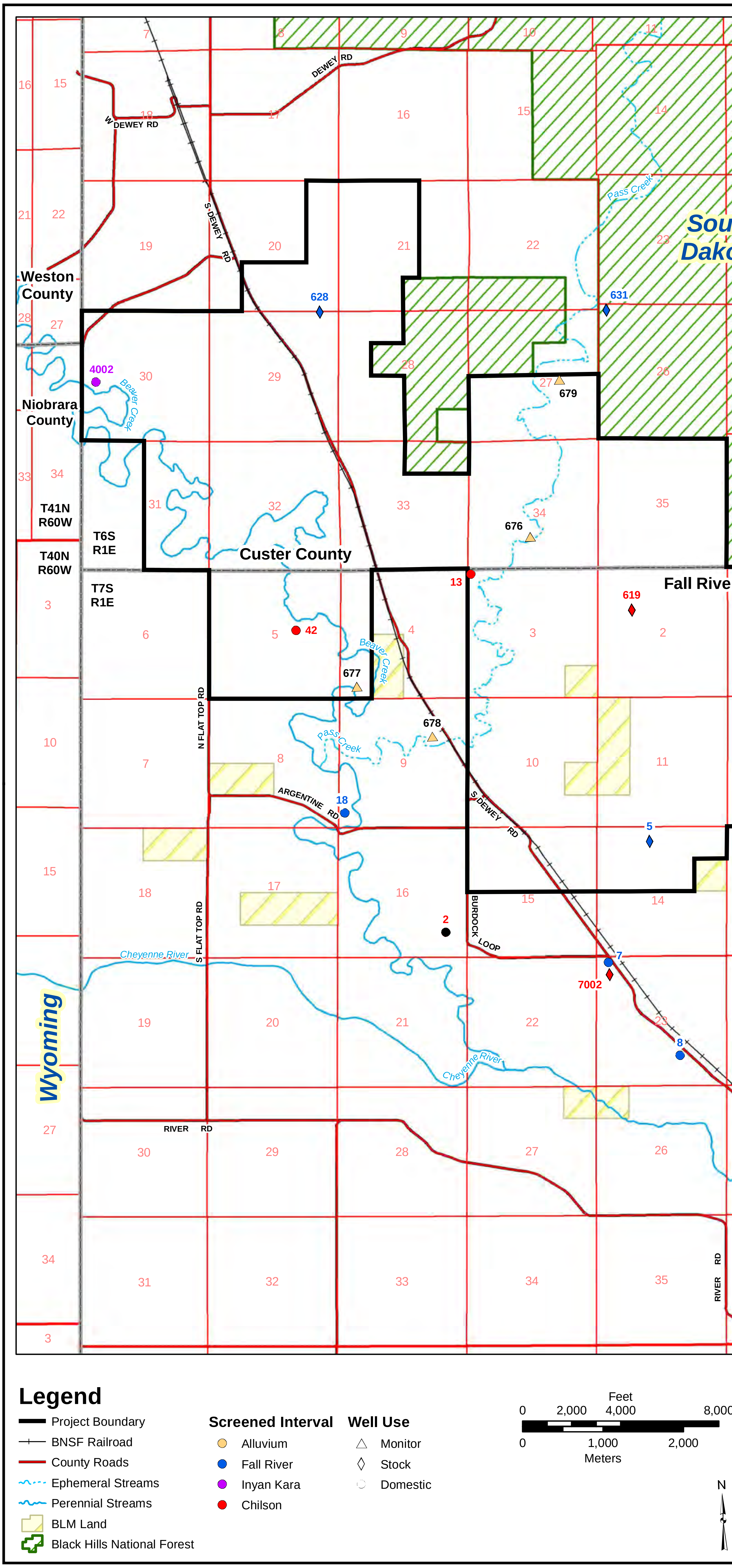


Figure 2.7-30

Baseline Water Quality
Quarterly Sampled Wells

Dewey-Burdock Project

DRAWN BY	R. Blubaugh
DATE	17-Jun-2013
FILENAME	Wells-BLQtrGndH2OQlty.mxd

POWERTECH (USA) INC.

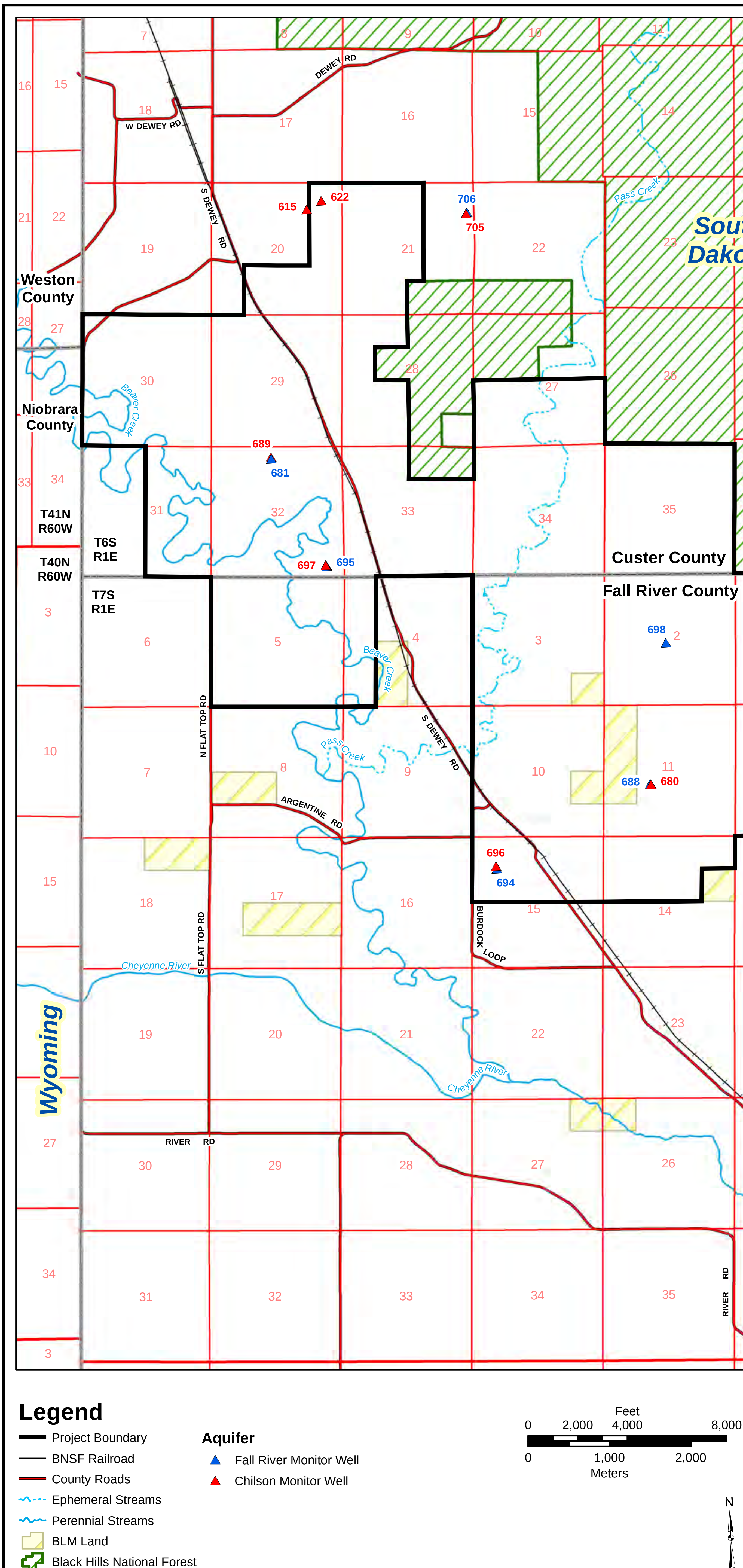


Figure 2.7-31

Baseline Water Quality Monthly Sampled Wells

Dewey-Burdock Project

DRAWN BY R. Blubaugh

DATE 17-Jun-2013

FILENAME Wells-BLQtrGrndH2OMthly.mxd

POWERTECH (USA) INC.

Table 2.7-28: 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
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.

Table 2.7-29: 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.

Table 2.7-30: Additional Well Data

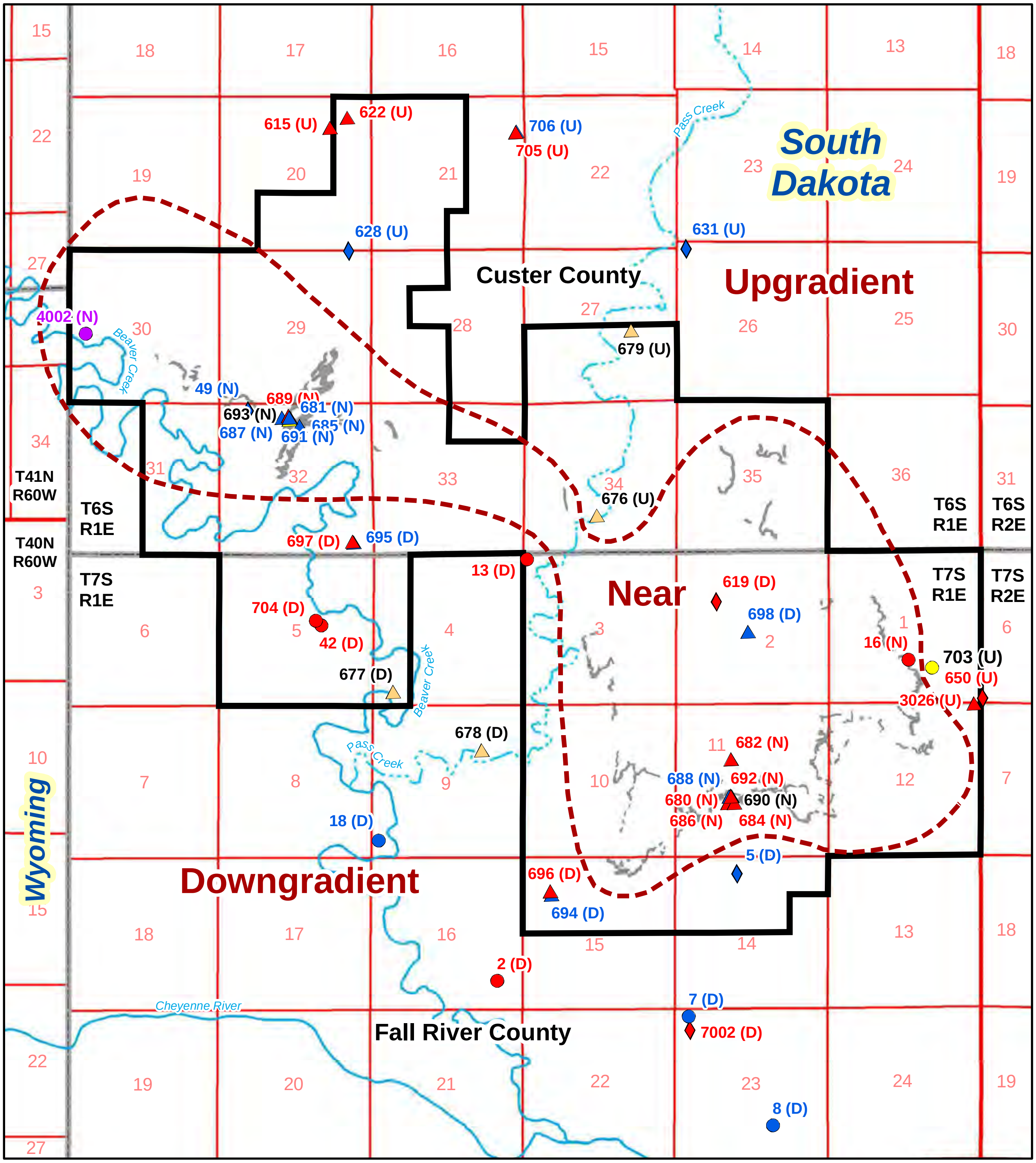
Hydro ID	Twn (N)	Rng (E)	Sec	Qtr Qtr	Easting[1]	Northing[1]	Screened Location	Well Use
49	6	1	32	NWNW	1018932	444022	Fall River	Stock
682	7	1	11	SENW	1035139	431257	Chilson	Monitor
684	7	1	11	NESW	1035191	429744	Chilson	Monitor
685	6	1	32	NWNE	1020690	443409	Fall River	Monitor
686	7	1	11	NESW	1034970	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.

Figure 2.7-32 shows the wells that are upgradient, near and downgradient of the proposed production areas at the site. Results of these samples were included in the statistical analyses.

Groundwater samples were analyzed for constituents listed in Table 2.7-22, which was developed based on NUREG-1569 groundwater parameters, Regulatory Guide 4.14 parameters, and added parameters from a constituent list review with DENR.

The procedures for measuring the static water level and calculating the water level elevation, or potentiometric surface elevation, in monitor wells are summarized below for non-flowing and flowing wells.



Legend

- Project Boundary
- Ephemeral Streams
- Perennial Streams
- Ore Bodies

Well Use
- △ Monitor
- ◊ Stock
- ○ Domestic

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 2.7-32

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

DRAWN BY	J. Mays
DATE	17-Jun-2013
FILENAME	Wells-UpDownGrad.mxd

POWERTECH (USA) INC.

Non-Flowing Wells

The following procedures apply to wells where the static water level is below the top of the casing (non-flowing wells):

- Measure the depth to water in the well using either an electric water level tape or a chalked tape. All measurements are made from a fixed reference point, either notched or clearly marked on the top of the casing. This reference point is surveyed so the elevation is known to the nearest 0.01 ft. For each well this reference point is the measuring point elevation (MPE). The depth to water is measured to the nearest one hundredth (0.01) of a foot.

- Record the measured depth to water in the log book, indicating the date and time that the measurement was taken.

- Note any field observations regarding the condition of the well, well casing, any leakage around the casing, noticeable odor, water color, etc. in field log book.

- Subtract the depth to water from the MPE to get the water surface elevation (potentiometric surface elevation) for that well on that date.

Flowing Artesian Wells

The following procedures are followed for wells in which the static water level is above the top of the casing (flowing wells):

- Install pressure gauge at the well head.
- Allow well to flow freely at surface to bleed off any air that may be trapped in the casing.
- Shut in well by closing all valves at the well head and check for leaks. Allow the pressure at the well head to stabilize.
- Measure and record the vertical distance between the surveyed reference point elevation (MPE) for each well and the center of the pressure gauge.
- Observe and record any field observations regarding condition of well head, well casing, piping and valves, leakage from the piping or around the casing, color of the water, odor, or inability to attain a constant pressure reading in the shut-in well.
- Read pressure gauge to nearest 0.01 pounds per square inch (psi) or 0.01 foot; record reading in field log book, noting date and time the measurement was taken.
- Convert pressure gauge reading to feet of water if necessary (psi x 2.307 = ft of water). This is the height of the potentiometric surface above the elevation of the pressure gauge.
- Add (or subtract) the difference in elevation between the MPE and the pressure gauge to get the elevation of the pressure gauge.
- Add the pressure reading in feet to the elevation of the pressure gauge to get the potentiometric surface elevation for that well on that date.

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.

2.7.3.2.2 Groundwater Quality Sampling Results

Water quality summary tables providing groundwater quality results for all aquifers are provided in Appendix 2.7-G, and analytical data are provided in Appendix 2.7-H. Appendix 2.7-N gives statistics for all groundwater constituents detected at or above PQL by constituent. Appendix 2.7-O gives the minimum and maximum value for all sampled constituents detected at or above the PQL, and the site ID and date of the sample that had minimum and maximum detection value.

Consistent with NRC guidance in Section 2.7.4 of NUREG-1569, groundwater analytical data are presented in tables on a date-by-date, parameter-by-parameter, and well-by-well basis, including the eight wells sampled during the 2008 pumping tests (Well IDs 49, 682, 684, 685, 686, 687, 691, and 692). An additional well, 683, was not sampled during the 2008 pump tests as originally planned. The following describes the presentation of data in Appendix 2.7-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 2.7-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 2.7-31 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 2.7-32 compares baseline groundwater quality to parameters with EPA MCLs and other standards.

Table 2.7-31: 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 2.7-31: 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 -	<0.0003 - 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 -	<0.001
Selenium-VI	mg/L	<0.001 - 0.012	<0.001 - 0.0007	<0.001 -	<0.001
Metals – Suspended					
Uranium	mg/L	0.001 - 0.020	<0.0003 -	<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 -	<0.001
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 -	<0.001	<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 -	<0.001 - 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 -	<0.001
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 2.7-31: 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 2.7-32: Groundwater Quality Comparison with EPA MCLs and Other Public Water Supply Standards

Test Analyte/Parameter	Units	MCL[a] or Other Standard	Number of Samples Analyzed*	Number of Detections	Number of Detections Equal to or Above Referenced Standard
Bulk Properties					
pH	standard units	<6.5; >8.5[b]	271	271	0; 8
TDS	mg/l	500[b]	271	271	271
Cations/Anions					
Sodium, Na	mg/l	20[c]; <30[d]; >60[d]	271	271	271 ; 0 ; 267
Chloride, Cl	mg/l	250[b]	271	271	4
Fluoride, F	mg/l	4; 2[b]	271	266	0; 0
Sulfate, SO4	mg/l	250[b]	271	271	271
Nitrate (as Nitrogen)	mg/l	10	271	30	0
Nitrite (as Nitrogen)	mg/l	1	271	1	0
Nitrate and Nitrite (Combined)	mg/l	10	271	158	0
Trace Metals (Total)					
Antimony, Sb	mg/l	0.006	228	1	0
Arsenic, As	mg/l	0[e]; 0.010	228	191	191; 28
Barium, Ba	mg/l	2	228	6	0
Beryllium, Be	mg/l	0.004	228	3	0
Boron, B	mg/l	6[f]	228	54	0
Cadmium, Cd	mg/l	0.005	228	0	0
Chromium, Cr (total)	mg/l	0.1	228	2	1
Copper, Cu	mg/l	1.0[b]; 1.3[g]	228	6	0; 0
Iron, Fe	mg/l	0.3[b]; 5[h]	228	217	114; 28
Mercury, Hg	mg/l	0.002	280	2	0
Manganese, Mn	mg/l	0.05[b]; 0.8[h]	228	227	215; 38
Molybdenum, Mo	mg/l	0.04[f]	228	7	2
Nickel, Ni	mg/l	0.1[f]	228	1	1
Lead, Pb	mg/l	0[e]; 0.015[g]	228	27	27; 8
Selenium, Se	mg/l	0.05	228	42	0
Silver, Ag	mg/l	0.10[b]	228	0	0
Strontium, Sr	mg/l	4[f]	228	227	64
Thallium, Tl	mg/l	0.0005[e]; 0.002	228	1	1; 1
Uranium, U	mg/l	0[e]; 0.030	232	171	171; 28
Zinc, Zn	mg/l	5[b]; 2[f]	228	57	0; 0
Trace Metals (Dissolved)					
Aluminum, Al	mg/l	<0.05[b]; >0.2[b]	271	1	0; 0
Arsenic, As	mg/l	0[e]; 0.010	271	146	146; 18
Barium, Ba	mg/l	2	271	0	0
Boron, B	mg/l	6[f]	271	70	0
Cadmium, Cd	mg/l	0.005	271	0	0
Chromium, Cr (total)	mg/l	0.1	271	0	0

Table 2.7-32: Groundwater Quality Comparison with EPA MCLs and Other Public Water Supply Standards (Continued)

Test Analyte/Parameter	Units	MCL[a] or Other Standard	Number of Samples Analyzed*	Number of Detections	Number of Detections Equal to or Above Referenced Standard
Trace Metals (Dissolved) (Continued)					
Copper, Cu	mg/l	1.0[b]; 1.3[g]	271	2	0; 0
Iron, Fe	mg/l	0.3[b]; 5[h]	271	103	44; 6
Mercury, Hg	mg/l	0.002	271	0	0
Manganese, Mn	mg/l	0.05[b]; 0.8[h]	271	266	234; 48
Molybdenum, Mo	mg/l	0.04[f]	271	2	2
Nickel, Ni	mg/l	0.1[f]	271	0	0
Lead, Pb	mg/l	0[e]; 0.015[g]	271	6	6; 0
Selenium, Se	mg/l	0.05	271	26	0
Silver, Ag	mg/l	0.10[b]	271	0	0
Uranium, U	mg/l	0[e]; 0.030	271	199	199; 37
Zinc, Zn	mg/l	5[b]; 2[f]	271	46	0; 0
Radionuclides					
Alpha Particles (Dissolved)	pCi/L	0[e]; 15	271	271	191; 191
Beta Particles and Photons (Dissolved)	mRem/yr	0[e]; 4	271	267	(i)
Radium-226 and 228 (Combined, Dissolved)	pCi/L	0[e]; 5	265	249	249; 101
Radon-222 (Total)	pCi/L	0[e]; 300[j]	251	251	249; 194

Notes:

(a) MCL - 40 CFR 141, National Primary Drinking Water Regulations, maximum contaminant level, enforceable.

(b) 40 CFR 141, National Secondary Drinking Water Regulations, non-enforceable standard, water exceeding standard may cause cosmetic and/or aesthetic effects.

(c) Drinking water advisory, non-enforceable, for persons on restricted sodium diets, from "2009 Edition of the Drinking Water Standards and Health Advisories," EPA 822-R-09-011, p. 12, U.S. Environmental Protection Agency, Washington, D.C., Fall 2009.

(d) Drinking water advisory, non-enforceable, taste threshold, from EPA 822-R-09-011, p. 12.

(e) 40 CFR 141, National Primary Drinking Water Regulations, maximum contaminant level goal, non-enforceable.

(f) Health advisory lifetime standard, non-enforceable, from EPA 822-R-09-011, pp. 8-9.

(g) 40 CFR 141, National Primary Drinking Water Regulations, action level, which, if exceeded, triggers treatment.

(h) Permit limit calculated by US EPA Region 8 drinking water toxicologist based on human-health criteria for Region 8 Underground Injection Control Class V permitting program (http://www.epa.gov/region8/water/uic/r8cvprog.html).

(i) Not compared; gross beta reported in pCi/L.

(j) Proposed maximum contaminant level.

* Number of samples includes quarterly samples from 19 wells (wells 2, 5, 7, 8, 13, 16, 18, 42, 619, 628, 631, 650, 675, 676, 677, 678, 679, 4002, 7002) collected between the third quarter of 2007 and the second quarter of 2008, one year of monthly samples from 12 wells (615, 622, 680, 681, 688, 689, 694, 695, 696, 697, 698, 3026) collected between early 2008 and early 2009, less one missed sample in March 2008 from 695, one year of monthly samples from 2 wells (705 and 706) collected between January and December 2010, 21 duplicate samples, and 7 mid-month samples (2 from 680, 3 from 681, and 1 from 688 and 689 each).

2.7.3.2.2.1 Alluvial Water Quality

As shown in Table 2.7-31, 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 2.7-33 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 EPA MCLs and one secondary standard (sulfate) (Table 2.7-34) shows that 100% of the wells yielded one or more samples with concentrations of gross alpha and sulfate above the standards. 80% of the wells also exceeded the uranium standard in one or more sample. With 100% of alluvial wells exceeding the gross alpha standard, radionuclide concentrations were relatively high in the alluvial wells compared to the MCL. 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.

2.7.3.2.2.2 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 2.7-35 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 EPA MCLs and one secondary standard (sulfate) (Table 2.7-34) shows that 100% of the wells yielded one or more samples with concentrations of sulfate above the standard. Additional standards exceeded in one or more samples included gross alpha (83% of wells), radium-226 (67% of wells), and uranium (8% of wells).

Table 2.7-33: 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 2.7-34: Groundwater Quality Comparison with Federal Drinking Water Standards

Parameter	Arsenic, Dissolved	Gross Alpha, Dissolved	Radium-226, Dissolved	Uranium, Dissolved	Sulfate
MCL	0.010 mg/L	15 pCi/L	5 pCi/L*	0.030 mg/L	250 mg/L**
Alluvial Wells					
Hydro ID					
675	---	X	---	X	X
676	---	X	---	X	X
677	---	X	---	X	X
678	---	X	---	X	X
679	---	X	---	---	X
Percentage exceeding MCL in one or more samples:	0% (0/5)	100% (5/5)	0% (0/5)	80% (4/5)	100% (5/5)
Fall River Wells					
Hydro ID					
5	---	---	---	---	X
7	---	X	X	---	X
8	---	---	---	---	X
18	---	X	X	---	X
628	---	X	X	---	X
631	---	X	X	---	X
681	---	X	X	---	X
688	---	X	X	---	X
694	---	X	---	---	X
695	---	X	X	---	X
698	---	X	X	X	X
706	---	X	---	---	X
Percentage exceeding MCL in one or more samples:	0% (0/12)	83% (10/12)	67% (8/12)	8% (1/12)	100% (12/12)
Chilson Wells					
Hydro ID					
2	---	---	---	---	X
13	---	X	---	---	X
16	---	X	X	---	X
42	---	X	X	X	X
615	X	X	X	---	X
619	---	X	X	---	X
622	---	X	X	---	X
650	---	---	---	---	X
680	X	X	X	X	X
689	---	X	X	---	X
696	---	X	---	---	X
697	---	X	X	---	X

Table 2.7-34: Groundwater Quality Comparison with Federal Drinking Water Standards (Continued)

Parameter	Arsenic, Dissolved	Gross Alpha, Dissolved	Radium-226, Dissolved	Uranium, Dissolved	Sulfate
Chilson Wells					
Hydro ID					
705	---	---	---	---	**X**
3026	**X**	**X**	**X**	---	**X**
7002	---	**X**	**X**	---	X
Percentage exceeding MCL in one or more samples:	20% (3/15)	80% (12/15)	67% (10/15)	13% (2/15)	100% (15/15)
Unkpapa Wells					
Hydro ID					
690	---	---	---	---	**X**
693	---	---	---	---	**X**
703	---	**X**	---	---	**X**
704	---	---	---	---	**X**
Percentage exceeding MCL in one or more samples:	0% (0/4)	25% (1/4)	0% (0/4)	0% (0/4)	100% (4/4)

Notes: **X** denotes that one or more analyses exceed the MCL.

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

** Secondary drinking water standard.

Table 2.7-35: 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.

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.

2.7.3.2.2.3 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 2.7-36 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 EPA MCLs and one secondary standard (sulfate) (Table 2.7-34) shows that 100% of the wells yielded one or more samples with concentrations of sulfate above the standard. Additional standards exceeded in one or more samples included dissolved arsenic (20% of wells), gross alpha (80% of wells), radium-226 (67% of wells) and uranium (13% 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.

Table 2.7-36: 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.

2.7.3.2.2.4 Unkpapa Water Quality

Four Unkpapa wells have been sampled as part of the baseline monitoring program. Two of these wells (690 and 693) were installed and used as monitor wells for the Burdock (well 690) and Dewey (well 693) pumping tests. These wells were sampled once in 2008 during the pumping tests. The other two wells (703 and 704) were installed in 2008 to replace domestic wells near potential well field areas. The former domestic wells were replaced because they were completed in the Fall River or Chilson targeted for ISR operations. One water quality sample was collected from each of these wells during baseline monitoring.

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 2.7-37 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).

A comparison between the Unkpapa water quality and EPA MCLs and one secondary standard (sulfate) (Table 2.7-34) shows that 100% of the wells yielded one or more samples with concentrations of sulfate above the standard. An additional standard exceeded in one or more samples included gross alpha (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 the gross alpha standard in one or more samples, radionuclide concentrations in the Unkpapa were below MCLs.

