APP-051

Dewey-Burdock Project Groundwater Discharge Plan Custer and Fall River Counties, South Dakota

Prepared for:

South Dakota Department of Environment and Natural Resources
Ground Water Quality Program
523 E. Capitol Avenue
Pierre, SD 57501

Prepared by:

Powertech (USA), Inc.
P.O. Box 812
Edgemont, SD 57735

March 2012

POWERTECH (USA) INC.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF PLATES

LIST OF APPENDICES

1.0 INTRODUCTION

Powertech (USA) Inc. (Powertech (USA)) submits this Groundwater Discharge Plan (GDP) and accompanying permit application to construct and operate two land application systems at the proposed Dewey-Burdock Project. The project will be located near Edgemont, South Dakota in Custer and Fall River Counties. The Dewey-Burdock Project is an in-situ recovery (ISR) uranium mine that will consist of a series of sequentially developed well fields, a satellite ion exchange (IX) facility at the Dewey portion of the project area and a central processing plant (CPP) and associated IX and process facilities at the Burdock portion of the project area to recover and process the final uranium product.

The uranium recovery process is primarily a closed loop in which groundwater is pumped from recovery wells, processed to remove uranium, and reinjected into injection wells. During uranium recovery and groundwater restoration, slightly more water will be pumped than is reinjected. This will create a cone of depression around the active well fields to control the movement of fluids. The excess water will be treated to remove radionuclides and disposed. In its application for a U.S. Nuclear Regulatory Commission (NRC) source and byproduct material license, Powertech (USA) proposes two alternatives for liquid waste disposal. The first and preferred alternative is treatment followed by injection in Class V wells completed in the Minnelusa or Deadwood Formations. Powertech (USA) is currently permitting the Class V disposal wells through the U.S. Environmental Protection Agency (EPA) Underground Injection Control (UIC) Program. In the event that the Class V UIC permit is not approved or insufficient disposal capacity is available, Powertech (USA) proposes to treat the liquid waste and dispose it in land application systems permitted under a Groundwater Discharge Plan through the South Dakota Department of Environment and Natural Resources (DENR).

The following GDP describes the proposed design and operation of the Dewey-Burdock land application systems. One system would be constructed near the Dewey satellite facility, and another would be constructed near the Burdock CPP. Both facilities have been designed to apply water at agronomic rates that prevent runoff and limit the potential for deep percolation beneath the land application areas. Hydrologic modeling presented in Section 5 demonstrates that groundwater is not expected to be impacted by the proposed land application systems. Nevertheless, Powertech (USA) proposes perimeter of operational pollution (POP) zones in the alluvial groundwater systems with perimeter compliance monitor wells to ensure protection of waters of the State of South Dakota. The proposed land application systems are separated from bedrock aquifers by some 25 to 500 feet of Graneros Group shales, which will eliminate any potential to impact bedrock aquifers.

2.0 PROJECT OVERVIEW

2.1 Owner/Operator Information

This GDP is submitted by Powertech (USA), which is the United States-based wholly owned subsidiary of 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.

The addresses and telephone numbers for the general office (Colorado) and the local office (South Dakota) of the applicant are listed as follows in accordance with ARSD 74:54:02:06 (1):

Name and address of discharger or person legally responsible for discharge:

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

Local representative or contact person if different from above:

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

2.2 General Description of Operation

2.2.1 ISR Description

The ISR process involves the oxidation and solubilization of uranium from its reduced state using leaching fluid (lixiviant). The lixiviant consists of groundwater with an oxidant (in this case gaseous oxygen) added to oxidize the uranium to a soluble valence and a complexing agent (in this case gaseous carbon dioxide) to complex the uranium ion. Powertech (USA) will inject lixiviant through Class III injection wells permitted through the EPA UIC Program. Once solubilized, the uranium-bearing groundwater will be pumped using submersible pumps from well field production wells to the surface, where the uranium will be bonded onto ion exchange (IX) resins. After the uranium is removed, the groundwater will be fortified with additional oxygen and carbon dioxide and reinjected. When loaded with uranium, the IX resin will be moved to an IX elution (stripping) column where the uranium will be eluted (stripped) from the resin by a saltwater solution. The resulting barren (stripped) resin will then be recycled to recover additional uranium. The saltwater eluate solution will be pumped to a precipitation process where the uranium will be precipitated as a yellow solid uranium oxide. The precipitated uranium oxide will then be filtered, washed, dried and packaged in sealed containers for shipment for further processing.

Following uranium recovery in each well field, the groundwater in each well field will be restored in accordance with NRC license requirements. Specifically, Powertech (USA) will restore groundwater quality consistent with the groundwater protection standards contained in 10 CFR 40, Appendix A, Criterion 5(B)(5) on a parameter-by-parameter basis using best practicable technology. The method of aquifer restoration will depend on the liquid waste disposal option. In the deep disposal well option, the primary method of aquifer restoration will be reverse osmosis treatment with injection of permeate (nearly pure water) into the well fields. In the land application option, the water pumped from the well fields undergoing aquifer restoration will be treated and disposed in the land application systems and clean makeup water from the Madison Limestone or another suitable aquifer will be injected into the well fields.

Sources of liquid waste proposed for discharge in the land application systems include groundwater from the ore zone removed during aquifer restoration, affected groundwater generated during well development, and liquid process wastes, such as the production bleed, resin transfer water, and the brine generated from the elution and precipitation circuits. The production bleed is a relatively small amount (0.5 to 3 percent) of the production flow rate that is not reinjected during uranium recovery in order to maintain a cone of depression within each

well field and maintain hydraulic well field control. No domestic (septic) waste will be disposed in the land application systems.

In the land application option, the vast majority of liquid waste (typically greater than 90 percent) will result from aquifer restoration. Additional information regarding liquid waste water quality and flow rate is found in Section 5.

2.2.2 Land Application Description

Each land application system will consist of irrigation center pivots, associated pumps and piping, and catchment areas. Associated facilities include radium settling ponds and storage ponds. Liquid waste will be treated to remove radionuclides in lined radium settling ponds. Treated water will be temporarily stored in lined storage ponds and then seasonally applied to the land application areas through center pivots. Powertech (USA) anticipates that land application will typically occur during late March through October, but it could occur during other times of the year weather permitting. Adequate capacity in the storage ponds will provide storage during the months when land application will not be used (typically November through early March). Additional design information for each of the land application systems is presented in Section 5.

2.3 Project Location

The Dewey-Burdock Project is located approximately 13 miles north-northwest of Edgemont, South Dakota, in an area encompassing portions of Fall River and Custer counties. The proposed NRC license area, which is the same as the proposed DENR large scale mine (LSM) permit area, encompasses approximately 10,580 acres of mostly private land on either side of S. Dewey Road (County Road 6463). It includes portions of Sections 1-5, 10-12, and 14-15, Township 7 South, Range 1 East and Sections 20-21, and 27-35, Township 6 South, Range 1 East, Black Hills Meridian. Approximately 240 acres are under the control of the Bureau of Land Management (BLM) located in portions of Sections 3 and 10-12. Figure 2.3-1 shows the project location and NRC license/LSM permit boundary (herein referred to as the project boundary or project area).

The proposed GDP includes two land application areas, one at the Dewey site and one at the Burdock site. Figure 2.3-2 shows the proposed land application areas. The total irrigated area at each site at any given time is anticipated to be 315 acres, consisting of 50-acre, 25-acre, and 15-acre pivots. In addition, each site will contain 65 acres of center pivots on standby, which can be used during repairs and maintenance of other center pivots or used on a rotating basis. The legal

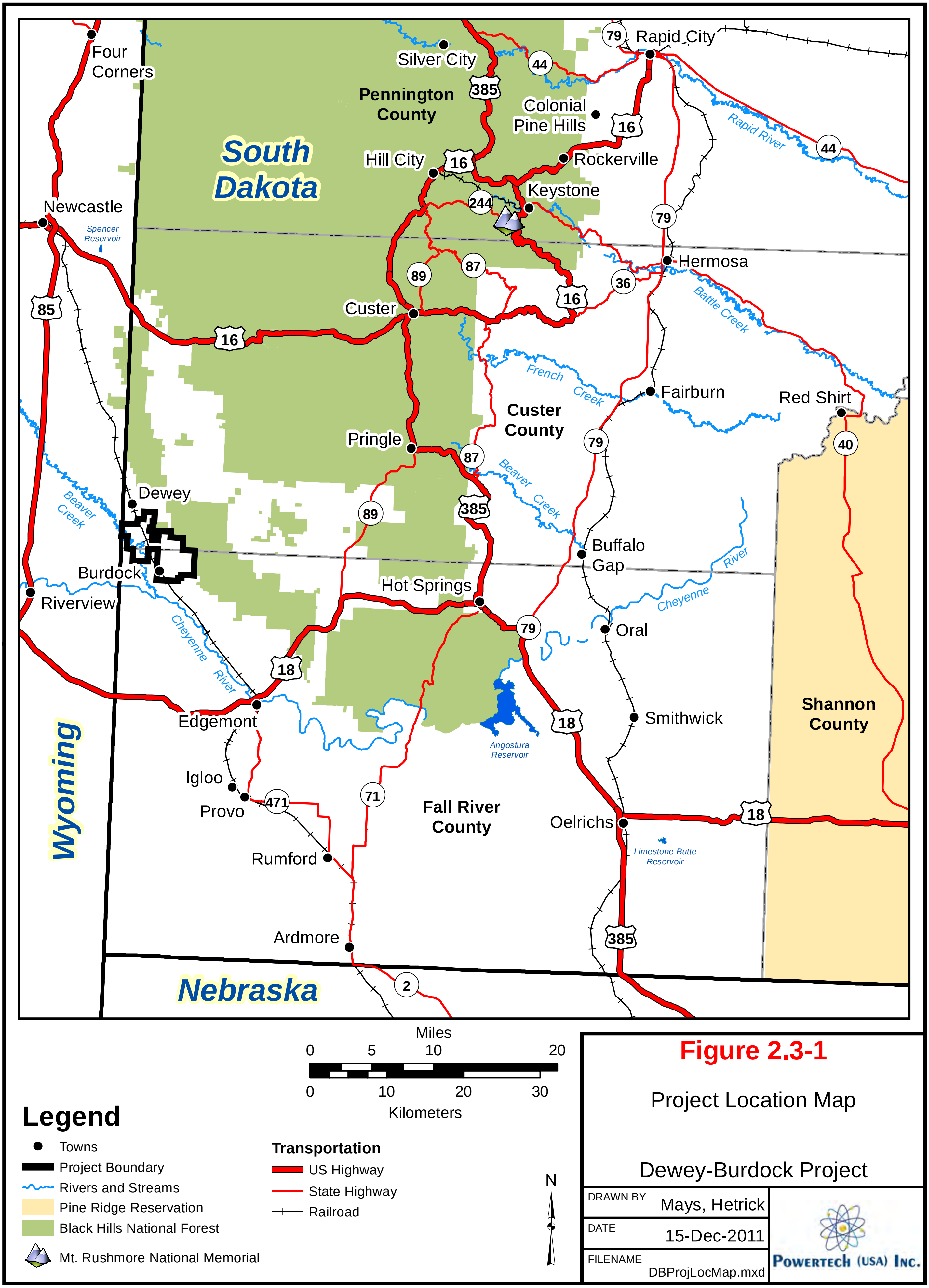


Figure 2.3-1

Project Location Map

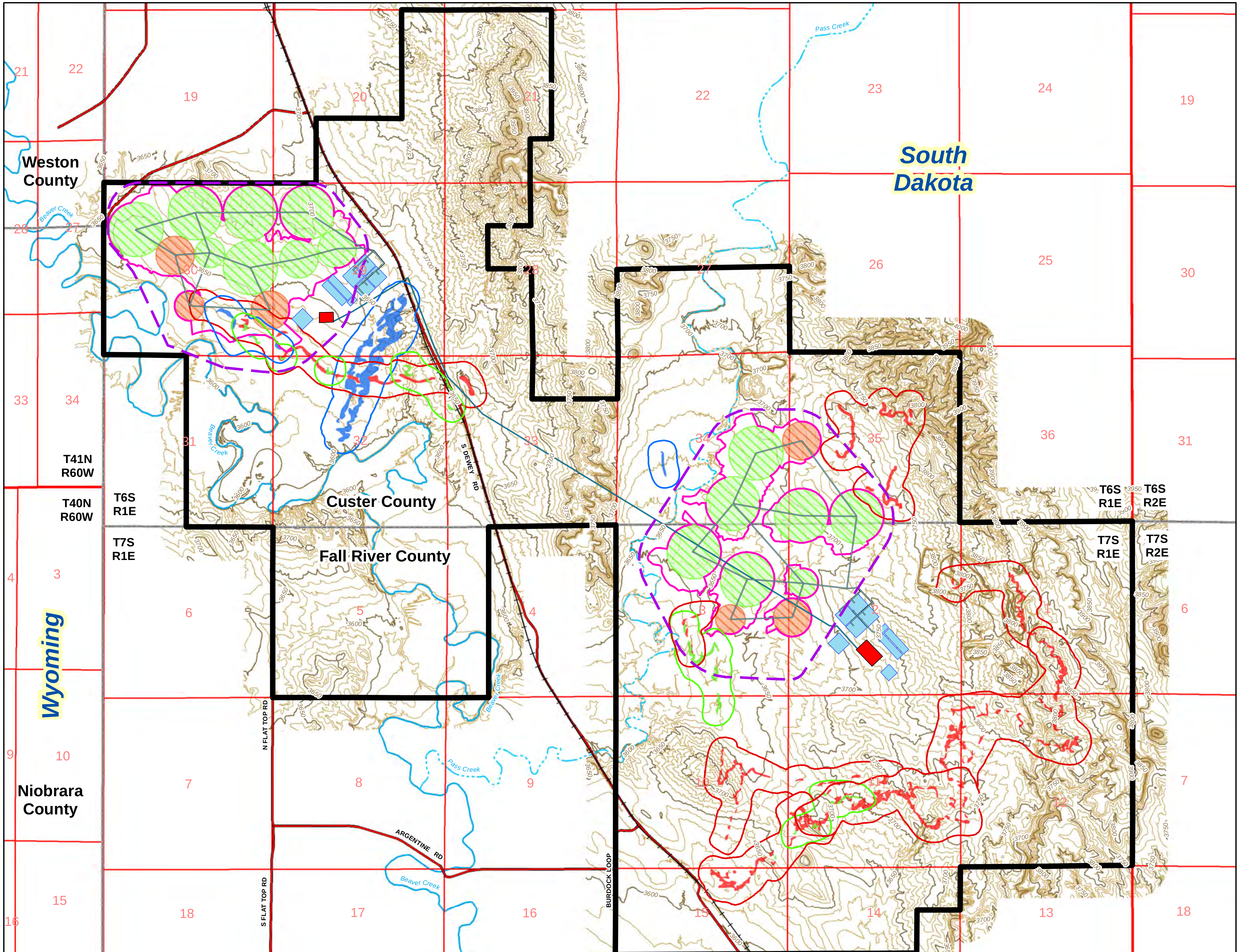


Figure 2.3-2

Proposed Land Application Systems

Dewey-Burdock Project

DRAWN BY S. Hetrick

DATE 18-Jun-2012

FILENAME LandApp-Systems.mxd

POWERTECH (USA) INC.

description of the land application areas and associated POP zones, in accordance with ARSD 74:54:02:06 (2), includes portions of the following quarter-quarter sections:

- Dewey site:
  - Custer County, Township 6 South, Range 1 East
    - Section 29 - NW¼; SW¼ NE¼; NW¼ SE¼; SW¼
    - Section 30 - all except SW¼ SW¼
    - Section 31 - N½ NE¼
    - Section 32 - NW¼ NW¼
- Burdock site:
  - Custer County, Township 6 South, Range 1 East
    - Section 34 - SE¼; S½ NE¼; E½ SW¼; SW¼ SW¼
    - Section 35 - S½ NW¼; SW¼; SW¼ SE¼
  - Fall River County, Township 7 South, Range 1 East
    - Section 2 - NW¼; W½ SW¼; NE¼ SW¼; NW¼ NE¼
    - Section 3 - all except SW¼ SW¼

2.4 Project Schedule

Following the issuance of an NRC source and byproduct material license, DENR LSM permit, and other relevant permits, it is anticipated that construction of the initial Burdock well fields, CPP and ancillary facilities including storage ponds and land application systems will commence. The construction of the initial Dewey well fields and ancillary facilities will follow shortly thereafter. 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. The projected construction, operation, restoration and decommissioning schedule is provided in Figure 2.4-1.

Land application will occur during production and restoration, which are shown on Figure 2.4-1 to occur from approximately year 2 through early year 10 after licensing/permitting (approximately 9.25 years total). The application rates during initial production, concurrent production and restoration, and restoration without concurrent production are discussed in Section 5.6.

2.5 Project History

Uranium was first discovered in the Edgemont District in 1952 by professors from the South Dakota School of Mines and Technology. They mined about 500 pounds of ore and hauled it to

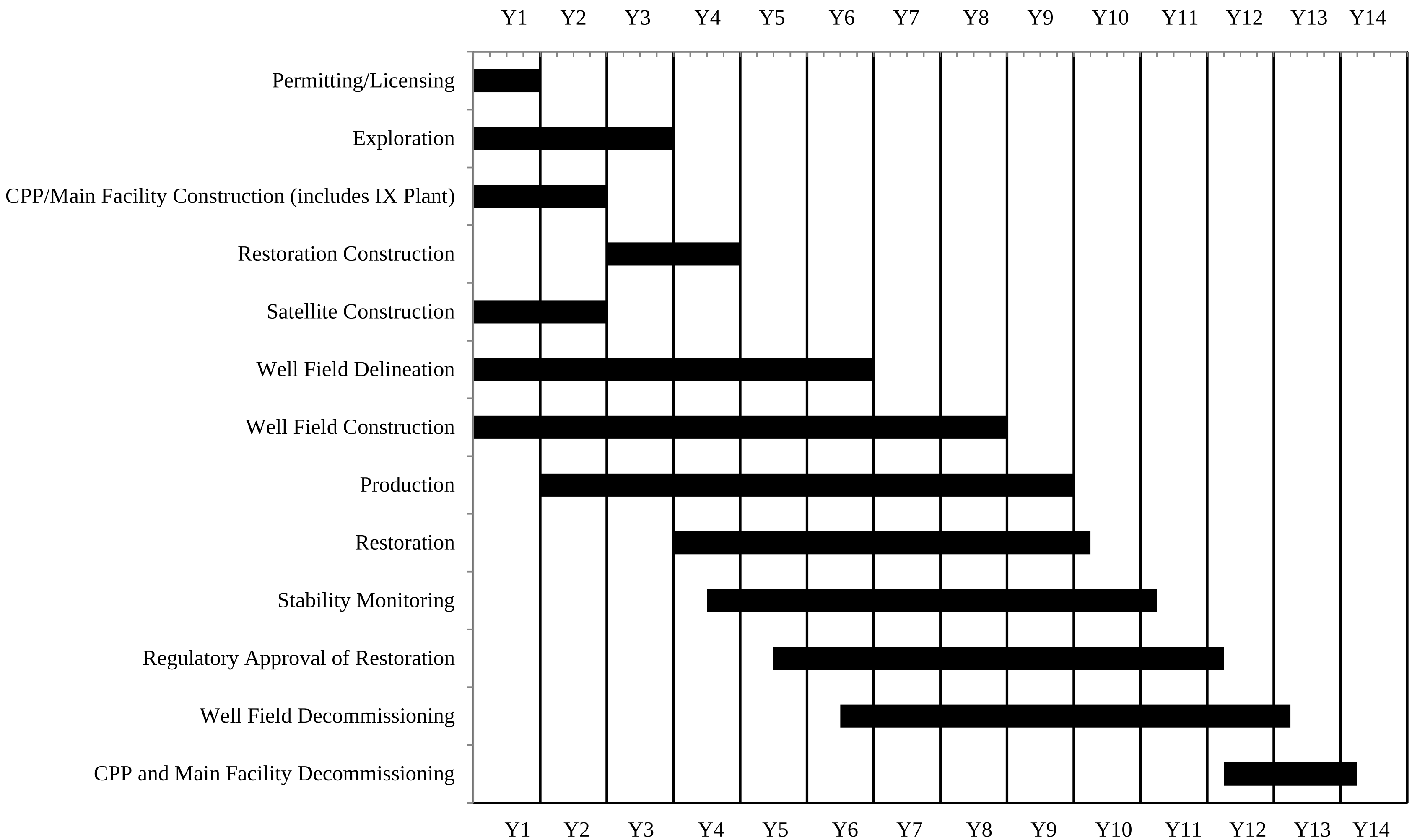


Figure 2.4-1: Projected Construction, Operation, Restoration and Decommissioning Schedule

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 began operating and soon expanded to 500 tons per day. In 1960 a vanadium circuit was added. Production from the Edgemont District (open pits in the Fall River Formation), some mines in the Powder River Basin and several mines in the northern Black Hills continued until 1972, when Susquehanna Western Inc. bought the Edgemont mill and took control of the mines in the Edgemont District. Until the late 1960'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 (WMC) acquired the Dewey properties from Homestake. In 1974, Tennessee Valley Authority (TVA) bought out the mill and mines from Susquehanna Western Inc. 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 4,000 exploration drill holes were completed on this project.