Powertech (USA) proposes to sample Unkpapa wells 690, 693, and 703 four times (including the initial samples) prior to ISR operations for parameters listed in Table 6.1-1. 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. Prior to ISR operations, well 704 will be replaced in accordance with procedures described in Section 5.7.1.3.3. Additionally, Powertech (USA) will include Unkpapa wells 690, 693, and 703 in the operational groundwater monitoring program as described in the Section 5.7.8.2. Quarterly samples will be analyzed for all parameters in Table 6.1-1.

Table 2.7-37: 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.

2.7.3.2.3 Comparison of Historical and Recent Water Quality near the Project

An analysis was conducted to determine if the well chemistry data collected at the PAA by the Tennessee Valley Authority (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 2.7-33). 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 2.7-38 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 2.7-39 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 was reviewed to define the chemical constituents that were similar between the monitoring programs with a focus on bulk properties.
- The reported values of alkalinity, conductivity, pH, and total dissolved solids (TDS) were compared from nine wells that were sampled during both project periods.
- Statistics calculated included mean, minimum, and maximum.
- 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 2.7-40). Complete groundwater quality data results are available in Appendix 2.7-G (Powertech (USA) results) and Appendix 2.7-J (TVA results).

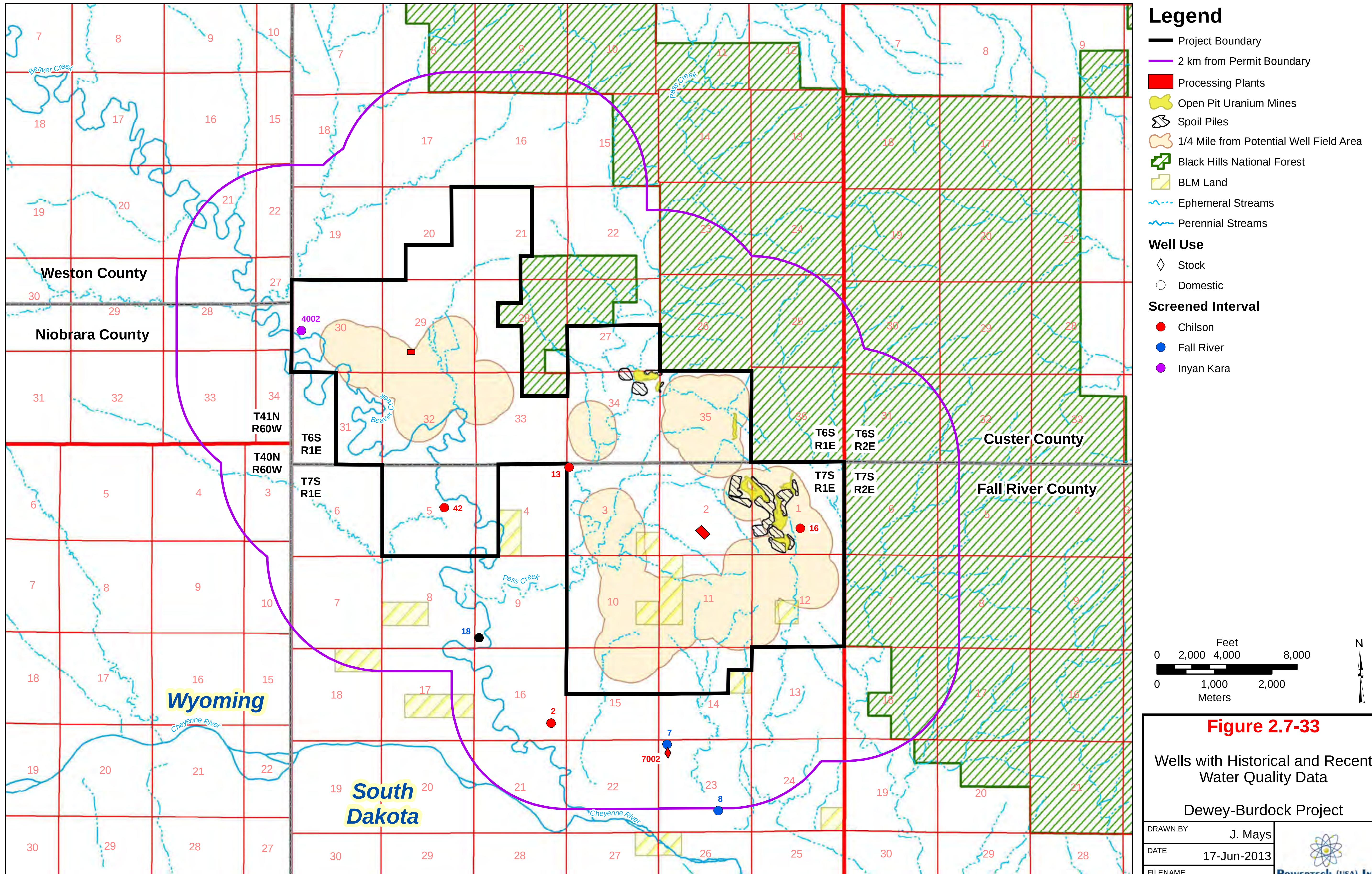


Figure 2.7-33

Wells with Historical and Recent Water Quality Data

Dewey-Burdock Project

DRAWN BY	J. Mays
DATE	17-Jun-2013
FILENAME	Wells-Paired.mxd

POWERTECH (USA) INC.

Table 2.7-38: 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 2.7-39: Parameters Analyzed During TVA Water Quality Monitoring

Test Analyte/Parameter	Units	Notes	Used in Historic/Recent Comparison
BULK PROPERTIES			
pH	pH Units	Field and Laboratory Program	**X**
Total Dissolved Solids (TDS)	mg/L		**X**
Total Suspended Solids (TSS)	mg/L		
Water Level	ft		
Conductivity	µmhos/cm	Field and Laboratory Program	**X**
Hardness			
CATIONS/ANIONS			
Calcium	mg/L		**X**
Alkalinity	mg/L		**X**
Bicarbonate (as HCO_3)	mg/L		**X**
Carbonate (as $CaCO_3$)	mg/L		**X**
Magnesium	mg/L		**X**
Potassium	mg/L		**X**
Sodium	mg/L		**X**
Sulfate	mg/L		**X**
Chloride	mg/L		**X**
Phosphate	mg/L		
Nitrogen	mg/L		
Cation/Anion Balance	%		

Table 2.7-39: Parameters Analyzed During TVA Water Quality Monitoring (cont'd)

Test Analyte/Parameter	Units	Notes	Used in Historic/Recent Comparison
TRACE METALS			
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	
Silcon-SiO_2	mg/L		
Uranium, U	mg/L	Total	
Vanadium, V	mg/L		
Zinc, Zn	mg/L	Dissolved	
RADIONUCLIDES			
Radium-226	pCi/L	Total	

Average alkalinity decreased slightly for all wells sampled except for No. 16 and No. 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 percent in the two data sets. A plot comparing average alkalinity between TVA and Powertech (USA) data is given in Figure 2.7-34.

Conductivity was overall slightly greater (5 percent) than in previous sampling years. It decreased slightly in No.16 and was essentially the same in No. 13 and No. 7002. Figure 2.7-35 is a plot of average conductivity compared between historic TVA and current Powertech (USA) data.

Values of pH were slightly higher in Powertech (USA) samples than in TVA samples, with the exception of wells No. 7 and No. 7002 (Figure 2.7-36). Mean pH values varied from 7.44 to 7.94 at wells with greater than five samples. The greatest difference in pH was at well No. 7, with mean pH of 8.5 for TVA data and mean pH of 8.11 for Powertech (USA) data.

The TDS values from the two different sampling periods were also very similar. Figure 2.7-37 gives a comparison between historic TVA and current Powertech (USA) mean TDS.

POWERTECH (USA) INC.

Table 2.7-40: 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 as CaCO3, mg/L	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 µmhos/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	7.9	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) = The absolute difference divided by the average.

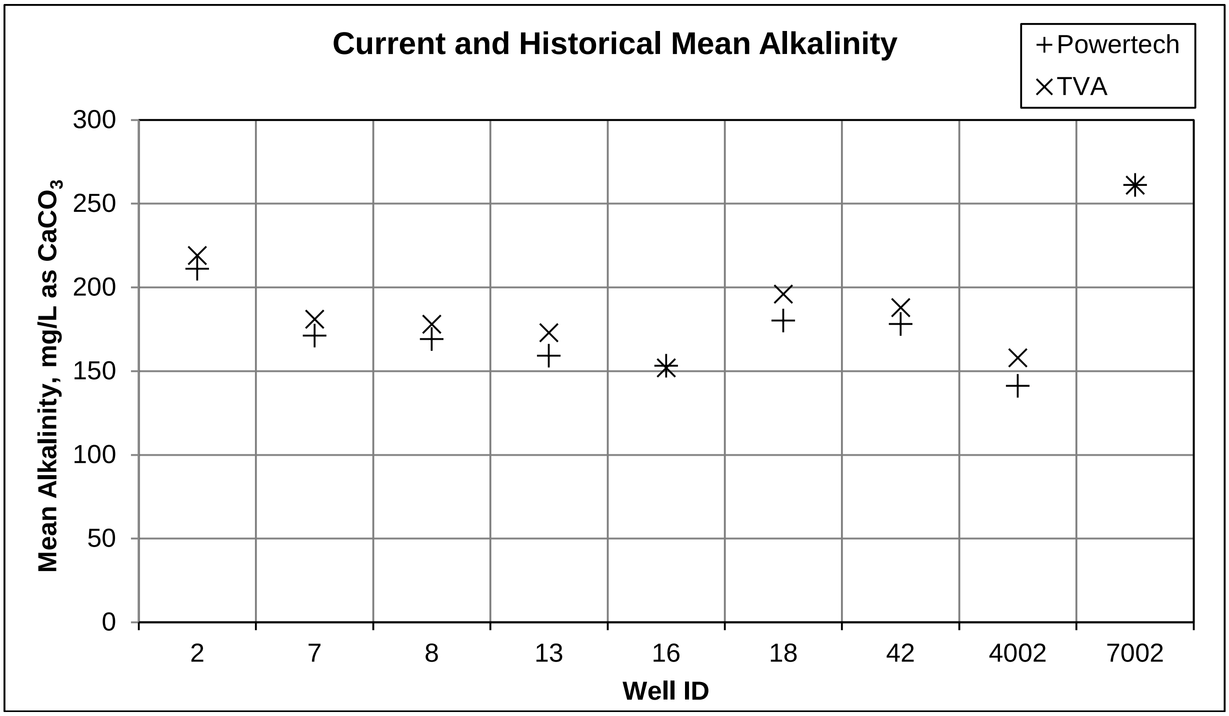


Figure 2.7-34: Mean Alkalinity Comparison between Historical and Current Data

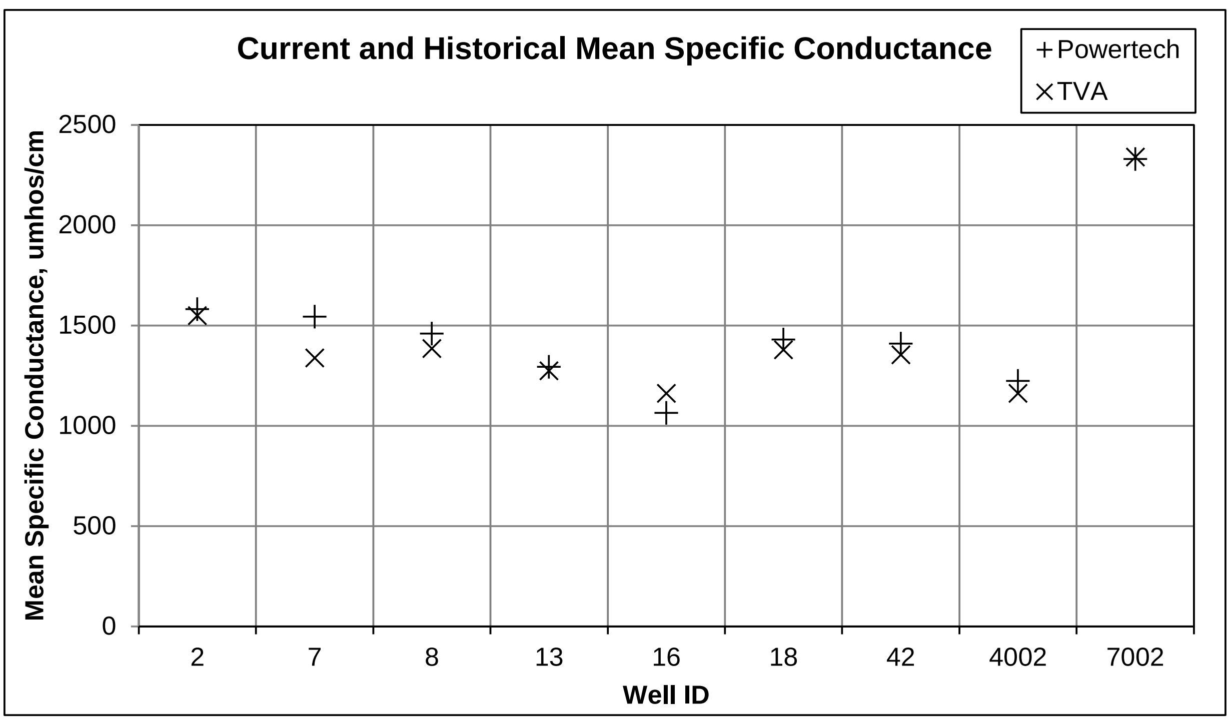


Figure 2.7-35: Mean Specific Conductance Comparison between Historical and Current Data

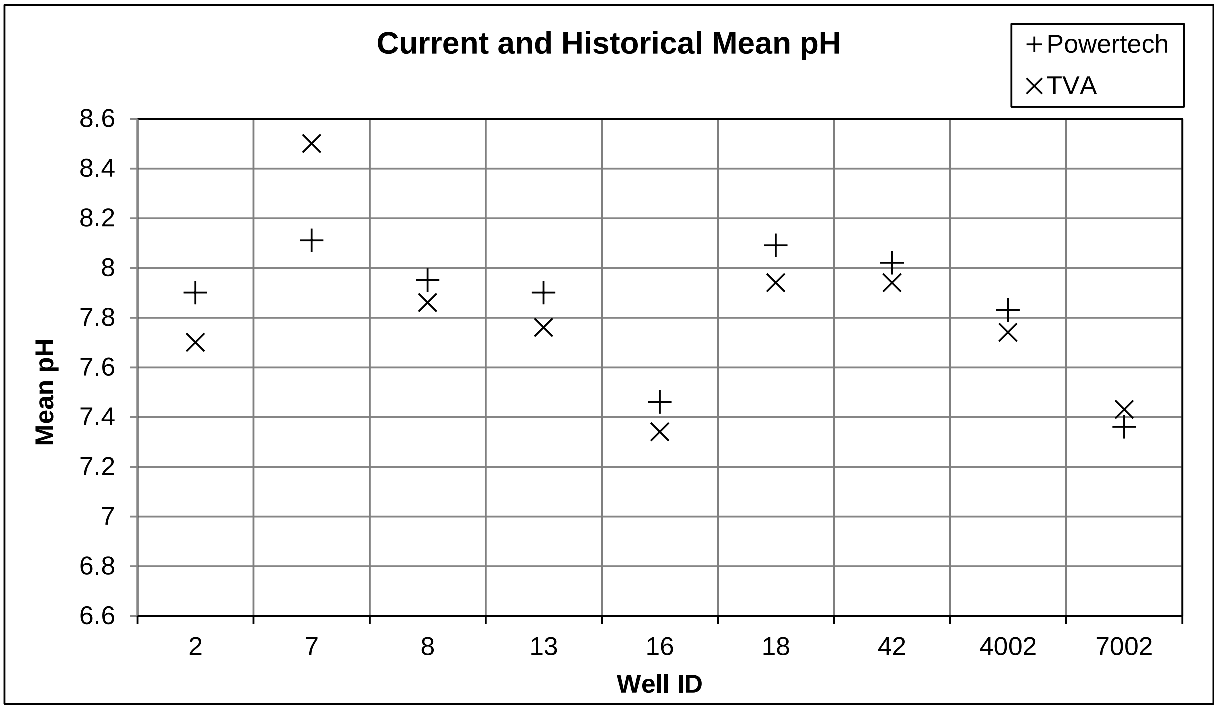


Figure 2.7-36: Mean pH Comparison between Historical and Current Data

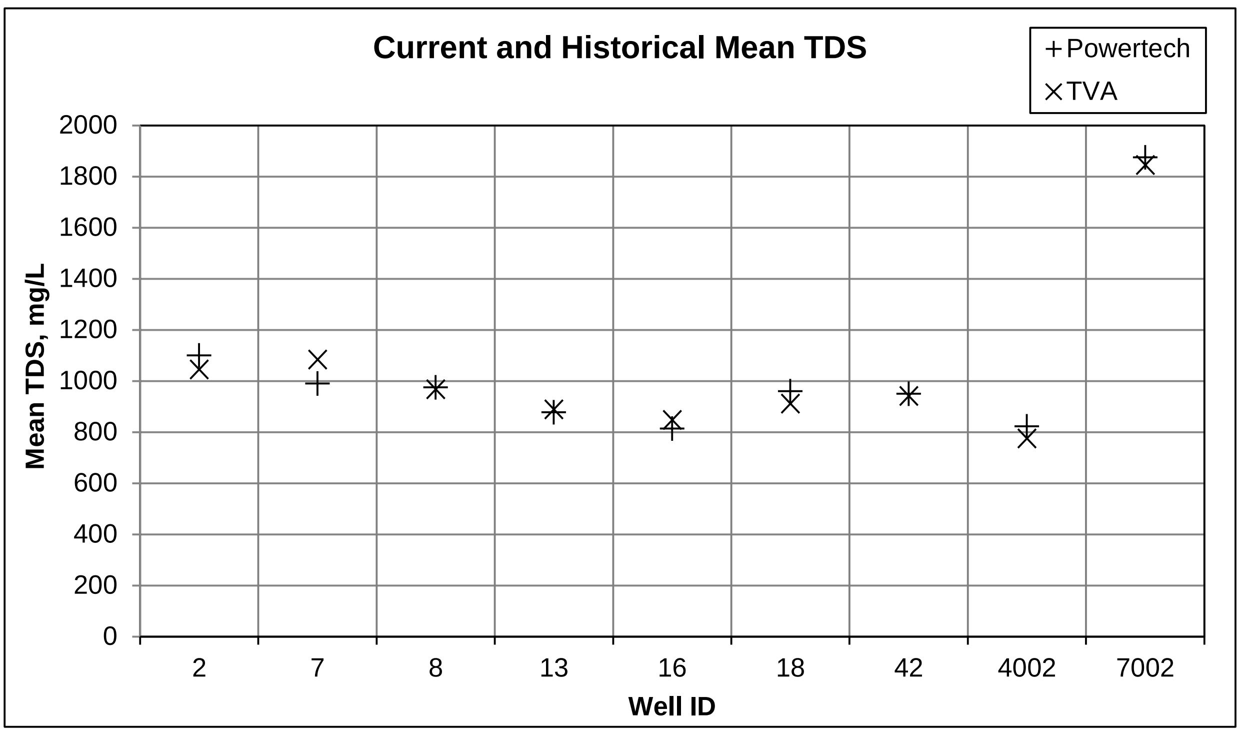


Figure 2.7-37: Mean TDS Comparison between Historical and Current Data

Piper diagrams were constructed for this group of wells with both historic and recent samples to determine if the general water quality type has changed over the course of the last 30 years (Figures 2.7-38 through 2.7-48). 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 for each 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 potassium (K+), calcium (Ca++), and magnesium (Mg++). Anions plotted include bicarbonate (HCO3-) plus carbonate (CO3--), sulfate (SO4--), 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.

Inspection of the resulting Piper diagrams reveals that water quality within both the Fall River and Chilson display a similar distribution. For both formations, sulfate is by far the dominant anion accounting for 70 to 80 percent meq/l (Figures 2.7-47 and 2.7-48). Relative abundance of calcium and magnesium are fairly even though most samples have a slightly higher percentage of calcium. Most samples contain between 55 and 85 percent meq/l sodium although water from the Chilson has a greater fluctuation with a group of samples having only 20 to 30 percent meq/l of sodium. Figures 2.7-47 and 2.7-48 display the water major ion concentrations sorted by aquifer and historical and recent data sets. In general, both the historic and recent data sets display the same trends and range in water type grading between a calcium-magnesium sulfate to sodium sulfate type.

Figures 2.7-38 through 2.7-46 display the proportional concentrations of major ions symbolized by well. These diagrams illustrate that samples for a particular well form a cluster, and hence it can be said that water quality has not greatly varied by sampling event. It is also apparent that the water type is variable from well to well. The geographical location and distance from the outcrop are therefore believed to be the main influences on water type, although well depth and screened interval may also have an effect. Wells that are located on or near the Inyan Kara outcrop (well 16 for example) yield a more calcium-magnesium sulfate type water, whereas wells further downgradient evolve to a sodium sulfate type water. This finding is inconsistent with that of Gott et al. (1974), who believed the difference in water type distribution resulted from recharge to the Inyan Kara from upward leaking Minnelusa aquifer water. It can be concluded

that relative ion concentration of Inyan Kara formation water is similar today to what it was during TVA sampling in the PAA.

Although a rigorous statistical analysis was not performed due to the small sample size of the Powertech (USA) and TVA well chemistry data, the general water quality parameters in the aquifers has shown good 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.

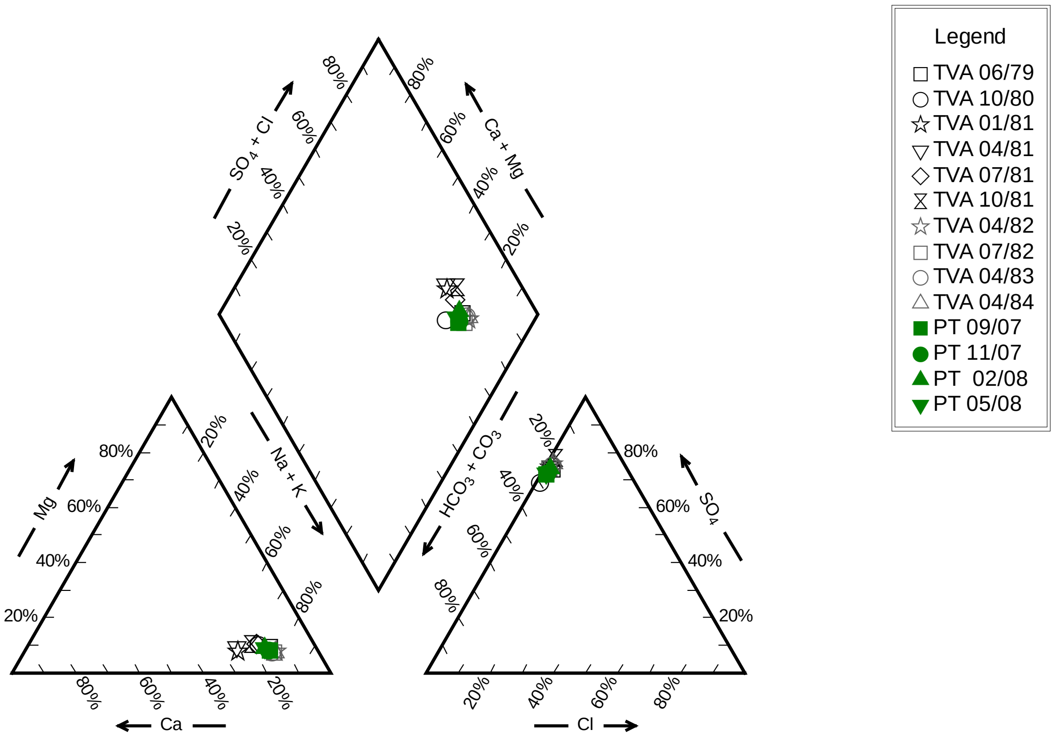


Figure 2.7-38: Piper Diagram of Historical and Current Data for Well 2

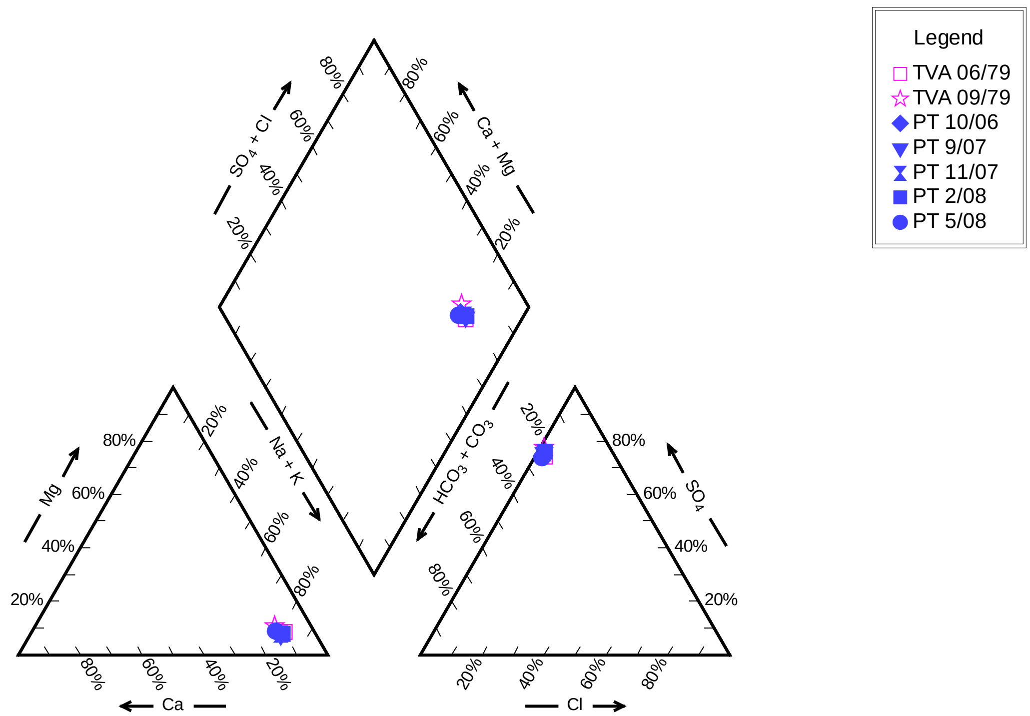


Figure 2.7-39: Piper Diagram of Historical and Current Data for Well 7

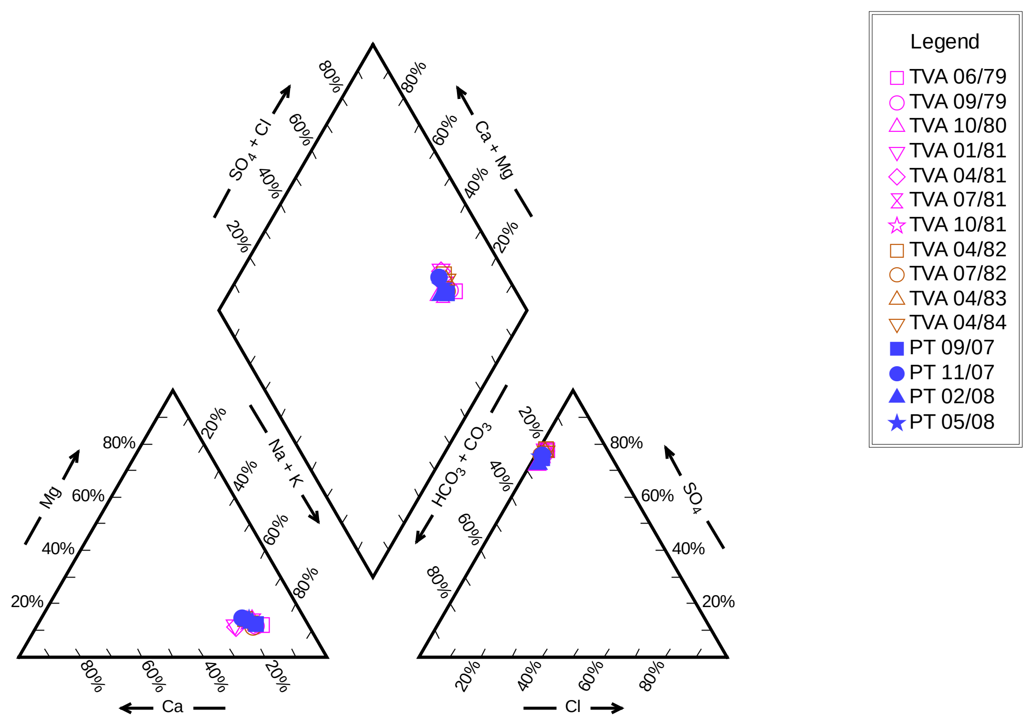


Figure 2.7-40: Piper Diagram of Historical and Current Data for Well 8

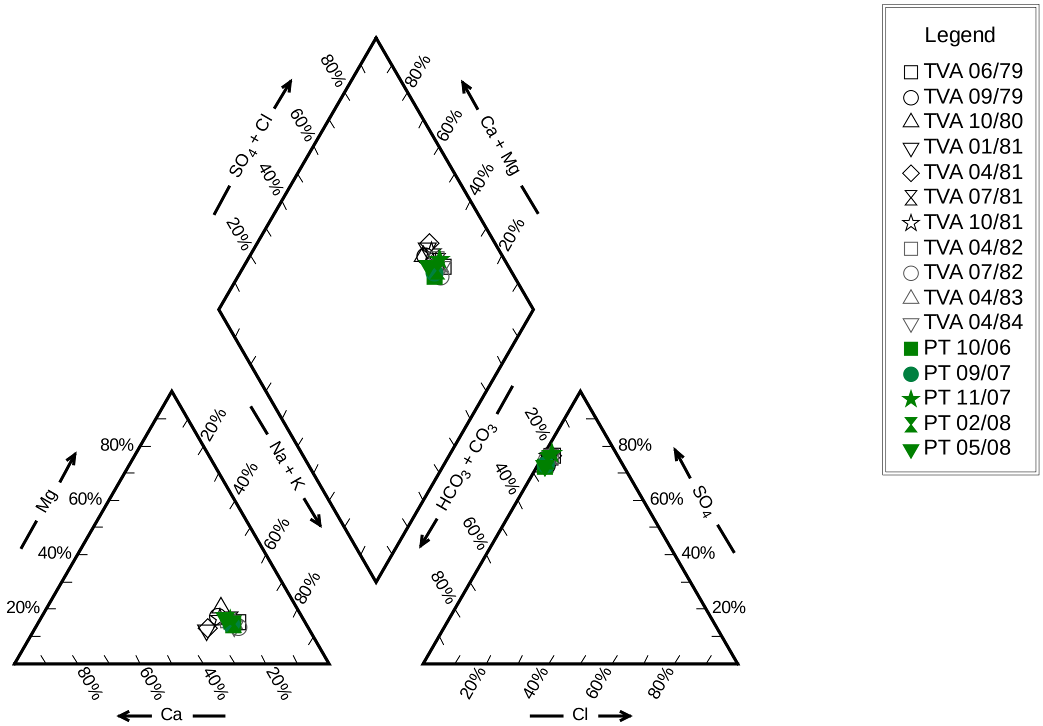


Figure 2.7-41: Piper Diagram of Historical and Current Data for Well 13

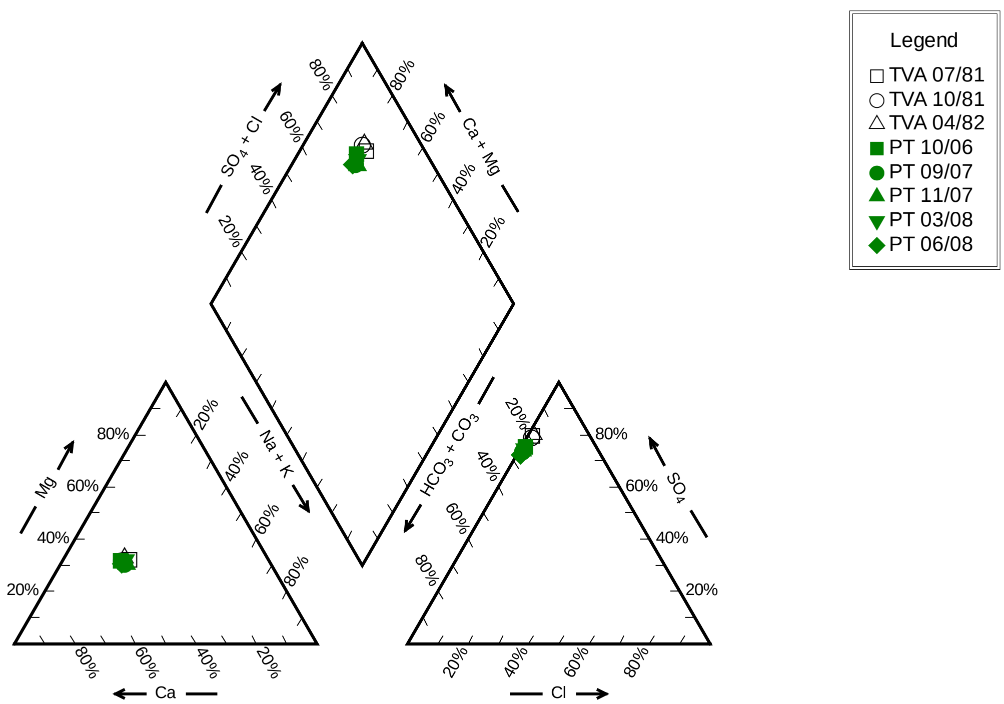


Figure 2.7-42: Piper Diagram of Historical and Current Data for Well 16

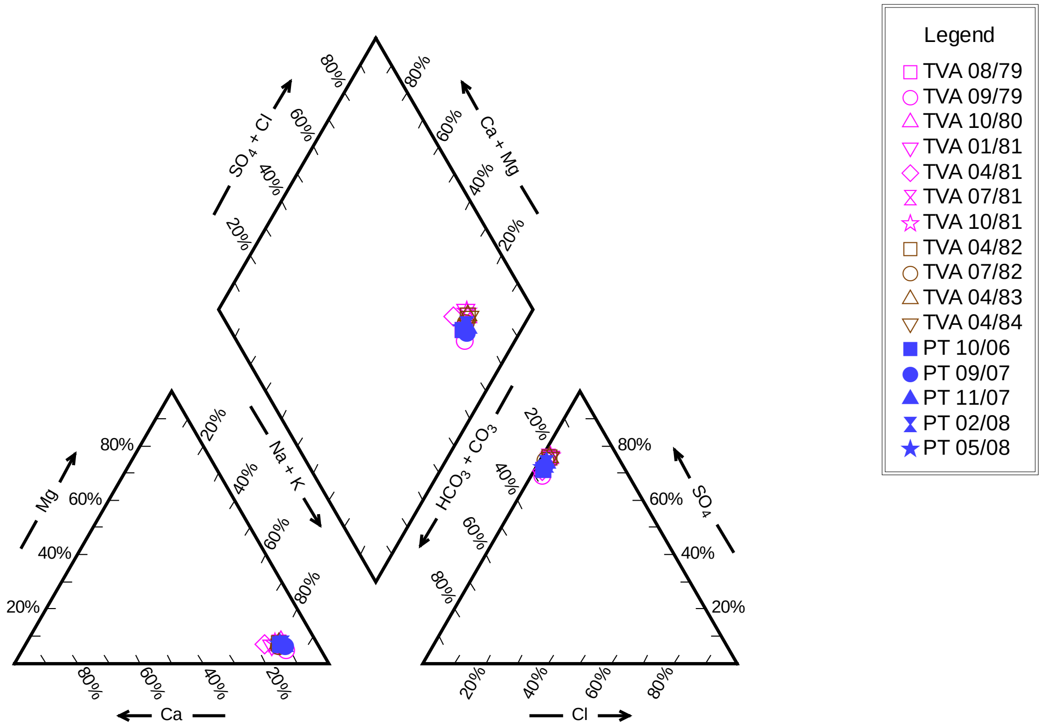


Figure 2.7-43: Piper Diagram of Historical and Current Data for Well 18

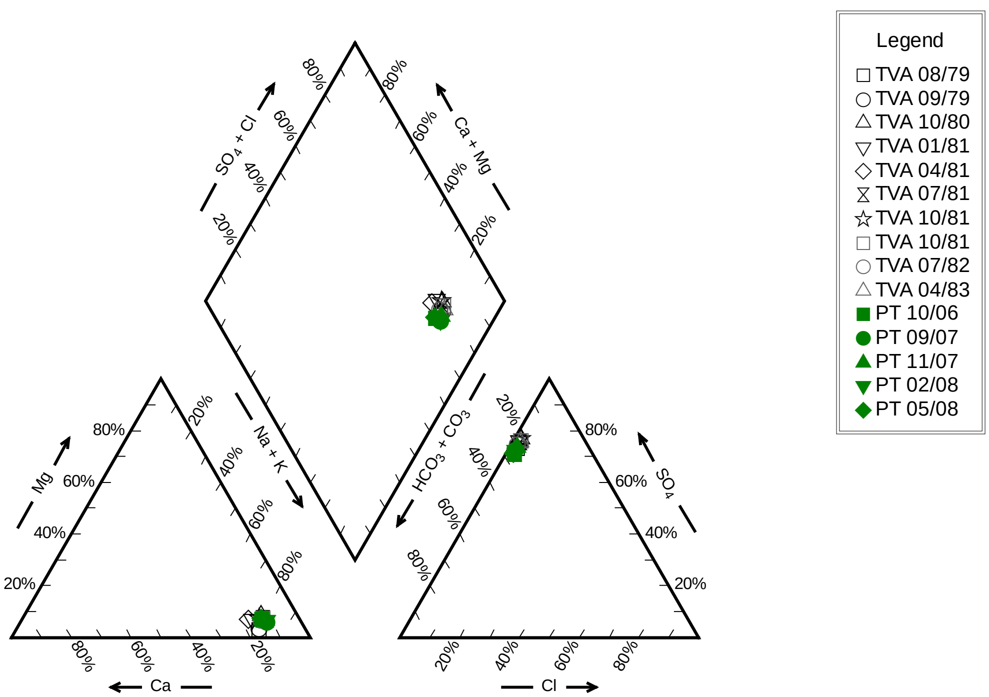


Figure 2.7-44: Piper Diagram of Historical and Current Data for Well 42

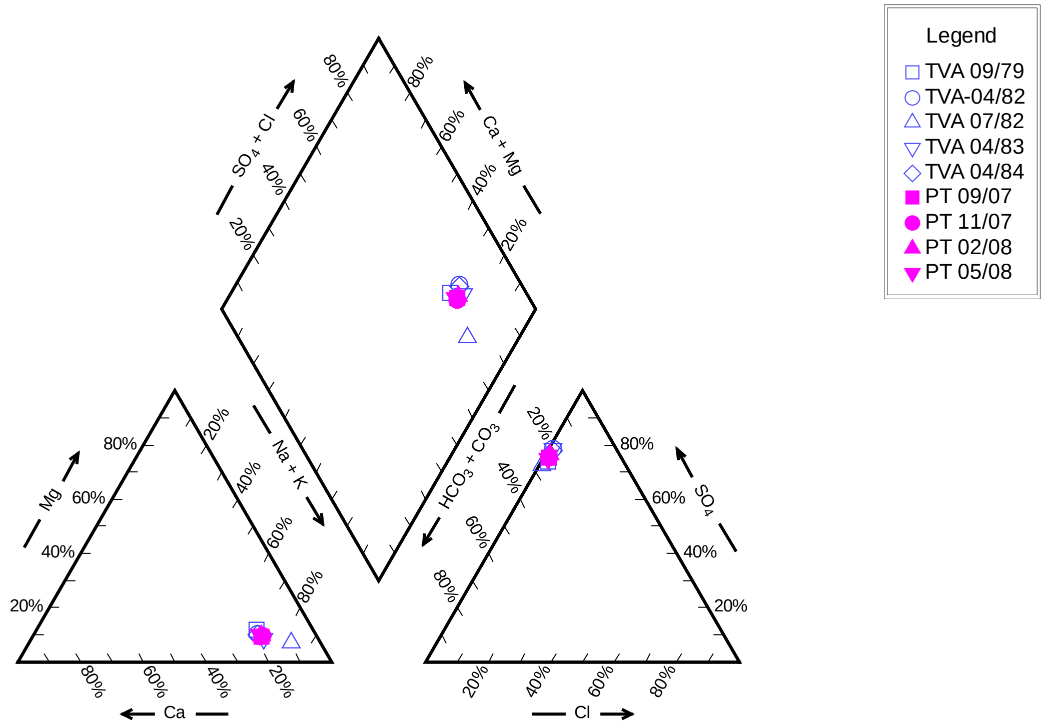


Figure 2.7-45: Piper Diagram of Historical and Current Data for Well 4002

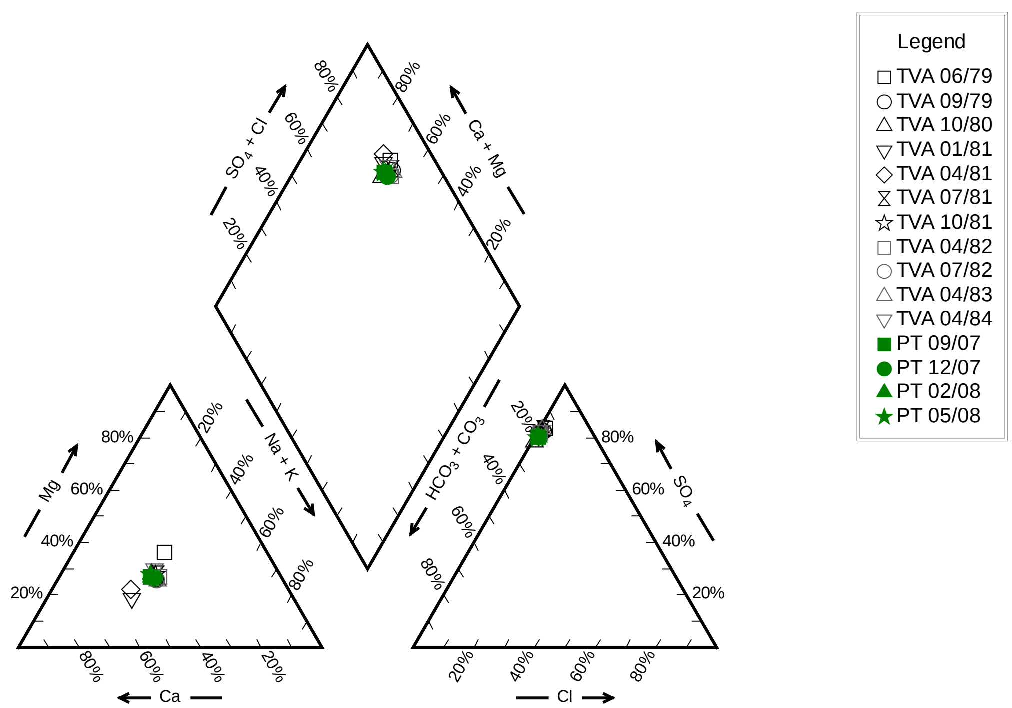


Figure 2.7-46 Piper Diagram of Historical and Current Data for Well 7002

Powertech (USA) Inc.

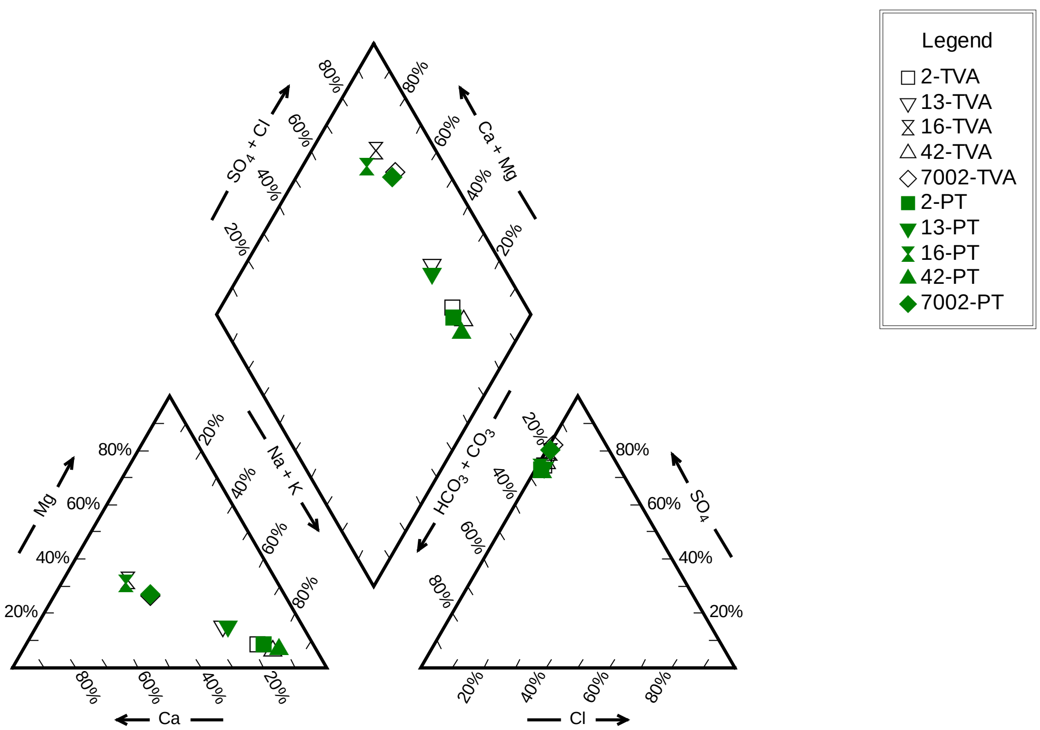


Figure 2.7-47: Piper Diagram of Historical and Current Data for Chilson Wells

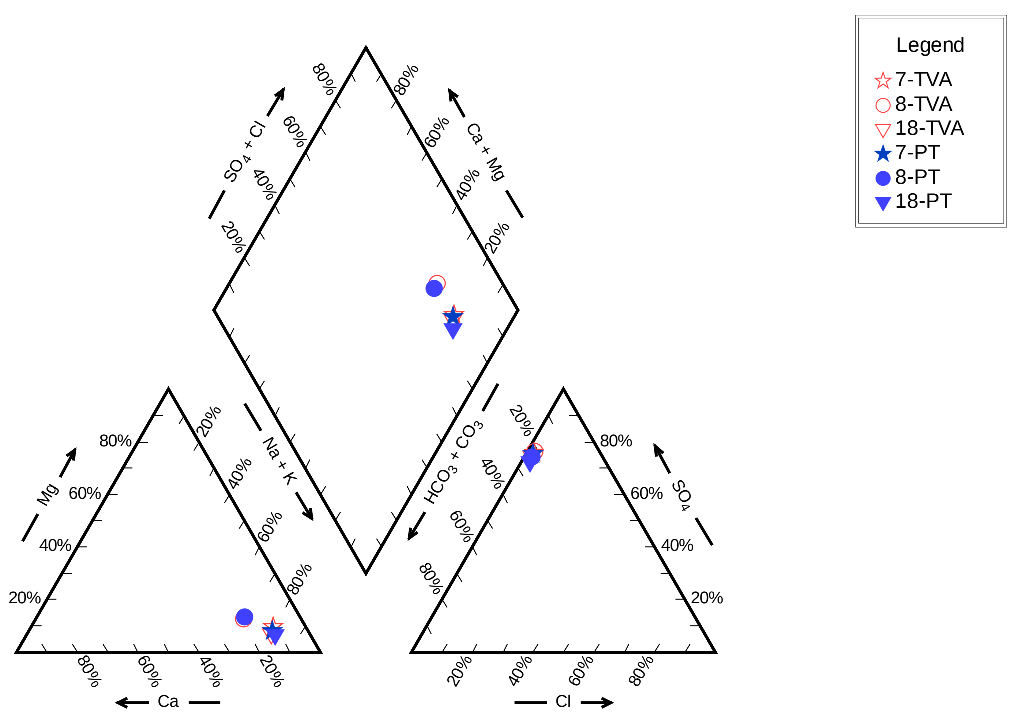


Figure 2.7-48: Piper Diagram of Historical and Current Data for Fall River Wells

2.7.4 References

ARSD 74:51:01 – 74:51:03, "*South Dakota Administrative Rules*", Accessed September 9, 2008 at URL http://legis.state.sd.us/rules/DisplayRule.aspx?Rule=74:51:01.

Boggs, J.M., 1983**, "***Hydrogeologic Investigations at Proposed Uranium Mine Near Dewey, South Dakota*", Report no WR28-520-128, Tennessee Valley Authority.

Boggs, J.M., and Jenkins, A.M., 1980**, "***Analysis of Aquifer Tests Conducted at the Proposed Burdock Uranium Mine Site, Burdock, South Dakota*", Report no. WR28-1-520-109, Tennessee Valley Authority.

Carter, J.M., Driscoll, D.G., and Hamade, G.R., 2001, "*Estimated Recharge to the Madison and Minnelusa Aquifers in the Black Hills Area, South Dakota and Wyoming, Water Years 1931-98*", U.S. Geological Survey Water-Resources Investigations Report 00-4278, 66 p.

Downey, J.S., 1984, Geohydrology of the Madison and Associated Aquifers in Parts of Montana, North Dakota, South Dakota, and Wyoming, USGS Professional Paper 1273-G, 47 p.

Driscoll, D., Carter, J., and Williamson, J.E., 2002, "*Hydrology of the Black Hills Area, South Dakota*", U.S. Geological Survey Water-Resources Investigations, Report 02-4094, 158 pgs.

Driscoll, F.M., 1986, *Groundwater and Wells*, Johnson Filtration Systems, Inc., St. Paul, MN, 1089 p.

ESI (Environmental Simulations Incorporated), 2003, $Aquifer^{Win32}$ aquifer test analysis software.

Flynn, K.M., Kirby, W.H., and Hummel, P.R., 2006, "*User's Manual for Program PeakFQ Annual Flood-Frequency Analysis Using Bulletin 17B Guidelines*", U.S. Geological Survey, Techniques and Methods Book 4, Chapter B4; 42 pgs.

Galloway, J.M., 2000, "*Select Hydrogeologic Data for the Inyan Kara, Minnekahta, Minnelusa, Madison, and Deadwood Aquifers in the Black Hills Area, South Dakota*", USGS Open-File Report 99-602.

Gott, G.B., Wolcott, D.E., and Bowles, C.G., 1974, "*Stratigraphy of the Inyan Kara Group and Localization of Uranium Deposits, Southern Black Hills, South Dakota and Wyoming*", USGS Professional Paper 763, 63 p.

Greene, E.A., 1993, Hydraulic Properties of the Madison Aquifer System in the Western Rapid City Area, South Dakota, USGS Water-Resources Investigations Report 93-4008, 56 p.

Halford, K.J. and E.L. Kuniansky, 2002, Documentation of Spreadsheets for the Analysis of Aquifer-test and Slug-test Data, USGS Open-File Report 02-197.

Hansen, E.M., Schreiner, L.C., and Miller, J.F., 1982, "*Hydrometeorological Report No. 52 – Application of Probable Maximum Precipitation Estimates, United States East of the 105th Meridian*", U.S. Department of Commerce and U.S. Department of the Army, Washington D.C., 168 pgs.

Hortness, J.E., and Driscoll, D.G., 1998, "*Streamflow Losses in the Black Hills of Western South Dakota*", U.S. Geological Survey Water-Resources Investigations Report 98-4116.

Jenkins, A.M., 1981, "*Burdock Mine Dewatering (Draft)*", Tennessee Valley Authority.

Johnson, B.N., 1933, "*A Climatological Review of the Black Hills*", The Black Hills Engineer, Rapid City, South Dakota School of Mines and Technology, 71 p.

Knight Piésold, 2008a., "*Pump Test Workplan, Dewey-Burdock In Situ Uranium Project*", April 25.

Knight Piésold, 2008b, "*2008 Pump Tests: Results and Analysis, Dewey-Burdock In Situ Uranium Project, Draft Report*", October 8, 2008.

Krantz, E., Larson, A. 2006, "*Upper Cheyenne River Watershed Assessment and TMDL: Fall River, Custer and Pennington Counties, South Dakota*", Unpublished.

Kyllonen, D.P., and Peter, K.D., 1987, "*Geohydrology and Water Quality of the Inyan Kara, Minnelusa, and Madison Aquifers of the Northern Black Hills, South Dakota and Wyoming, and Bear Lodge Mountains, Wyoming*", USGS Water-Resource Investigations Report 86-4158, pp. 66.

Miller, S.L., 2005, Influences of fractures and geologic structure on ground-water flow paths in the Mississippian Madison aquifer in the Rapid City area, South Dakota: Unpublished Ph-D Dissertation, South Dakota School of Mines and Technology, Rapid City, S.D.

Neuman, S.P., and P.A. Witherspoon, 1972, Field Determination of the Hydraulic Properties of Leaky Multiple Aquifer Systems, Water Resources Research 8(5), p. 1284-1298.

Rahn, P.H., 1985, Ground Water Stored in the Rocks of Western South Dakota, in F.J. Rich (ed.), *Geology of the Black Hills, South Dakota and Wyoming* (2nd ed.): Geological Society of America, Field Trip Guidebook, American Geological Institute, p. 154-174.

Rao, A.R., and Hamed, K.H., 2000, "*Flood Frequency Analysis*", CRC Press.

RESPEC, 2008a. *Geological Characterization of the Dewey-Burdock Uranium Project, Fall River and Custer Counties, South Dakota*, RSI-2013, prepared by RESPEC, Rapid City, SD, for Powertech (USA) Inc., Edgemont, SD.

Ries, K.G., III, and Crouse, M.Y., 2002, "*The National Flood Frequency Program, Version 3: A Computer Program for Estimating Magnitude and Frequency of Floods for Ungaged*

Sites, 2002", U.S. Geological Survey Water-Resources Investigations Report 02-4168, 42 p.

Sando, Steven, US Department of the Interior, US Geological Survey, "*Techniques for Estimating Peak-Flow*", GPO, 1998.

Schreiner, L.C., and Riedel, J.T., 1978, "*Hydrometeorological Report No. 51 – Probable Maximum Precipitation Estimates, United States East of the 105th Meridian*", U.S. Department of Commerce and U.S. Department of the Army, Washington D.C. pp. 48-77.

SD DENR, 2002, "*The 2002 South Dakota Report to Congress*", South Dakota Department of Environment and Natural Resources, Pierre, SD.

SD DENR, 2003, "*Standard Operating Procedures for Field Samplers Volume I – Tributary and Inlake Sampling Techniques*", South Dakota Department of Environment and Natural Resources, Pierre, SD.