In 1981 TVA completed a mine feasibility study on the project deposits. A draft environmental statement (DES) was prepared by TVA to address the potential impacts of a proposed underground mine in the project area, but the NEPA process was never completed by TVA. In 1994 Energy Fuels Nuclear (EFN) acquired the mineral interests within the project area. Their intention was to extract the uranium by ISR. EFN did no additional exploration drilling on the project. In 2000 the leases were dropped.

In 2005, Powertech (USA) acquired control of the property, which currently consists of approximately 10,580 acres. Since spring 2007, Powertech (USA) has drilled approximately 115 exploration holes, including 20 monitor wells on the project. Both the historical and recent drill holes have been used to generate the geologic model and delineate the extent of the mineralized sands.

2.6 Statement of Procedural Completeness

This GDP has been prepared to meet the requirements of applicable Administrative Rules of South Dakota (ARSD) and South Dakota Codified Law (SDCL). Specifically, this GDP addresses the application requirements for groundwater discharge permits in ARSD 74:54:02:06 and other ARSD 74:54:01 and 74:54:02 requirements listed on the DENR permit application

form that accompanies the GDP. Table 2.6-1 lists the applicable ARSD and the section of the GDP that fulfills each requirement.

Table 2.6-1: Groundwater Discharge Permit Application Checklist

Regulation	Information Required	GDP Reference
ARSD 74:54:01:03	Classification of groundwater	Section 4.2.3
ARSD 74:54:01:04	Standards for groundwater of 10,000 mg/L TDS concentration or less	Section 6.1.1.4
ARSD 74:54:02:06 (1)	The name and address of the owner and operator of the project	Section 2.1
ARSD 74:54:02:06 (2)	The legal location of the facility by county, quarter, quarter, quarter, quarter, section, township, and range	Section 2.3
ARSD 74:54:02:06 (3)	The name of the project or facility and the type of operation, facility, or development, including the expected project life	Sections 2.2 and 2.4
ARSD 74:54:02:06 (4)	A plat map showing all wells, water bodies, drainages, natural or man-made structures, and water usage within a one-mile radius of the discharge. The plat map must show the location and depth of existing or proposed wells to be used for monitoring groundwater quality	Figures 3.5-1, 3.7-2, 3.7-3, 3.7-9, and 3.7-10; Tables 3.7-3, 3.7-4 and 4.1-3
ARSD 74:54:02:06 (5)	Geologic, hydrologic, and agricultural description of the area of review, including topography, soil types, aquifers, groundwater flow direction, aquifer material, and well logs. The hydrologic description must include a projected area of influence	Sections 3.1 through 3.7
ARSD 74:54:02:06 (6)	The type, source, and chemical, physical, radiological, and toxic characteristics of the effluent or leachate to be discharged; the average and maximum daily amount of effluent or leachate discharged (gpd), the discharge rate (gpm), and the expected concentrations of any contaminant (mg/L)	Sections 5.1, 5.2, 5.6 and 5.8
ARSD 74:54:02:06 (7)	Information which shows that the discharge can be controlled and will not migrate into or adversely affect the quality of any other waters of the state	Sections 5.7 and 8.0
ARSD 74:54:02:06 (8)	If applicable, the description of the POP, including the dimensions and hydrologic and geologic data used to determine the dimensions, the proposed compliance monitoring point, and justification of necessary economic or social development for the POP	Section 7.0
ARSD 74:54:02:06 (9)	Proposed monitoring plan	Section 6.0
ARSD 74:54:02:06 (9)(b)	Discussion of failure detection system	Section 6.3.3
ARSD 74:54:02:06 (10)	Plans and specifications relating to construction, modification, or operation of discharge systems	Section 5.0
ARSD 74:54:02:06 (11)	Description of the groundwater most likely to be affected by the discharge, including water quality information of the receiving groundwater prior to discharge, a description of the aquifer in which the groundwater occurs, the depth to the groundwater, the saturated thickness, flow direction, porosity, hydraulic conductivity, and flow system characteristics	Sections 3.7.2 and 4.2

Table 2.6-1: Groundwater Discharge Permit Application Checklist (cont'd)

Regulation	Information Required	GDP Reference
ARSD 74:54:02:06 (12)	Distance to the nearest well, the use and the water quality of that well, and a listing of all water wells in the area of review and the status of each	Section 3.7.2.3 and Appendices 4.2-A and 4.2-B
ARSD 74:54:02:06 (13)	A compliance sampling plan which includes provisions for sampling of effluent and for flow monitoring, to determine the volume and chemistry of the discharge onto or below the surface of the ground and a plan for sampling monitoring wells and appropriate nearby water wells which includes the parameters to be sampled for	Section 6.0
ARSD 74:54:02:06 (14)	A description of the flooding potential of the discharge site, including the 100-year flood plain, and any applicable flood protection measures	Sections 3.7.1.3 and 8.2
ARSD 74:54:02:06 (15)	A contingency plan for bringing the facility into compliance if permitted allowable limits are exceeded	Section 8.0
ARSD 74:54:02:06 (16)	Methods and procedures for inspections of the facility operations and for detecting failure of the system	Section 10.0
ARSD 74:54:02:11	Board issuance of water quality variance permit	Section 7.0
ARSD 74:54:02:17	Perimeter of operational pollution (POP)	Section 7.0
ARSD 74:54:02:18	Ambient water quality determination	Sections 4.1 and 4.2
ARSD 74:54:02:20	Periodic submission of monitoring reports to secretary	Section 11.0
ARSD 74:54:02:21	The operator of a groundwater discharge facility shall immediately notify the secretary of any mechanical or discharge system failures. The secretary shall require a written statement confirming the oral report within 30 days.	Section 11.0
ARSD 74:54:02:22	Correction of adverse effects required	Section 8.0
ARSD 74:54:02:25	Report of spills, leaks, and accidental releases to secretary	Section 11.0
ARSD 74:54:02:27	An accelerated schedule of monitoring is required upon determination of probable out-of-compliance status	Section 8.1.1

Note: This checklist includes sections of ARSD 75:54:01 and 74:54:02 from the GDP application.

3.0 ENVIRONMENTAL SETTING

3.1 Climate

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

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

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

Along with the site weather station, data compiled from several sites surrounding the project area (listed in Table 3.1-1 and shown on Figure 3.1-12) 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 Dewey-Burdock project area. The Newcastle, Wyoming WRC compliance site was the only site with adequate representative data to characterize wind speed/direction.

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

Table 3.1-1: Meteorological Stations Included in Climatology Analysis

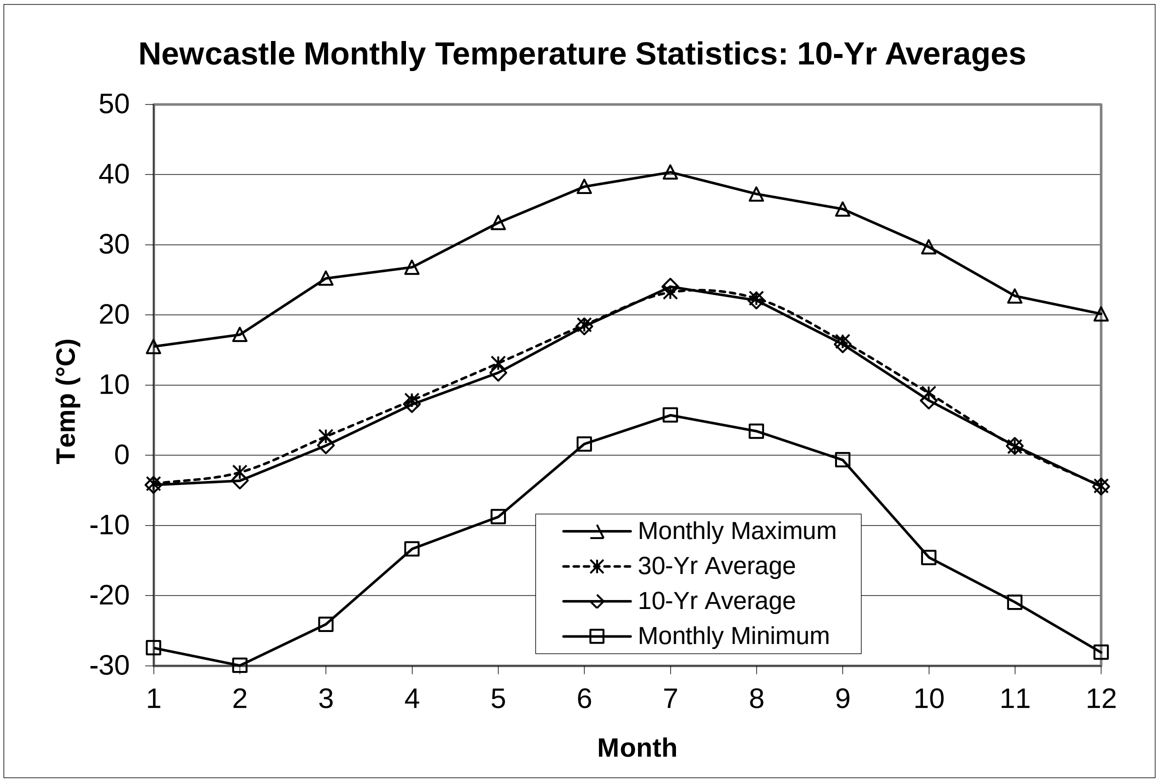
Name	Data Source	X (°W)	Y (°N)	Z (ft)	Years of Operation
Redbird	NCDC[(a)]	104.17	43.15	3,890	1948–2006
Oral	SDSU[(b)]	103.16	43.24	2,960	1971–2007
Oelrichs	NCDC	103.14	43.11	3,340	1948–2007
Newcastle	NCDC	104.14	43.51	4,380	1918–2006
Edgemont	NCDC	103.49	43.18	3,440	1948–2007
Custer	NCDC	103.36	43.46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

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

3.1.1 Regional Overview

Meteorological data from the WRC compliance site at Newcastle, Wyoming were assembled and analyzed to determine whether the baseline monitoring year's data (July 18, 2007 to July 17, 2008) were representative of longer-term (approximately 10-year) meteorological conditions in the area. The Newcastle site began monitoring on January 1, 2002, and meteorological data were available through August 31, 2011. The parameters analyzed were temperature, wind speed, wind direction, and standard deviation of wind direction. A comprehensive discussion of wind patterns at Newcastle is presented in Section 3.1.5.

The average daily temperature over the baseline monitoring year at Newcastle was 51.9°F, which is slightly warmer than the 10-year average (historic) daily temperature of 47.2°F. Figure 3.1-1 compares monthly temperature statistics for the two periods. It can be seen that both the average and extreme monthly temperatures for the baseline year are within a few degrees of the longer-term averages. The 10-year graph also includes 30-year average temperatures for Newcastle, obtained from the Western Regional Climate Center, demonstrating the 10-year average temperatures at the WRC site to be nearly identical to the 30-year average temperatures at the NWS Coop Site #486660 in Newcastle.



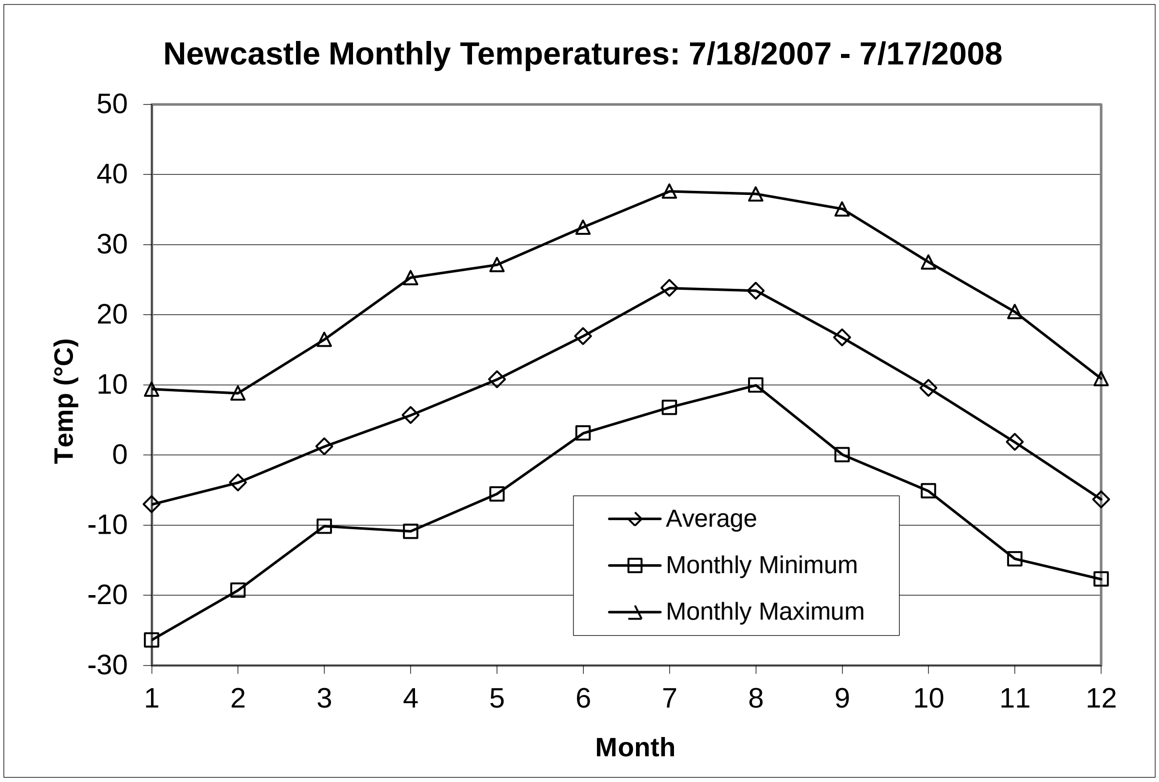


Figure 3.1-1: Short and Long-Term Temperatures at the Newcastle, Wyoming WRC Compliance Site

The average daily wind speed at Newcastle over the baseline monitoring year was 7.0 miles per hour (mph), very close to the 10-year historical average of 6.8 mph. Figure 3.1-2 compares the monthly average and maximum wind speeds for the short and long-term periods.

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

3.1.1.1 Temperature

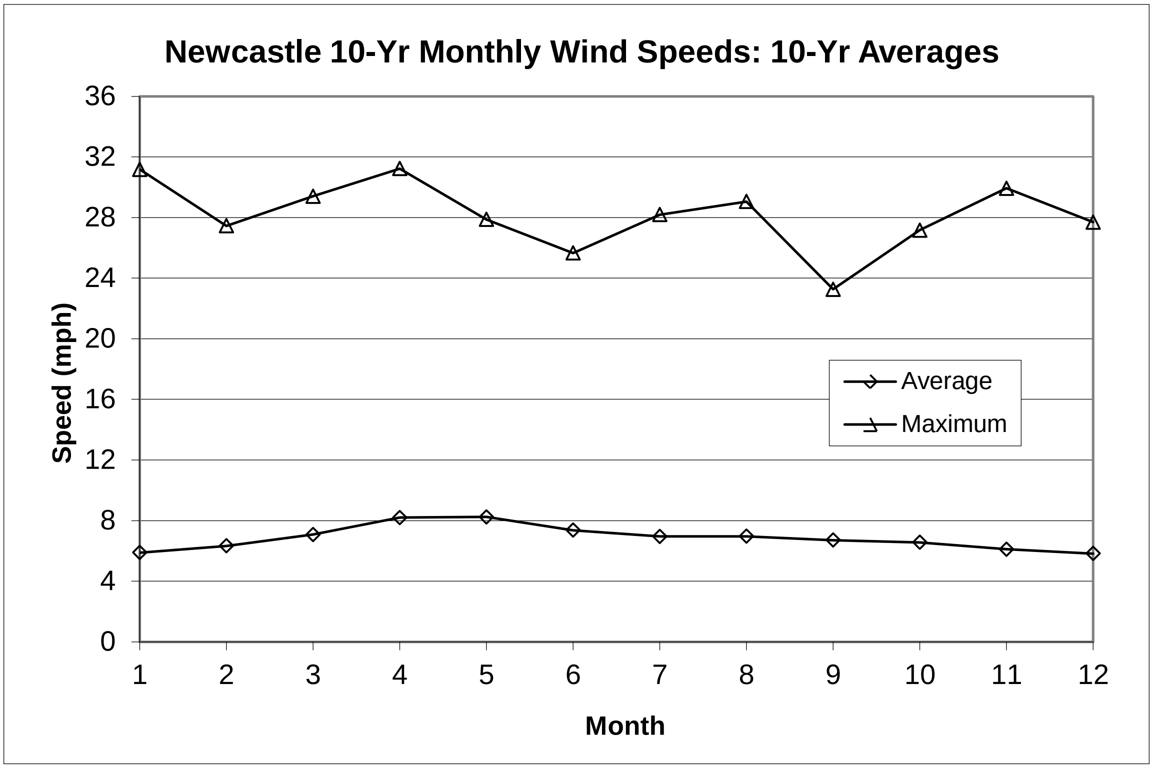
Long-term temperature statistics were also obtained from regional NWS sites. The annual average temperature in this region is 46.7°F. Figure 3.1-3 and Table 3.1-2 display the monthly, annual, and seasonal average temperatures. This region has its warmest days in the summer months with the hottest month being July (average temperature of 72.8°F). The coldest month of the year is January, with an average temperature of 23.0°F. During the months of April through October, when the proposed land application systems will operate, the average temperature is above freezing for all regional sites. The differences seen between sites can be attributed to elevation. Custer and Jewel Cave have the lowest average temperature primarily because these sites are nearly 1,000 feet higher in elevation than all other sites.

Figures 3.1-4 and 3.1-5 show the average maximum and minimum temperatures in the region. The average maximum temperature is 60.7°F annually, while the annual average minimum temperature is 32.7°F, as shown in Tables 3.1-3 and 3.1-4. Table 3.1-4 shows that the average minimum temperature for the Edgemont site is above freezing during April through October, when the proposed land application systems will operate. The highest average maximum temperatures in the region usually fall during the month of July (88.3°F). The lowest minimum temperatures can be found in January with a regional average of 10.4°F.

Figure 3.1-6 displays diurnal temperature variations by season for the Newcastle WRC site over the last 10 years. The figure shows large variations in average diurnal temperatures, especially during the summer months.

3.1.1.2 Relative Humidity

Relative humidity measures the ratio of moisture in the air to saturated moisture content at a certain temperature. This parameter was recorded for the Newcastle WRC site. Figure 3.1-7 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



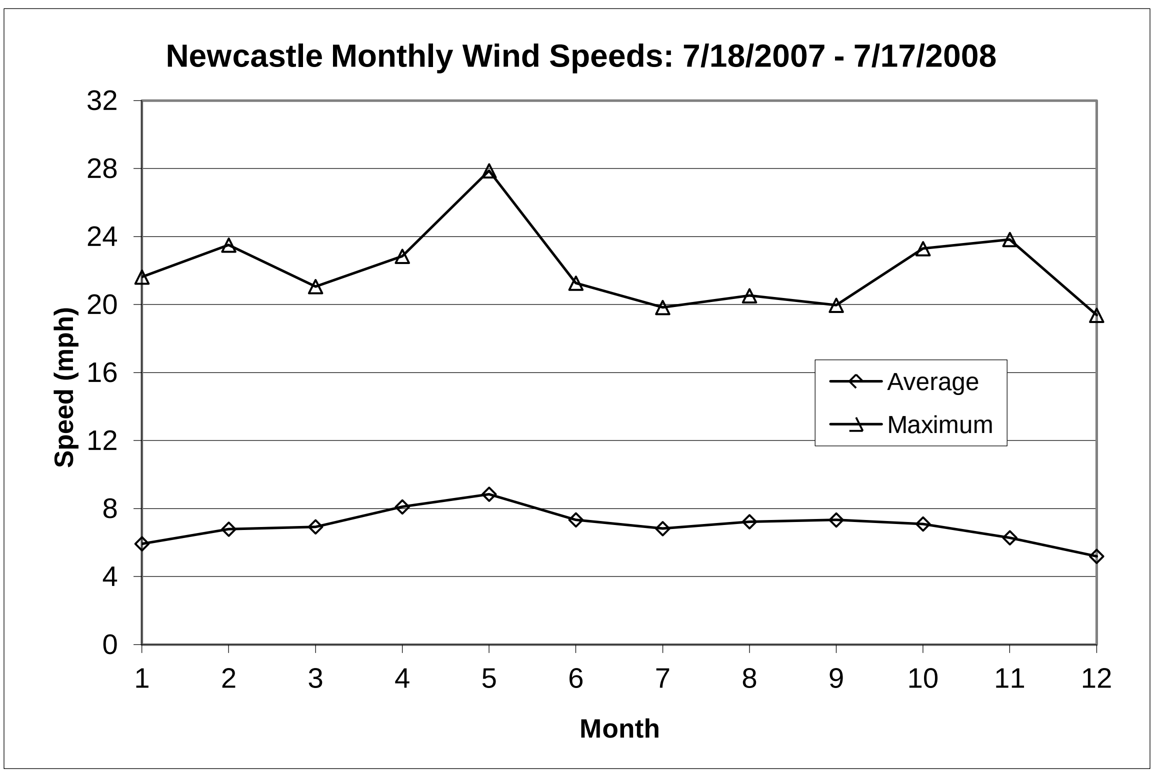


Figure 3.1-2: Short and Long-Term Wind Speeds at the Newcastle, Wyoming WRC Compliance Site

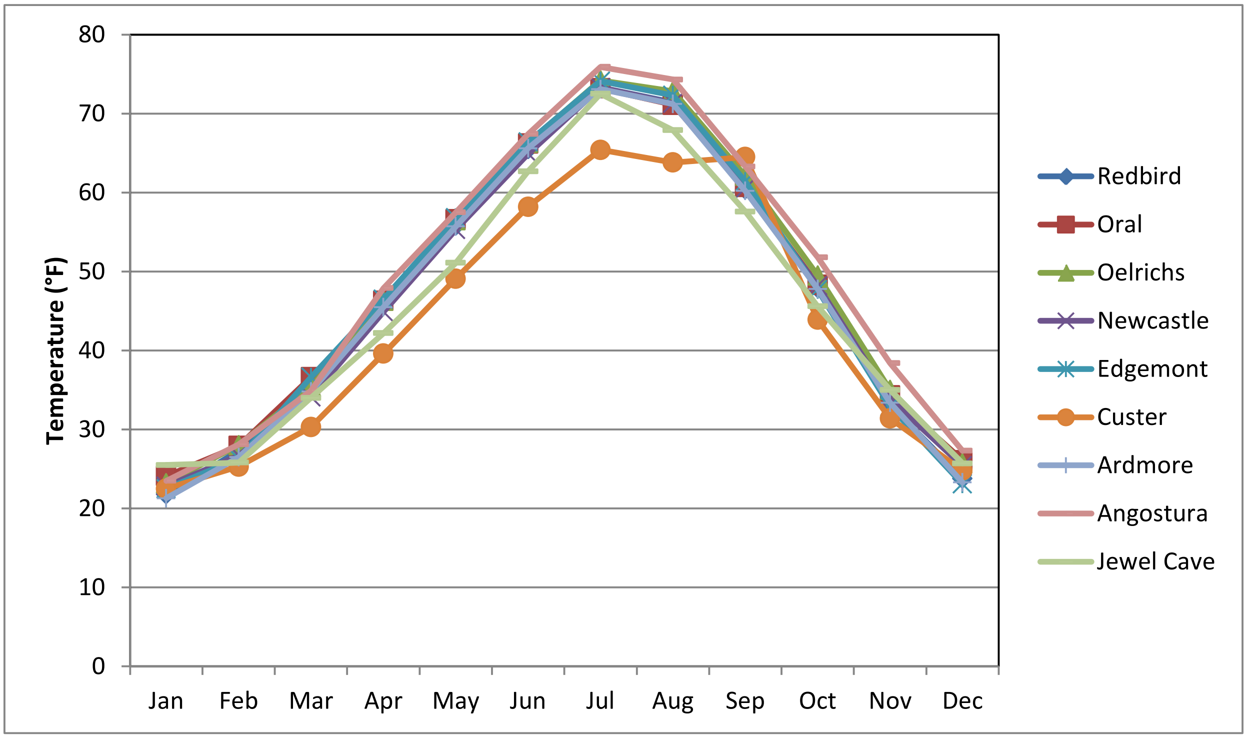


Figure 3.1-3: Average Monthly Temperatures for Regional Sites

Table 3.1-2: 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: HPRCC, 2008; SDSU, 2008

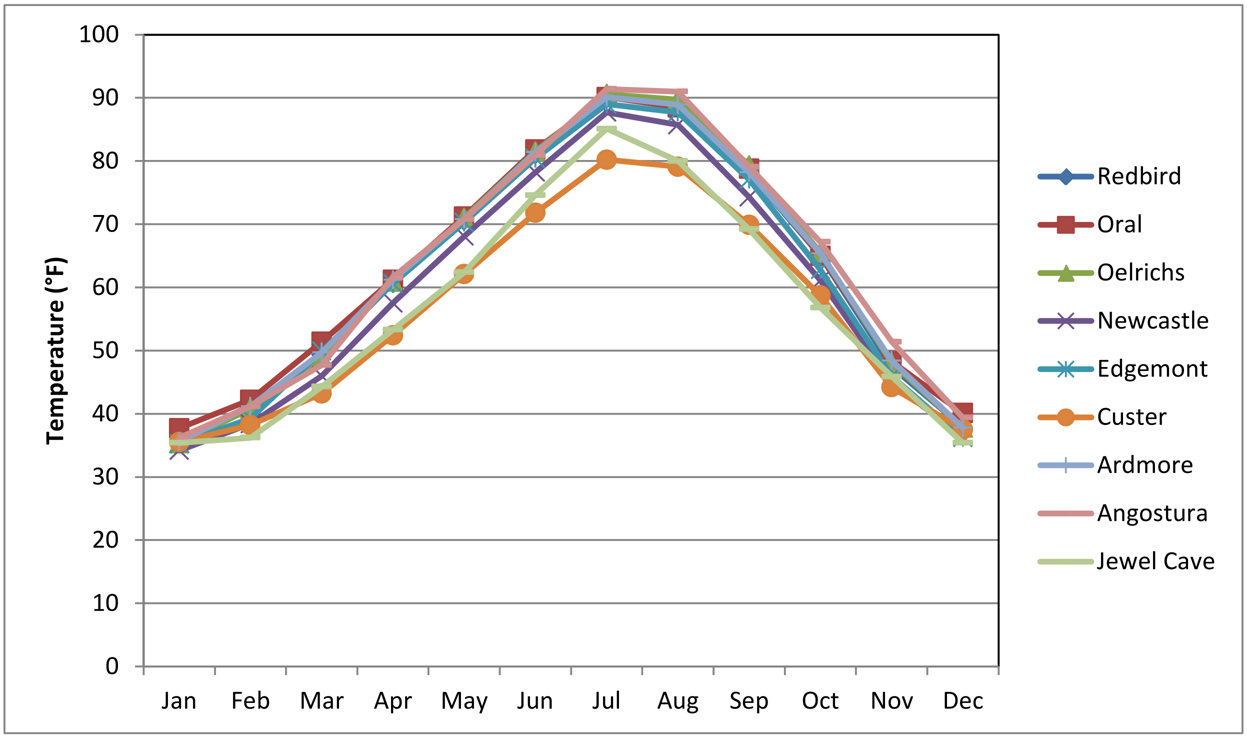


Figure 3.1-4: Average Monthly Maximum Temperatures for Regional Sites

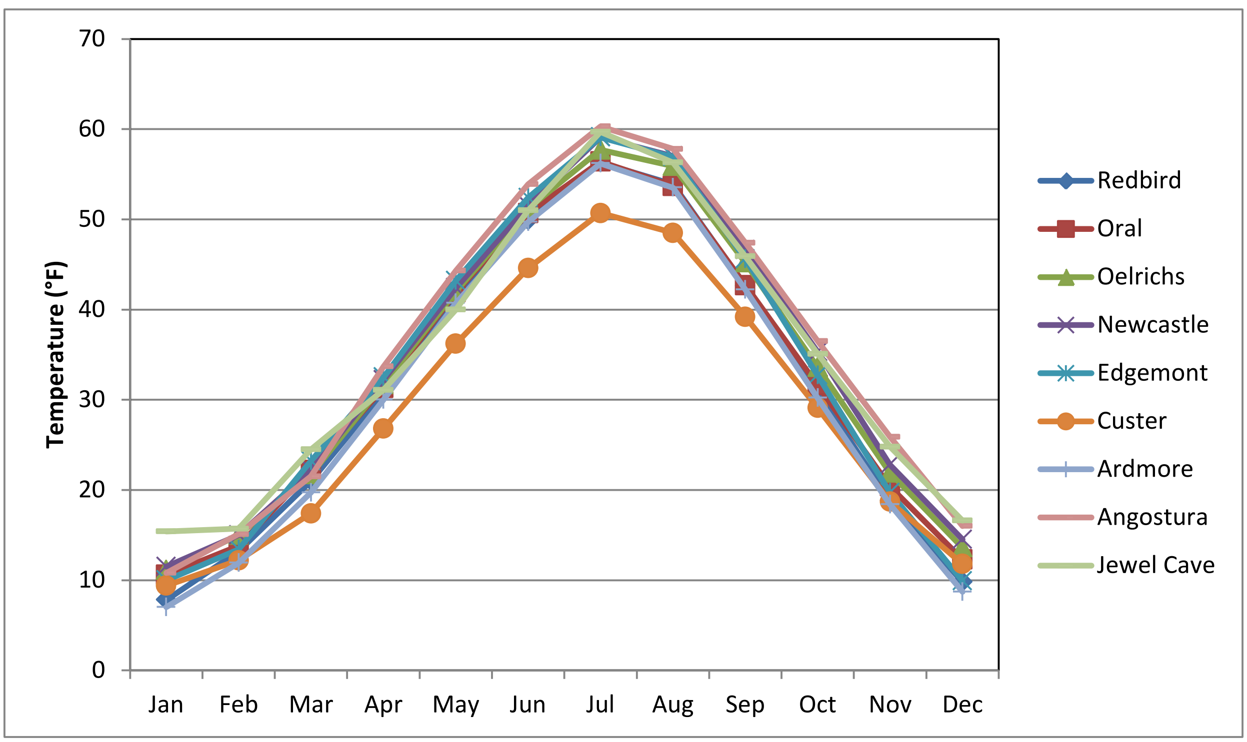


Figure 3.1-5: Average Monthly Minimum Temperatures for Regional Sites

Table 3.1-3: Average Monthly, Annual, and Seasonal Maximum Temperatures for Regional Sites

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

Source: HPRCC, 2008; SDSU, 2008

Table 3.1-4: 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

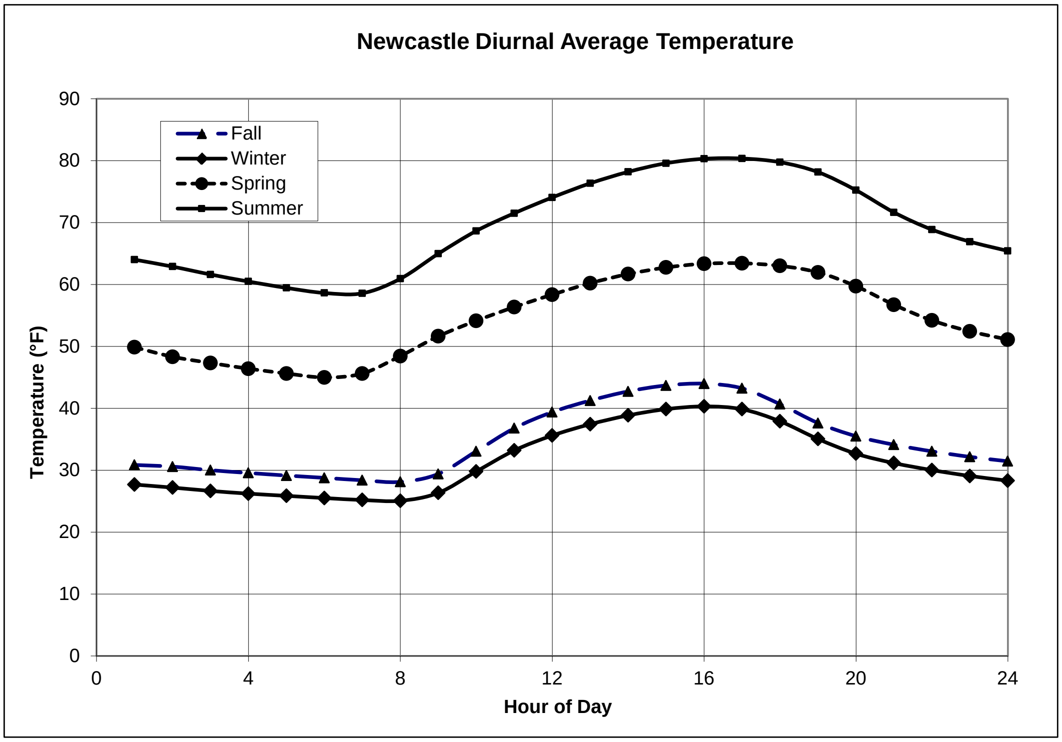


Figure 3.1-6: Newcastle, Wyoming, Seasonal Diurnal Temperature Variations

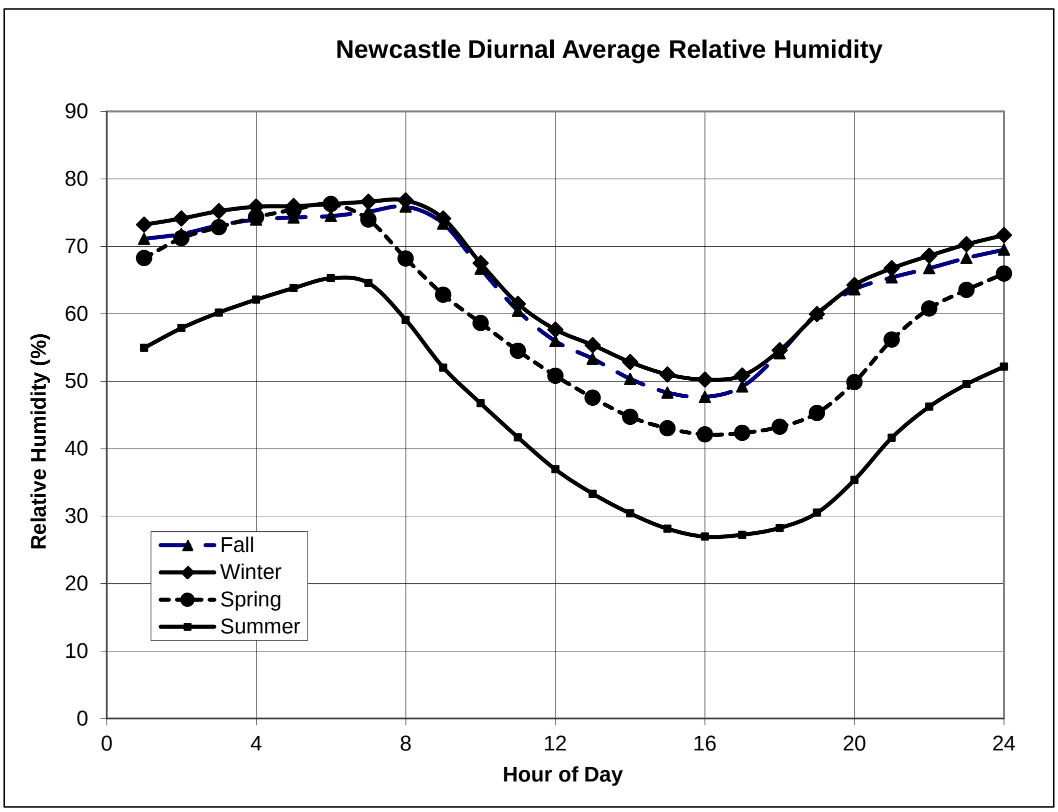


Figure 3.1-7: Newcastle, Wyoming, Seasonal Diurnal Relative Humidity Variations

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.

3.1.1.3 Precipitation

Figure 3.1-8 shows average monthly precipitation at the Newcastle NWS Coop site for the past 30 years. For comparison, Figure 3.1-9 shows monthly precipitation totals for the baseline monitoring year. It can be seen that unusually high precipitation was measured in the months of May and July of 2008.

Figure 3.1-10 and Table 3.1-5 show average monthly and seasonal precipitation amounts for all of the available meteorological monitoring sites in the area. This area can be very dry at times with a regional annual average precipitation of 16.5 inches. Most of the precipitation occurs during May, June, and July (48 percent of the annual). Typically, May is the wettest month of the year for this region with an average total of 2.8 inches. Winter receives roughly 8 percent of the annual accumulated precipitation. January is the driest month of the year with an average accumulation of 0.36 inch of precipitation.

This region receives an average of 38 inches of snowfall each year. As shown in Figure 3.1-11, most snowfall occurs during the month of March with a regional average of 8.5 inches. Custer receives the most annual snowfall (48 inches). This can be attributed to the higher elevation and the influence of the surrounding Black Hills (Figure 3.1-12).

3.1.1.4 Wind Patterns

A meteorological station in Newcastle, Wyoming was used to evaluate long-term representativeness of the data collected at the site. The closest NWS station to the project site with hourly wind data is Chadron, Nebraska. Chadron was eliminated from consideration as it is more than 60 miles from the project area and is lower in elevation. The wind patterns are substantially different, most likely due to the effect of the Black Hills on the Dewey-Burdock site. While the Newcastle meteorological station is not strictly representative of the Dewey-Burdock site, it is sufficiently close in distance and geography to infer the regional relationship between the baseline monitoring period (7/18/2007 to 7/17/2008) and long-term conditions. The following describes how the baseline monitoring period is representative of long-term meteorological conditions in the region.

Figures 3.1-13 and 3.1-14 show wind roses at the Newcastle WRC site for the nearly 10 years of monitoring and for the one year corresponding to the Dewey-Burdock baseline monitoring