SD DENR, 2004, "*The 2004 South Dakota Integrated Report for Surface Water Quality Assessment*", South Dakota Department of Environment and Natural Resources, Pierre, SD.

SD DENR, 2006, "*The 2006 South Dakota Integrated Report for Surface Water Quality Assessment*", South Dakota Department of Environment and Natural Resources, Pierre, SD.

Strobel, M.L., J.M. Galloway, G.R. Hamade and G.J. Jarrell, 2000a. Potentiometric Surface of the Inyan Kara Aquifer in the Black Hills Area, South Dakota, USGS Hydrologic Atlas HA-745-A, 2 sheets, scale 1:100,000.

_____, 2000b. Potentiometric Surface of the Minnekahta Aquifer in the Black Hills Area, South Dakota. USGS Hydrologic Atlas HA-745-B, 2 sheets, scale 1:100,000.

_____, 2000c. Potentiometric Surface of the Minnelusa Aquifer in the Black Hills Area, South Dakota. USGS Hydrologic Atlas HA-745-C, 2 Sheets, scale 1:100,000.

_____, 2000d. Potentiometric Surface of the Madison Aquifer in the Black Hills Area, South Dakota. USGS Hydrologic Atlas HA-745-D, 2 Sheets, scale 1:100,000.

_____, 2000e. Potentiometric Surface of the Deadwood Aquifer in the Black Hills Area, South Dakota. USGS Hydrologic Atlas HA-745-E, 2 Sheets, scale 1:100,000.

Strobel, M.L., G.J. Jarrell, J.F. Sawyer, J.R. Schleicher and M.D. Fahrenbach, 1999, Distribution of Hydrologic Units in the Black Hills Area, South Dakota, USGS Hydrologic Investigations Atlas HA-743, 3 sheets, scale 1:100,000.

Whitehead, R.L., 1996, Ground Water Atlas of the United States-Segment 8, Montana, North Dakota, South Dakota, Wyoming: USGS Hydrologic Investigations Atlas 730-I, 24 p.

Williamson, J.E. and J.M. Carter, 2001, Water-Quality Characteristics in the Black Hills Area, South Dakota, USGS Water-Resources Investigations Report 01-4194, 196 p.

2.8 Ecological Resources

2.8.1 Introduction

This section describes the existing ecological resources within the PAA. The analysis consisted of a review of existing local and regional documents, agency databases, and previous relevant reports, as well as targeted field surveys.

All vegetation sampling procedures were designed according to previous experience with similar projects and in collaboration with the South Dakota Department of Game, Fish and Parks (SDGFP).

Background information on terrestrial vertebrate wildlife species, and aquatic vertebrates and invertebrates in the vicinity of the project was obtained from several sources, including records from SDGFP, Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (USFWS), U.S. Forest Service (USFS), and the original Draft Environmental Statement (DES) prepared by the Tennessee Valley Authority (TVA) in 1979. Site-specific data for the project and surrounding perimeter were obtained from those same sources, with current data collected during regular site visits and targeted surveys conducted from July 2007 through early August 2008.

2.8.2 Regional Setting

The PAA is within the mixed grass eco-region of the Northern Great Plains (EPA 1993), near the southwestern extension of the Black Hills. The elevation within the PAA ranges from approximately 3,600 feet to 3,900 feet above mean sea level, with the highest elevations along the pine breaks that overlap its eastern boundary. Topography in the PAA and surrounding lands is primarily gently rolling in the western quarter, with more varied terrain in the pine breaks and dissected hills that comprise the rest of the area.

The PAA is comprised of five main vegetative communities, in descending order: Ponderosa Pine Woodland, Big Sagebrush Shrubland, Greasewood Shrubland, Upland Grassland, and Cottonwood Gallery. Despite the overall ranking, Upland Grassland was present in the largest individual parcels. Interspersed among those primary habitats are smaller inclusions of Silver Sagebrush Shrubland, Agricultural Land, creek channels, and numerous ephemeral draws.

The PAA is located within the Cheyenne River watershed. Two main stream channels pass through the PAA: Beaver Creek (perennial) and Pass Creek (ephemeral). Both flow south into the Cheyenne River, which runs from west to east approximately 2.5 miles south of the PAA

boundary. A few small stock reservoirs are scattered throughout the area, though they may not retain water year-round.

Trees are present along the riparian corridors of both primary creeks, and on the higher elevation hilltops in the PAA. The plains cottonwood (*Populus deltoides*) was the only tree present along the creek channels, and was more prevalent in the Pass Creek corridor. Ponderosa pine (*Pinus ponderosa*) dominates the higher elevation hilltops and breaks in the central and eastern portions of the PAA, with Rocky Mountain juniper (*Juniperus scopulorum*) present as individual trees or small inclusions in some of the dry drainages.

2.8.3 Climate

The PAA is characterized as semi-arid continental or steppe with a dry winter season. The area commonly experiences low precipitation levels, high evaporation rates, low relative humidity, and plentiful sunshine. Temperatures are moderate, with large diurnal and annual variations, and extremes ranging from approximately -37 degrees F in the winter to 114 degrees F in the summer. The first freeze typically occurs in mid- to late September, with the last freeze often recorded during late May.

Yearly precipitation totals average about 14 inches. Approximately one-half of the annual precipitation falls during the months of May, June, and July. As expected, most of the winter precipitation occurs as snow, with an annual average of 37 inches. Thunderstorms are relatively frequent in the PAA during the summer months, averaging 40-45 days per year. Much of the annual rainfall is associated with these events.

Windy conditions are fairly common in the PAA, generally averaging 9 mph. Prevailing winds come from the west-northwest during much of the year, though east-southeast winds are also common.

2.8.4 Baseline Data

Ecological baseline studies for flora and fauna were collected to fulfill the objectives specified in U.S. Nuclear Regulatory Commission (NRC) NUREG-1569, "*Standard Review Plan for In Situ Leach Uranium Extraction License Applications*". Ecological surveys were also conducted in accordance with applicable SD Department of Environment and Natural Resources (DENR), SDGFP, and USFWS established guidelines. These agencies were consulted prior to initiating

field surveys to ensure that adequate objectives, survey methodologies, and data collection techniques were employed.

Vegetation sampling was conducted by BKS Environmental Associates, Inc. (BKS) of Gillette, Wyoming. Initial surveys were conducted during July 2007, with supplemental sampling performed to adjust to subsequent changes in the PAA boundary. Wildlife and aquatics sampling were conducted by ICF Jones & Stokes (formerly Thunderbird-Jones & Stokes), of Gillette, Wyoming from July 2007 through early August 2008 to meet agency requirements of one year of baseline data, and to accommodate changes to the PAA boundary during that period.

The following sections were generated from the final survey reports completed by BKS and Jones & Stokes for this project.

2.8.5 Terrestrial Ecology

Powertech (USA) conducted terrestrial ecological baseline field surveys including vegetation, wetlands, wildlife. The methodology and results are discussed in the following sections.

2.8.5.1 Vegetation

2.8.5.1.1 Survey Methodology

General

All sampling procedures were designed according to previous experience with similar projects, and the methodology was submitted to Powertech (USA) for its approval. Refer to Appendix 2.8-A for the submitted methodology.

Mapping

Seven different plant communities were identified for the PAA, 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 infra-red (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 hand-held Garmin Global Positioning System (GPS), and these points were later plotted on the final vegetation survey map (Plate 2.8-1).

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 for the Cottonwood Gallery and 30 samples for the Upland Grassland community for a total of 157 cover points in the PAA.

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 2.8-B).

Total Vegetation Cover

Vegetation data cover was 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 are contained in Appendix 2.8-C.

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

This data was taken at the time of cover sampling to ensure adequate use of field time. Summarization of that data can be found in Appendix 2.8-C.

Shrub density data was 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

This data was taken at the time of cover sampling to ensure adequate use of field time. Summarization of that data can be found in Appendix 2.8-D.

Tree density data was 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 2.8-B by vegetation community type for each of the five 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, 3rd Edition) 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.

Sample Adequacy

A minimum of 20 cover transects per vegetation type was sampled in five vegetation communities. Sample adequacy was calculated and an incremental number of cover transects was sampled up the maximum of 50.

The following sample adequacy formula was utilized to determine the minimum required size of the sample population.

$$n_{min} \geq \frac{2(sz)^2}{(dx)^2}$$

Where n_{min}= minimum number of sampled line transects needed to adequately represent native vegetation types
s= sample standard deviation
z= the z statistic
d= the amount of reduction desired
x= sample mean for cover

This sample adequacy formula is used by the Wyoming Department of Environmental Quality (WDEQ). The 2 in the numerator makes this a very conservative test. The term "grassland" indicates that a community has less than or equal to 20 percent relative cover by shrub species while a "shrubland" is greater than or equal to 20 percent relative cover by shrub species according to the WDEQ.

The five vegetation communities have been identified as “grassland”, or “shrubland”. Upland Grassland is identified as grassland while the Ponderosa Pine Woodland, Big Sagebrush Shrubland, Greasewood Shrubland, and Cottonwood Gallery communities are identified as shrublands. The constant values to be used in statistical tests for cover are: “z”=1.28 and “d” = 0.1 for grasslands and shrublands. All sampled vegetation was included in the sample adequacy test (i.e., “undesirable” species were not eliminated from the equation). Also as adjustments were made to the permit boundary, the samples that fell outside of the boundary were not excluded as they were initially part of the boundary at the time of survey.

Extended Reference Area

The Extended Reference Area (EXREFA) is a native land unit used to evaluate revegetation success on portions of the same native plant community that was affected by the proposed operation. This study shows the operation will affect five plant communities, Big Sagebrush Shrubland, Cottonwood Gallery, Greasewood Shrubland, Ponderosa Pine Woodland, and Upland Grassland. All areas of these communities not affected by production activities will serve as the EXREFA.

2.8.5.1.2 Vegetation Survey Results

The PAA acreage is 10,580 acres. Of these acres, Big Sagebrush Shrubland was 2,501.74 acres (23.70 percent), Greasewood Shrubland was 2,190.45 acres (20.75 percent), Ponderosa Pine Woodland was 2,183.76 acres (20.69 percent), Upland Grassland was 2,187.56 acres (20.72 percent), Agricultural Land was 780.79 acres (7.40 percent), Disturbed areas were 14.7 acres (0.14 percent), existing mine pits were 326.99 acres (3.10 percent), Cottonwood Gallery was 240.6 acres (2.28 percent), Silver Sagebrush Shrubland was 119.49 acres (1.13 percent), water was 8.94 acres (0.08 percent), and Shale Outcrop was 2.19 acres (0.02 percent). Refer to Table 2.8-1 for acreage of each vegetation community by permit acreage, and ½-mile buffer acreage.

Table 2.8-1: Acreage and Percent of Total Area for Each of the Map Units

Map Unit	Permit area	% of Area	1/2 Mile Buffer Area	% of Area
Sampled Vegetation Communities				
Big Sagebrush Shrubland	2,501.56	23.70	2,639.45	31.75
Greasewood Shrubland	2,190.45	20.75	837.66	10.07
Ponderosa Pine Woodland	2,183.76	20.69	2,036.58	24.49
Upland Grassland	2,187.56	20.72	2,027.18	24.38
Cottonwood Gallery	240.6	2.28	103.13	1.24
Described Vegetation Communities				
Agricultural Land	780.79	7.40	604.19	7.27
Disturbed	14.7	0.14	--	--
Existing Mine Permit	326.99	3.10	--	--
Silver Sagebrush Shrubland	119.49	1.13	53.65	0.65
Shale Outcrop	2.19	0.02	--	--
Water	8.94	0.08	12.6	0.15
TOTAL	**10,557.03**	**100.00**	**8,314.44**	**100.00**

General

The Extended Reference Area EXREFA will remain unaffected over the course of the proposed operation and will be used to evaluate revegetation success. The EXREFA will include portions of the same native plant communities that area affected by the proposed operation but located outside those disturbed areas and within the project boundary.

2.8.5.1.3 Big Sagebrush Shrubland

Cover

The Big Sagebrush Shrubland community comprised 2,501.56 of the 10,557.03 acres of the PAA (23.70 percent). Twenty-seven cover transects were sampled for this community. Absolute total vegetation cover was 45.89 percent. Absolute bare soil and litter/rock percentages were 14.07 percent and 38.52 percent, respectively. Absolute total ground cover was 85.78 percent. *Bouteloua gracilis* (blue grama), provided the highest relative vegetation cover at 24.38 percent, while *Buchloe dactyloides* (buffalograss) provided the next highest relative vegetation cover at 20.98 percent. Refer to Table 2.8-2 for the absolute cover values.

Table 2.8-2: 2007 Absolute Cover for the Big Sagebrush Shrubland Vegetation Community

Vegetation Parameter
Absolute Total Vegetation Cover (45.89%)
Absolute Total Cover (85.78%)

Sample Adequacy

There were 27 samples taken in the Big Sagebrush Shrubland plant community. The sample adequacy formula outlined earlier was utilized to determine the minimum required size of the sample population. Big Sagebrush Shrubland met sample adequacy

Refer to Table 2.8-3 below for sample adequacy values.

Table 2.8-3: Summary of Sample Adequacy Calculations for Percent Vegetation Cover in the Big Sagebrush Shrubland

Map Unit	Mean	Standard Deviation	Sample Adequacy	Actual Sample #	Z-Value	Confidence Level Achieved
Big Sagebrush Shrubland						
Total Vegetation Cover	22.75	6.52	26.91	27.00	2.56	99.48
Total Ground Cover	42.64	3.49	2.20	27.00	8.98	NA

Shrub Density

Big Sagebrush Shrubland supported an average of 3,661.46 shrubs per acre or 0.90 shrubs/m^2. The following full and half/sub-shrub species were found: *Artemisia tridentata* (big sagebrush), *Artemisia frigida* (fringed sagewort), and *Gutierrezia sarothrae* (broom snakeweed). Refer to Appendix 2.8-D for a complete Big Sagebrush Shrubland density summary.

Species Composition

Species composition for the Big Sagebrush Shrubland community was dominated by warm season perennial grasses with 46.33 percent relative vegetation cover, followed by cool season perennial grasses with 20.33 percent relative vegetation cover. Perennial shrubs had 15.82 percent relative vegetation cover, while annual grasses had 10.15 percent relative vegetation cover . Annual forbs had 1.90 percent relative vegetation cover. Perennial forbs had 1.11 percent relative vegetation cover; sub-shrubs had a total of 2.59 percent relative vegetation cover. Succulents had 1.77 percent relative vegetation cover. The cool season perennial grasses were mainly *Elymus smithii* (western wheatgrass), *Carex filifolia* (threadleaf sedge), and *Poa secunda* (Sandberg bluegrass). The warm season perennial grasses were mainly blue grama, buffalograss, and *Bouteloua curtipendula* (sideoats grama). Annual grasses were *Bromus japonicus* (Japanese brome) and *Bromus tectorum* (cheatgrass). Perennial forbs were dominated by *Calochortus nuttallii* (sego lily), *Phlox spp.* (phlox), and *Sphaeralcea coccinea* (scarlet globemallow). Annual forbs included *Alyssum desertorum* (desert alyssum) and *Lepidium densiflorum* (prairie peppergrass). Present shrubs/sub-shrubs was big sagebrush, fringed sagewort, and broom snakeweed. Also present was the succulent *Opuntia polyacantha* (plains prickly pear). Refer to Table 2.8-4 for relative Big Sagebrush Shrubland cover summary and Appendix 2.8-C for a complete Big Sagebrush Shrubland cover summary.

Table 2.8-4: Vegetation Cover Sampling Data Summary of Species by Lifeform for the Big Sagebrush Shrubland Community

	Vegetation Cover	
	Absolute	**Relative (%)**
Cool Season Perennial Grasses	9.33	20.33
Warm Season Perennial Grasses	21.26	46.33
Annual Grasses	4.66	10.15
Annual Forbs	0.87	1.90
Perennial Forbs	0.51	1.11
Perennial Shrubs	7.26	15.82
Perennial Sub-Shrubs	1.19	2.59
Succulents	0.81	1.77

2.8.5.1.4 Greasewood Shrubland

Cover

The Greasewood Shrubland community comprised 2,190.45 of the 10,557.03 acres of the PAA (20.75 percent). Thirty-seven cover transects were sampled for this community. Absolute total vegetation cover was 37.11 percent. Absolute bare soil and litter/rock percentages were 18.70 percent and 42.54 percent, respectively. Absolute total ground cover was 81.41 percent. Western wheatgrass provided the highest relative vegetation cover at 23.31 percent. *Sarcobatus vermiculatus* (greasewood), provided the next highest cover at 22.88 percent. Refer to Table 2.8-5 for the absolute cover values.

Table 2.8-5: 2007 Absolute Cover for the Greasewood Shrubland Vegetation Community

Vegetation Parameter	**Mean**
Absolute Vegetation Cover (%)	37.11
Absolute Total Cover (%)	81.41

Sample Adequacy

There were 37 samples taken in the Greasewood Shrubland community. The sample adequacy formula outlined earlier was utilized to determine the minimum required size of the sample

population. Greasewood Shrubland met sample adequacy. Refer to Table 2.8-6 for sample adequacy values.

Table 2.8-6: Summary of Sample Adequacy Calculations for Percent Vegetation Cover in the Greasewood Shrubland

Map Unit	Mean	Standard Deviation	Sample Adequacy	Actual Sample #	Z-Value	Confidence Level Achieved
Greasewood Shrubland						
Total Vegetation Cover	18.84	5.80	31.06	37.00	2.79	99.74
Total Ground Cover	40.70	6.74	8.99	37.00	5.19	NA

Shrub Density

Greasewood Shrubland supported an average of 2,589.42 shrubs per acre or 0.64 shrubs/m^2. The following full and half/sub-shrub species were found: greasewood, big sagebrush and *Artemisia cana* (silver sagebrush), *Ericameria nauseosa* (rubber rabbitbrush), and fringed sagewort. Refer to Appendix 2.8-D for a complete Greasewood Shrubland density summary

Species Composition

Species composition for the Greasewood Shrubland community was dominated by perennial shrubs with 28.70 percent relative vegetation cover, followed by cool season perennial grasses with 27.67 percent relative vegetation cover. Warm season perennial grasses had 24.31 percent relative vegetation cover. Annual grasses had 4.96 percent relative vegetation cover while annual forbs had 10.32 percent relative vegetation cover. Perennial forbs had 0.40 percent relative vegetation cover. Succulents had 3.64 percent relative vegetation cover. The cool season perennial grasses were mainly western wheatgrass, *Agropyron cristatum* (crested wheatgrass), threadleaf sedge, *Bromus inermis* (smooth brome), and *Elymus lanceolatus* (thickspike wheatgrass). Warm season perennial grasses were mainly blue grama, buffalograss, *Distichlis stricta* (inland saltgrass), and *Sporobolus airoides* (alkali sacaton). Annual grasses were dominated by Japanese brome and cheatgrass. Perennial forbs were dominated by scarlet globemallow, *Ambrosia psilostachya* (western ragweed), and *Convolvulus arvensis* (field bindweed). Annual forbs included *Bassia sieversiana* (summer cypress), *Plantago patagonica* (Pursh's plantain), and *Monolepis nuttalliana* (Nuttall's povertyweed). Shrubs included greasewood, big sagebrush and silver sagebrush. Plains prickly pear was also present. An area

dominated by silver sagebrush was present within this community. This area was wetter than the typical greasewood community. The species composition was likely similar except for the dominance of silver sagebrush in the shrub component which is due to the increased moisture present within this area. Refer to Table 2.8-7 for relative Greasewood Shrubland cover summary and Appendix 2.8-C for a complete Greasewood Shrubland cover summary.

Table 2.8-7: Vegetation Cover Sampling Data Summary of Species by Lifeform for the Greasewood Shrubland Community

	Vegetation Cover	
	Absolute	**Relative (%)**
Cool Season Perennial Grasses	10.27	27.67
Warm Season Perennial Grasses	9.02	24.31
Annual Grasses	1.84	4.96
Annual Forbs	3.83	10.32
Perennial Forbs	0.15	0.40
Perennial Shrubs	10.65	28.70
Succulents	1.35	3.64

2.8.5.1.5 Ponderosa Pine Woodland

<u>Cover</u>

The Ponderosa Pine Woodland community comprised approximately 1,555.64 of the 7,960.77 acres of the PAA (19.54 percent). Thirty-seven cover transects were sampled for this community. Absolute total vegetation cover was 34.33 percent. Absolute bare soil and litter/rock percentages were 10.54 and 53.57, respectively. Absolute total ground cover was 88.92 percent. *Pinus ponderosa* (ponderosa pine) provided the highest relative vegetation cover at 45.03 percent, while *Carex geyeri* (Geyer's sedge) provided the next highest relative vegetation cover at 13.37 percent. Refer to Table 2.8-8 for the absolute cover values.

Table 2.8-8: 2007 Absolute Cover for the Ponderosa Pine Woodland Vegetation Community

Vegetation Parameter	Mean
Absolute Total Vegetation Cover (%)	34.33
Absolute Total Cover (%)	88.92

Sample Adequacy

There were 37 samples taken in the Ponderosa Pine Woodland community. The sample adequacy formula outlined earlier was utilized to determine the minimum required size of the sample population. Ponderosa Pine Woodland met sample adequacy. Refer to Table 2.8-9 below for sample adequacy values.

Table 2.8-9: Summary of Sample Adequacy Calculations for Percent Vegetation Cover in the Ponderosa Pine Woodland

Map Unit	Mean	Standard Deviation	Sample Adequacy	Actual Sample #	Z-Value	Confidence Level Achieved
Ponderosa Pine Woodland						
Total Vegetation Cover	17.19	5.25	30.56	37.00	2.82	97.67
Total Ground Cover	44.19	3.86	2.50	37.00	3.80	NA

Shrub Density

Ponderosa Pine Woodland supported an average of 1,224.27 shrubs per acre or 0.30 shrubs/m^2. The following full and half/sub-shrub species were found: big sagebrush, silver sagebrush, rubber rabbitbrush, *Chrysothamnus viscidflorus* (Douglas rabbitbrush), fringed sagewort, broom snakeweed, *Rosa arkansana* (prairie rose), and *Yucca glauca* (yucca or small soapweed). Refer to Appendix 2.8-D for a complete Ponderosa Pine Woodland density summary.

Tree Density

Ponderosa Pine Woodland supported an average of 75.88 ponderosa pine trees per acre or 0.019 trees/m^2. *Juniperus scopulorum* (Rocky Mountain juniper) was also observed within this community; however no quantitative evaluations were made for this species. Refer to Appendix 2.8-E for a complete tree density summary for the Ponderosa Pine Woodland community.

Species Composition

Species composition for the Ponderosa Pine Woodland community was dominated by trees with 52.58 percent relative vegetation cover, followed by warm season perennial grasses with 22.34 percent relative vegetation cover. Cool season perennial grasses had 19.34 percent relative vegetation cover. Annual grasses had 0.79 percent relative vegetation cover while annual forbs

had 0.44 percent relative vegetation cover. Biennial forbs had 0.15 percent relative vegetation cover, while perennial forbs had 1.22 percent relative vegetation cover. Succulents had 0.47 percent relative vegetation cover while perennial shrubs and sub-shrubs had 2.04 percent and 0.64 percent relative vegetation cover, respectively. The trees were dominated by ponderosa pine and *Juniperus scopulorum* (Rocky Mountain juniper). The cool season perennial grasses were mainly Geyer's sedge, western wheatgrass and *Hesperostipa comata* (needleandthread). Warm season perennial grasses were mainly blue grama, sideoats grama, *Schizachyrium scoparium* (little bluestem), and *Aristida purpurea var. fendleriana* (Fendler's threeawn). Annual grasses were dominated by Japanese brome and cheatgrass. Perennial forbs were dominated by *Erigeron spp.* (fleabane), *Thermopsis rhombifolia* (prairie thermopsis), *Antennaria parvifolia* (small-leaf pussytoes), *Liatris punctata* (dotted blazing star), and *Vicia americana* (American vetch). Annual forbs included *Chenopodium berlandieri* (pitseed goosefoot), *Draba nemorosa* (yellow draba), and *Lappula redowski* (beggars-tick). Biennial forbs included *Melilotus officinalis* (yellow sweetclover). The shrubs and subshrubs present were big sagebrush, silver sagebrush, and fringed sagewort. Plains prickly pear was also present. Refer to Table 2.8-10 for relative Ponderosa Pine Woodland cover summary and Appendix 2.8-C for a complete Ponderosa Pine Woodland cover summary.

Table 2.8-10: Vegetation Cover Sampling Data Summary of Species by Lifeform for the Ponderosa Pine Woodland Community

	Vegetation Cover	
	Absolute	**Relative (%)**
Cool Season Perennial Grasses	6.64	19.34
Warm Season Perennial Grasses	7.67	22.34
Annual Grasses	0.27	0.79
Annual Forbs	0.15	0.44
Biennial Forbs	0.05	0.15
Perennial Forbs	0.42	1.22
Perennial Shrubs	0.70	2.04
Perennial Sub-Shrubs	0.22	0.64
Succulents	0.16	0.47
Trees	18.05	52.58

2.8.5.1.6 Upland Grassland

Cover

The Upland Grassland community comprised approximately 2,187.56 of the 10,557.03 acres of the PAA (20.72 percent). Thirty cover transects were sampled for the Upland Grassland community. Originally there were 31 transects sampled in this community, however, upon review transect 26 was discarded due to the fact that it was not representative of the community. Absolute total vegetation cover was 46.02 percent. Absolute bare soil and litter/rock percentages were 11.07 and 41.13, respectively. Absolute total ground cover was 88.95 percent. Buffalograss provided the highest relative vegetation cover at 27.81 percent, while blue grama provided the next highest relative vegetation cover at 27.10 percent. Refer to Table 2.8-11 for the absolute cover values.

Table 2.8-11: Absolute Cover for the Upland Grassland Vegetation Community

Vegetation Parameter	Mean
Absolute Total Vegetation Cover (%)	46.02
Absolute Total Cover (%)	88.47

Sample Adequacy

There were 30 samples taken in the Upland Grassland community. The sample adequacy formula outlined earlier was utilized to determine the minimum required size of the sample population. Upland Grassland met sample adequacy. Refer to Table 2.8-12 for sample adequacy values.

Table 2.8-12: Summary of Sample Adequacy Calculations for Percent Vegetation Cover in the Upland Grassland

Map Unit	Mean	Standard Deviation	Sample Adequacy	Actual Sample #	Z-Value	Confidence Level Achieved
Upland Grassland						
Total Vegetation Cover	23.00	6.88	29.32	30.00	1.29	90.15
Total Ground Cover	44.23	3.04	1.55	30.00	5.63	NA

Shrub Density

Upland Grassland supported an average of 51.01 shrubs per acre or 0.01 shrubs/m^2. The following full and half/sub-shrub species were found: big sagebrush, fringed sagewort, and broom snakeweed. Refer to Appendix 2.8-D for a complete Upland Grassland density summary.