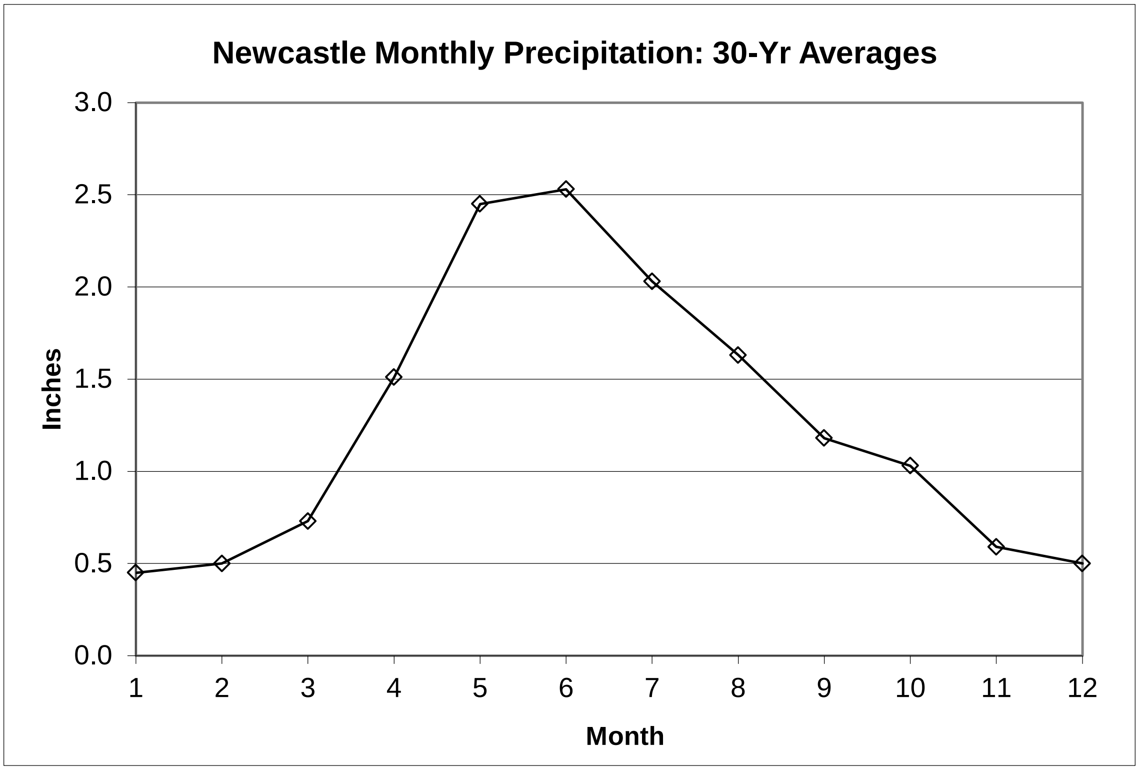


Figure 3.1-8: Average Monthly Precipitation for Newcastle, Wyoming

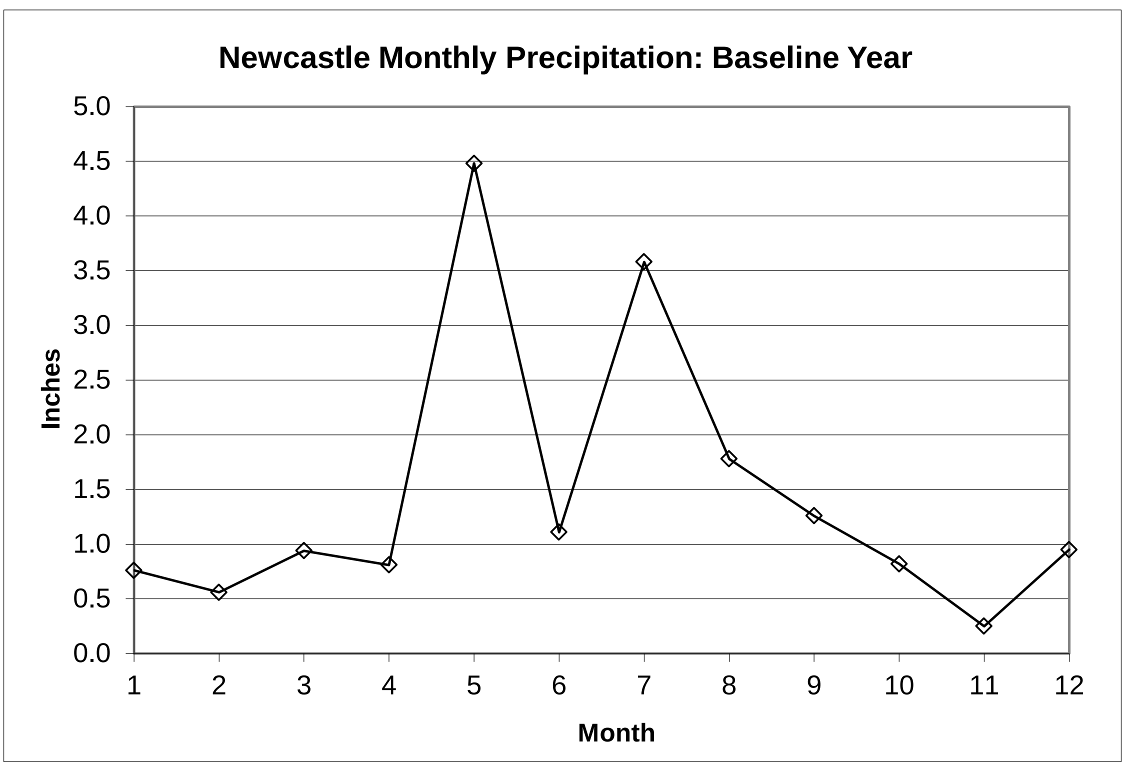


Figure 3.1-9: Baseline Year Monthly Precipitation for Newcastle, Wyoming

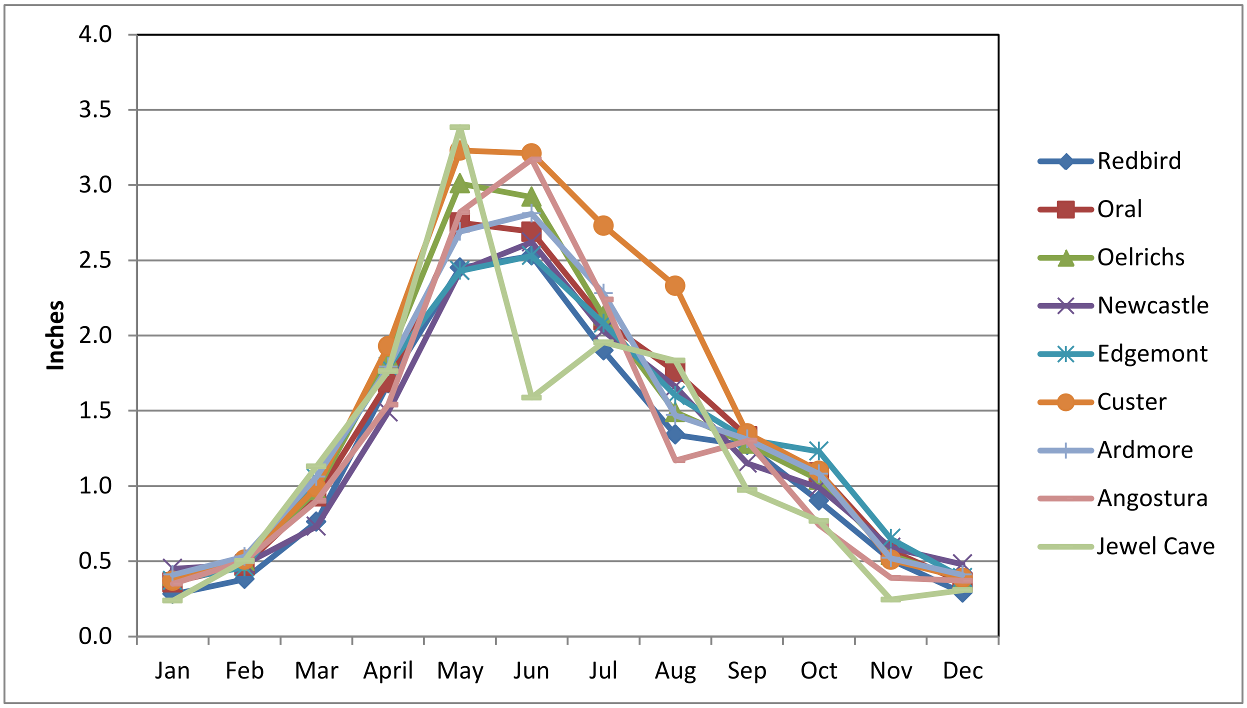


Figure 3.1-10: Average Monthly Precipitation for Regional Sites

Table 3.1-5: Average Seasonal and Annual Precipitation for Regional Sites

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

Source: HPRCC, 2008; SDSU, 2008

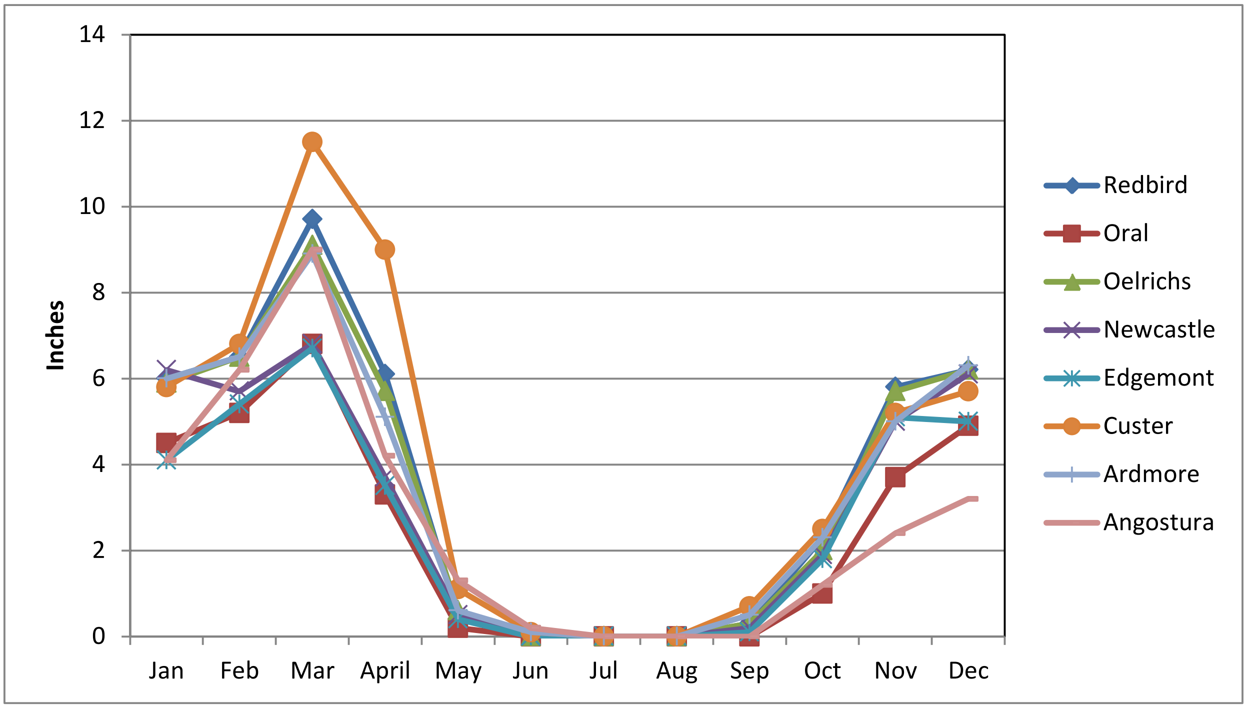


Figure 3.1-11: Average Monthly Snowfall at Regional Sites

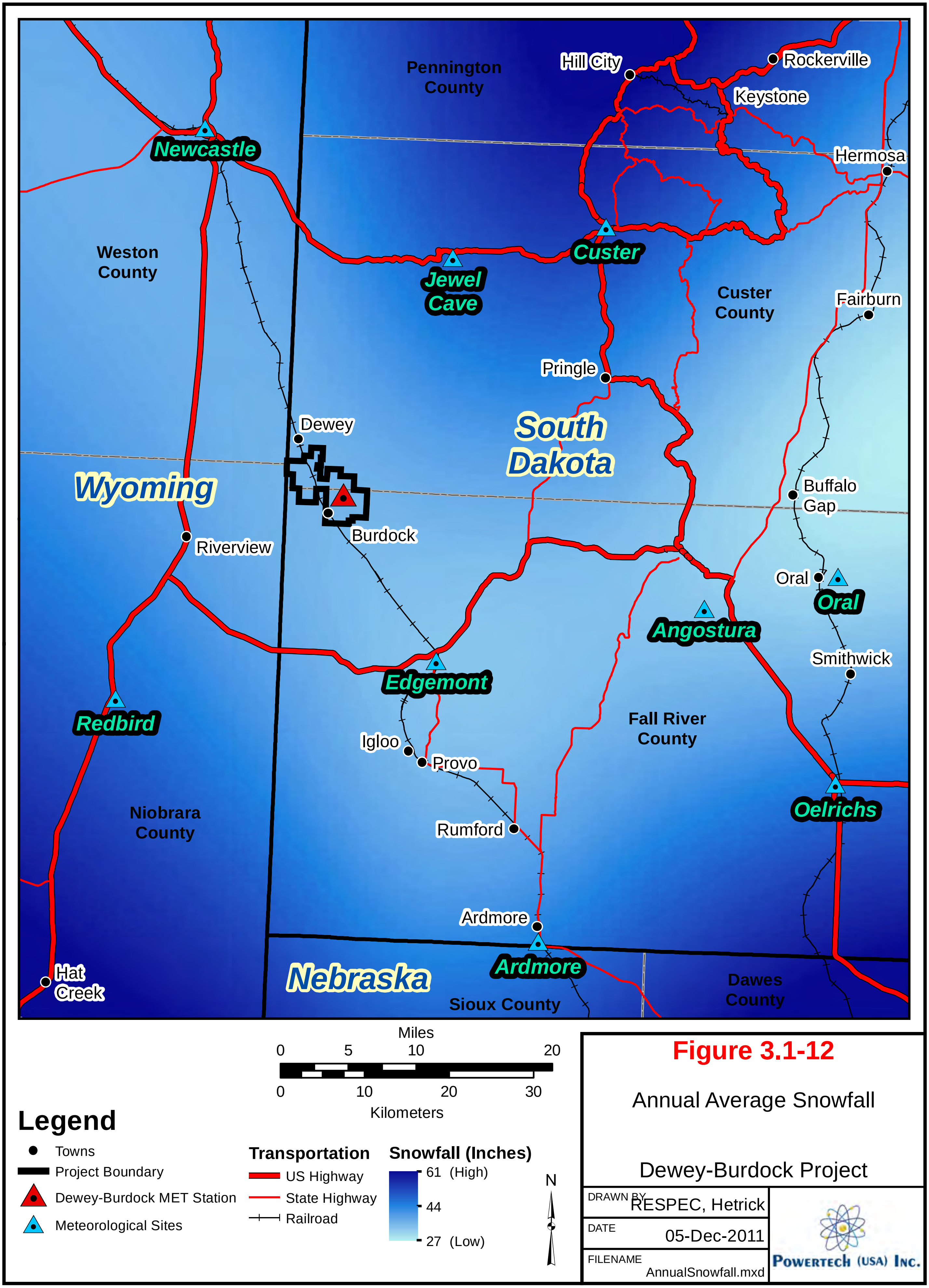


Figure 3.1-12

Annual Average Snowfall

Dewey-Burdock Project

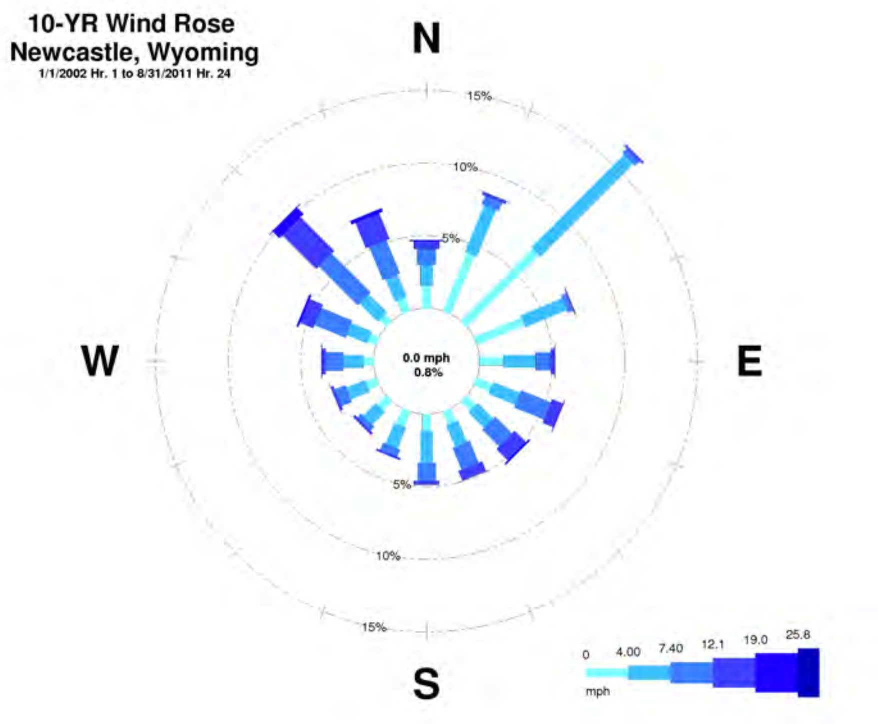


Figure 3.1-13: Newcastle 10-Year Wind Rose

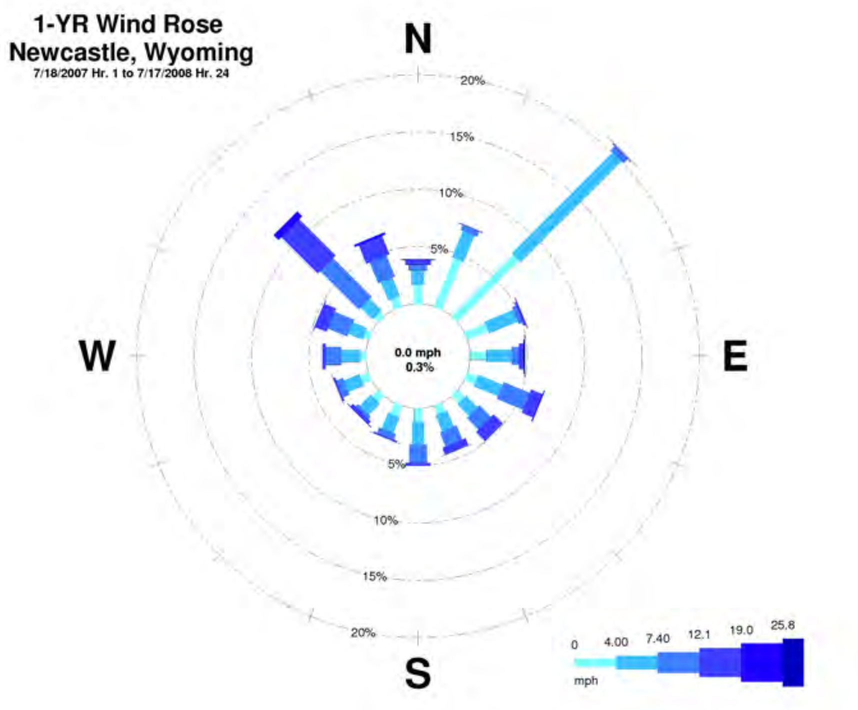


Figure 3.1-14: Newcastle 1-Year Wind Rose

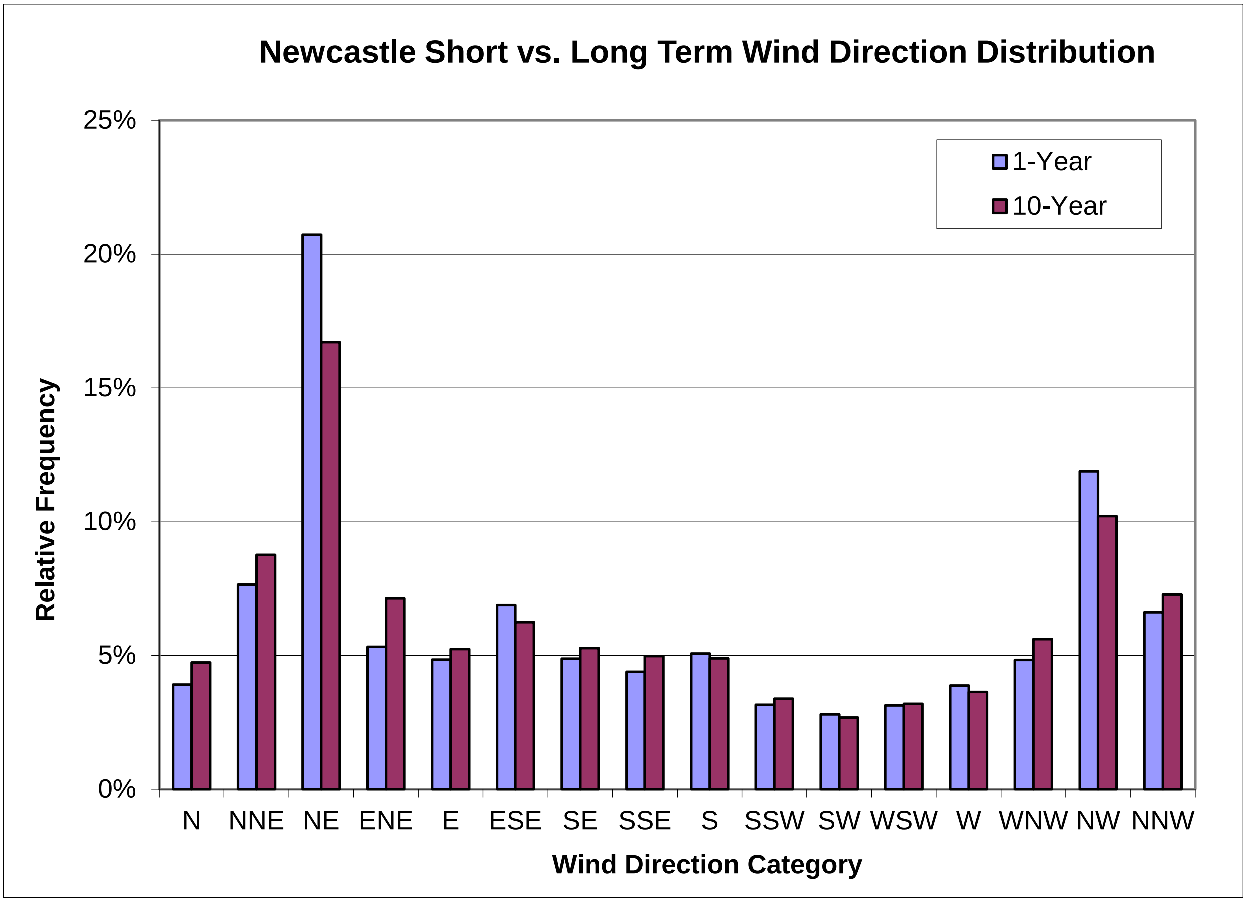


Figure 3.1-15: Newcastle Wind Direction Distributions

period. Figure 3.1-15 presents a graphical comparison of short and long-term wind direction distributions. Together these figures demonstrate qualitatively that the period from 7/18/2007 to 7/17/2008 is representative of the longer term.

3.1.1.5 Cooling, Heating and Growing Degree Days

The graphs shown in Figures 3.1-16, 3.1-17, and 3.1-18 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 elevations of these two sites.

Figure 3.1-19 presents these three measures for Newcastle on one graph. All degree days calculations used a base temperature of 55°F. Heating and cooling degree days are included to show deviation of the average daily temperature from the chosen base temperature. The number of heating degree days is computed by taking the average of the high and low temperature occurring that day and subtracting it from the base temperature. The number of growing degree days and cooling degree days is computed in the opposite fashion where the base temperature is subtracted from the average of the high and low temperature for the day. Negative values are disregarded for both calculations.

3.1.1.6 Evapotranspiration

The American Society of Civil Engineers (ASCE) Standardized Reference Evapotranspiration Equation was used to calculate daily evapotranspiration (ET) using a tall reference crop coefficient. Note that these calculations were performed to estimate regional ET only; as described in Section 5.7.3, hydrologic modeling of the land application systems conservatively assumed no crop (bare soil). The weather parameters needed to calculate ET using this method are daily maximum and minimum temperature, maximum and minimum relative humidity, total solar radiation, and average wind speed. The Oral site was the only one in the region where all these weather parameters were sampled, and was, therefore, the site used for the regional analysis. The data were available from May 8, 2003 to July 20, 2008. Figure 3.1-20 displays a graph of the average accumulated ET for each month. Most ET occurs during the summer months of June, July, and August with an average monthly accumulation of 10.3 inches. During the winter months, low ET (2.8 inches) occurs because of low temperatures and low solar radiation.