Species Composition

Species composition for the Upland Grassland community was dominated by warm season perennial grasses with 54.91 percent relative vegetation cover, followed by cool season perennial grasses with 27.66 percent relative vegetation cover. Annual grasses had 9.00 percent relative vegetation cover, while annual forbs had 3.35 percent relative vegetation cover. Perennial forbs had 0.43 percent relative vegetation cover. Subshrubs had a total 0.15 percent relative vegetation cover. Succulents had 4.50 percent relative vegetation cover. The cool season perennial grasses were dominated by western wheatgrass, threadleaf sedge, and crested wheatgrass. Warm season grasses were dominated by blue grama and buffalograss. Annual grasses were dominated by Japanese brome and cheatgrass. Perennial forbs included scarlet globemallow. Annual forbs included desert alyssum, prairie peppergrass, and *Thlaspi arvense* (field pennycress). Fringed sagewort was the only sub-shrub present. Also present was plains prickly pear. Refer Table 2.8-13 for relative Upland Grassland cover summary and to Appendix 2.8-C for a Upland Grassland complete cover summary.

Table 2.8-13: Vegetation Cover Sampling Data Summary of Species by Lifeform for the Upland Grassland Community

	Vegetation Cover	
	Absolute	**Relative (%)**
Cool Season Perennial Grasses	12.73	27.66
Warm Season Perennial Grasses	25.27	54.91
Annual Grasses	4.14	9.00
Annual Forbs	1.54	3.35
Perennial Forbs	0.20	0.43
Perennial Sub-Shrubs	0.07	0.15
Succulents	2.07	4.50

2.8.5.1.7 Cottonwood Gallery

Cover

The Cottonwood Gallery community comprised approximately 240.60 of the 10,557.03 acres of the PAA (2.28 percent). Twenty-six cover transects were sampled for the Cottonwood Gallery community. Absolute total vegetation cover was 62.61 percent. Absolute bare soil and litter/rock percentages were 1.19 and 17.50, respectively. Absolute total ground cover was 97.62 percent. Smooth brome provided the highest relative vegetation cover at 29.12 percent, while western wheatgrass provided the next highest relative vegetation cover at 26.29 percent. Refer to Table 2.8-14 for the absolute cover values.

Table 2.8-14: 2007 Absolute Cover for the Cottonwood Gallery Vegetation Community

Vegetation Parameter	Mean
Absolute Total Vegetation Cover (%)	62.61
Absolute Total Cover (%)	97.62

Sample Adequacy

There were 26 samples taken in the Cottonwood Gallery community. The sample adequacy formula outlined earlier was utilized to determine the minimum required size of the sample population. Cottonwood Gallery met sample adequacy. Refer to Table 2.8-15 for sample adequacy values.

Table 2.8-15: Summary of Sample Adequacy Calculations for Percent Vegetation Cover in the Cottonwood Gallery

Map Unit	Mean	Standard Deviation	Sample Adequacy	Actual Sample #	Z-Value	Confidence Level Achieved
Cottonwood Gallery						
Total Vegetation Cover	31.31	7.65	19.56	26.00	2.95	99.84
Total Ground Cover	48.81	2.08	0.60	26.00	16.92	NA

Shrub Density

Cottonwood Gallery supported an average of 567.60 shrubs per acre or 0.14 shrubs/m^2. The following full and half/sub-shrub species were found: big sagebrush, silver sagebrush, rubber

rabbitbrush, greasewood, and *Symphoricarpos occidentalis* (western snowberry). Refer to Appendix 2.8-D for a complete Cottonwood Gallery density summary.

Tree Density

Tree species within this community were counted on an aerial photograph. Upon counting the number of plains cottonwoods within the community was 295.

Species Composition

Species composition for the Cottonwood Gallery community was dominated by cool season perennial grasses with 55.41 percent relative cover, followed by trees with 21.37 percent relative cover. Warm season perennial grasses had 0.37 percent relative cover. Annual forbs had 18.06 percent relative cover while annual grasses had 1.23 percent relative cover. Perennial forbs had 2.33 percent relative cover. Shrubs had a total 1.23 percent relative cover. The cool season perennial grasses were dominated by smooth brome and western wheatgrass. The warm season perennial grasses included inland saltgrass. Annual grasses were dominated by Japanese brome and cheatgrass. Perennial forbs were dominated by *Cirsium arvense* (Canada thistle) and *Achillea millefolium* (common yarrow). Annual forbs included summer cypress and *Chenopodium album* (lambsquarters goosefoot). Present shrubs were silver sagebrush, greasewood, and *Symphoricarpos occidentalis* (western snowberry). *Populus deltoides* (plains cottonwood) was the only tree present. Refer to Table 2.8-16 below for relative Cottonwood Gallery cover summary and to Appendix 2.8-C for a Cottonwood Gallery complete cover summary.

Table 2.8-16: Vegetation Cover Sampling Data Summary of Species by Lifeform for the Cottonwood Gallery Community

	Vegetation Cover	
	Absolute	**Relative (%)**
Cool Season Perennial Grasses	34.69	55.41
Warm Season Perennial Grasses	0.23	0.37
Annual Grasses	0.77	1.23
Annual Forbs	11.31	18.06
Perennial Forbs	1.46	2.33
Perennial Shrubs	0.77	1.23
Trees	13.38	21.37

2.8.5.1.8 Vegetation Survey Discussion

The proposed 10,580 acre PAA consists of five vegetation communities: Big Sagebrush Shrubland, Greasewood Shrubland, Ponderosa Pine Woodland, Upland Grassland, and Cottonwood Gallery. Each community was investigated for baseline vegetation information in support of a NRC Source Materials License and SD DENR Regular Mine Permit Application.

No threatened or endangered species were encountered within the PAA. The presence of the state 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.

2.8.5.2 Wetlands

2.8.5.2.1 Wetland Survey Methodology

The wetland surveys were conducted in accordance with the Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Region. All WoUS and 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 PAA. 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.

Plate 2.8-2 presents the results of the wetland surveys.

THIS PAGE INTENTIONALLY LEFT BLANK

THIS PAGE INTENTIONALLY LEFT BLANK

THIS PAGE INTENTIONALLY LEFT BLANK

Natural Resources Conservation Service (NRCS) soils mapping for Custer and Fall River Counties, South Dakota, (2007) and BKS soil mapping of the PAA 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 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 PAA.

Field sample locations and resulting wetland boundaries were recorded with a hand-held Garmin GPS map 60Cx Global Positioning System (GPS) unit in NAD 1983 UTM Zone 13. BKS provided drafting services for the project.

2.8.5.2.2 Wetland Survey Results

The PAA was generally characterized by Big Sagebrush Shrubland, Greasewood Shrubland, and Ponderosa Pine Woodland with pockets of Upland Grassland and Agricultural land, mine pit, Silver Sagebrush Shrubland, Shale Outcrop, or Pass Creek. Beaver Creek had Agricultural land to the south and Greasewood Shrubland and Big Sagebrush Shrubland to the north. Agricultural land comprised 399.83 acres, Greasewood Shrubland comprised 2,252.15 acres and Big Sagebrush Shrubland comprised 2,738.85 acres. 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 Pass Creek 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. Please refer to Section 2.8.5.1 for further information regarding the vegetation within the PAA.

The PAA 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 throughout the PAA. The wetland classification along Beaver Creek was Riverine Lower Perennial Emergent (R2EM) and Palustrine Emergent (PEM) WoUS in Pass Creek and other small drainages. The mine pits were primarily designated as Palustrine Unconsolidated Bottom (PUB) OWUS and depressions were typically PEM or PUB designations.

The proposed project may affect a total of 35.114 acres of R2EM, R4SB7 (Riverine Intermittent Streambed vegetated), and PEM stream channel, Palustrine Aquatic Bed Intermittently Flooded Diked (PABJh), Palustrine Unconsolidated Shore Temporarily Flooded (PUSA), PEM, PUB, PUS, and PEMC (seasonally flooded) isolated ponds, and open water (OW). The acreage of OW consists of approximately 9.451 acres.

The area had previously been mined for uranium through several open pit mines; some of the mines had been filled in with water. One livestock watering tank was identified on the survey.

Soils information for the PAA was obtained by NRCS Web Soil Survey for Custer and Fall River Counties, South Dakota, (2007).

There are two main drainage basins located in the PAA; each of the drainages had different soil types. Beaver Creek had Haverson loam, 0-2 percent slopes throughout the drainage. Pass Creek had Barnum silt loam in the south half of the drainage and Barnum-Winetti complex, 0-6 percent slopes. The old mine pits were also classified as Barnum silt loam and Barnum-Winetti complex.

None of the soil map units were found on the hydric soils list for Fall River County or Custer County, South Dakota.

Table 2.8-17 is a summary list of the wetlands in the PAA along with several details about each wetland, including location, delineation designation, geomorphic setting, comments, and jurisdictional recommendations. Table 2.8-18 provides of summary of the 2007 wetland delineation results.

POWERTECH (USA) INC.

Table 2.8-17: Summary of Wetlands within the Proposed Action Area

Map and Plot ID (no Data Form if italicized)	Legal Description	Roll # Photo #	2007 Delineation Designation	Cowardin Classification	Acreage of Cowardin Classification	Geomorphic Setting	Comments	Jurisdictional Recommendation
W1	Sec 32 T6S R1E	R1 P1	Wetland	PEMC	0.005	Depression in tributary	--	Non-jurisdictional
W2	Sec 32, T6S R1E	No photos	Wetland	R2EM	0.017	Tributary to Beaver Creek, wetland channel	--	Jurisdictional
W3	Sec 32, T6S R1E	R1 P12 R1 P13	Non-wetland	--	--	Tributary to Beaver Creek	--	--
W4	Sec. 32, T6S R1E	R1 P2 R1 P3 R1 P4	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
W5	Sec 32, T6S R1E	R1 P5	Non- wetland	--	--	Drainage	Bank of Beaver Creek	--
W6	Sec. 32, T6S R1E	R1 P16	Non-wetland	--	--	Upland tributary	--	--
W7	Sec. 32, T6S R1E	R1 P17 R1 P18	Wetland	R4SB7	0.002	Upland tributary, wetland channel	--	Non-jurisdictional
W8	Sec. 31, T6S R1E	R1 P19 R1 P20	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
W9	Sec. 32, T6S R1E	R1 P23 R1 P24	Wetland	PABJh	0.26	Depression w/ berm	Previously mapped as PABFh	Non-jurisdictional
W10	Sec. 32, T6S R1E	R2 P1 R2 P2	Wetland	PUSA	0.03	Depression	Previously mapped as PEMF	Non-jurisdictional
W11	Sec. 32 T6S R1E	R2 P3 R2 P4	Non-wetland	--	--	Drainage by berm	Previously mapped as PEMF	--
W12	Sec. 32 T6S R1E	R2 P5 R2 P6	Non-wetland	--	--	Drainage	Previously mapped as PEMF	--
W13	Sec. 32 T6S R1E	No photos	Wetland	R4US	0.036	Drainage, wetland channel	Beaver Creek	Jurisdictional
W14	Sec. 32 T6S R1E	R2 P7 R2 P8 R2 P9	Wetland	R4US	0.012	Isolated Drainage, wetland channel	Tributary	Non-jurisdictional
W15	Sec. 30 T6S R1E	R2 P12 R2 P13	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
W16	Sec. 31 T6S R1E	R2 P18 R2 P19	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional

Table 2.8-17: Summary of Wetlands within the Proposed Action Area (cont'd)

Map and Plot ID (no Data Form if italicized)	Legal Description	Roll # Photo #	2007 Delineation Designation	Cowardin Classification	Acreage of Cowardin Classification	Geomorphic Setting	Comments	Jurisdictional Recommendation
W17	Sec. 31 T6S R1E	R2 P22 R2 P23	Non-Wetland	--	--	Ditch around Agricultural area	Previously mapped as PEMA	--
W18	Sec. 31 T6S R1E	R3 P1 R3 P2	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
W19	Sec. 31 T6S R1E	R3 P3 R3 P4	Non-wetland	--	--	Low area	Previously mapped as PEMF	--
W20	Sec. 9 T7S R1E	R3 P8 R3 P9	Wetland	PEM	0.503	Drainage, wetland channel	Pass Creek	Non-jurisdictional
W21	Sec. 9 T7S R1E	R3 P10 R3 P11 R3 P12	Wetland					
W22	Sec. 9 T7S R1E	R3 P13 R3 P14	Wetland					
W23	Sec. 10 T7S R1E	R3 P17 R3 P18	Wetland					
W25	Sec. 34 T6S R1E	R4 P1 R4 P2	Non-wetland	--	--	Drainage	Pass Creek	--
W26	Sec. 34 T6S R1E	R4 P3 R4 P4	Non-wetland	--	--	Drainage	Pass Creek	--
W27	Sec. 34 T6S R1E	R4 P11 R4 P12	Non-wetland	--	--	Drainage	Pass Creek	--
W28	Sec. 34 T6S R1E	R4 P13 R4 P14	Non-wetland	--	--	Drainage	Pass Creek	--
W29	Sec. 3 T7S R1E	R4 P17 R4 P18	Non-wetland	--	--	Drainage	Pass Creek	--
W30	Sec. 10 T7S R1E	R4 P19 R4 P20	Non-wetland	--	--	Depression	--	--
W31	Sec. 10 T7S R1E	R4 P21 R4 P22	Wetland	PUB	1.801	Depression	--	Non-jurisdictional
W32	Sec. 10 T7S R1E	R4 P24 R4 P25	Wetland	PUB	1.475	Depression	--	Non- jurisdictional
W33	Sec. 14 T7S R1E	R5 P1 R5 P2	Wetland	PEM	1.417	Pond	--	Non- jurisdictional
W34	Sec. 14 T7S R1E	R5 P9 R5 P10	Non-wetland	--	--	Drainage	--	--

Table 2.8-17: Summary of Wetlands within the Proposed Action Area (cont'd)

Map and Plot ID (no Data Form if italicized)	Legal Description	Roll # Photo #	2007 Delineation Designation	Cowardin Classification	Acreage of Cowardin Classification	Geomorphic Setting	Comments	Jurisdictional Recommendation
W35	Sec. 14 T7S R1E	R5 P11 R5 P12	Wetland	PUB	1.972	Depression	--	Non-jurisdictional
W36	Sec. 10 T7S R1E	R5 P20 R5 P21	Wetland	PEM	0.253	Outfall	Drainage	Non-jurisdictional
W37	Sec. 34 T6S R1E	R6 P6 R6 P7 R6 P8 R6 P9 R6 P10	Non-wetland	OW	7.635	Old Mine Pit	--	--
W38	Sec. 2 T7S R1E	R6 P13 R6 P14	Wetland	PUS	1.099	Depression	--	Non-jurisdictional
W39	Sec. 2 T7S R1E	R6 P16 R6 P17	Wetland	PUS	0.308	Depression w/ manmade berm	--	Non-jurisdictional
W40	Sec. 1 T7S R1E	R6 P18	Wetland	PEM	0.213	Pond	--	Non-jurisdictional
W41	Sec. 1 T7S R1E	R6 P19 R6 P20	Wetland	PUB	0.008	Old Mine Pit	--	Non-jurisdictional
W42	Sec. 1 T7S R1E	R6 P22 R6 P23 R6 P24	Wetland	PUB	0.167	Old Mine Pit	--	Non-jurisdictional
W43	Sec. 36 T6S R1E	Outside of PAA, deleted photographs from Appendix 2.8-F and datasheet from Appendix 2.8-G						
W44	Sec. 2 T7S R1E	R7 P24 R8 P1 R8 P2	Wetland	PEM	0.378	Depression near drainage	--	Non-jurisdictional
W45	Sec. 1 T7S R1E	R8 P4 R8 P5	Wetland	PEM	0.035	Depression	--	Non-jurisdictional
Wpt 3	Sec. 32 T6S R1E	R1 P6 R1 P7	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
Wpt 4	Sec. 32 T6S R1E	R1 P8 R1 P9	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
Wpt 22	Sec. 30 T6S R1E	R2 P14 R2 P15	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional

Table 2.8-17: Summary of Wetlands within the Proposed Action Area (cont'd)

Map and Plot ID (no Data Form if italicized)	Legal Description	Roll # Photo #	2007 Delineation Designation	Cowardin Classification	Acreage of Cowardin Classification	Geomorphic Setting	Comments	Jurisdictional Recommendation
Wpt 26	Sec. 31 T6S R1E	R2 P24	Wetland	R2EM	13.376 total	Drainage, wetland channel	Beaver Creek	Jurisdictional
Wpt 27	Sec. 31 T6S R1E	R3 P5	Non-wetland	--	--	Depression	Previously mapped as PEMFh, no longer present	--
Wpt 29	Sec. 30 T6S R1E	R3 P6 R3 P7	Non-wetland	--	--	Depression	Previously mapped as PEMC and PEMFx, no longer present	--
Wpt. 35	Sec. 3 T7S R1E	R3 P23 R3 P24	Non-wetland	--	--	Drainage	Cottonwood Drainage	--
Wpt. 56	Sec. 3 T7S R1E	R5 P3 R5 P4	Non-wetland	--	--	Depression	Previously mapped as PEMAf- not present	--
Wpt. 57	Sec. 14 T7S R1E	R5 P5	Non-wetland	--	--	Depression	--	--
Wpt. 58	Sec. 14 T7S R1E	R5 P8	Wetland	PEM	1.417	Pond	Same as W33	Non- jurisdictional
Wpt. 60 and Wpt. 61	Sec. 15 T7S R1E	R5 P13 R5 P14 R5 P15	Non-wetland	--	--	Depression	Salt Crust present	--
Wpt. 62	Sec. 10 T7S R1E	R5 P16 R5 P17	Non-wetland	--	--	Depression	Previously mapped as PEMCh, not present	
Wpt. 68	Sec. 10 T7S R1E	R5 P18 R5 P19	Wetland	PEM	0.253	Outfall	Same as W36	Non-jurisdictional
Wpt. 74	Sec. 11 T7S R1E	R6 P1 R6 P2	Non-wetland	--	--	Depression	Previously mapped as PEMCh, not present	
Wpt. 78	Sec. 12 T7S R1E	R6 P5	Non-wetland	--	--	Depression	Previously mapped as PEMCh, not present. Nor the PEMCh just north of the point.	

Table 2.8-17: Summary of Wetlands within the Proposed Action Area (concl.)

Map and Plot ID (no Data Form if italicized)	Legal Description	Roll # Photo #	2007 Delineation Designation	Cowardin Classification	Acreage of Cowardin Classification	Geomorphic Setting	Comments	Jurisdictional Recommendation
Wpt. 83	Sec. 2 T7S R1E	R6 P15	Wetland	PUS	0.308	Depression w/ manmade berm	Same as W39	Non-jurisdictional
Wpt. 88 and Wpt. 89	Sec. 1 T7S R1E	R7 P1 R7 P2	Non-wetland	--	--	Old Mine Pit	Dominated by rabbit brush and *Hordeum jubatum*	--
Wpt. 92	Sec. 1 T7S R1E	R7 P5 R7 P6 R7 P7	Non-wetland	OW	0.452	Old Mine Pit	Mine Pit filled with water	--
Wpt. 94	Sec. 1 T7S R1E	R7 P9	Non-wetland	--	--	Old Mine Pit	Mine pit is dry, no vegetation	--
Wpt. 97	Sec. 1 T7S R1E	R7 P14	Non-wetland	--	--	Depression	Previously mapped PEMCh not present	--
Wpt 103	Sec. 2 T7S R1E	R7 P20	Wetland	PEM and OW	2.364	Old Mine Pit	--	Non-jurisdictional
Wpt 104	Sec. 2 T7S R1E	R7 P21 R7 P22 R7 P23	Wetland	PUS	1.299	Depression	--	Non-jurisdictional

Table 2.8-18: Summary of 2007 Wetland Delineation Results

Summary		
Number of Features	**Name**	**Acres**
2	Wetland Channel (PEM)	0.756
2	Wetland Channel (R2EM)	13.393
1	Wetland Channel (R4SB7)	0.002
2	Wetland Channel (R4US)	0.048
4	PEM Isolated Ponds	2.043
1	PEMC Isolated Pond	0.005
1	PABJh Isolated Ponds	0.260
1	PUSA Isolated Ponds	0.030
3	PUB Isolated Depression	5.248
3	PUS Isolated Depression	2.706
5	Mine Pits PUB, PEM, OW	10.626
	Total	**35.114**
	Wetland Channel (PEM)	1,842.05 Linear Feet (0.35 mi)
	Wetland Channel (R2EM)	34,079.65 Linear Feet (6.45 mi)

Results:

Beaver Creek

Beaver Creek is located in the northwest of the PAA in Sections 30, 31, and 32 in T6S, R1E. The entire stretch of Beaver Creek within the project boundary is designated as a R2EM wetland, for a total of 13.376 acres. Seven data forms were filled out for the variety of lengths in the drainage as well as four photo waypoints. The most common vegetation that was identified along the drainage was *Spartina pectinata* (prairie cordgrass), *Juncus balticus* (Baltic rush), and *Schoenoplectus pungens* (common threesquare). These plants have an indicator status of FACW (facultative wet), FACW, and OBL (obligate) respectively.

Pass Creek

Pass Creek is centrally located within the PAA in T7S, R1E in Sections 3, 9, and 10, and T6S, R1E in Section 34. Pass Creek only had wetlands present in Section 9, primarily due to an old open flowing well on the other side of the road outside the project boundary. The wetland totaled 0.503 acres of PEM, a total of four datasheets were filled out. The common vegetation found within the wetland was prairie cordgrass and common threesquare. The remaining drainage was walked and delineated, however no other wetlands were present. Five non-wetland

datasheets were filled out and photo points were taken. Refer to Table 2.8-17, Summary of Wetlands within the PAA for more details.

Previously Mapped Wetlands Confirmed as a Non-Wetland

There were several National Wetlands Inventory 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 Table 2.8-17, Summary of Wetlands within the PAA for more details. Previously mapped wetlands that are no longer present do not appear on the map (Plate 2.8-2).

Old Mine Pits

There are seven old uranium open pits present within the PAA. 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 T7S, R1E in Section 1 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 totaled 7.635 acres another small mine pit located at waypoint 92 is Section 1 T7S R1E was classified as OW at 0.452 acres. There were approximately 1.172 acres of wetlands and 9.451 acres of open water within old mine pits in the PAA. Refer to Table 2.8-17, Summary of Wetlands within the PAA for more details.

Depressional Areas and Ponded Areas Identified as Wetlands

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. There were approximately 10.292 acres of wetland depressions and ponds present within the PAA. Refer to Table 2.8-17, Summary of Wetlands within the PAA for more details.

Expanded Boundary Analysis

Surveys for wetlands were conducted inside the buffer boundary and not inside the expanded boundary.

Beaver Creek Update

Beaver Creek is likely to have wetlands throughout the entire PAA 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, the SW1/4 of Section 4 of 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 SW of the Beaver Creek Drainage is 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 of the PAA the likelihood of the depressions being classified as a wetland is rare.

Pass Creek Update

In 2007, Pass Creek had 0.503 acres of PEM wetlands surveyed along its stretch; however due to the recent boundary change there are now only 0.05 acres 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 project boundary.

In 2007, Pass Creek was surveyed from the southern project 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

No changes to the acreages on the 2007 identified old mine pits wetland occurrences.

Depressional Areas and Ponded Areas Identified as Wetlands

No changes 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 SW 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.

2.8.5.3 References

Dorn, R.D., 2001, "Vascular Plants of Wyoming, 3rd Edition", Mountain West Publishing, Cheyenne, Wyoming. 289 pp.

U.S. Army Corps of Engineers. (2008). "Interim Regional Supplement to the corps of Engineers Wetland Delineation Manual: Great Plains Region," J.S. Wakeley, R.W. Lichvar, and C.V. Noble, eds., Technical Report ERDC/EL TR-08-12, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Natural Resource Conservation Service. 2007. Web Soil Survey. http://websoilsurvey.nrcs.usda.gov/app/ May 21, 2007

U.S. Fish and Wildlife Service. 1997. National List of Vascular Plant Species that Occur in Wetlands: 1996 National Summary.

Wyoming Game and Fish. 2007. National Wetlands Inventory Mapping from 1976.

2.8.5.4 Wildlife

2.8.5.4.1 General Setting

This section provides a general discussion of the affected environment for vertebrate terrestrial wildlife and aquatic species (vertebrates and macro-invertebrates). Background information for terrestrial and aquatic fauna in the vicinity of the project was obtained from several sources, including records from SDGFP, BLM, USFWS, USFS, and the TVA DES for similar operations overlapping the PAA. Site-specific data for the project and surrounding perimeter were obtained from those same sources, with current data collected during regular site visits and targeted surveys conducted for this project.

Survey protocols and timing were developed collaboratively with SDGFP to meet species-specific requirements. The survey area included the PAA and one-mile perimeter for threatened and endangered (T&E) species, bald eagle winter roosts, all nesting raptors, upland game bird leks, and big game. Surveys conducted only in the PAA included other vertebrate species of concern tracked by the South Dakota Natural Heritage Program (SDNHP), as well as bats, small mammals, lagomorphs, prairie dog (*Cynomys* spp.) colonies, breeding birds, predators, and herptiles (reptiles and amphibians). Aquatic sampling occurred at water gauge stations located in Beaver Creek upstream of the PAA, and in Beaver Creek and the Cheyenne River downstream of the area. In addition to these targeted efforts, incidental observations of all vertebrate wildlife species seen within the PAA were recorded during each site visit during the year-long baseline survey period. Surveys for black-footed ferrets (*Mustela nigripes*) were not required for this project due to a block clearance issued by the USFWS that includes the entire PAA and vicinity. All surveys were conducted by qualified biologists using standard field equipment and appropriate field guides. Most observations were recorded from vantage points during

pedestrian or vehicular surveys to avoid disturbing wildlife; exceptions included small mammal trapping and aquatic species sampling. Raptor nests, prairie dog colonies, and other features or observation points of special interest were mapped in the field using a hand-held Global Positioning System (GPS) receiver to record the Universal Transverse Mercator (UTM, NAD27) coordinates.

2.8.5.4.2 Big Game

No crucial big game habitats or migration corridors are recognized by the SDGFP in the PAA or surrounding one-mile perimeter. Crucial range is defined as any particular seasonal range or habitat component that has been documented as the determining factor in a population's ability to maintain and reproduce itself at a certain level.

Pronghorn (*Antilocapra americana*) and mule deer (*Odocoileus hemionus*) are the only two big game species that regularly occur in the PAA, and both are considered year-round residents. Elk (*Cervus elaphus*) and white-tailed deer (*O. 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 different times of the year.

The pronghorn is the most common big game species in the project survey area, though no species is prevalent. The pronghorn is a browse species and sagebrush-obligate, using shrubs for both forage and cover (Fitzgerald et al. 1994). Pronghorn herds were most often observed in sagebrush stands just beyond the north-central boundary of the PAA during winter 2007-2008. Conversely, herds were widely distributed throughout grassland habitats in the northwestern and southeastern portions of the survey area during spring, summer, and early fall 2008. In June, after the ground and water pools had dried up, water availability became a limiting factor and pronghorn began to move to, and concentrate around, more dependable water sources such as Beaver Creek and livestock tanks, and to draws with more succulent forage.

Mule deer use nearly all habitats, but prefer sagebrush-grassland, rough breaks, and riparian bottomland (Jones et al. 1983). Browse is an important component of the mule deer's diet throughout the year, comprising as much as 60 percent of total intake during autumn, while forbs and grasses typically make up the rest of their diet (Fitzgerald et al. 1994). In the project survey area, mule deer were observed as individuals or in small herds in ponderosa pine and cottonwood riparian habitats along Beaver and Pass Creeks, and in the pine breaks along the eastern edge of the PAA. They are considered year-round residents in the survey area.