No ET data were available for the Newcastle site. The nearest relevant evaporation data in Wyoming were obtained from the Wyoming Water Research Center (WWRC) for Casper,

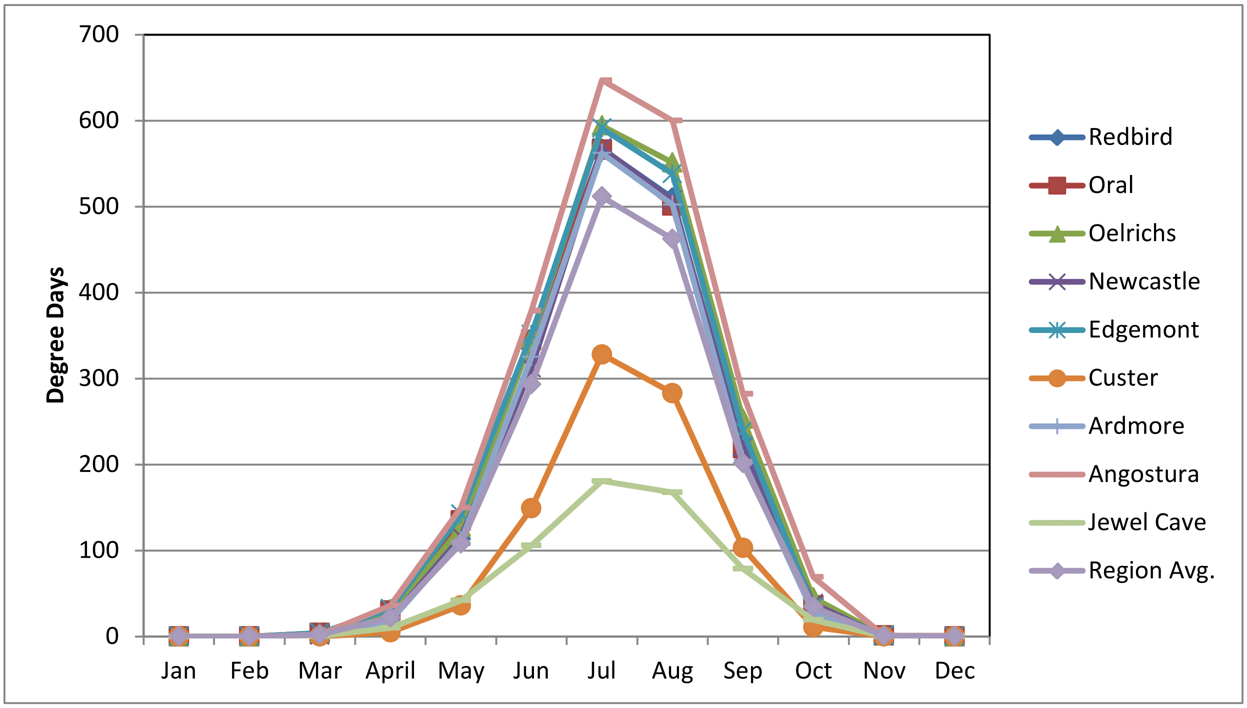


Figure 3.1-16: Growing Degree Days for Regional Sites

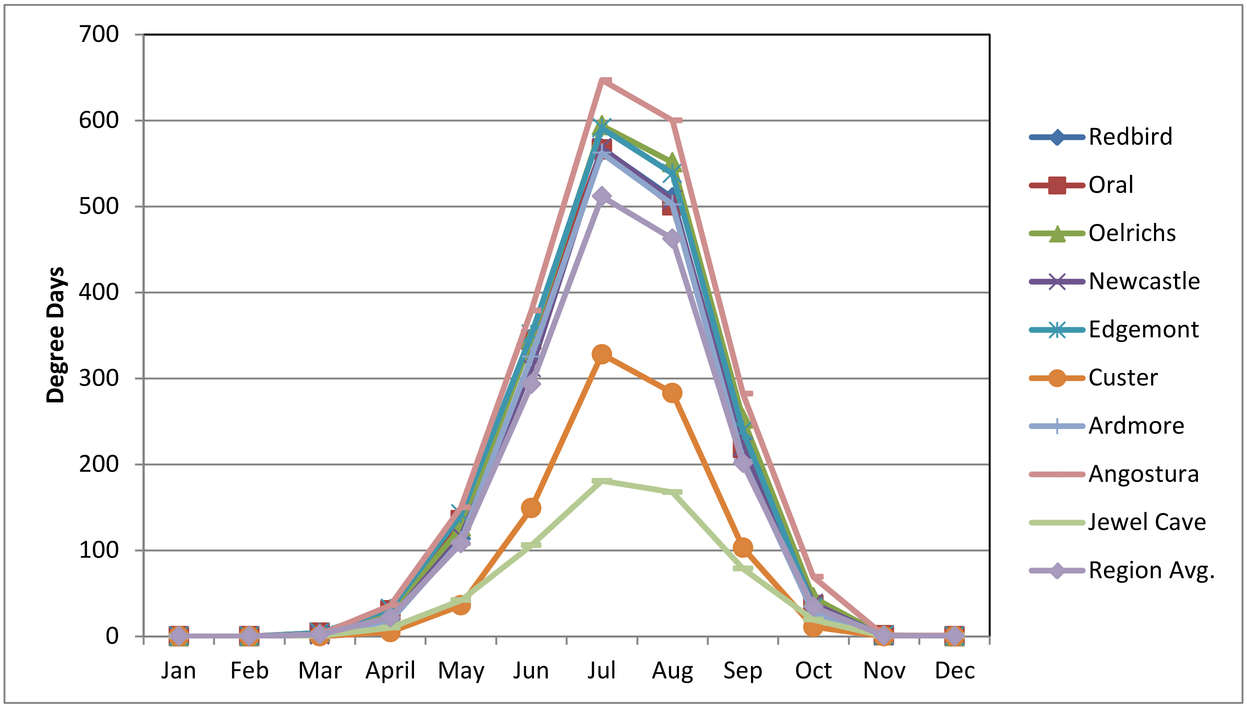


Figure 3.1-17: Cooling Degree Days for Regional Sites

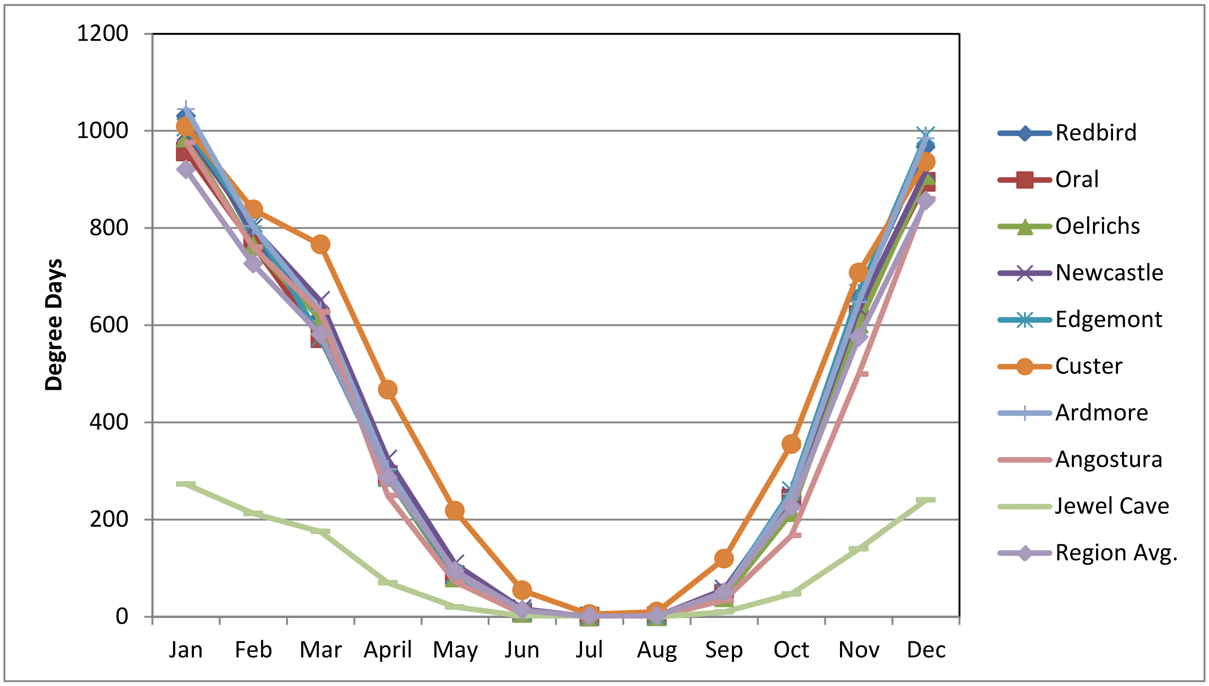
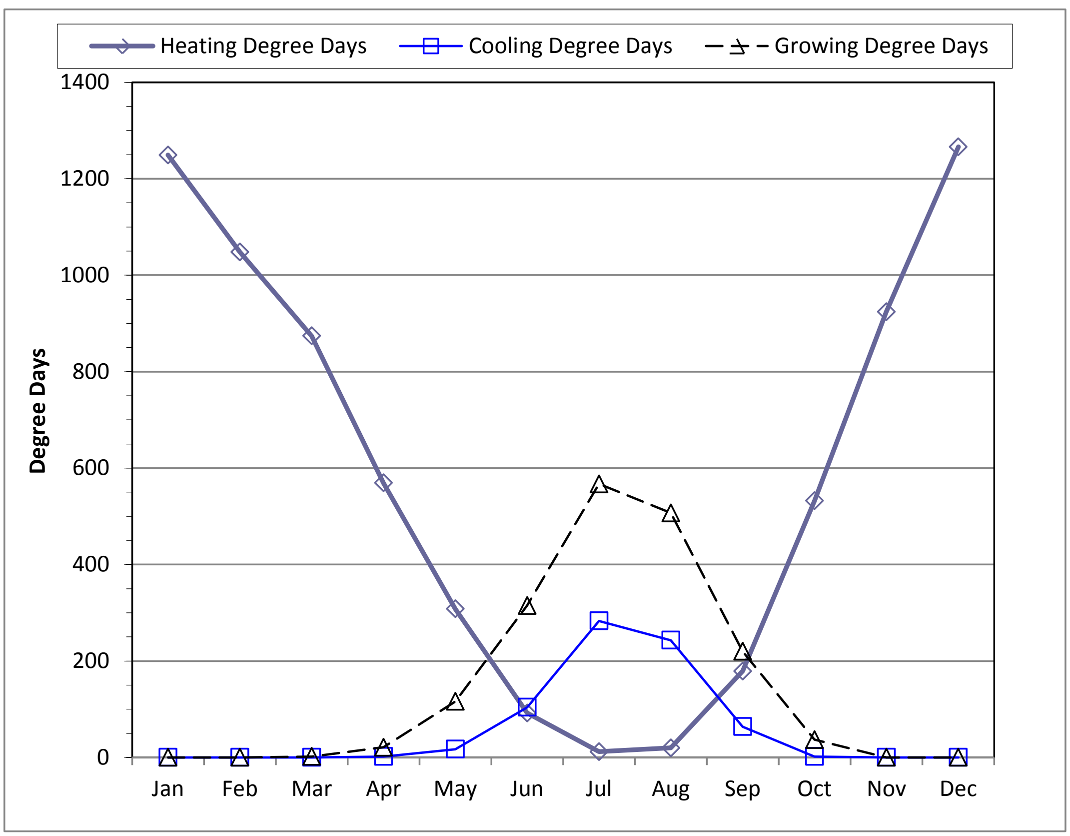


Figure 3.1-18: Heating Degree Days for Regional Sites



Source: WRCC, 2011

Figure 3.1-19: Degree Days for Newcastle NWS Site

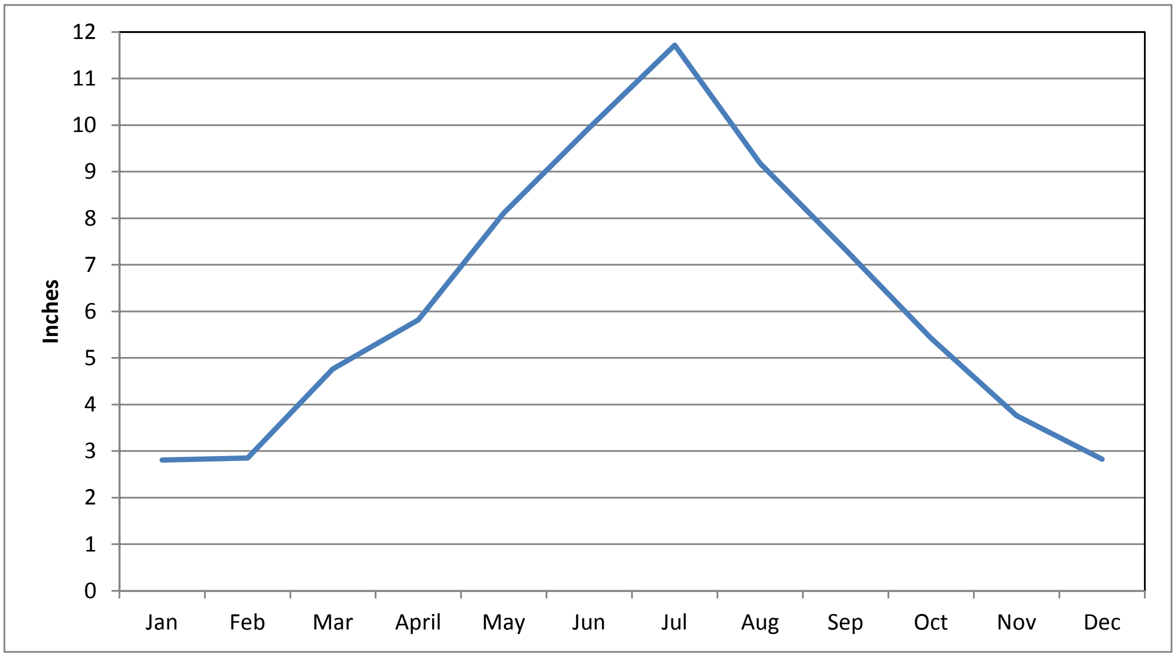


Figure 3.1-20: Average Monthly Accumulated Evapotranspiration for Oral, South Dakota

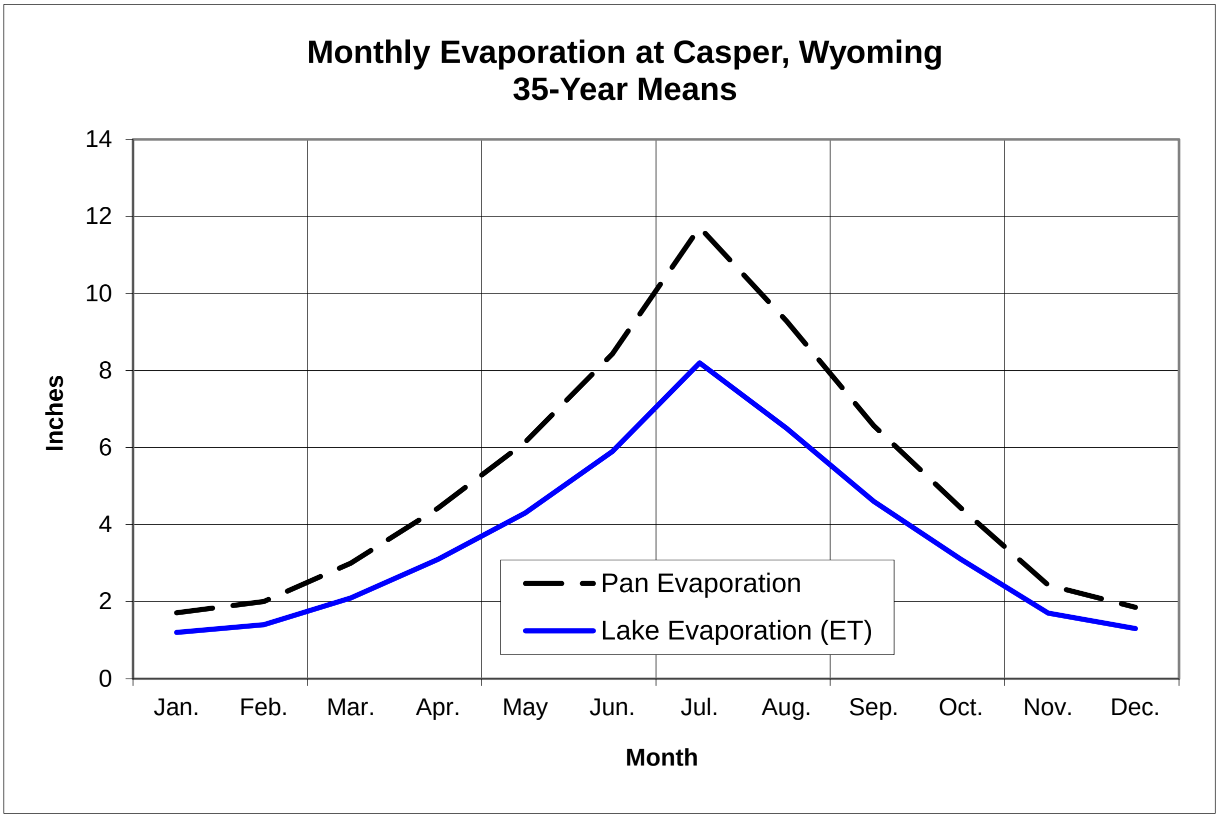


Figure 3.1-21: Average Monthly Evaporation for Casper, Wyoming

Wyoming (Figure 3.1-21). Casper experiences solar radiation values similar to Newcastle. Higher winds and lower rainfall at Casper suggest that ET should be higher than at Newcastle.

The lake evaporation rates in Figure 3.1-21 are computed from pan evaporation measurements by applying a 0.70 multiplier which is typical practice in this region. The WWRC source document states that "the potential evapotranspiration estimates are sometimes considered to be equivalent to lake evaporation." Therefore, the lake evaporation provides a surrogate measure of ET in Casper.

It will be noted by comparing Figures 3.1-20 and 3.1-21 that projected ET values are significantly higher at Oral, South Dakota than at Casper, Wyoming. This could be attributed to the use of a tall reference crop coefficient at the Oral, South Dakota site. Regardless, the Newcastle site is expected to more closely resemble Casper, Wyoming.

3.1.2 Site-Specific Analysis

The site-specific analysis was completed using data collected from a weather station installed in approximately the center of the proposed NRC license boundary. Twelve months of data from July 18, 2007 to July 17, 2008 are used for this analysis.

This site was installed in cooperation with the South Dakota State Climatology office according to the standards they use to install their Automatic Weather Data Network (AWDN) stations. The parameters being sampled at the site are air temperature, solar radiation, humidity, precipitation, and wind speed/direction at both 3- and 10-meter heights (9.8 and 32.8 feet). Table 3.1-6 lists the model number and specifications of the sensors that were installed.

3.1.2.1 Temperature

The average hourly temperature over the year for the site was 45.5°F. A maximum temperature of 104°F was reached on both July 21, 2007 and August 13, 2007, while the minimum temperature for the period of record was –28°F on January 22, 2008. A boxplot of the average temperature by month is shown in Figure 3.1-22. July was the warmest month with a median temperature of 76°F with a first quartile value 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. The temperature was well above freezing for the months of April through October, during which the proposed land application systems will operate.

There were large variations in seasonal and diurnal temperature (Figure 3.1-23). In the summer season, average temperatures were from 60°F at 6 a.m. to 83.6°F at 5 p.m. In the winter season,

Table 3.1-6: Specifications for Weather Instruments Installed to Perform Site-Specific Analysis

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

temperatures averaged 11°F between 7 a.m. and 8 a.m. and rose to nearly 27°F at 4 p.m. The diurnal variations are the result of the lack of relative humidity in the atmosphere at the site, which causes the earth's surface to rapidly absorb and release the energy supplied by the sun.

Figure 3.1-24 shows a probability plot of average hourly temperature for the year. Temperatures above or below 46°F were expected at the site 50 percent of the time, and temperatures dipped below the freezing mark (32°F) 31 percent of the time.

3.1.2.2 Wind Patterns

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

As shown in Table 3.1-7, 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 3.1-25 and 3.1-26 show the quarterly wind roses for the Dewey-Burdock project area. The period from January through March was used for the 1st Quarter, April through June for 2nd Quarter, July through September for 3rd Quarter and October through December for 4th Quarter. The 3rd Quarter wind rose reflects hourly data from both 2007 and 2008. Figure 3.1-27

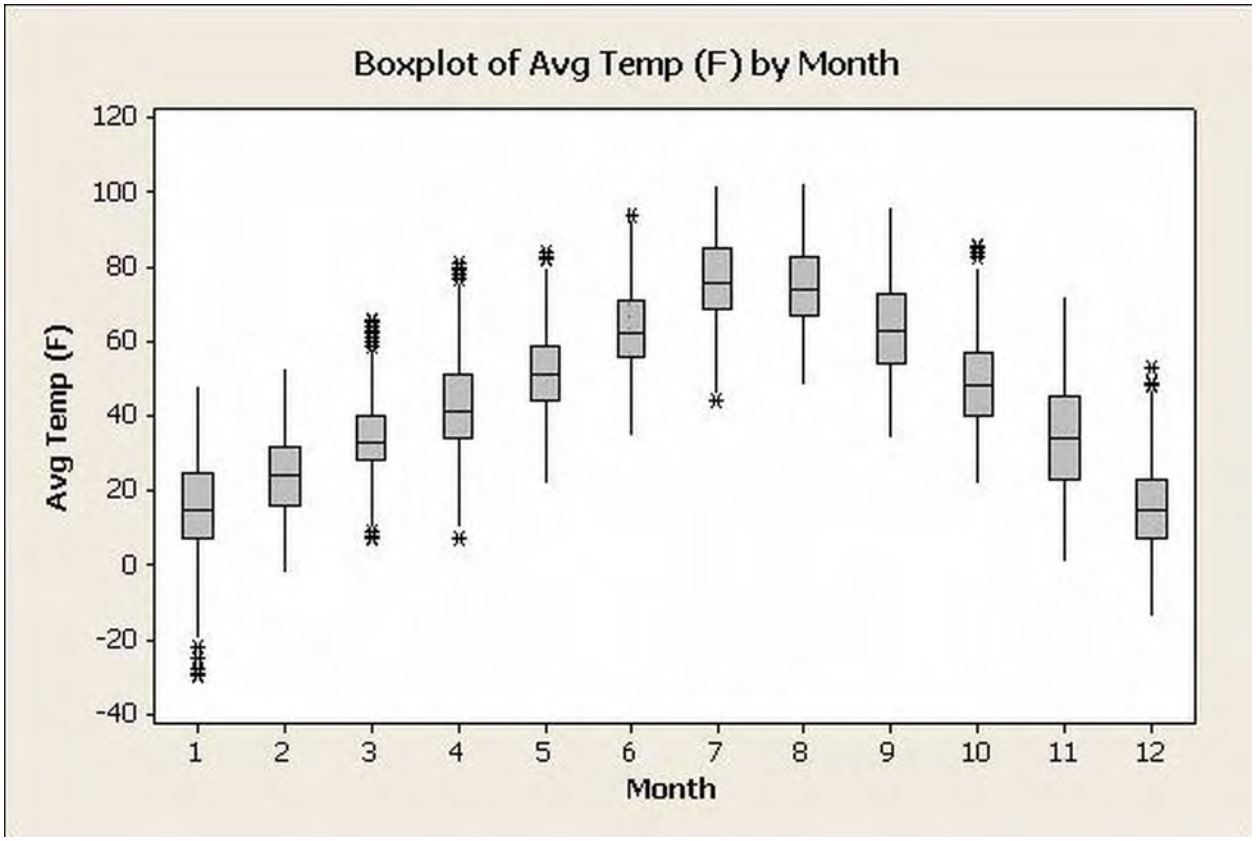


Figure 3.1-22: Average Temperature by Month from the Project Meteorological Site

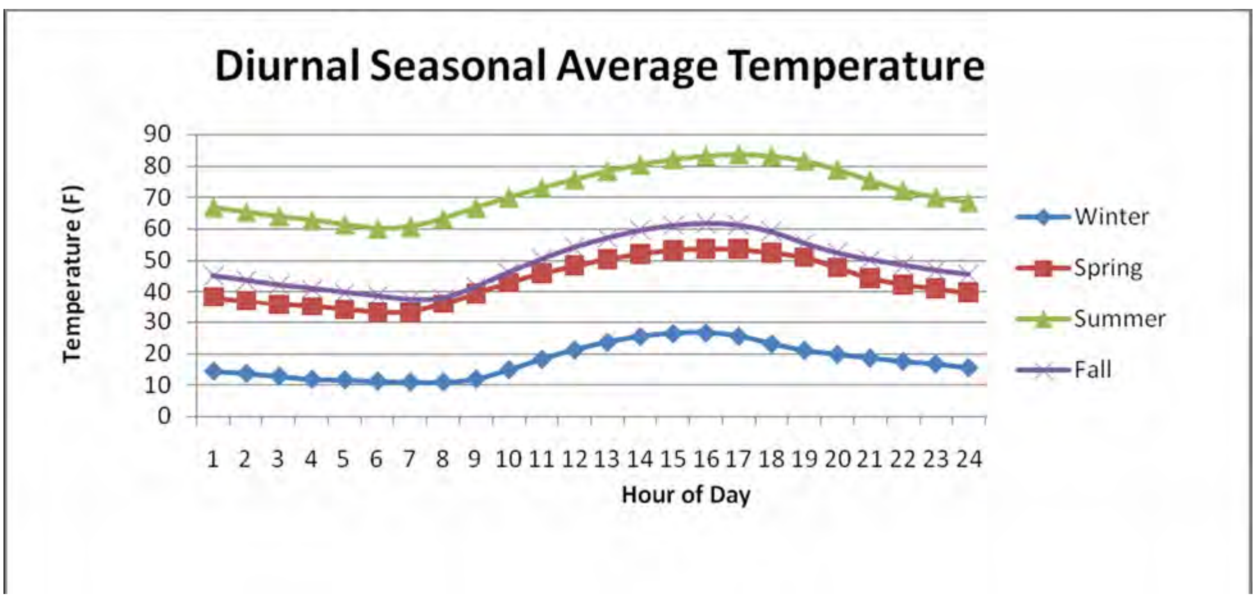


Figure 3.1-23: Diurnal Average Temperature for the Project Meteorological Site by Season

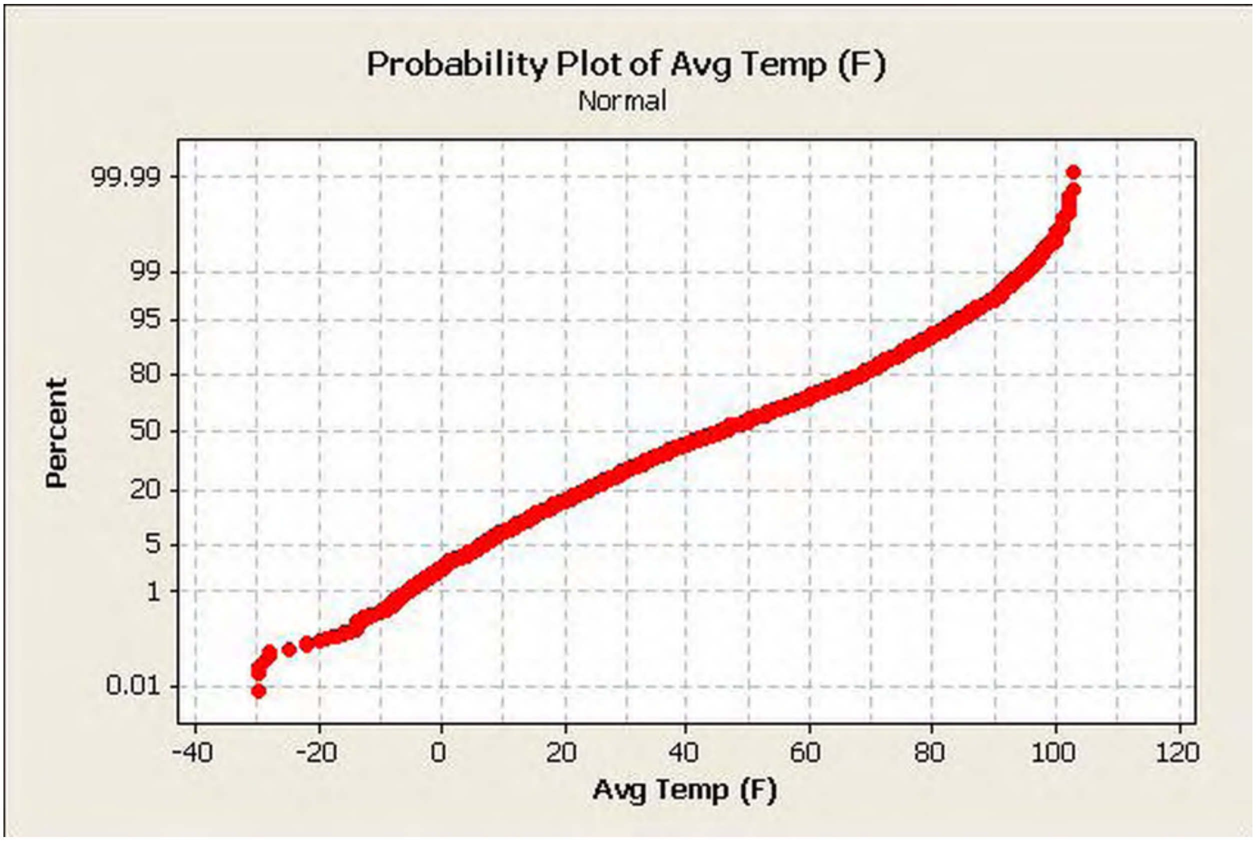
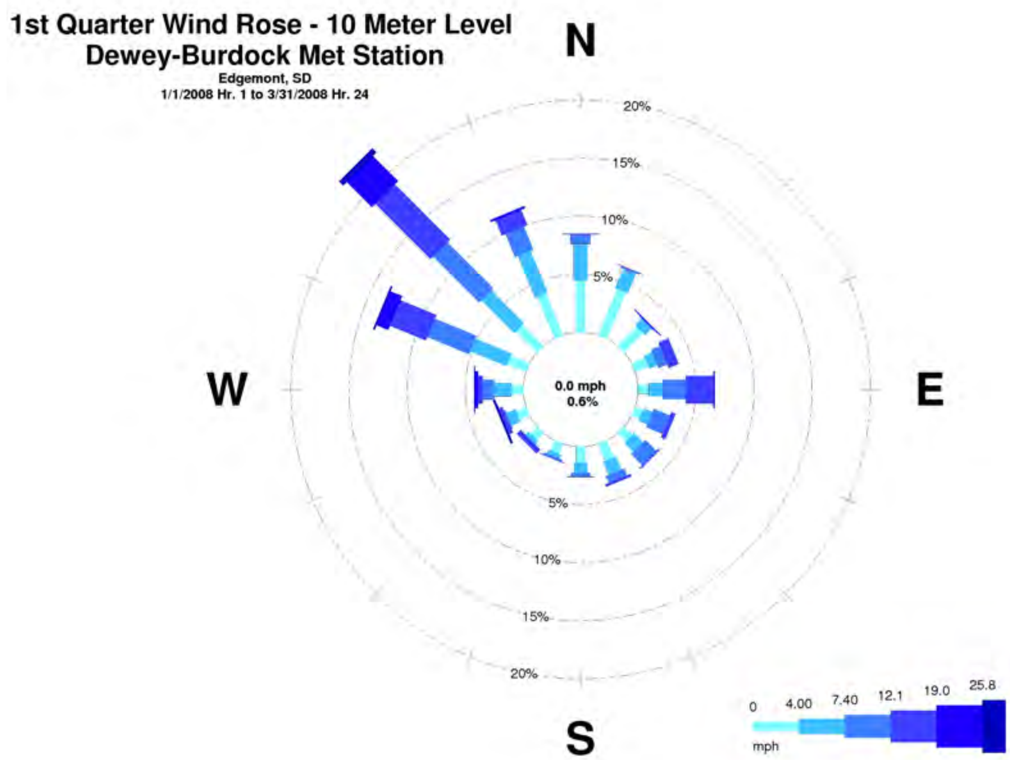


Figure 3.1-24: Probability Plot of Average Temperature from the Project Meteorological Site

Table 3.1-7: Normalized Frequency Distribution of Wind at the Project Meteorological Site

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

Source: SDSU, 2008



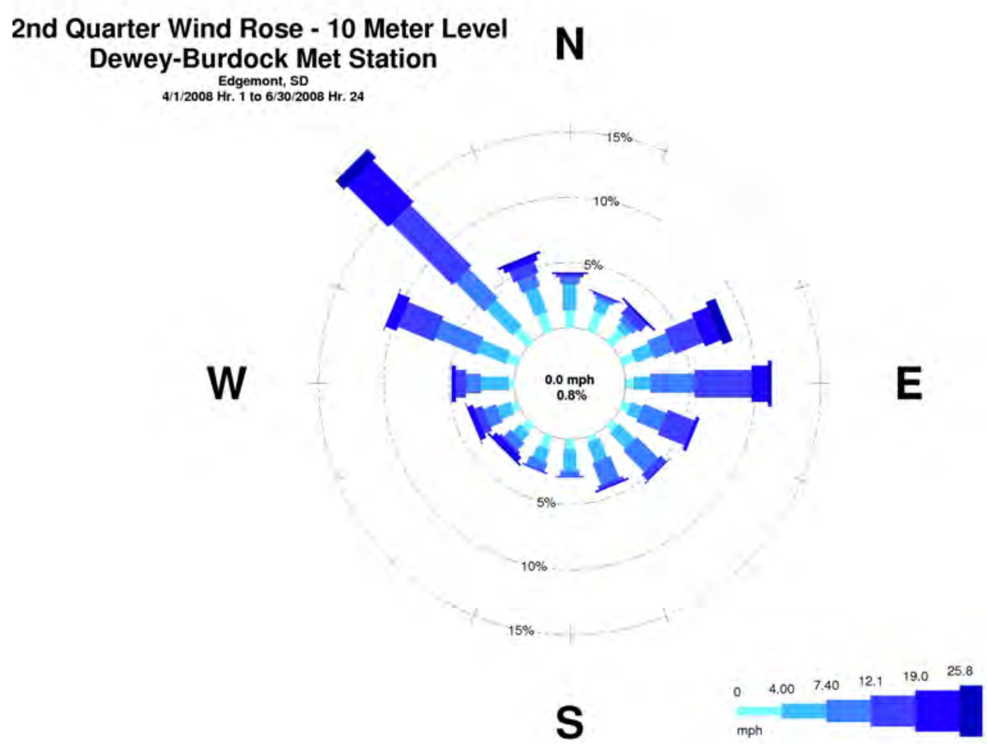
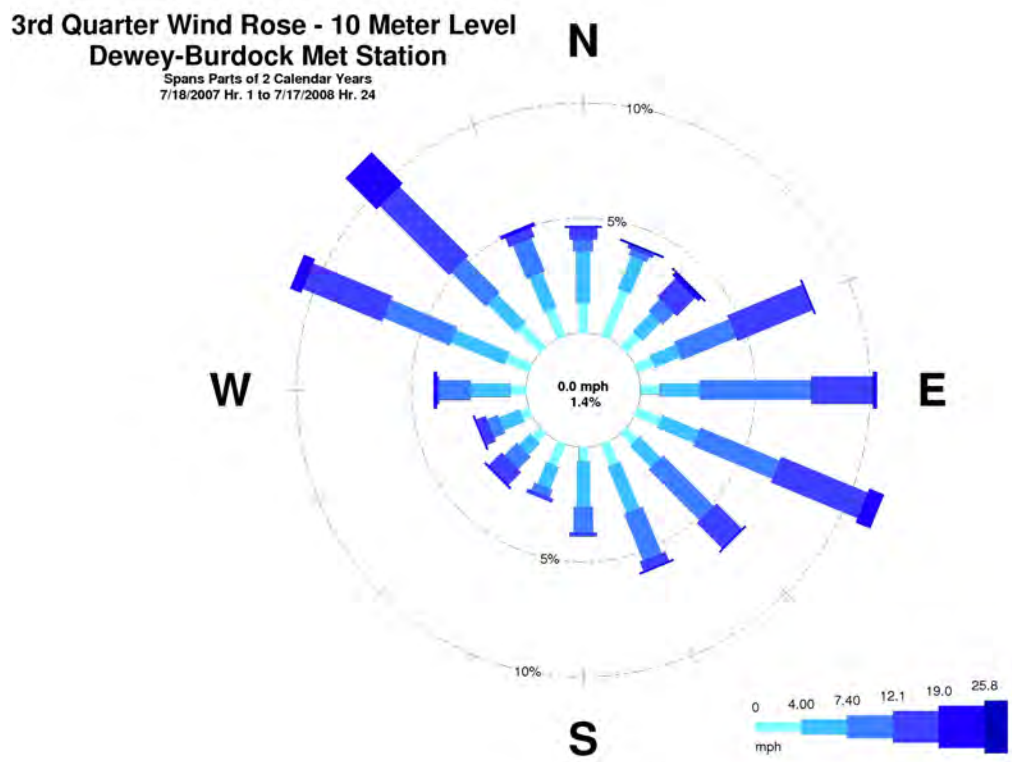


Figure 3.1-25: First and Second Quarter Wind Roses



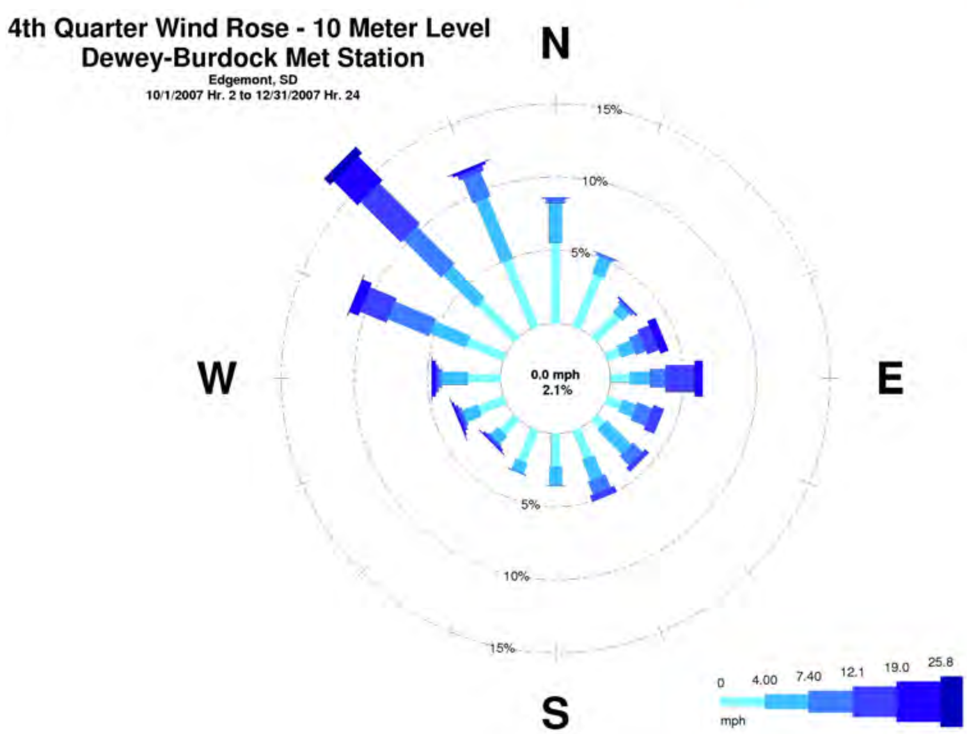


Figure 3.1-26: Third and Fourth Quarter Wind Roses

POWERTECH (USA) INC.

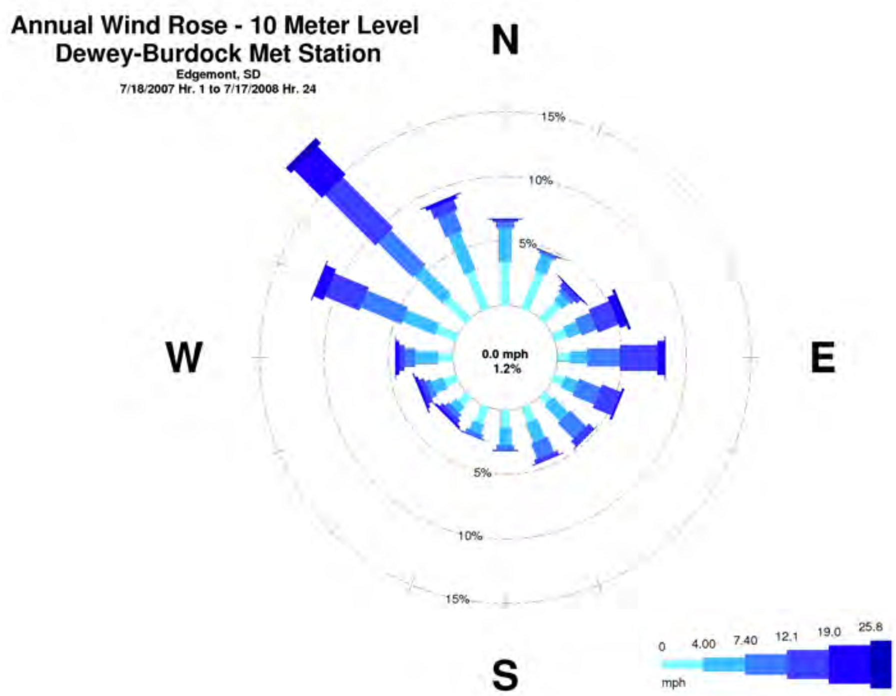


Figure 3.1-27: Annual Wind Rose

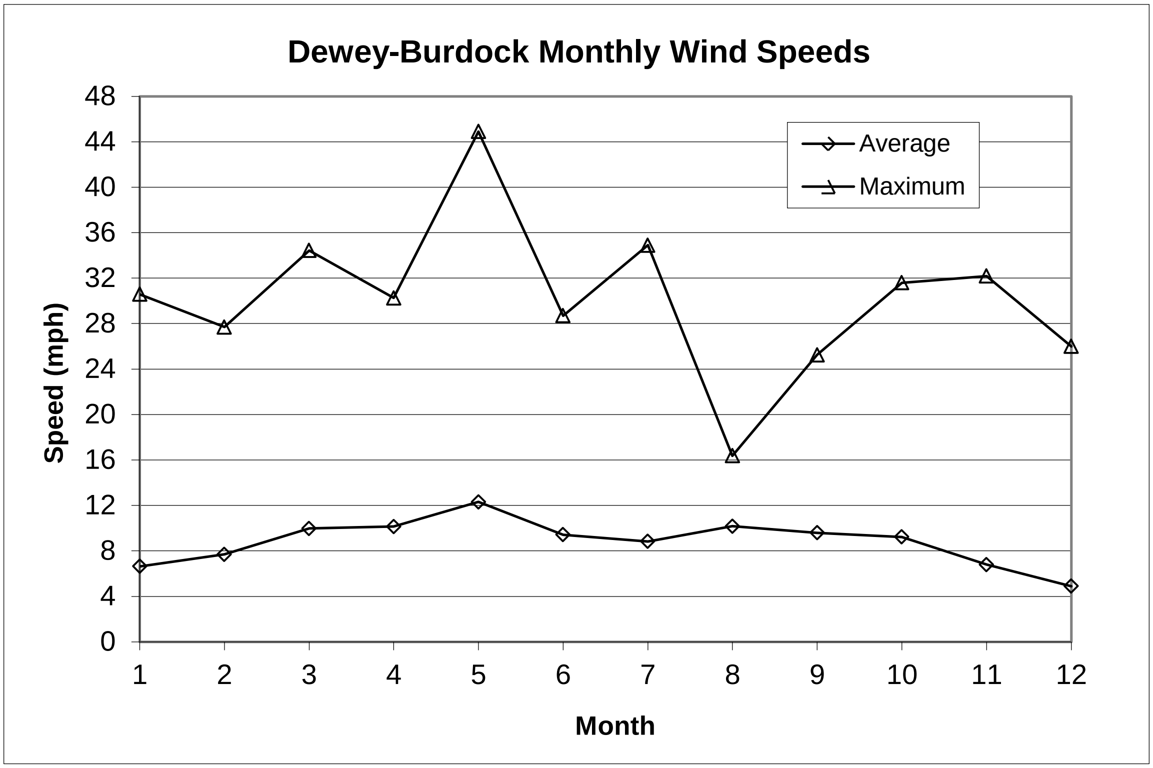


Figure 3.1-28: Dewey-Burdock Monthly Wind Speeds

shows the annual wind rose for the project site, with northwesterly and west-northwesterly winds dominating. Figure 3.1-28 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.