By nature, elk are shy animals that are less accepting of human disturbance than pronghorn (Fitzgerald et al. 1994) or deer. Elk in the project survey area share their range with pronghorn and domestic cattle from spring through fall. Because elk prefer grass to shrubs, the resident herd competes more directly with domestic cattle and wild horses than with pronghorn in the spring and summer months. A herd of six bull elk was observed in the survey area in ponderosa pine habitat on one occasion (June 2008) during the baseline survey period, but local residents report that elk are frequently seen in the pine stands, especially during fall and winter.

White-tailed deer are typically associated with forests, woodlands, and treed galleries along streams (Fitzgerald et al. 1994). Small numbers of white-tailed deer were observed in the project survey area during the baseline survey period, predominantly in the cottonwood corridor along Pass Creek in the central portion of the PAA. Most sightings of white-tailed deer were actually in the cottonwood corridor along the Cheyenne River, approximately 2-2.5 miles south of the PAA. This species is considered an uncommon year-round resident in the survey area itself.

2.8.5.4.3 Other Mammals

A variety of small and medium-sized mammalian species have the potential to occur in the project survey area, although not all were observed in the PAA itself during the baseline wildlife surveys. These potential species include a variety of 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.), jackrabbits (*Lepus* spp.), and cottontails (*Sylvilagus* spp.) can also be found in the project 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. Jackrabbit sightings were uncommon and cottontail sightings were below normal, suggesting these species are currently in a local downward trend. Observations of small mammals occurred most often near Beaver and Pass Creeks, in the northwestern and central portions of the survey area, respectively.

One black-tailed prairie dog (*Cynomys ludovicianus*) colony is located in the northwestern corner of the PAA, and two others are present in the southwestern portion of the one-mile perimeter.

Local ranchers use shooting and other control methods to reduce and/or eradicate prairie dogs from the PAA (private surface) and surrounding private lands.

Other mammal species such as the striped skunk (*Mephitis mephitis*), porcupine (*Erethizon dorsatum*), and various weasels (*Mustela* spp.) inhabit sage-steppe communities, but no sightings or confirmed scat were recorded for these species during the surveys. Infrequent, incidental bat sightings (species unknown) occurred during nocturnal amphibian surveys and spotlighting efforts at targeted ponds in the PAA during the baseline period. A northern river otter (*Lontra canadensis*) carcass was unexpectedly discovered at one of the fisheries sampling points along Beaver Creek in April 2008. The otter may have come up the creek during the flooding that occurred in early April, though the cause of death was not apparent. The carcass was gone by the July sampling period, presumably washed back downstream with the next flood event. Otters are tracked by the SDNHP.

Small mammal trapping was conducted during fall 2007 as part of the baseline survey requirements for the project. Trapping occurred in nine transects spread among six habitat types: Upland Grassland, Ponderosa Pine, Greasewood, Cottonwood Gallery, Clay Breaks, and Pine/Sage Edge. Grassland habitats occupy the largest parcels throughout the area, and held four transects; the remaining habitats held one transect each. Each transect included a combination of 20 live traps, 10 snap traps, and 5 pitfall traps. All traps were baited daily, with cotton balls placed in the live and pitfall traps for nesting material. Each transect was run for three consecutive days and nights (per SDGFP). The deer mouse (*Peromyscus maniculatus*) dominated the captures, with only seven individuals of other species recorded (Table 2.8-19). Deer mice are known for their ubiquitous presence and generalized habitat use, and these survey results are similar to those from other recent trapping efforts in northwest South Dakota.

Table 2.8-19: Small Mammal Abundance[1] during Trapping within the Proposed Action Area in September 2007

Species	Total
Deer mouse (*Peromyscus maniculatus*)	152
Olive-backed pocket mouse (*Perognathus fasciatus*)	3
Western harvest mouse (*Reithrodontomys megalotis*)	3
Northern grasshopper mouse (*Onychomys leucogaster*)	1
Totals	**159**

Lagomorph (hares and rabbits) surveys are also a common component of baseline wildlife inventories. Spotlight lagomorph counts were conducted on two consecutive nights in fall 2007. Cottontail abundance was twice that of jackrabbits, though neither count was especially high (Table 2.8-20). Results from lagomorph surveys conducted in northeast Wyoming annually since 1984 indicate that the regional lagomorph population is experiencing a downward trend in its regular cyclic pattern. Although no data is available from the PAA prior to 2007, its proximity to the annual survey area in Wyoming suggests that the population trend is similar in southwestern South Dakota.

Table 2.8-20: Total Lagomorphs Observed During Spotlight Surveys and Abundance Indices within the Proposed Action Area in September 2007

	Species		
	White-tailed jackrabbit	**Cottontail**	**Totals**
Total Count	**12**	**28**	**40**
Lagomorphs/Survey Mile	**1.5**	**3.4**	**4.9**

[1] Survey route totaled 8.2 miles.
[2] Number given is highest count per species from two survey nights.

2.8.5.4.4 Raptors

Raptor species observed during the project baseline wildlife surveys included the bald eagle, red-tailed hawk (*Buteo jamaicensis*), golden eagle (*Aquila chrysaetos*), ferruginous hawk (*Buteo regalis*), 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 (*Bubo virginianus*), and long-eared owl (*Asio otus*). Other raptor species could also occur in the survey area, particularly as seasonal migrants, but were not seen during the 2007 and 2008 inventories.

Raptor sightings were recorded frequently throughout the project survey area during 2007 and 2008 in ponderosa pine, cottonwood riparian, and grassland habitats. Observations were most concentrated in proximity to Beaver Creek and Pass Creek, perhaps because of prey availability due to the presence of water and better vegetative cover along those drainages. Raptors were observed hunting, perching on nest trees, power poles, and topographic features, nest tending, incubating, and exhibiting nest defense. 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 during the baseline survey period, though some of those species may leave the area under harsher winter conditions.

Biologists watched for active raptor nests and breeding behavior (territory defense, courtship flights, prey deliveries, etc.) during all site visits within the breeding season. Additional nest searches were conducted concurrent with other surveys completed during the non-breeding season. Nests were monitored from a distance using binoculars and a spotting scope early in the nesting season to avoid impacting active nests. All active nests were monitored throughout the breeding season to determine their success and production level.

Five confirmed, intact (i.e., material present) raptor nests and one potential nest site were documented in the PAA during the 2007-2008 baseline survey period; two additional nests were recorded in the one-mile survey perimeter (see Plate 2.8-3). All eight nests are listed in Table 2.8-21, including their locations, and their status and productivity in 2008. Three raptor species tracked by the SDNHP nested in the PAA. The bald eagle and long-eared owl (*Asio otus*) successfully nested within the PAA. A merlin (*Falco columbarius*) was recorded at a potential nest site in the pine breaks east of the proposed project boundary. The bird exhibited defensive behavior near the nest site, but no young or signs of active use (e.g., droppings, prey remains, egg shells, etc.) were recorded there.

Table 2.8-21: Raptor Nest Locations and Activity in and Within1 Mile of the Proposed Action Area during Baseline Wildlife Surveys from mid-July 2007 through early August 2008

Species[1,2]	¼ Section	Township/Range	Habitat	Status	Location
LEOW	**SESW 35**	**6 South/1 East**	**Ponderosa Pine**	**1+ owl fledged**	**Permit area**
RTHA (2 nests)	SENE 29	6 South/1 East	Ponderosa Pine	1 hawk fledged	Permit area
RTHA	SESW34	6 South/1 East	Cottonwood-riparian	2 hawks fledged	Permit area
BAEA	**Mid-SW 30**	**6 South/1 East**	**Cottonwood-riparian**	**1 eagle fledged**	**Permit area**
MERL	**NWSW 36**	**6 South/1 East**	**Ponderosa Pine**	**Nest defense but no confirmed young**	**1-mile perimeter**
GHOW	SWNE 5	7 South/1 East	Lone, live cottonwood tree	Status unknown[3]	Permit area
Unk Buteo	NWSE 27	41 North/60 West (Wyoming)	Lone, dead cottonwood tree	Inactive	1-mile perimeter

[1] **Bold** species are tracked by the South Dakota Natural Heritage Program – South Dakota Department of Game, Fish and Parks (SDGFP web page, last updated September 2, 2008).
[2] Species Codes:
BAEA = Bald eagle
GHOW = Great horned owl
LEOW = Long-eared owl
MERL = Merlin
RTHA = Red-tailed hawk
Unk Buteo = Unknown *Buteo* (soaring hawks) species
[3] One adult GHOW was observed in the nest tree, but no chicks, feathers, droppings, or prey items were observed in or on the nest, or on the ground under the nest.

2.8.5.4.5 Upland Game Birds

The wild turkey (*Meleagris gallopavo*) and mourning dove (*Zenaida macroura*) were the only upland game bird species observed in the project 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 PAA.

Three grouse species could potentially occur in the PAA (PAA and one-mile perimeter): the greater sage-grouse (*Centrocercus urophasianus*), sharp-tailed grouse (*Tympanuchus phasianellus*), and ruffed grouse (*Bonasa umbellus*). The greater sage-grouse is a species of great concern throughout the west, and is considered a "landscape species" due to its use of wide expanses of sagebrush as primary habitat during each phase of its life cycle. Searches for grouse

leks were completed between April 7 and May 12, 2008. Surveys were conducted between first light and approximately one hour after sunrise. Biologists searched for displaying grouse by driving through the PAA and one-mile perimeter, and making frequent stops at vantage points to scan and listen for strutting birds. 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 PAA in recent years. No grouse were observed during the entire year-long baseline survey period for this project. Potential habitat for sage-grouse is present, but only in small stands of sage surrounded by grasslands and pine breaks; such habitat is not conducive to supporting a population of sage-grouse.

2.8.5.4.6 Other Birds

Lists of avian species tracked by the SDNHP were obtained from Mr. S. Michals (SDGFP) in July 2007 and the SDGFP website in September 2008. Biologists watched for all vertebrate species of concern during each site visit to the PAA during the year-long baseline survey period. All observations were recorded, including notes on species, number of individuals, age and sex (when possible), location, habitat, and activity. Three species of special interest (i.e., tracked by the SDNHP) were observed while conducting other surveys during the baseline inventory period: the Cooper's hawk (*Accipiter cooperii*), golden eagle (*Aquila chrysaetos*), and Clark's nutcracker (*Nucifraga columbiana*). All three species were briefly observed flying over the PAA, but no known nesting or other targeted use was recorded by these species.

In addition to those incidental observations, targeted surveys for breeding birds (primarily passerines) were conducted in the same habitats and along the same general transects within the PAA as the small mammal trapping. Four transects were surveyed in Upland Grassland, and one each in the remaining five habitat types. Breeding bird surveys were conducted using belt transects measuring 100 m wide by 1,000 m long. Transects were surveyed by slowly walking through the center of each line and stopping at least every 50 m to watch and listen for birds. Individuals observed while walking were also recorded, with efforts made to avoid double counting birds. Each transect was surveyed on three consecutive mornings in June 2008. To reduce bias, surveys started in a different habitat type each morning. Surveys began between dawn and sunrise, and were completed within four hours. All birds were identified to species. Flyovers and birds seen and heard beyond the transect boundaries were recorded as incidentals, but were not included in the analysis. Surveys were not conducted during inclement weather (precipitation, moderate to heavy winds, etc.).

Weather conditions during all surveys were mostly calm and clear, with a light breeze and approximately 25 percent high, thin cloud cover. Thirty-six species were observed within the breeding bird transects during spring 2008, with two additional unknown species logged (Table 2.8-22). 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 species of the 36 observed that is tracked by the SDNHP. As expected, several species were associated with specific habitat types. For example, the curlew was only seen in the grassland transects (Table 2.8-22). Likewise, several species typically associated with trees were only observed in or immediately adjacent to the Cottonwood Gallery or Ponderosa Pine transects: the chipping sparrow (*Spizella passerina*), mountain bluebird (*Sialia currucoides*), black-capped chickadee (*Poecile atricapillus*), and yellow-rumped warbler (*Dendroica coronata*), among others. Similar associations were noted between other species and habitats.

Table 2.8-22: Breeding Bird Species Richness and Relative Abundance in Six Habitat Types within the Proposed Action Area in June 2008

	Average Number of Birds per Habitat Type[1]						
Species[2]	**BB**	**COT GAL**	**G**	**GW**	**P-SB Edge**	**PP**	**AVG #/PLOT**
Western meadowlark (*Sturnella neglecta*)	3.0	1.7	2.9	7.0	2.0	---	2.8
Mourning dove (*Zenaida macroura*)	5.0	1.7	1.9	0.7	0.3	2.0	1.9
Long-billed curlew (*Numenius americanus*)	---	---	1.9	---	---	---	0.9
Chipping sparrow (*Spizella passerina*)	---	---	---	0.3	4.0	1.6	0.6
Lark sparrow (*Chondestes grammacus*)	3.7	---	---	---	1.7	---	0.6
Grasshopper sparrow (*Ammodramus savannarum*)	---	---	0.1	4.3	---	---	0.5
Northern flicker (*Colaptes auratus*)	---	4.3	---	0.3	---	---	0.5
Mountain bluebird (*Sialia currucoides*)	---	---	---	---	2.3	2.0	0.5
Brewer's blackbird (*Euphagus cyanocephalus*)	---	3.7	---	---	---	---	0.4
Spotted towhee (*Pipilo maculatus*)	---	1.3	---	0.3	0.7	1.0	0.4
American kestrel (*Falco sparverius*)	0.3	2.3	0.2	---	---	---	0.4
Brown-headed cowbird (*Molothrus ater*)	---	0.3	---	---	2.0	1.0	0.4
House wren (*Troglodytes aedon*)	---	2.7	---	---	---	---	0.3
Yellow warbler (*Dendroica petechia*)	---	2.0	---	---	---	---	0.2
Say's phoebe (*Sayornis saya*)	---	0.3	---	---	1.3	---	0.2
Bullock's oriole (*Icterus bullockii*)	---	1.7	---	---	---	---	0.2
Unknown flycatcher	---	---	---	---	---	1.7	0.2
Eastern kingbird (*Tyrannus tyrannus*)	---	1.3	---	---	---	---	0.1
Red-tailed hawk (*Buteo jamaicensis*)	---	0.3	0.1	0.3	---	---	0.1
Black-capped chickadee (*Poecile atricapillus*)	---	0.3	---	---	---	0.7	0.1
Yellow-rumped warbler (*Dendroica coronata*)	---	0.3	---	---	---	0.7	0.1

Table 2.8-22: Breeding Bird Species Richness and Relative Abundance in Six Habitat Types within the Proposed Action Area in June 2008 (Concl.)

	Average Number of Birds per Habitat Type[1]						
Species[2]	**BB**	**COT GAL**	**G**	**GW**	**P-SB Edge**	**PP**	**AVG #/PLOT**
European starling (*Sturnus vulgaris*)	---	1.0	---	---	---	---	0.1
Great horned owl (*Bubo virginianus*)	---	1.0	---	---	---	---	0.1
Vesper sparrow (*Pooecetes gramineus*)	---	---	0.3	---	---	---	0.1
American crow (*Corvus brachyrhynchos*)	---	---	0.1	---	---	0.3	0.1
Red-headed woodpecker (*Melanerpes erythrocephalus*)	---	0.7	---	---	---	---	0.1
Rock wren (*Salpinctes obsoletus*)	0.7	---	---	---	---	---	0.1
Western kingbird (*Tyrannus verticalis*)	I	0.7	---	---	---	---	0.1
American robin (*Turdus migratorius*)	---	0.3	---	---	---	---	<0.1
Common nighthawk (*Chordeiles minor*)	---	I	---	---	---	0.3	<0.1
Indigo bunting (*Passerina cyanea*)	---	0.3	---	---	---	---	<0.1
Killdeer (*Charadrius vociferous*)	---	---	0.1	---	---	---	<0.1
Lazuli bunting (*Passerina amoena*)	---	0.3	---	---	---	---	<0.1
Western wood peewee (*Contopus sordidulus*)	---	---	---	---	0.3	---	<0.1
Yellow-breasted chat (*Icteria virens*)	---	0.3	---	---	---	---	<0.1
Red-winged blackbird (*Agelaius phoeniceus*)	---	---	I	---	---	---	I
Turkey vulture (*Carthartes aura*)	I	I	---	---	---	---	I
Average # Birds/Transect	12.3	29.0	7.7	13.3	15.3	10.7	12.4
TOTAL SPECIES	5	23	10	7	10	10	36

BB = Bentonite breaks; GW = Greasewood
COT GAL = Cottonwood Gallery; P-SB = Pine-sagebrush
G = Grassland; PP = Ponderosa pine
I = Incidental flyover during breeding bird survey (not counted in totals)

[2] **Bold** species are tracked by the South Dakota Natural Heritage Program – South Dakota Department of Game, Fish and Parks (SDGFP web page, last updated September 2, 2008).

2.8.5.4.7 Waterfowl, Shorebirds

Under natural conditions, the PAA provides limited seasonal habitat for waterfowl and shorebirds. As described previously, natural aquatic habitats in the PAA occur mainly in Beaver Creek and Pass Creek, with a few scattered stock reservoirs also present. Because of the limited precipitation in the area, such habitats are available primarily during the spring migration period, with less reliable nesting and brood-rearing habitat in the area.

Although specific surveys for waterfowl and shorebirds were not required for the project, biologists recorded all birds seen during the year-long survey period. Eight species associated specifically with water and/or wetlands were observed during the baseline inventories: the American white pelican (*Pelecanus erythrorhynchos*), great blue heron (*Ardea herodias*), Canada goose (*Branta canadensis*), mallard (*Anas platyrhynchos*), American wigeon (*Anas americana*), killdeer (*Charadrius vociferus*), long-billed curlew, and upland sandpiper (*Bartramia longicauda*). The pelican, heron, and curlew are tracked by the SDNHP.

2.8.5.4.8 Reptiles and Amphibians

The aquatic resources present within the PAA and surrounding perimeter have been thoroughly described in the General Setting and Waterfowl and Shorebird sections, above. Water is a limiting factor throughout the survey area and surrounding lands, with only one perennial stream passing through the western extent of the PAA and all other natural flow categorized as intermittent or ephemeral. Even the perennial Beaver Creek experiences extended periods of low volume and flow in most years. The creeks are meandering streams with extended reaches of muddy soil substrates and intermittent riparian vegetation. Aquatic species are not locally common inhabitants of the PAA. The lack of deep-water habitat and multiple perennial water sources limits the presence of fish, and decreases the potential for other aquatic species to exist.

Three aquatic or semi-aquatic amphibian species and one aquatic reptile were recorded during the 2007 and 2008 surveys in the PAA: 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 PAA, or near stock reservoirs. All four species are common to the PAA, and the region as a whole. One additional aquatic reptile was recorded in the perimeter surrounding the PAA, the western spiny softshell (*Trionyx spiniferus*). That observation also occurred in Beaver Creek, during the July 2008 fisheries sampling session.

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 snake skin 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*).

2.8.5.5 Threatened, Endangered, or Candidate Species and Species Tracked by SDNHP

2.8.5.5.1 Federally Listed Species

No federally listed vertebrate species were documented in the project survey area (current PAA and one-mile perimeter) during the year-long survey period. The black-footed ferret was the only federal T&E vertebrate species that could potentially occur in the PAA. The U.S. Fish and Wildlife Service issued a block-clearance for ferrets throughout the entire state of South Dakota in recent years, including the project survey area in extreme southwestern Custer County and northwestern Fall River County. The only exception to that clearance is in Custer State Park in northern Custer County. Although surveys were not required for the project, they were conducted in the general vicinity of the PAA during monitoring performed for the TVA DES in fall 1977 (TVA DES 1979). No ferrets or evidence of their presence (e.g., trenching, tracks, or scat) were observed during those historic surveys, or during the recent survey period.

2.8.5.5.2 State Listed Species

The State of South Dakota lists 23 vertebrate species as threatened or endangered:

- Threatened: 4 fish, 4 birds, 2 mammals, 1 snake, and 1 turtle
- Endangered: 5 fish, 4 birds, 1 mammal, and 1 snake

The current list of these state species is available on the SDGFP website: http://www.sdgfp.info/Wildlife/Diversity/TES.htm.

Only 1 of those 23 state-level T&E species was documented within the PAA or one-mile perimeter during the survey period (mid-July 2007 through early August 2008). Although the bald eagle was removed from the federal listing process in August 2007, it is still considered as a threatened species at the state level in South Dakota. Bald eagles were repeatedly observed along Beaver Creek in the western portion of the proposed permit area and perimeter during

winter roost surveys conducted in late 2007 and early 2008. One active bald eagle nest is located in the northwestern portion of the revised permit area in mid-SW¼ Section 30, Township 6 South, Range 1 East. The nest is in a cottonwood tree along Beaver Creek. The nest fledged one young in 2008.

2.8.5.5.3 Species Tracked by SDNHP

As described in previous sections, current lists of other vertebrate species of interest or concern tracked by the SDNHP were obtained from SDGFP through personal contacts (July 2007) and from the agency's website (September 2008).

Six vertebrate sensitive species or species of local concern other than the bald eagle were documented within the current (September 2008 configuration) PAA during the baseline survey period: the long-billed curlew, great blue heron, golden eagle, Cooper's hawk, 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 heron, golden eagle, Cooper's hawk, and pelican were merely observed flying over the area; those four species were recorded only once each.

These six 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 six are considered to be either rare and local throughout their statewide ranges, or locally abundant in restricted portions of those ranges.

Four additional vertebrate species of concern were documented at least once each in the one-mile perimeter: the northern river otter, merlin, Clark's nutcracker, and plains topminnow (*Fundulus sciadicus*). The otter and birds were described in preceding sections of this document. The topminnow was captured during fisheries sampling efforts in Beaver Creek, beyond all permit boundary outlines, in July 2008. Additional information about those survey efforts and results is presented in Section 2.8.5.5 (Aquatic Resources), below.

2.8.5.6 Aquatic Resources

2.8.5.6.1 Aquatic Species and Habitats

2.8.5.6.1.1 Aquatic Species and Habitat-Survey Methods

Because Beaver Creek is the only perennial stream in the PAA, and is the receiving water for drainage from the portions of the PAA identified for proposed future ISL 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 PAA to obtain additional site data. Beaver Creek is listed as impaired under Section 303(d) of the federal Clean Water Act for the following constituents: oil, specific conductivity, temperature, total dissolved solids, and total suspended solids (EPA 2008).

Baseline monitoring stations were located at sites that were previously established as water quality monitoring locations on Beaver Creek and the Cheyenne River. Using these sites allows a comparison with past and ongoing water quality records. One site (BVC04) is located upstream and the other (BVC01) is downstream of the proposed ISL activities (refer to Figure 2.9-11 for site locations). Fish sampling for species, abundance, and radiological testing was conducted at both Beaver Creek sites, and at a site on the Cheyenne River downstream of the Beaver Creek confluence (site CHR05).

Baseline sampling of aquatic habitat, benthic macro-invertebrates, and fish was conducted according to protocols developed by the South Dakota Department of Environment and Natural Resources (SDDENR 2002) and the SDPFG (S. Michals, personal communication 2008). Aquatic data collected at the two Beaver Creek sites during the baseline sampling included: stream habitat description; aquatic benthic macro-invertebrate community composition; the variety, condition, and relative abundance of fish species; and radiological analysis of fish collected. As indicated, fish sampling also occurred at CHR05, though SDGFP did not require the other aquatic sampling efforts to be conducted at that location.

Based on conversations with area landowners and the SDGFP, there are no known fish populations in any impoundments within the project area or in any impoundments outside of the project area but immediately downstream from proposed activities within the project area. Field verification of the presence or absence of fish was not made for the relatively small and often dry impoundments within and immediately downstream from the project area.

Powertech (USA) reviewed and discussed the fish sampling plan with SDGFP. SDGFP expressed far greater interest in the potential impacts to flowing water (i.e., Beaver Creek and the Cheyenne River) rather than ephemeral streams such as Pass Creek, ephemeral impoundments, or mine pits. Therefore, an alternative fish sampling program that did not include sampling impoundments was developed in cooperation with SDGFP due to the ephemeral nature of most streams and impoundments within the project area and the absence of known fish populations in impoundments within the project area. Results of the fish sampling are summarized in Table 2.8-23.

Habitat, invertebrate, and fish sampling was conducted during spring (April) and summer (July) conditions in 2008 to provide a baseline for semi-annual monitoring described in NRC Guide 4.14 (NRC 1990). 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. Consequently, neither sampling effort represented the low summer flow conditions that have typically occurred at these sites in recent years (M. Hollenbeck, personal communication 2008).

The habitat description and invertebrate collection efforts followed the SDDENR protocol (SDDENR 2002). 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 accomplished by blocking and seining a 100-meter survey reach downstream of each sample site, according to SDGFP guidelines (S. Michals, personal communication 2008). 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 (mm) 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 (i.e., 6 fish per sample site, 18 total fish), though fewer fish were retained if the target was not achieved. Many of the specimens collected in April 2008 contained no detectable uranium. In an effort to improve the protocol to better represent conditions in

sampled fish populations, up to five individuals of each of six species (i.e., 30 fish per sample site, 90 total fish) were collected in July (when available in the catch) and processed for radiology.

Live fish were bagged, frozen, and kept frozen until they were analyzed for the following:

- Uranium (mg/kg)
- Uranium (µCi/kg)
- Thorium-230 (µCi/kg)
- Radium-226 (µCi/kg)
- Lead-210 (µCi/kg)
- Polonium-210 (µCi/kg)

These analytes are specified in NRC Guide 4.14. Analysis was conducted by Energy Laboratories Inc., in Casper, Wyoming. Lab results are included in Appendix 2.8-H, and are summarized in Table 2.8-23.