3.1.2.3 Relative Humidity

As mentioned in previous sections, the relative humidity at the site is low. Mean values range from a low of 51 percent in the summer months to a high of 77 percent in the winter months. Relative humidity values varied greatly throughout the day, especially in the summer and spring months. On average, during the spring, summer, and fall months, relative humidity reached its maximum from 5 a.m. to 7 a.m. and then declined steadily until 4 p.m. to 5 p.m. when it began its evening ascent (Figure 3.1-29). During the winter months, the diurnal relative humidity range was much less because of less intense and shorter duration solar radiation.

3.1.2.4 Precipitation

Data for this site were collected using a Vaisala VRG 101 all-weather precipitation gauge. The region received 12.42 inches of precipitation during the year of monitoring. Figure 3.1-30 displays the precipitation totals by month. The largest monthly precipitation total occurred in May (3.8 inches) and the least occurred in November (0.10 inch). The greatest daily precipitation total (1.29 inches) occurred on May 23, 2008. Also on May 23, 2008, the area received 0.71 inch of precipitation between the hours of 8 p.m. and 9 p.m., which was the most intense event of the sampled year.

3.1.2.5 Potential Evapotranspiration

The potential ET data were taken from July 18, 2007 to July 14, 2008. The ASCE Standardized Reference Evapotranspiration Equation for a tall reference crop was used to estimate daily ET. The weather parameters needed to estimate ET using this method are daily, maximum and minimum temperature, maximum and minimum relative humidity, total solar radiation, and average wind speed. Most ET occurs during the months of July, August, and September with an average monthly accumulation of 10.3 inches (Figure 3.1-31) 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.

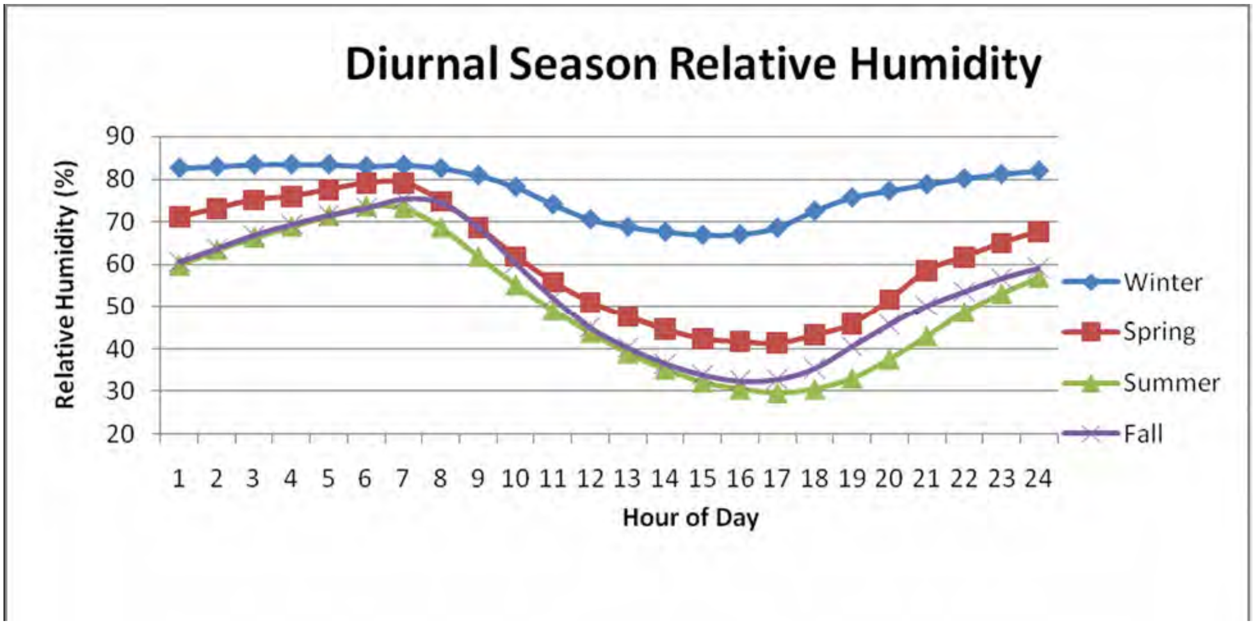


Figure 3.1-29: Diurnal Relative Humidity by Season from Project Meteorological Site

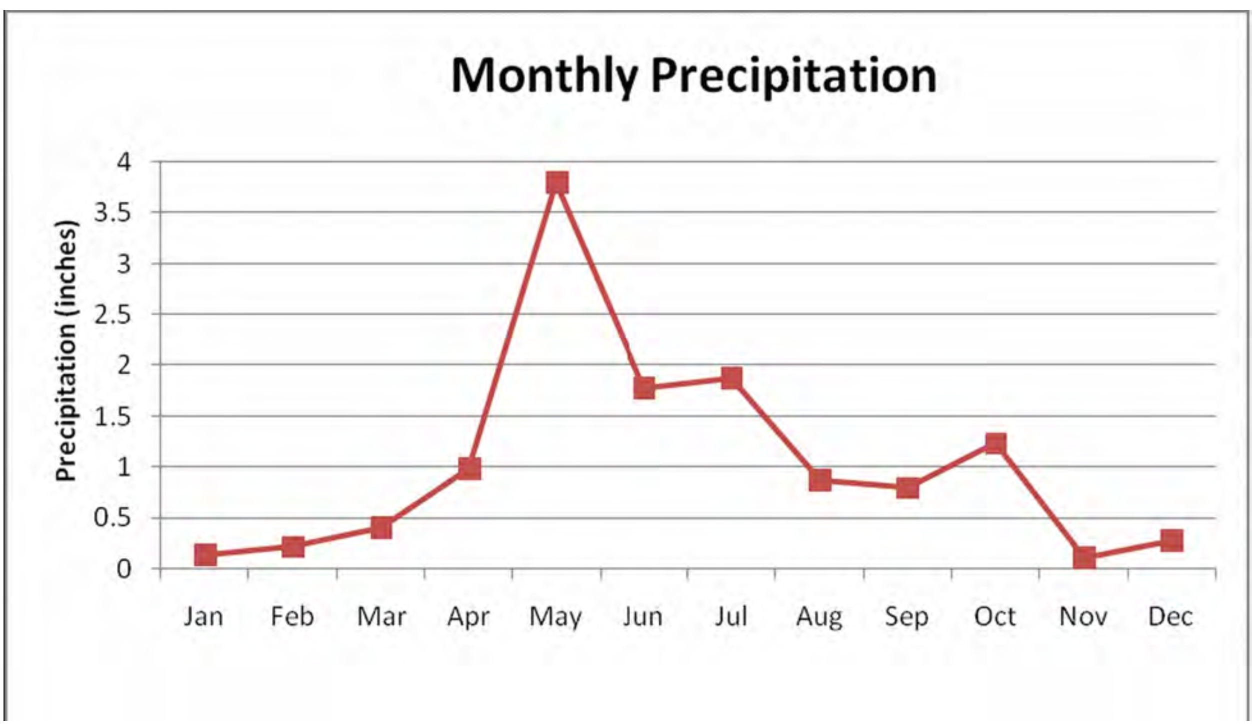


Figure 3.1-30: Monthly Precipitation from the Project Meteorological Site

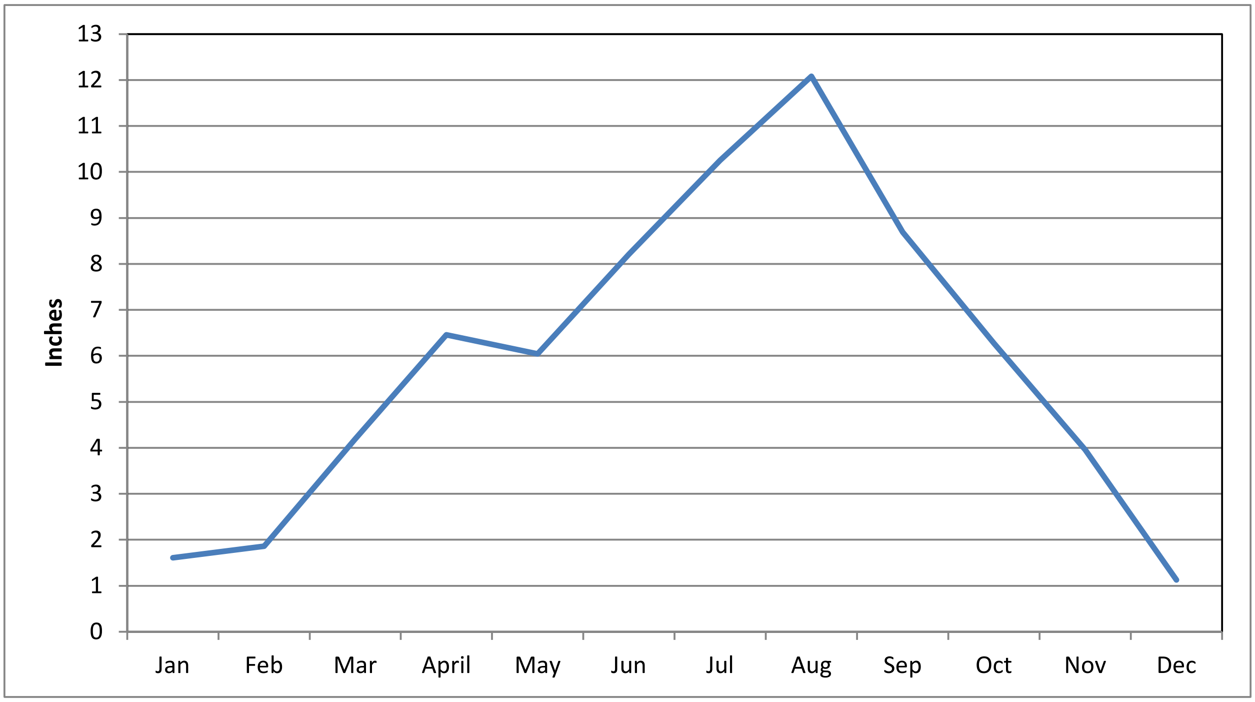


Figure 3.1-31: Estimated Evapotranspiration Calculated Using Weather Data Collected at the Project Meteorological Site

3.2 Soils

3.2.1 General Soil Description

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

3.2.2 Soil Survey Methodology

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 http://www.nrcs.usda.gov.

BKS Environmental Associates, Inc. (BKS) of Gillette, WY performed the 2007 soil survey field work and compiled the resulting report. All soil analysis was handled by Energy Labs in Gillette, Wyoming.

Construction of the soil map was completed according to techniques and procedures of the National Cooperative Soil Survey. A total of 10,557 acres were included in the final soil mapping of the proposed NRC license area, in which 1,882 acres were located in the proposed POP zones.

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 37 sites within and around the proposed NRC license boundary were sampled for analysis; all had corresponding soil profile descriptions written. Of these, eight sites were located within proposed POP zones.

3.2.3 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 are presented in Appendix 3.2-A.

3.2.4 Results and Discussion

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 in the project area were generally a clayey or very fine texture throughout with patches of sandy loam on upland areas and fine, clay textured soils occurring in or near drainages. The project area contained deep soils on level upland areas with shallow and very shallow soils located on hills, ridges and breaks. Plate 3.2-1 shows the soil map for the proposed NRC license area. Tables 3.2-1 and 3.2-2 provide the soil mapping unit designations and associated acreage within the Dewey and Burdock POP zones, respectively. Figure 3.2-1 provides the soils map at the Dewey land application area, and Figure 3.2-2 shows the soil map at the Burdock land application area.

The primary purpose of the 2007 fieldwork was to characterize the soils in terms of topsoil salvage depths and related physical and chemical properties. Refer to Appendix 3.2-A for soil mapping unit descriptions and soil series descriptions for those soils within the land application areas and associated POP zones.

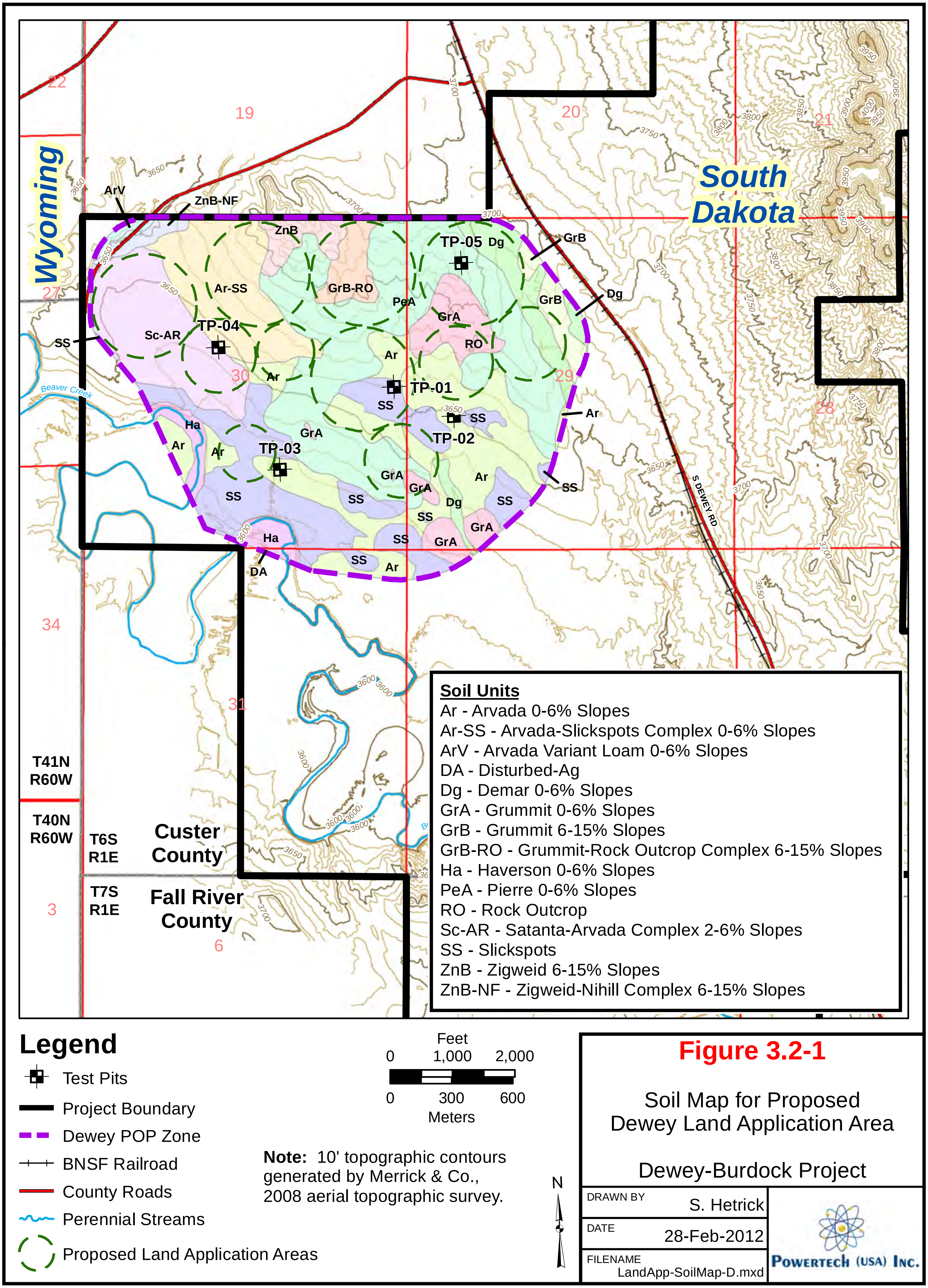
Analyzed parameters are in Appendix 3.2-A. Laboratory soil texture analysis did not include percent fine sands. Field observations of fine sands within individual pedestals as well as sample site topographic position were used in conjunction with laboratory analytical results to determine series designation. Where applicable, field observation of fine sands is also included in the textures found in the soil series descriptions in Appendix 3.2-A. 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.