Table 2.8-23: Baseline Radiological Analysis of Whole Fish

Site	Species	Number	Length[a] mm	Sample Weight[b] (g)	U Conc.[c] mg/kg	U RL (LLD) mg/kg	U Conc.[c] uCi/kg	U RL (LLD) uCi/kg	Po-210 Conc. uCi/Kg	Po-210 Precision (±) uCi/Kg	Po-210 RL (LLD)	Pb-210 Conc. uCi/Kg	Pb-210 Precision (±) uCi/Kg	Pb-210 RL (LLD)	Th-230 Conc. uCi/Kg	Th-230 Precision (±) uCi/Kg	Th-230 RL (LLD)	Ra-226 Conc. uCi/Kg	Ra-226 Preci-ion (±) uCi/Kg	Ra-226 RL (LLD)
BVC01 April	GRS	1	120	22.96	<MDC	0.02	<MDC	2.0E-05	0.0E+00	6.0E-05	6.0E-05	0.0E+00	2.0E-04	5.0E-05	0.0E+00	2.0E-05	1.0E-05	3.0E-04	9.0E-05	1.0E-04
	PLK	1	48	1.77	<MDC	0.3	<MDC	2.0E-04	0.0E+00	8.0E-04	5.0E-04	2.0E-02	2.0E-02	5.0E-04	2.0E-04	3.0E-04	1.0E-04	-4.0E-04	4.0E-04	9.0E-04
	LND	1	48	0.64	<MDC	0.9	<MDC	6.0E-04	2.0E-03	3.0E-03	1.0E-03	0.0E+00	7.0E-03	1.0E-03	1.0E-03	1.0E-03	3.0E-04	-2.0E-03	1.0E-03	3.0E.-03
	FHM	1	30-60	4	<MDC	0.1	<MDC	1.0E-04	4.0E-04	5.0E-04	2.0E-04	0.0E+00	1.0E-03	2.0E-04	0.0E+00	7.0E-05	5.0E-05	-1.0E-04	2.0E-04	5.0E-04
BVC04 April	PLK	1	40-60	0.72	<MDC	0.8	<MDC	5.0E-04	0.0E+00	1.0E-03	1.0E-03	0.0E+00	8.0E-03	1.0E-03	0.0E+00	4.0E-04	3.0E-04	-1.0E-03	1.0E-03	2.0E-03
	RIC	1	111	18.79	<MDC	0.03	<MDC	2.0E-05	4.0E-04	2.0E-04	5.0E-05	0.0E+00	3.0E-04	5.0E-05	2.0E-05	3.0E-05	1.0E-05	-2.0E-05	6.0E-05	1.0E-04
	GRS	1	50	2.16	<MDC	0.3	<MDC	2.0E-04	6.0E-04	7.0E-04	4.0E-04	0.0E+00	3.0E-03	4.0E-04	8.0E-04	6.0E-04	4.0E-04	-3.0E-04	4.0E-04	9.0E-04
	FHM	1	30-70	~1.2	<MDC	0.02	<MDC	1.0E-05	0.0E+00	2.0E-05	5.0E-05	0.0E+00	9.0E-05	5.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-04	3.0E-05	3.0E-05
	CHC	1	215	72	0.05	0.05	3.0E-05	3.0E-05	9.0E-04	3.0E-04	8.0E-05	0.0E+00	5.0E-04	8.0E-05	2.0E-05	3.0E-05	2.0E-05	-8.0E-05	6.0E-05	1.0E-04
CHR05 April	RIC	1	97	13.73	<MDC	0.04	<MDC	3.0E-05	8.0E-04	3.0E-04	7.0E-05	0.0E+00	4.0E-04	7.0E-05	0.0E+00	5.0E-05	1.0E-05	-9.0E-05	5.0E-05	1.0E-04
	GRS	1	98	13.67	<MDC	0.04	<MDC	3.0E-05	8.0E-05	1.0E-04	7.0E-05	0.0E+00	4.0E-04	7.0E-05	1.0E-05	5.0E-05	1.0E-05	-6.0E-05	7.0E-05	1.0E-04
	SRS	1	169	55.05	<MDC	0.02	<MDC	1.0E-05	2.0E-04	1.0E-04	5.0E-05	0.0E+00	1.0E-04	5.0E-05	2.0E-05	2.0E-05	1.0E-05	-1.0E-05	2.0E-05	3.0E-05
	CRC	1	30-70	2.92	<MDC	0.2	<MDC	1.0E-04	0.0E+00	3.0E-04	3.0E-04	0.0E+00	2.0E-03	3.0E-04	0.0E+00	2.0E-04	7.0E-05	-2.0E-04	3.0E-04	6.0E-04
	PLK	1	32-74	1.51	<MDC	0.4	<MDC	3.0E-04	0.0E+00	1.0E-03	6.0E-04	0.0E+00	3.0E-03	6.0E-04	1.0E-03	8.0E-04	1.0E-04	-5.0E-04	5.0E-04	1.0E-03
	SAS	1	30-60	1.51	<MDC	0.4	<MDC	3.0E-04	0.0E+00	5.0E-04	6.0E-04	0.0E+00	3.0E-03	6.0E-04	1.0E-03	7.0E-04	1.0E-04	-3.0E-04	6.0E-04	1.0E-03

Table 2.8-23: Baseline Radiological Analysis of Whole Fish (Continued)

Site	Species	Number	Length[a] mm	Sample Weight[b] (g)	U				Po-210			Pb-210			Th-230			Ra-226		
					Conc.[c] mg/kg	RL (LLD) mg/kg	Conc.[c] uCi/kg	RL (LLD) uCi/kg	Conc. uCi/Kg	Precision (±) uCi/Kg	RL (LLD)	Conc. uCi/Kg	Precision (±) uCi/Kg	RL (LLD)	Conc. uCi/Kg	Precision (±) uCi/Kg	RL (LLD)	Conc. uCi/Kg	Preci-ion (±) uCi/Kg	RL (LLD)
BVC01 July	FHM	5	42-67	~8	0.026	0.0050	1.8E-05	3.4E-06	4.0E-04	2.3E-04	9.3E-05	1.4E-03	3.6E-03	6.0E-03	-1.2E-05	6.2E-05	1.9E-05	-2.2E-04	1.2E-04	2.9E-04
	PLT	5	48-71	12	0.021	0.0050	1.4E-05	3.4E-06	3.5E-04	2.8E-04	1.1E-04	-2.0E-03	4.2E-03	7.1 E-03	1.0E-04	1.0E-04	2.2E-05	-2.0E-04	1.1E-04	2.7E-04
	PLK	5	57-71	9	0.035	0.0050	2.4E-05	3.4E-06	4.7E-04	3.1E-04	1.1E-04	1.2E-03	4.2E-03	7.1E-03	5.7E-06	1.0E-04	2.2E-05	-2.0E-04	1.lE-04	2.8E-04
	SAS	5	46-62	7	0.031	0.0050	2.1E-05	3.4E-06	2.3E-04	2.6E-04	1.6E-04	3.8E-03	6.1E-03	1.0E-02	9.8E-05	1.6E-04	3.2E-05	-3.0E-04	1.6E-04	4.0E-04
	CAP	1	171	73	0.0098	0.0050	6.7E-06	3.4E-06	7.8E-04	1.9E-04	5.0E-05	7.6E-05	5.0E-04	8.4E-04	-7.4E-07	9.2E-06	2.6E-06	-2.3E-05	1.6E-05	3.6E-05
BVC04 July	SAS	5	45-58	~6.7	0.024	0.0050	1.6E-05	3.4E-06	5.4E-04	5.4E-04	1.1E-04	6.4E-04	4.4E-03	7.3E-03	2.7E-05	1.0E-04	2.3E-05	-7.7E-05	1.3E-04	2.5E-04
	SRS	1	136	130	0.0072	0.0050	4.9E-06	3.4E-06	1.7E-04	1.0E-04	5.0E-05	I.2E-04	1.2E-03	2.0E-03	1.9E-06	2.3E-05	6,3E-06	-3.7E-05	3.2E-05	6.9E-05
	FHM	5	42-61	~3.7	0.031	0.0050	2. 1E-05	3.4E-06	1.8E-04	3. 1E-04	1.2E-04	7.9E-04	4.7E-03	7.9E-03	-1.2E-05	6.9E-05	2.5E.05	-1.2E-04	1.6E-04	3.2E-04
	PLK	5	48-68	~7.2	0.019	0.0050	1.3E-05	3.4E-06	8.5E-05	1.3E-04	1.2E-04	3.2E-03	4.7E-03	7.8E-03	9.4E-05	9.1E-05	2.4E-05	-2.1E-04	1.1E-04	2.8E-04
	CAP	1	260	237	0.014	0.0050	9.4E-06	3.4E-06	1.6E-04	7.1E-05	4.0E-06	9.2E-05	1.5E-04	2.6E-04	2.3E-06	3.7E-06	8.0E-07	-4.8E-06	4.2E-06	9.1E-06
CHR05 July	SAS	5	42-60	~1.5	0.04	0.0050	2.7E-05	3.4E-06	4.9E-04	3.2E-04	1.4E-04	4.5E-03	5.3E-03	8.8E-03	1.4E-04	1.1E-04	2.7E-05	-2.8E-04	1.5E-04	3.8E-04
	FHM	5	38-60	~0.7	0.024	0.0050	1.6E-05	3.4E-06	4.2E-04	2.8E-04	1.1E-04	1.5E-03	4.3E-03	7.2E-03	1.3E-05	4.5E-05	2.2E-05	-2.1 E-04	1.3E-04	3.0E-04
	PLK	4	46-68	~7.4	0.017	0.0050	1.2E-05	3.4E-06	4.7E-04	3.5E-04	1.7E-04	-1.8E-03	6.5E-03	1.lE-02	1.6E-05	8.9E-05	3.4E-05	-2.2E-04	1.9E-04	4. 1E-04
	SRS	2	146-160	78	0.0066	0.0050	4.4E-06	3.4E-06	5.0E-04	1.3E-04	1.3E-05	2.3E-04	4.9E-04	8.1 E-04	3.2E-06	5.3E-06	2.5E-06	-8.7E-05	1.8E-05	3.4E-05
	CAP	1	135	31	0.01	0.0050	6.9E-06	3.4E-06	7.4E-04	2.2E-04	3.1E-05	1.5E-04	1.2E-03	2.0E-03	1.7E-05	2.7E-05	6.1E-06	-6.4E-05	4.4E-05	1.0E-04
	CHC	3	181-290	265	0.017	0.0050	1.2E-05	3.4E-06	1.6E-04	5.2E-05	3.5E-06	3.2E-05	1.4E-04	2.3E-04	9.0E-06	2.6E-05	7.0E-07	-1.6E-06	4.4E-06	8.4E-06
	RIC	4	381-415	5150	0.031	0.0050	2.1E-05	3.4E-06	6.6E-07	3.2E-06	2.7E-06	1.1E-05	1.0E-04	1.7E-04	-1.3E-05	2.3E-05	5.3E-07	8.0E-06	5.4E-06	7.3E-06

Notes:
GRS = Green Sunfish, PLK = Plains Killifish; LND = Longnosed Dace; RIC = River Carpsucker; FHM = Fathead Minnow; CHC = Channel Catfish; SRS = Shorthead Redhorse Sucker; CRC = Creek Chub; SAS = Sand Shiner. U = Uranium; Po = Polonium; Pb = Lead; Th = Thorium; Ra = Radium. [a]Lengths reported as a range when multiple specimens were combined as a composite sample, or when the individual processed for radiology was not recorded separately. [b]Approximate sample weights from field average weights for the species measured in the field. [c]MDC = minimum detectable concentration = RL (reporting limit) in this case.

2.8.5.6.1.2 Aquatic Species and Habitat-Survey Results

2.8.5.6.1.2.1 Habitat

Compiled habitat data forms may be found in Appendix 2.8-I. Summaries of results by site are described below.

Site BVC04

Site BVC04 is located downstream of the Old Highway 85 bridge over Beaver Creek in Weston County, WY (refer to Figure 2.9-11 for site locations). This site was selected as the background site as it is upstream of all proposed project. At BVC04, Beaver Creek is a low gradient prairie stream that is deeply incised in places, is subject to large fluctuations in flow, and shows significant evidence of active erosion (bank slumping, bare soil) and sediment deposition on stream banks and in slow moving pools.

April

The preliminary average channel width at BVC04 was 7.35 meters. Sample transects were located 18.5 meters apart, with a total surveyed reach length of 185 meters. During the April

habitat survey, water temperature varied from 7.0° C to 16.0° C, indicating that stream temperature is highly variable during the day. In general, riparian vegetation is limited to herbaceous and short shrubs, with only occasional trees. With the exception of the bridge, there was no shade present in the center of the channel. As a result, the creek is subject to substantial solar heating during the day. Water was clear during the survey, although specific conductivity was high (5,109 µS/cm), indicating a high concentration of dissolved solids typical of prairie streams in this region. Discharge at BVC04 was 7.31 cfs on April 14.

Within the BVC04 survey reach, habitat included two large pools, two glides, and 3 riffles. The total length of riffles was 54.6 m.

Beaver Creek carries a heavy sediment load during high flow, resulting in a deep layer (up to 2 feet) of fine silt deposited in pools. Silt dominates the sediment composition of the reach, although sand, gravel and cobbles dominate the substrate of the faster moving riffle and glide areas. The cumulative and proportional particle distribution of sediment in the BVC04 reach during the April survey is shown in Figure 2.8-4. This distribution indicates a predominance of silt and sand, with gravel in the riffle areas. Large wood in the reach was located in riffle and glide areas and was generally comprised of small (0.1 to 0.25 m diameter) pieces in the portion of the channel between the wetted channel and the bank full elevation.

Beaver Creek is significantly incised. Bank slumpage was observed at eight transects and erosion at ten of the eleven transects in this reach. The wetted stream width during the survey was 4.2 to 10.7 meters; bank-full width ranged from 5.3 to 11.3 meters; and the width at the top of bank was 10.7 to 17.1 meters. Bank height was up to 2.0 meters. Riparian land use is rangeland with no riparian buffer, cattle have access to the stream, especially in the vicinity of the bridge. Woody vegetation has probably been sparse along Beaver Creek stream banks for many years, which may have contributed to channel down-cutting and erosion, and a general lack of large woody debris and cover in the channel. Examples of channel dimensions in pool, riffle, and run habitat types of the upstream (BVC04) site are shown in Figures 2.8-5, 2.8-6, and 2.8-7, below.

As mentioned previously, pools contained a large volume of silt. This silt reduces the depth and volume of the pools, reducing the quality and quantity of available fish habitat. Due to pool filling and lack of cover, pool quality is poor.

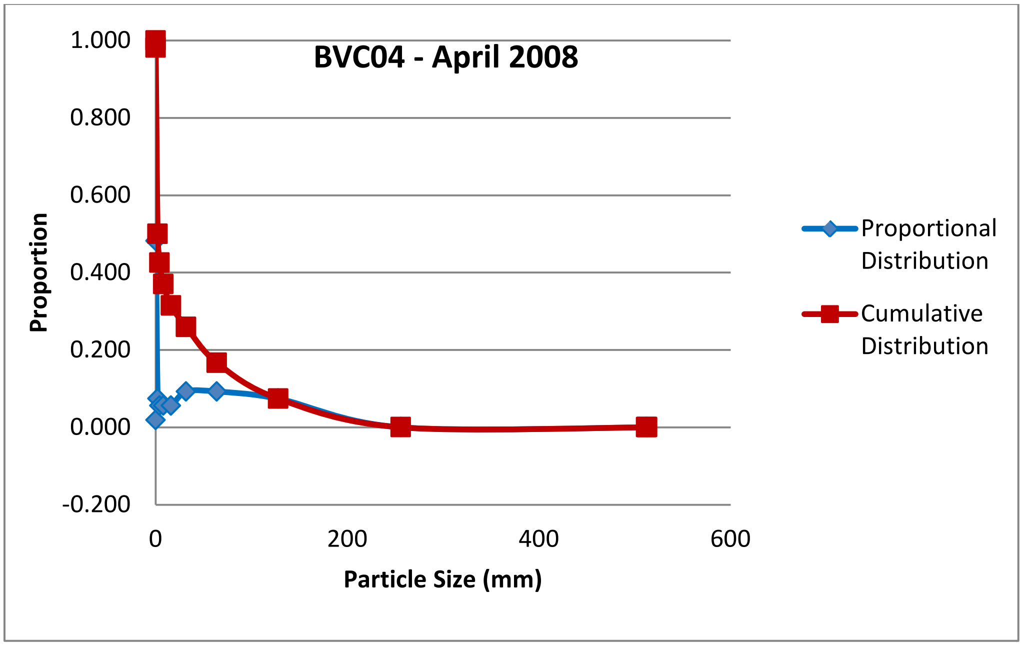


Figure 2.8-4: Cumulative and Proportional Sediment Particle Distribution at Site BVC04, Transects 1 through 11 Combined, April 2008

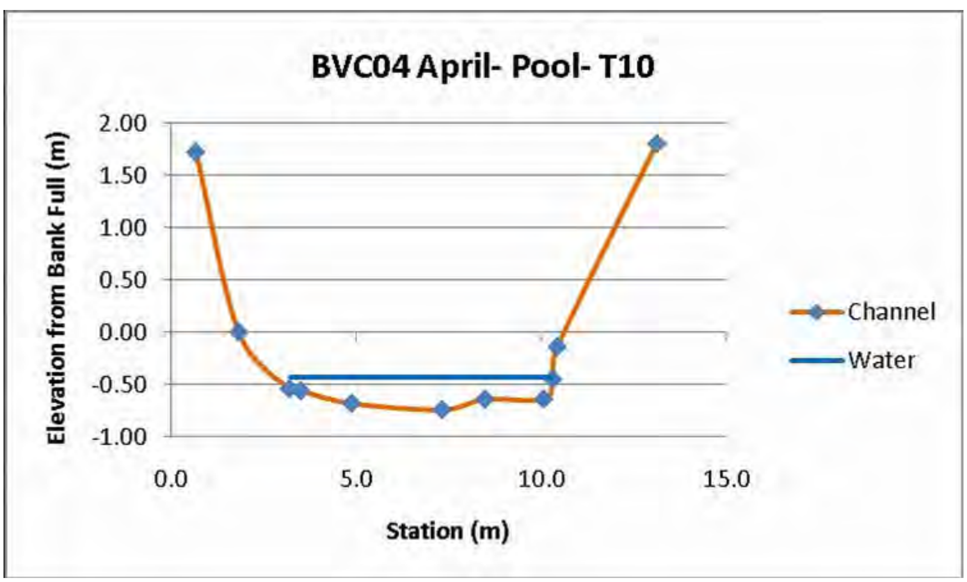


Figure 2.8-5: Channel Dimensions in Pool Habitat, Transect 10

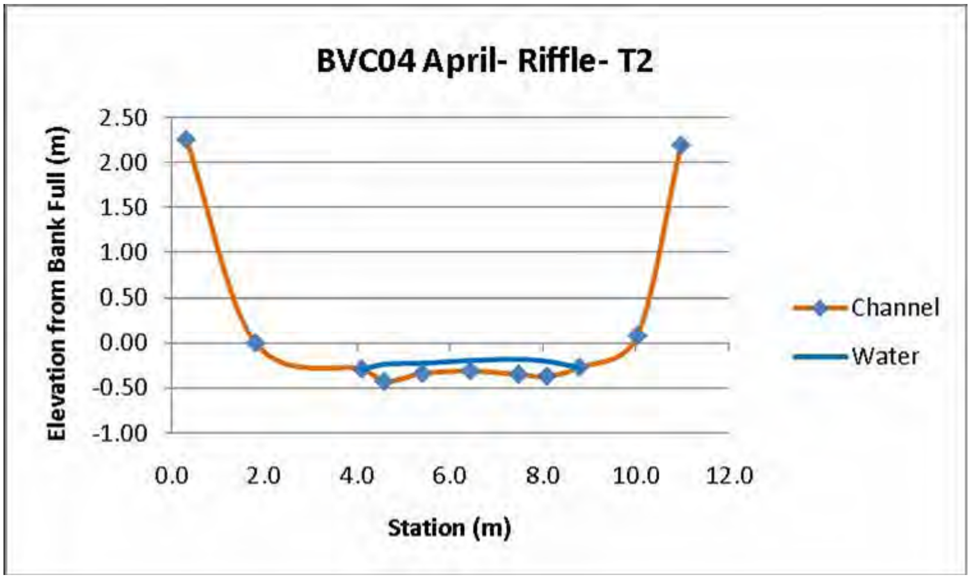


Figure 2.8-6: Channel Dimensions in Riffle Habitat, Transect 2

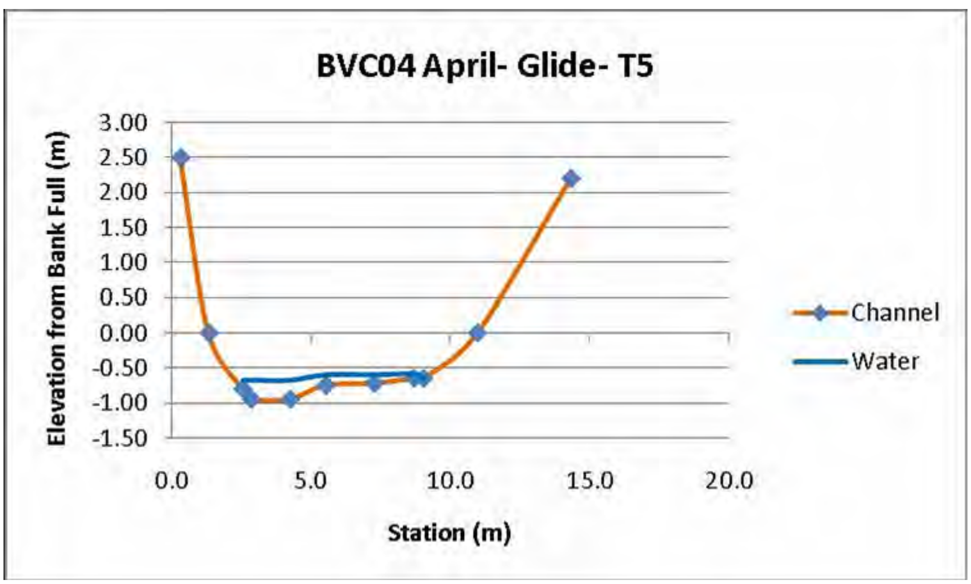


Figure 2.8-7: Channel Dimensions in Glide Habitat, Transect 5

<u>July</u>

In July 2008, the channel dimensions were essentially the same as measured during April, with some localized changes. Between the April and July field visits Beaver Creek experienced high flows that appeared to have resulted in somewhat less fine sediment in the pools, and transport of woody debris out of the survey reach. Stream discharge in July was 12.3 cfs, approximately 5

cfs higher than in April. The average wetted width measured was 6.9 meters in April and 7.5 meters in July.

The July air temperature reached 25° to 35° C and water temperatures were quite warm at 23° C to 24° C. As during April, riparian vegetation was limited to herbaceous and short shrubs, with only occasional trees. Shade along the banks was greater in July, since trees were generally bare in April and fully leafed-out in July. However, most of the stream channel itself was unshaded during both site visits indicating a high degree of solar warming is typical in Beaver Creek.

Within the BVC04 survey reach, habitat included 1 pool, 3 glides, and 3 riffles. The total length of riffles was 59.9, although two riffle segments ran to either side of an island. If these two are considered together, the riffle length measured 43.9 m.

As described under spring conditions, fine silt dominated the sediment composition of the reach and filled the larger part of the pools in at this site. Sand, gravel and cobbles dominate the substrate of the faster moving riffle and glides. The cumulative and proportional particle distribution of sediment for the BVC04 reach during the summer survey is shown in Figure 2.8-8 demonstrating a slightly higher proportion of gravel in the overall substrate composition than in April.

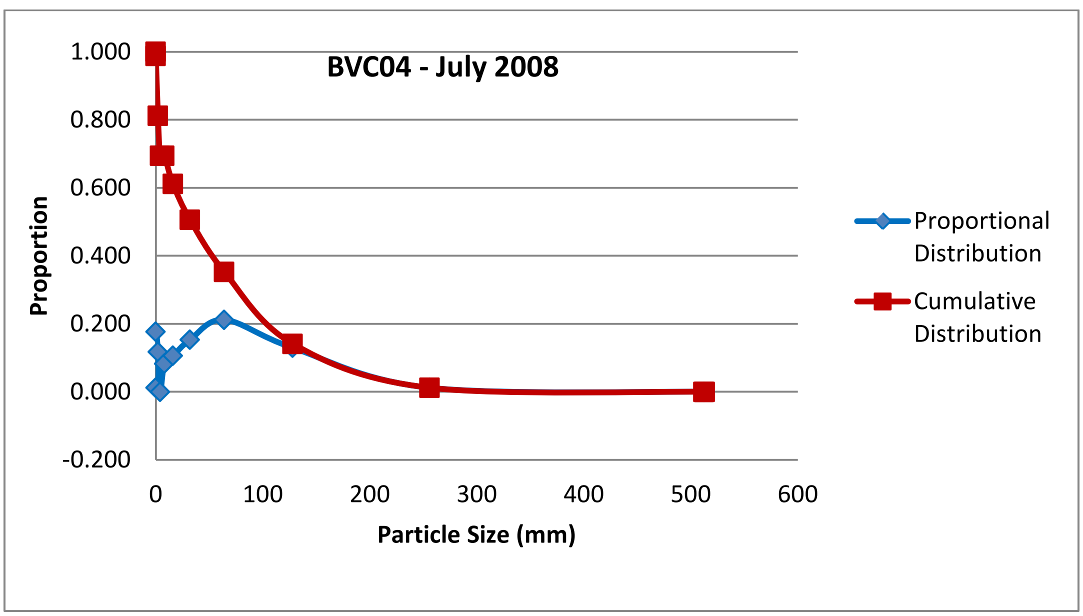


Figure 2.8-8: Cumulative Sediment Particle Distribution at Site BVC04, Transects 1 through 11 Combined during July

Large wood in the reach was essentially absent in July. Small pieces that had been present in April apparently were washed out of the survey reach during the peak flows that occurred in June.

The wetted stream width during the summer survey was 4.3 to 10.1 meters; bank-full width ranged from 6.0 to 11.2 meters; and the width at the top of bank was 15.0 to 21.0 meters. Bank height was 2.1 to 3.9 meters.

As mentioned previously, pools contained a large volume of silt. This silt reduces the depth and volume of the pools, reducing the quality and quantity of available fish habitat. Due to pool filling and lack of cover, pool quality is poor.

Site BVC01

Site BVC01 is located upstream of the Argentine Road bridge over Beaver Creek in Fall River County, SD. This site was selected as the test site as it is downstream of most proposed operations and all proposed land application sites.

At BVC01, Beaver Creek is still a low gradient, incised prairie stream as it is at BVC04. However, the stream gradient is slightly higher and banks are generally lower. Riparian habitat along BVC01 is more actively managed for cattle grazing than BVC04 and there are fewer trees and shrubs and more grass at BVC01 than at BVC04. Fine sediment was present in pools. However, there appeared to be less fine sediment in July indicating that high flows transported sediment out of this reach.

April

The preliminary average channel width at BVC01 was 7.35 meters. Sample transects were located 22 meters apart, with a total surveyed reach length of 220 meters.

During the April habitat and fish surveys, water temperature varied from 11.8° C to 16.9° C, indicating that stream temperature at this site is also variable during the day. As was the case at site BVC04, riparian vegetation at BVC01 was limited to herbaceous and short shrubs, with only a single boxelder tree in the survey reach. With the exception of the bridge, there was no shade present in the center of the channel and the creek is subject to substantial solar heating during the day.

Water was clear during the survey, although specific conductivity was high (7,186 µS/cm); somewhat higher than observed at BVC04. Discharge at BVC01 was 5.08 cfs on April 14, 2008.

Within the BVC01 survey reach, habitat included 3 pools, 2 glides, and 3 riffles. The total length of riffles was 28 meters.

Overall, gravel dominated the sediment composition of the BVC01 reach. The cumulative and proportional particle distribution of sediment for the BVC01 reach during the April survey is shown in Figure 2.8-9. This distribution indicates a predominance of gravel with some fine sediment. The fine sediment was primarily confined to pool areas.

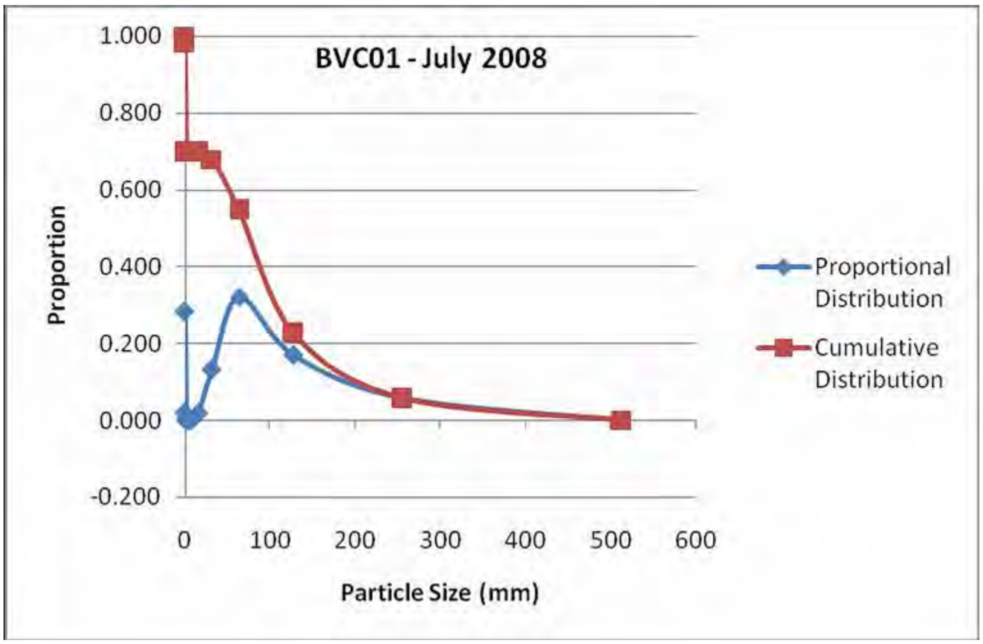


Figure 2.8-9: Cumulative and Proportional Sediment Particle Distribution at Site BVC01, Transects 1 through 11 Combined, April 2008

Beaver Creek is significantly incised along the BVC01 reach, although bank height was generally lower than at the upstream (BVC04) site. Bank slumpage was observed at nine transects and erosion at seven of the eleven transects in this reach. The wetted stream width during the April survey was 3.5 to 7.8 meters; bank-full width ranged from 6.5 to 10.2 meters; and the width at the top of bank was 12.0 to 17.4 meters. Bank height was 1.3 to 2.0 meters. Riparian land use is rangeland with no riparian buffer, cattle have access to the stream, especially in the vicinity of the bridge and transect 1. Woody vegetation is nearly absent from the vicinity of BVC01 and no woody debris was observed in the BVC01 survey reach.

Examples of channel dimensions in pool, riffle, and run habitat types are shown in Figures 2.8-10, 2.8-11, and 2.8-12 below.

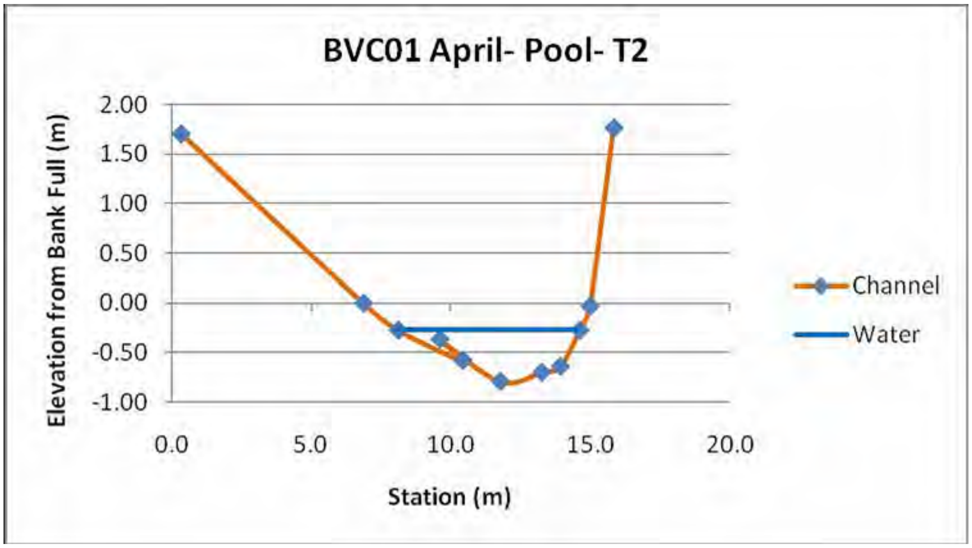


Figure 2.8-10: Channel Dimensions in Pool Habitat, Transect 2

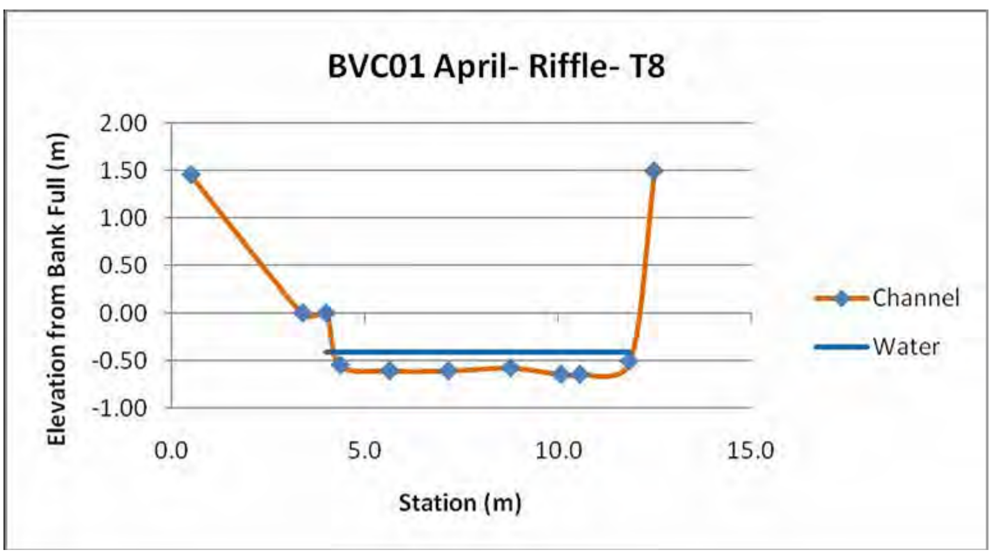


Figure 2.8-11: Channel Dimensions in Riffle Habitat, Transect 8

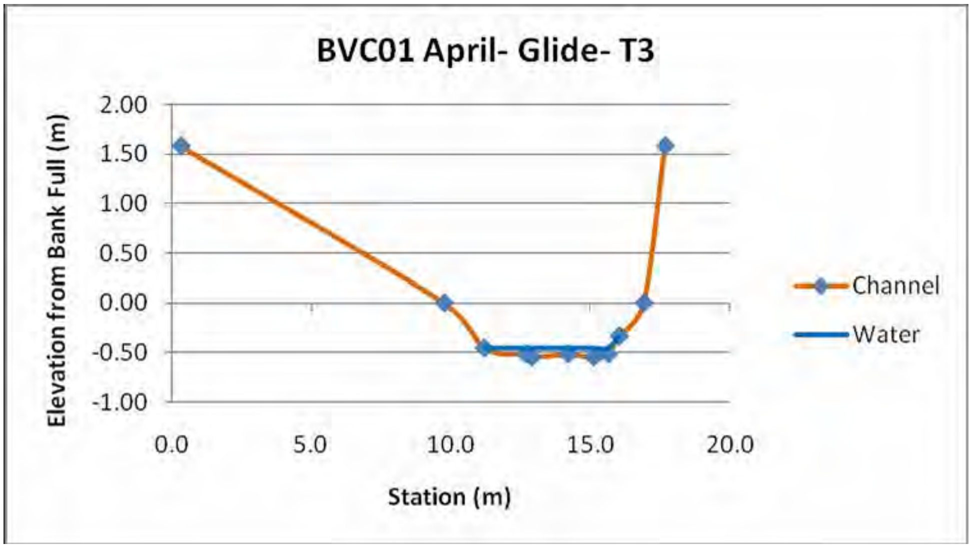


Figure 2.8-12: Channel Dimensions in Glide Habitat, Transect 3

Pools in reach BVC01 were not as deep or long as those in BVC04 and therefore were less conducive to fine sediment deposition. Due to shallow pool depth and lack of cover, pool quality was poor.

<u>July</u>

In July, 2008, the channel dimensions were essentially the same as measured during April, with some localized changes. The high flows that Beaver Creek experienced between the April and July field visits appeared to have resulted in somewhat less fine sediment in the pools. Stream discharge in July was 7.5 cfs, approximately 48 percent higher than in April. In both April and July, discharge was higher at the upstream site (BVC04) than at the downstream site (BVC01). The average wetted width 6.2 meters in April and 7.5 meters in July.

In July the air temperature at BVC01 a water temperatures of 24° C was recorded at 9:20 AM. Although trees were generally bare in April and fully leafed-out in July, the one tree in the riparian buffer was too far from the stream to provide shade to the wetted portion of the channel.

Within the BVC01 survey reach, habitat included 2 pools, 1 glide, and 2 riffles during July. The total length of riffles was 70.8 meters. This represented a change from what was observed in April that was due to increased flow and probably some redistribution of gravel substrate in the channel during high flows.

In contrast to April conditions, very little silt was observed within BVC01 during July. Where fine sediment was present it was restricted to slow moving water in pools and along banks. The

cumulative and proportional particle distribution of sediment for the BVC01 reach during the summer survey is shown in Figure 2.8-13, demonstrating the dominance of gravel in the particle size distribution.

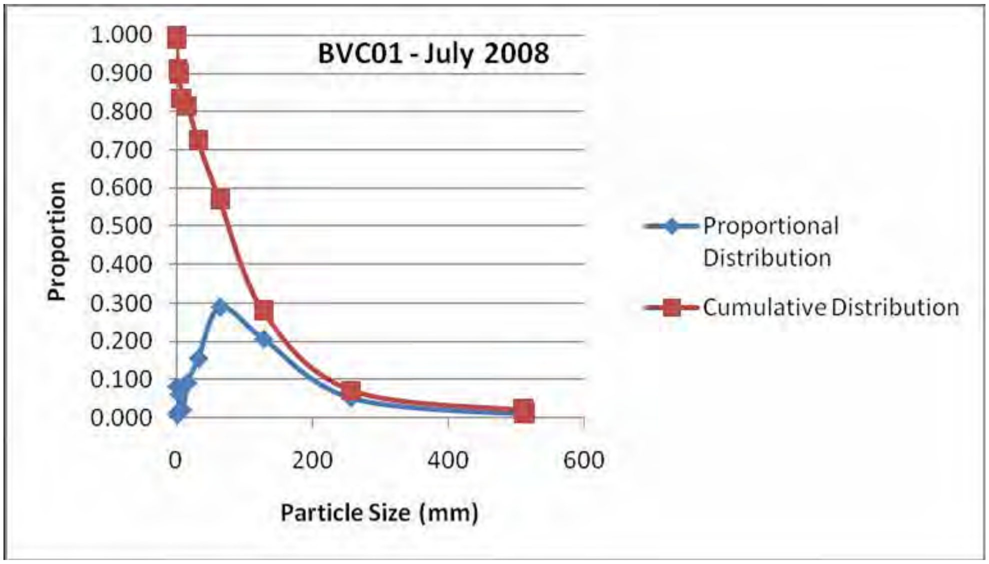


Figure 2.8-13: Cumulative Sediment Particle Distribution at Site BVC01, Transects 1 through 11 Combined during July

Large wood in the reach was essentially absent in July as in April.

The wetted stream width during the summer survey was 4.1 to 8.2 m; bank-full width ranged from 6.8 to 11.3 m; and the width at the top of bank was 12.6 to 18.9 m. Bank height was 1.5 to 2.8 m.

As mentioned previously, pools were considered poor due to lack of depth and cover. Emergent rushes (*Juncus* spp.) and submerged stonewort (*Chara* spp.) were observed growing along the banks in pools during the July survey providing some cover for small fish and substrate for aquatic invertebrates.

2.8.5.6.1.2.2 Habitat/Species Relationships

Benthic Invertebrates

Benthic invertebrates can be useful indicators of habitat quality, providing an index of quality that is integrated over time. Different taxa of aquatic invertebrates (primarily insects, crustaceans, and mollusks) exhibit different habitat requirements, feeding strategies, and tolerances to environmental perturbation. Therefore, there are several metrics of benthic invertebrate community composition that are indicative of aquatic habitat quality. Several of the most indicative and most commonly described of these metrics are summarized in Table 2.8-24.

The invertebrate communities sampled indicate poor habitat conditions in Beaver Creek. The counts of each taxa are shown in Table 2.8-25, and a synopsis of the Community composition metrics is shown in Table 2.8-26. The total number of invertebrates and the taxonomic richness (number of species) were both very 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 very tolerant taxa, *Culiciodes*, were collected at the downstream site (BVC01) in April. All other taxa collected are considered moderately tolerant.

Table 2.8-24: Benthic Invertebrate Community Composition Metrics and Predicted Direction of Response to Perturbation

Category	Metric	Definition	Predicted response to increasing perturbation
Richness measures	Total taxa	Measures the overall variety of the macroinvertebrate assemblage	Decrease
	EPT taxa	Number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)	Decrease
	Ephemeroptera taxa	Number of mayfly taxa (usually genus or species level)	Decrease
	Plecoptera taxa	Number of stonefly taxa (usually genus or species level)	Decrease
	Trichoptera taxa	Number of caddisfly taxa (usually genus or species level)	Decrease
Composition measures	% EPT	Percent composite of mayfly, stonefly, and caddisfly taxa	Decrease
	% Ephemeroptera	Percent of mayfly nymphs	Decrease
Tolerance/Intolerance measures	No. of Intolerant taxa	Taxa richness of those organisms considered to be sensitive to perturbation	Decrease
	% Tolerant organisms	Percent of macrobenthos considered to be tolerant of various types of perturbation	Increase
	% Dominant taxon	Measures the dominance of the single most abundant taxon. Can be calculated as dominant 2, 3, 4, or 5 taxa.	Increase
Feeding measures	% Filterers	Percent of the macrobenthos that filter fine organic particulate matter from the water column or sediment.	Variable
	% Grazers and Scrapers	Percent of the macrobenthos that scrape or graze upon periphyton	Decrease
Habitat measures	Number of clinger taxa	Number of taxa of clinging insects	Decrease
	% Clingers	Percent of insects having fixed retreats or adaptations for attachment to surfaces in flowing water.	Decrease

Source:Barbour et al. 1999

Table 2.8-25: Benthic Macroinvertebrate Counts for Composite Samples Collected April and July 2008

	Site and Date			
	BVC01	**BVC04**	**BVC01**	**BVC04**
Taxa	**14-Apr-08**	**14-Apr-08**	**9-Jul-08**	**9-Jul-08**
Phylum:Mollusca Class:Gastropoda Order: Bassommatophora Family: Physidae	2		2	1
Phylum: Arthropoda Class: Insecta Order: Diptera Family: Ceratopogonidae Genus*: Culiciodes*	1			
Family: Chironomidae Subfamily: Orthocladiinae	14	33		2
Subfamily: Chironomnae		11		1
Subfamily: Tanypodinae			4	23
Family: Siluliidae Genus: *Simulium*	2			1
Order: Trichoptera Family: Hydropsychidae Genus: *Cheumatopsyche*				76
Family: Lepidostomadtidae Genus: *Lepidostoma*	1			
Family: Limnephilidae Genus: *Limnephilus*	3	2		
Order: Coleoptera Family: Elmidae			1	3

Table 2.8-26: Community Composition Metrics for Benthic Macro-invertebrates Collected at the Beaver Creek Sites

							Abundance			
			Functional Feeding Group		Habitat/ Behavior		BVC01	BVC04	BVC01	BVC04
Measures	**Taxa**	**Tolerance**	**Primary**	**Secondary**	**Primary**	**Secondary**	**April**	**April**	**July**	**July**
Taxa	Physidae	8	SC				2		2	1
	Culicoides	10	PR	GC	bu		1			
	Orthocladiinae	5	GC		bu		14	33		2
	Chironominae	6	GC					11		1
	Tanypodinae	7	PR		bu				4	23
	Simulium	6	FC				2			1
	Cheumatopsyche	5	FC							76
	Lepidostoma	1	SH				1			
	Limnephilus	5	SH		sp		3	2		
	Elmidae (early instar)	4	GC		cn	bu			1	3
Abundance	Abundance						23	46	7	107
Richness	Total Taxa						6	3	3	7
	EPT Taxa						3	1	0	1
	Ephemeroptera Taxa						0	0	0	0
	Plecoptera Taxa						0	0	0	0
	Trichoptera Taxa						3	1	0	1
Composition	% EPT Taxa						17.4%	4.3%	0.0%	71.0%
	% Ephemeroptera						0%	0%	0%	0%
Tolerance	Number of Intolerant Taxa						1	0	0	0
	% Tolerant Macrobenthos						13.0%	0.0%	28.6%	0.9%
	% Dominant Taxa						60.9%	71.7%	0.0%	1.9%
Feeding	% Filterers						8.7%	0.0%	0.0%	72.0%
	% Grazers & Scrapers						69.6%	95.7%	42.9%	6.5%
Habitat	Number of Clinger Taxa						0	0	0	0
	% Clingers						0%	0%	20%	3%
Notes:	SC=Scraper, PR = Predator, GC = Gatherer collector, FC = Filterer/collector, SH = Shredder									
	bu = burrower, sp = sprawler, cn = clinger									
	Tolerance scores on scale of 1-10 with 1 being most sensitive, and 10 most tolerant of environmental stressors									

The downstream site, BVC01, had very low abundance, particularly in the July samples. During the month of June 2008, very high flows occurred in Beaver Creek. It is likely that the high flows mobilized a large volume of sediment and probably resulted in considerable scouring of the sediment, particularly at this site. The reduced macro-benthos present in July may have been due, at least in part, to the high flows that occurred in June.

During a year with more moderate flows, the macro-benthos would likely show an increase in abundance and taxonomic richness throughout the growing season, while a year with drought conditions might have no flow in the riffles where the greatest diversity of benthic invertebrates is typically seen.

High pH, conductivity, temperatures and a high volume of fine sediment all may contribute to the de-pauperate invertebrate communities observed in Beaver Creek.

2.8.5.6.1.2.3 Fish

A total of 12 fish species were collected from the three sampling locations: BVC04 – Beaver Creek upstream of the PAA; BVC01 – Beaver Creek downstream of the PAA; and CHR05 – Cheyenne River downstream of the confluence of Beaver Creek. The species, trophic category, and habitat notes are summarized in Table 2.8-27. The abundance (presented as catch per unit effort or fish per meter of stream length), and average sizes of fish are shown in Table 2.8-28. Fish collection data forms are presented in Appendix 2.8-J.

Table 2.8-27: Fish Species and Trophic Categories

Species Code	Common Name	Latin Name	Trophic Category	Notes
SAS	Sand shiner	*Notropis stramineus*	Omnivore	
CRC	Creek chub	*Semotilus atromaculatus*	Primarily carnivorous omnivore	
PLM	Plains Minnow	*Hybognathus placitus*	Primarily herbiverous	Generally in slower water and side channels of turbid streams. Eats benthic algae & other plant material.
CAP	Common carp	*Cyprinus carpio*	Omnivore	Introduced species. Bottom feeder.
LND	Longnosed dace	*Rhynichthys cataractae*	Primarily carnivorous omnivore	Primarily in riffles
FHM	Fathead minnow	*Pimephales promelas*	Primarily herbiverous	Widely cultivated for bait, and extensively used in toxicological studies
RIC	River Carpsucker	*Carpoides carpio*	Bottom feeding omnivore	
SHR	Shorthead Redhorse Sucker	*Moxostoma macrolepidotum*	Bottom feeding carnivore	
CHC	Channel Catfish	*Ictalurus punctatus*	Bottom feeding omnivore	Species most likely to be eaten by humans.
PLT	**Plains topminnow**	*Fundulus sciadicus*	**Surface feeding carnivore**	
PLK	Plains Killifish	*Fundulus zebrinus*	Surface feeding carnivore	
GRS	Green sunfish	*Lepomis cyanellus*	Carnivore	Palatable but generally too small for human consumption

Bold species are tracked by the South Dakota Natural Heritage Program – South Dakota Department of Game, Fish and Parks (SDGFP web page, last updated September 2, 2008).

Table 2.8-28: Summary of Fish Size and Abundance

Location	Date	Common Name	CPUE (fish/m)	Average total length (mm)	Average weight (g)
CHR05 – Cheyenne River at Marietta	4/15/08	Green sunfish	0.01	98	20
		Sand shiner	0.53	48	4.6
		Creek chub	1.00	47	0.9
		River Carpsucker	0.01	97	13
		Shorthead Redhorse Sucker	0.14	145	115
		Plains topminnow	**0.01**	**51**	**<1**
		Plains killifish	0.48	49	1.5
CHR05 – Cheyenne River at Marietta	7/09/08	Common carp	0.01	135	31
		Longnosed dace	0.01	74	4
		Fathead minnow	0.10	47	0.7
		Sand Shiner	0.45	49	1.5
		Shorthead Redhorse Sucker	0.14	153	39
		River Carpsucker	0.04	407	1,038
		Channel catfish	0.03	222	88
		Plains killifish	0.07	58	1.9
BVC01 – Beaver Creek at Argentine Road	4/16/08	Fathead minnow	0.64	48	1.3
		Plains killifish	0.02	45	4
		Longnosed dace	0.01	48	<1
		Green sunfish	0.01	120	25
BVC01 – Beaver Creek at Argentine Road	7/10/08	Common carp	0.01	171	73
		Sand Shiner	0.10	50	1.1
		Fathead minnow	0.33	50	1.5
		Longnosed dace	0.01	59	2
		Plains minnow	0.01	73	1
		Plains topminnow	**0.06**	**56**	**2**
		Plains killifish		60	1.8
BVC04 – Beaver Creek at old Hwy 85 Bridge	4/16/08	Common carp	0.03	75	9.3
		Fathead minnow	0.84	45	1.1
		Channel catfish	0.01	215	72
		Plains killifish	0.10	44	1.4
		Green sunfish	0.04	66	7.5
BVC04 – Beaver Creek at old Hwy 85 Bridge	7/10/08	Common carp	0.01	260	230
		Sand Shiner	0.26	52	1.3
		Fathead minnow	0.47	50	1.4
		Longnosed dace	0.02	63.5	2.5
		Shorthead redhorse sucker	0.01	136	130
		Plains killifish	0.09	55	1.4

Notes: 1CPUE = Catch per unit effort.

Bold species are tracked by the South Dakota Natural Heritage Program – South Dakota Department of Game, Fish and Parks (SDGFP web page, last updated September 2, 2008).

2.8.5.6.1.2.3.1 Locally Significant Fish Species

Recreational anglers fish Beaver Creek, although the Cheyenne River and Angostura Reservoir provide greater fishing opportunities in the area. Channel catfish is the species most likely to be caught and eaten from Beaver Creek.

Hampton (1998) calculated the relative weight index (Wr) for channel catfish in the Cheyenne River to assess the condition of this species in the Cheyenne River. Hampton (1998) reported a curvilinear relationship between weight and length (Ws=63.75 +5,780/L where Ws= standard weight, and L= total length). Comparing the weight/length ratio of channel catfish collected in this study to the standard weight (Ws) described above, the relative weight (Wr=100*W/Ws) can be used as an indicator of fish condition. Generally, relative weights greater than 100 indicate better than average condition and those less than 100 indicate poorer than average condition. The weight of the largest (290 mm) channel catfish collected from the Cheyenne River had a very high relative weight (Wr = 198) while the other catfish collected from the Cheyenne River had low relative weights (Wr = 51 and 52), and the one channel catfish collected from Beaver Creek (at BVC04) had a moderately low relative weight (Wr=79). Although the average Wr for the Cheyenne River channel catfish (100.8) indicates good agreement with Hampton's (1998) modeled relationship, the weight/length ratio of individual fish varied considerably. A larger sample size would be needed to draw any conclusions about the relative condition of fish from these sites.

Relative weights are shown in Table 2.8-29 below.

Table 2.8-29: Relative weight index for channel catfish collected at Beaver Creek and Cheyenne River

Site	Date	Length	Weight	Standard Weight (Ws)	Relative Weight (Wr)
BVC04	Apr-08	215	72	90.6	79.4
CHR05	Jul-08	290	166	83.6	198.4
CHR05	Jul-08	186	50	94.8	52.7
CHR05	Jul-08	181	49	95.6	51.2
CHR05 Average					100.8

2.8.5.6.1.2.3.2 Threatened and Endangered Aquatic Species

No threatened or endangered aquatic species are known to inhabit Beaver Creek, particularly within 1.0 mile of the permit boundary.

2.8.5.6.1.2.4 Radiological Testing

The channel catfish was the only species collected in April that contained detectable uranium (0.05 mg/kg, and 3 X 10^{-5}µCi/kg) (Table 2.8-23). This species was collected from the downstream Beaver Creek site (BVC04). In July, channel catfish were collected from the Cheyenne River site (CHR05). The channel catfish is the only species collected in the PAA that is typically caught for human consumption.

Uranium was detected in all of the fish collected in July 2008 due, in large part, to increased sample sizes (Table 2.8-23). As indicated, April samples showed little, if any, detectable uranium, however, the detection limits were higher during that sampling effort due to matrix interference. Therefore, it is not possible to determine if there was an actual seasonal difference in fish tissue uranium concentration. Uranium concentrations and uranium radioactivity were generally low and similar across sample sites when compared by species. Radioactivity from Polonium-210, Thorium-230, and Radium-226 was detectable, but low in most samples. Lead-210 was only detected in one specimen (plains killifish [*Fundulus zebrinus*]) collected in April at the downstream Beaver Creek site (BVC01). Although this measurement was relatively high (0.02 µCi ±0.02 µCi), it should be noted that, due to matrix interference, the precision was limited on this sample. Lead-210 was not detected in any of the other samples.

THIS PAGE INTENTIONALLY LEFT BLANK

2.8.5.7 References

Fitzgerald, J.P., C.A. Meaney, and D.M. Armstrong, 1994 "*Mammals of Colorado*" Denver Museum of Natural History, Denver, Colorado.

Hampton, D.R., 1998, "*A Survey of the Fishes and Habitat of the Cheyenne River in South Dakota*".

Hollenbeck, Mark, Project Manager, Powertech Uranium Corporation, Powertech (USA) Inc., "*Personal Communication*".

Jones Jr., J.K, D.M. Armstrong, R.S. Hoffmann, and C. Jones, 1983, "*Mammals of the northern Great Plains*", University of Nebraska Press, Lincoln, NE.

Lusher, J., 2003, "*Standard Review Plan for In Situ Leach Uranium Extraction License Applications, Final Report*", NUREG-1569, Division of Fuel Cycle Safety and Safeguards, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C., June.

Personal Communication with Michals, Stan, Wildlife Division - Energy and Minerals Coordinator, South Dakota Game, Fish, and Parks, 2008, White paper: "*Prairie Stream Sampling – Summary. South Dakota Department of Game, Fish, and Parks, Region 1"*.

South Dakota Department of Environment and Natural Resources (SDDENR), 2002, "*Field Operations Manual for Physical Habitat Characterization of Wadeable Streams"*, Water Resources Assistance Program, July.

South Dakota Department of Parks, Fish & Game (SDDPFG), Undated, "*Prairie Stream Sampling, Region 1*", 2 pages.

Tennessee Valley Authority, 1979, "*Draft Environmental Statement for the Edgemont Uranium Mine*".

US Department of Agriculture, Natural Resources Conservation Service (NRCS), 2006, ftp://ftp-fc.sc.egov.usda.gov/WY/CSP/beaverdata.pdf

US Environmental Protection Agency (EPA), 2008, "*Section 303(d), List Fact Sheet for Watershed BEAVER*", Last updated May 9, 2008, Available: http://iaspub.epa.gov/tmdl/huc_rept.control?p_huc=10120107&p_huc_desc=BEAVER Accessed: May 9, 2008.

U.S. Environmental Protection Agency, 1993, "*Ecoregions of the United States*", Derived from J. W. Omernik; "*Ecoregions of the Coterminous United States; Scale 1:7,500,000*", Annals of the Association of American Geographers 77:118-125.