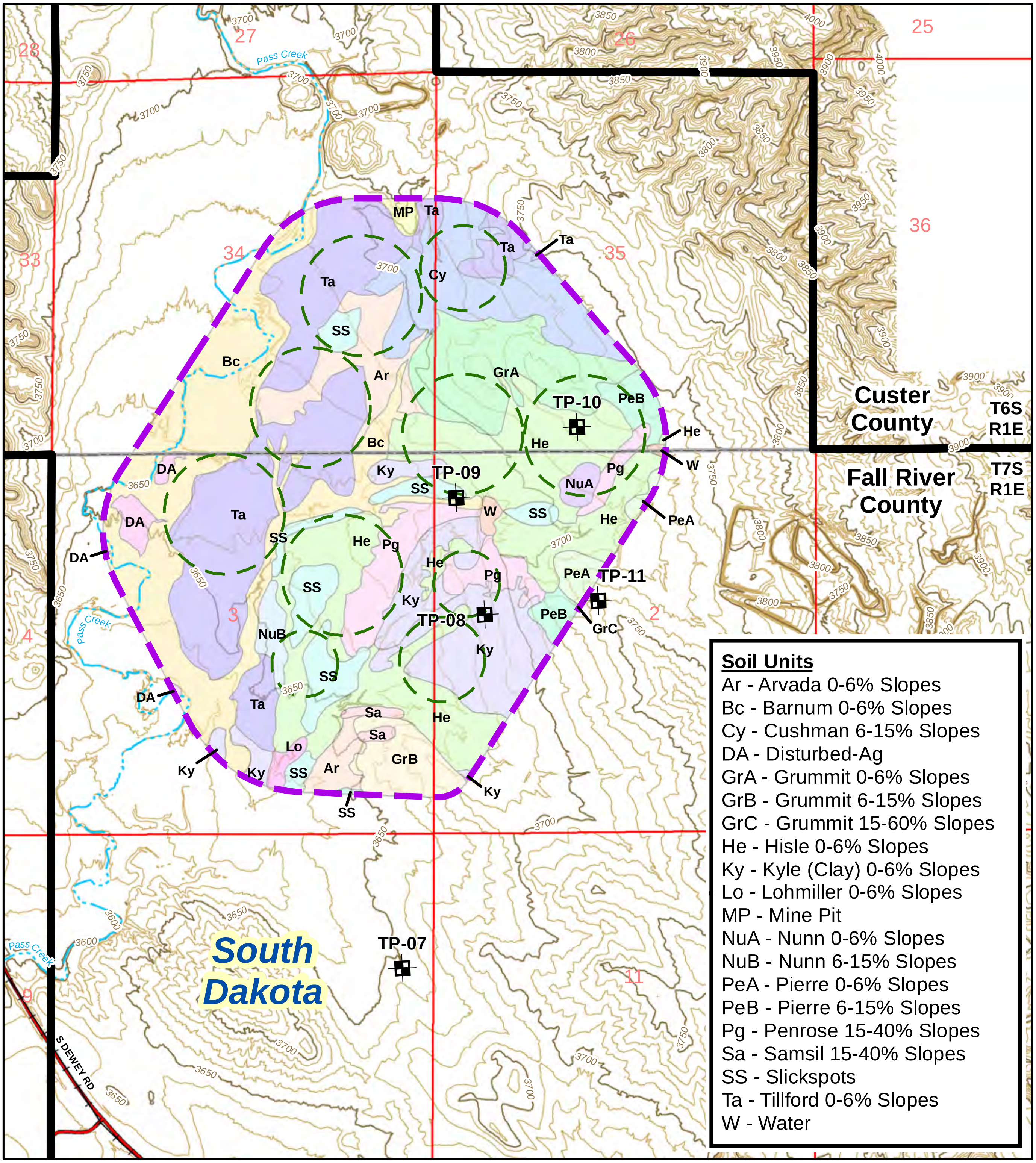
Table 3.2-1: Soil Mapping Unit Acreage within Proposed Dewey POP Zone

Map Symbol	Map Unit Description	Acreage	% Total Acreage
Ar	Arvada, 0 to 6 percent slopes	153.40	18.43
ArV	Arvada Variant Loam, 0 to 6 percent slope	3.64	0.44
Ar-SS	Arvada-Slickspots Complex, 0 to 6 percent slopes	80.46	9.67
Dg	Demar, 0 to 6 percent slopes	38.82	4.67
DA	Disturbed-Ag	0.20	0.02
GrA	Grummit, 0 to 6 percent slopes	47.95	5.76
GrB	Grummit, 6 to 15 percent slopes	16.24	1.95
GrB-RO	Grummit-Rock Outcrop Complex, 6 to 15 percent slopes	19.38	2.33
Ha	Haverson, 0 to 6 percent slopes	21.89	2.63
PeA	Pierre, 0 to 6 percent slopes	206.99	24.87
RO	Rock Outcrop	0.35	0.04
Sc-Ar	Satanta-Arvada Complex, 0 to 6 percent slopes	85.04	10.22
SS	Slickspots	131.62	15.82
ZnB	Zigweid, 6 to 15 percent slopes	17.17	2.07
ZnB-NF	Zigweid-Nihill Complex, 6 to 15 percent slopes	8.98	1.08
Total		**832.13**	**100.00**

Table 3.2-2: Soil Mapping Unit Acreage within Proposed Burdock POP Zone

Map Symbol	Map Unit Description	Acreage	% Total Acreage
Ar	Arvada, 0 to 6 percent slopes	47.31	4.51
Bc	Barnum, 0 to 6 percent slopes	176.57	16.82
Cy	Cushman, 6 to 15 percent slopes	73.17	6.97
DA	Disturbed-Ag	9.07	0.86
GrA	Grummit, 0 to 6 percent slopes	70.53	6.72
GrB	Grummit, 6 to 15 percent slopes	26.85	2.56
GrC	Grummit, 15 to 60 percent slopes	0.14	0.01
He	Hisle, 0 to 6 percent slopes	197.25	18.79
Ky	Kyle, 0 to 6 percent slopes	92.30	8.79
Lo	Lohmiller, 0 to 6 percent slopes	4.09	0.39
MP	Mine Pit	4.19	0.40
NuA	Nunn, 0 to 6 percent slopes	5.80	0.55
NuB	Nunn, 6 to 15 percent slopes	9.15	0.87
Pg	Penrose, 15 to 40 percent slopes	48.82	4.65
PeA	Pierre, 0 to 6 percent slopes	10.85	1.03
PeB	Pierre, 6 to 15 percent slopes	17.71	1.69
Sa	Samsil, 15 to 40 percent slopes	4.42	0.42
SS	Slickspots	51.42	4.89
Ta	Tillford, 0 to 6 percent slopes	196.87	18.75
W	Water	3.43	0.33
Total		**1,049.94**	**100.00**


Wyoming
South Dakota
19
20
21
22
27
28
29
30
31
34
3
6
TP-01
TP-02
TP-03
TP-04
TP-05
ArV
ZnB-NF
ZnB
Ar-SS
GrB-RO
PeA
Dg
GrB
GrA
RO
Sc-AR
SS
Ar
Ha
DA
Beaver Creek
S DEWEY RD
T41N R60W
T40N R60W
T6S R1E
T7S R1E
Custer County
Fall River County
Soil Units
Ar - Arvada 0-6% Slopes
Ar-SS - Arvada-Slickspots Complex 0-6% Slopes
ArV - Arvada Variant Loam 0-6% Slopes
DA - Disturbed-Ag
Dg - Demar 0-6% Slopes
GrA - Grummit 0-6% Slopes
GrB - Grummit 6-15% Slopes
GrB-RO - Grummit-Rock Outcrop Complex 6-15% Slopes
Ha - Haverson 0-6% Slopes
PeA - Pierre 0-6% Slopes
RO - Rock Outcrop
Sc-AR - Satanta-Arvada Complex 2-6% Slopes
SS - Slickspots
ZnB - Zigweid 6-15% Slopes
ZnB-NF - Zigweid-Nihill Complex 6-15% Slopes
Legend
Test Pits
Project Boundary
Dewey POP Zone
BNSF Railroad
County Roads
Perennial Streams
Proposed Land Application Areas
Feet
0 1,000 2,000
0 300 600
Meters
Note: 10' topographic contours generated by Merrick & Co., 2008 aerial topographic survey.
N
Figure 3.2-1
Soil Map for Proposed Dewey Land Application Area
Dewey-Burdock Project
DRAWN BY S. Hetrick
DATE 28-Feb-2012
FILENAME LandApp-SoilMap-D.mxd
POWERTECH (USA) INC.



Legend

- Test Pits
- Project Boundary
- Burdock POP Zone
- BNSF Railroad
- County Roads
- Ephemeral Streams
- Proposed Land Application Areas

Feet: 0, 1,000, 2,000
Meters: 0, 300, 600

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

N

Figure 3.2-2

Soil Map for Proposed Burdock Land Application Area

Dewey-Burdock Project

DRAWN BY	S. Hetrick
DATE	28-Feb-2012
FILENAME	LandApp-SoilMap-B.mxd

POWERTECH (USA) INC.

3.2.5 Test Pits

To further characterize the soils at the land application sites, 11 test pits were excavated on July 11 and 12, 2008. Samples were collected at various depths and analyzed for particle size distribution, dry bulk density, permeability, and other geotechnical parameters. Test pits 1 through 5 were excavated at the Dewey land application area, and test pits 6 through 11 were excavated in and around the Burdock land application area. The test pit locations are shown on Figures 3.2-1 and 3.2-2. Table 3.2-3 shows the USDA soil texture and dry bulk density for the test pit samples. These parameters were used as input to the SPAW model as described in Section 5.7.

The particle size distributions for the NRCS soil mapping units were compared to the laboratory particle size distributions for the test pit soil samples. This comparison showed that the laboratory results for the test pit samples generally fell within the range of particle size distributions for the NRCS survey soil mapping units.

In addition to soil data from test pits, soil samples were obtained from auger holes located as shown on Plate 3.2-1. Soil samples were collected by BKS at various depths and analyzed for selected physical/chemical characteristics including saturated paste extracts for electrical conductivity (EC), pH, Ca, Mg, Na, Cl, SO_4, HCO_3, As, Ba, Cd, Cr, Pb, Hg, Se, and Ag. USDA percent sand, silt and clay, as well as organic matter, natural moisture content, and saturation moisture content also were determined. Table 3.2-4 summarizes average values at each site for EC, pH, organic matter, Ca, Mg, Na, sodium adsorption ratio (SAR), exchangeable sodium percentage (ESP), residual sodium carbonate (RSC), USDA soil texture, and as concentrations for the upper soil layer (0 to 11 inches below ground surface) and the deeper soil layer (approximately 50 inches below ground surface) for the auger samples. These are the parameters that are used to assess the success of crop growth using the treated land application water.

Analysis of Table 3.2-4 indicates that the existing soils to be irrigated at both the Dewey and Burdock sites are fine grained, comprised of primarily clay, clay loam, and silty clay textures. Particularly at Dewey, the sodicity of the soils, as reflected by SAR, could be a source of concern if these soils are irrigated. As described in Section 8.3, the land application water is expected to have a relatively low SAR, which will pose a low risk to soil infiltration rates. Should soil SAR increase and pose a risk to soil infiltration, Powertech (USA) will use amendments as necessary such as sulfur or gypsum. At both the Dewey and Burdock sites the physical/chemical constituents increase with soil depth and are typically high values below the top one foot of soil, as would be expected in these fine-grained soils of marine sediment parent material.

Table 3.2-3: Soil Test Pit Physical Properties

Sample No.	Depth (ft)	Gravel (% by wt)	Sand (% by wt)	Silt (% by wt)	Clay (% by wt)	Dry Bulk Density (lb/ft^3)	Permeability (cm/sec)
TP01-1	1	0.20	26.20	38.00	35.60	N/A	5.10E-05
TP01-3	3	0.10	25.70	27.20	47.00	101.20	
TP01-7	7	0.90	8.10	57.20	33.80	86.30	
TP02-1	1	0.00	19.90	40.70	39.40	94.50	
TP02-4	4	0.00	16.70	34.60	48.70	101.50	
TP02-7	7	0.20	26.70	34.80	38.30	92.50	
TP03-1	1	0.00	24.30	24.80	50.90	90.00	8.30E-05
TP03-7	7	0.00	2.40	25.10	72.50	104.60	
TP03-11	11	60.00	25.00	8.90	6.10		
TP04-1	1	2.20	47.80	18.20	31.80	98.10	
TP04-7	7	1.30	27.50	28.00	43.20	113.30	
TP05-1	1	1.50	24.00	31.60	42.90	97.00	
TP05-4	4	2.00	30.00	23.40	44.60	94.80	3.20E-05
TP05-8	8	0.80	22.10	57.60	19.50	106.30	
TP06-1	1	0.30	17.90	30.80	51.00	NA	
TP06-7	7	0.00	42.00	31.80	26.20	NA	
TP06-10	10	0.00	40.00	31.20	28.80	NA	
TP07-1	1	0.60	17.40	27.30	54.70	105.30	
TP07-5	5	0.1	22.1	25.9	51.9	103.90	
TP07-10	10	0.3	19.7	6.9	73.1	105.40	
TP08-2	2	0.1	11.9	35.7	52.3	95.20	5.70E-04
TP08-6	6	0.4	56.6	25.4	17.6	103.40	
TP09-1	1	0.3	15.2	39	45.5	94.90	
TP09-4	4	0.1	35.9	37.8	26.2	109.60	5.50E-06
TP10-1	1	1.8	21.1	34.8	42.3	99.10	
TP10-7	7	0.4	11.1	30.3	58.2	105.80	1.60E-07

Notes: NA = Results for these samples were not available.

Table 3.2-4: Summary of Dewey and Burdock Soil Physical/Chemical Characteristics in Land Application Areas

Area	Depth	EC	pH	Organic Matter	Ca	Mg	Na	SAR	ESP[6]	Texture	As
	(in)	(mS/cm)	(std. units)	(%)	(meq/L)	(meq/L)	(meq/L)	(unitless)	(unitless)	(unitless)	(mg/kg)
Dewey[1]	0 - 11	1.22	6.8	1.6	4.4	2.8	6.3	3.19	3.33	C-CL-SiCL	16.8
	≈50	5.40	6.8	0.5	16.9	27.0	33.0	7.39	8.79	SiC-CL-C-SL	13.1
Dewey[3]	84	--[5]	--[5]	1.3	100.4	50.2	78.6	10.90	12.91	C	--[5]
Burdock[2]	0 - 11	1.64	7.3	1.8	8.2	4.1	5.3	1.91	1.53	C-CL-SiC	9.6
	≈50	5.98	7.7	0.7	24.5	34.7	37.5	6.16	7.26	C-CL-SiC-L	9.4
Burdock[4]	84	--[5]	--[5]	1.1	100.6	84.9	28.3	4.80	5.50	CL	--[5]

(1) Average of auger cores. BKS Environmental Associates, Inc. (Oct. 7, 2008)
(2) Average of auger cores. BKS Environmental Associates, Inc. (Oct. 7, 2008)
(3) Average of 3 values from test pits. Knight Piésold and Co. (2008)
(4) Average of 2 values from test pits. Knight Piésold and Co. (2008)
(5) -- means no data available
(6) Calculated from average SAR

The two potential issues associated with long-term application of treated process water to the Dewey and Burdock sites are changes in the physical properties of the soils (lower hydraulic conductivity and crusting) and changes to the chemical properties of the soils (increased salts and trace metals). These potential changes will be closely monitored as described in Section 6.

3.3 Vegetation

3.3.1 Regional Setting

The project area 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 project area 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 project area 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 project area is comprised of five main vegetative communities, in descending order according to size: Big Sagebrush Shrubland, Greasewood Shrubland, Upland Grassland, Ponderosa Pine Woodland, 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, disturbed areas, creek channels, and numerous ephemeral draws.

Trees are present along the riparian corridors of both primary creeks and on the higher hilltops in the project area. 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 hilltops and breaks in the central and eastern portions of the project area, with Rocky Mountain juniper (*Juniperus scopulorum*) present as individual trees or small inclusions in some of the dry drainages.

3.3.2 Vegetation Survey Methodology

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 (SDGF&P). Refer to Appendix 3.3-A for the submitted methodology.

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

Mapping

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

Transect Origin Selection

The transects were randomly located in the field within each sampled vegetation community. Each transect was at least 150 feet from the previous transect. Random numbers between 1 and 360 were generated to determine cover transect direction, and compasses were utilized to orient transects to the nearest 1/8 of 360 degrees in the field. Each sample site was marked with a hand-held Garmin global positioning system (GPS), and these points were later plotted on the final vegetation survey map (Plate 3.3-1).

Cover

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

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

Percent cover measurements record “first-hit” point-intercepts by live foliar vegetation species, litter, rock, or bare ground. Multiple hits on vegetation were recorded, but used only for the purpose of constructing a plant species list for each plant community (Appendix 3.3-A).

Total Vegetation Cover

Vegetation cover data were recorded by species, using first hit data. All point intercepts of living vegetation and growth produced during the current growing season were counted toward total vegetation cover. Total vegetation cover measurements were expressed in absolute percentages for each sample point. Percent vegetation cover is the vertical projection of the general outline of plants to the ground surface. Cover summaries for each vegetation community within the proposed POP zones are contained in Appendix 3.3-A.

Total Ground Cover

Total ground cover data was recorded by live vegetation, litter, or rock, minus bare ground. Litter includes all organic material that is dead including manure. Rock fragments were recorded when equal to or greater than two centimeters in size (i.e., sheet flow, minimum non-erodible particle size). Total ground cover measurements were expressed in absolute percentages for each sample point. Total ground cover equals the sum of cover values for percent vegetation, percent litter, and percent rock.

Shrub Density

This data was taken at the time of cover sampling to ensure adequate use of field time. Summarization of that data for the proposed POP zones can be found in Appendix 3.3-A.

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

Data were collected at the time of cover sampling to ensure adequate use of field time. Summarization of that data for the proposed POP zones can be found in Appendix 3.3-A.

Tree density data were collected in the Ponderosa Pine Woodland vegetation community in conjunction with randomly selected cover transects, wherever possible. Tree density in this community was determined using the point-center quarter method. Trees within the Cottonwood Gallery or Riparian areas were directly counted on an aerial photograph. Within other vegetation communities, individual *Pinus ponderosa* (Ponderosa Pine) or other tree species found were

directly counted for numbers. Sample adequacy was not calculated on the point-center quarter plots.

Species Composition

A list of plant species encountered during 2007 quantitative sampling is compiled in Appendix 3.3-A by vegetation community type for each of the five vegetation communities in the proposed POP zones. 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.

3.3.3 Results

The NRC license acreage is 10,580 acres and comprises five main vegetative communities: Big Sagebrush Shrubland, Greasewood Shrubland, Upland Grassland, Ponderosa Pine Woodland, and Cottonwood Gallery. Minor vegetation communities also include: Agricultural Land, Disturbed Areas, Existing Mine Pits, Silver Sagebrush Shrubland, Water, and Shale Outcrop. Refer to Tables 3.3-1 and 3.2-2 for acreage of each vegetation community within the land application sites and associated POP zones. Figures 3.3-1 and 3.3-2 provide the vegetation maps for Dewey and Burdock POP zones, respectively. Plate 3.3-1 provides the vegetation map for the Dewey-Burdock project area.

Table 3.3-1: Vegetation Mapping Unit Acreage within Proposed Dewey POP Zone

Map Unit	Acreage	% of Area
Sampled Vegetation Communities		
Greasewood Shrubland	645.2	77.5
Ponderosa Pine Woodland	2.2	0.2
Upland Grassland	157.7	19.0
Described Vegetation Communities		
Agricultural Land	20.5	2.5
Disturbed	4.2	0.5
Silver Sagebrush Shrubland	2.3	0.3
TOTAL	**832.1**	**100.0**

Table 3.3-2: Vegetation Mapping Unit Acreage within Proposed Burdock POP Zone

Map Unit	Permit area	% of Area
Sampled Vegetation Communities		
Big Sagebrush Shrubland	315.8	30.1
Greasewood Shrubland	426.8	40.7
Upland Grassland	162.8	15.5
Cottonwood Gallery	73.8	7.0
Described Vegetation Communities		
Existing Mine Permit	1.3	0.1
Silver Sagebrush Shrubland	66.9	6.4
Shale Outcrop	2.5	0.2
TOTAL	**1,049.9**	**100.0**

3.4 Livestock and Grazing Animals

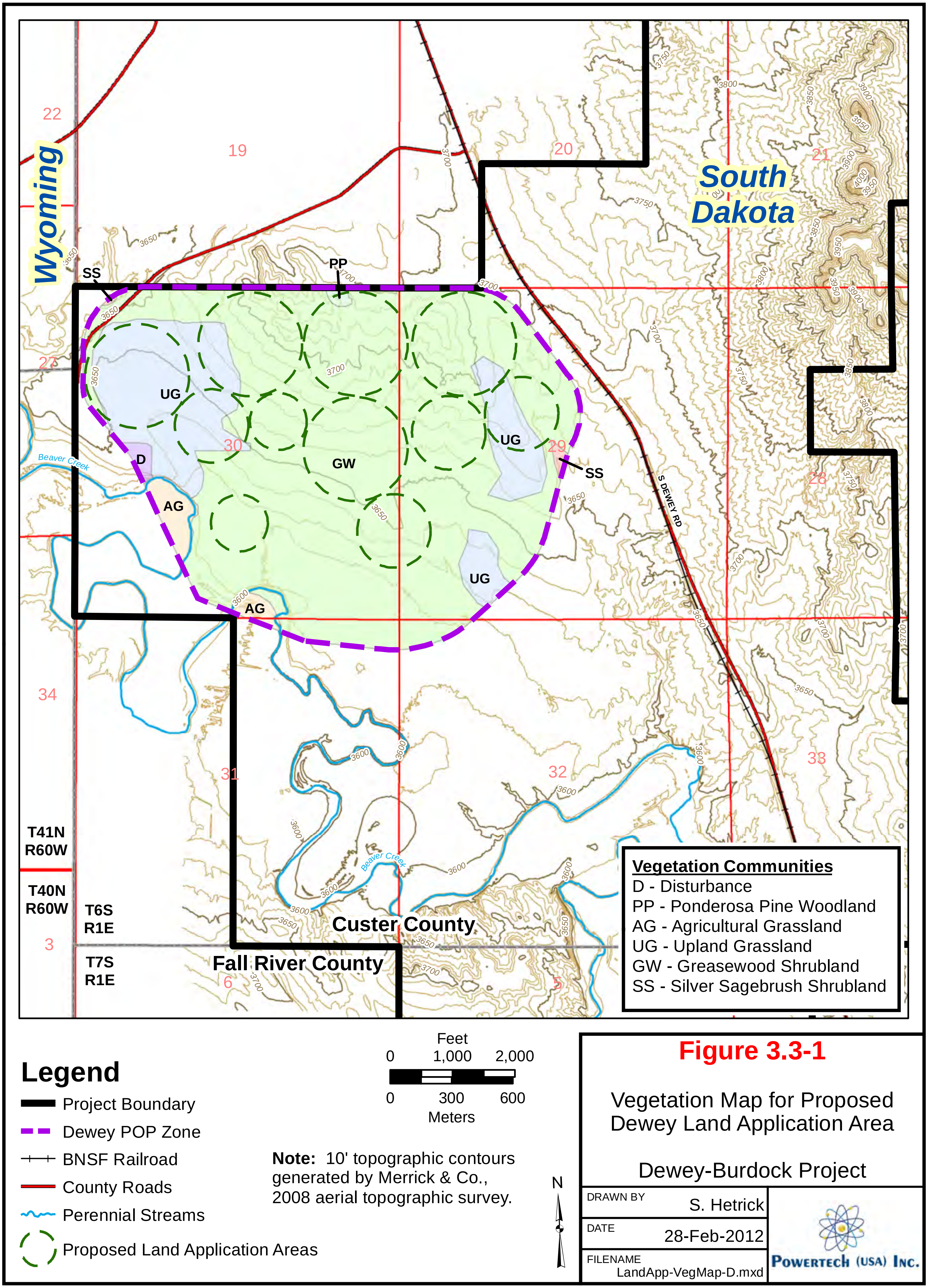
3.4.1 Regional Setting

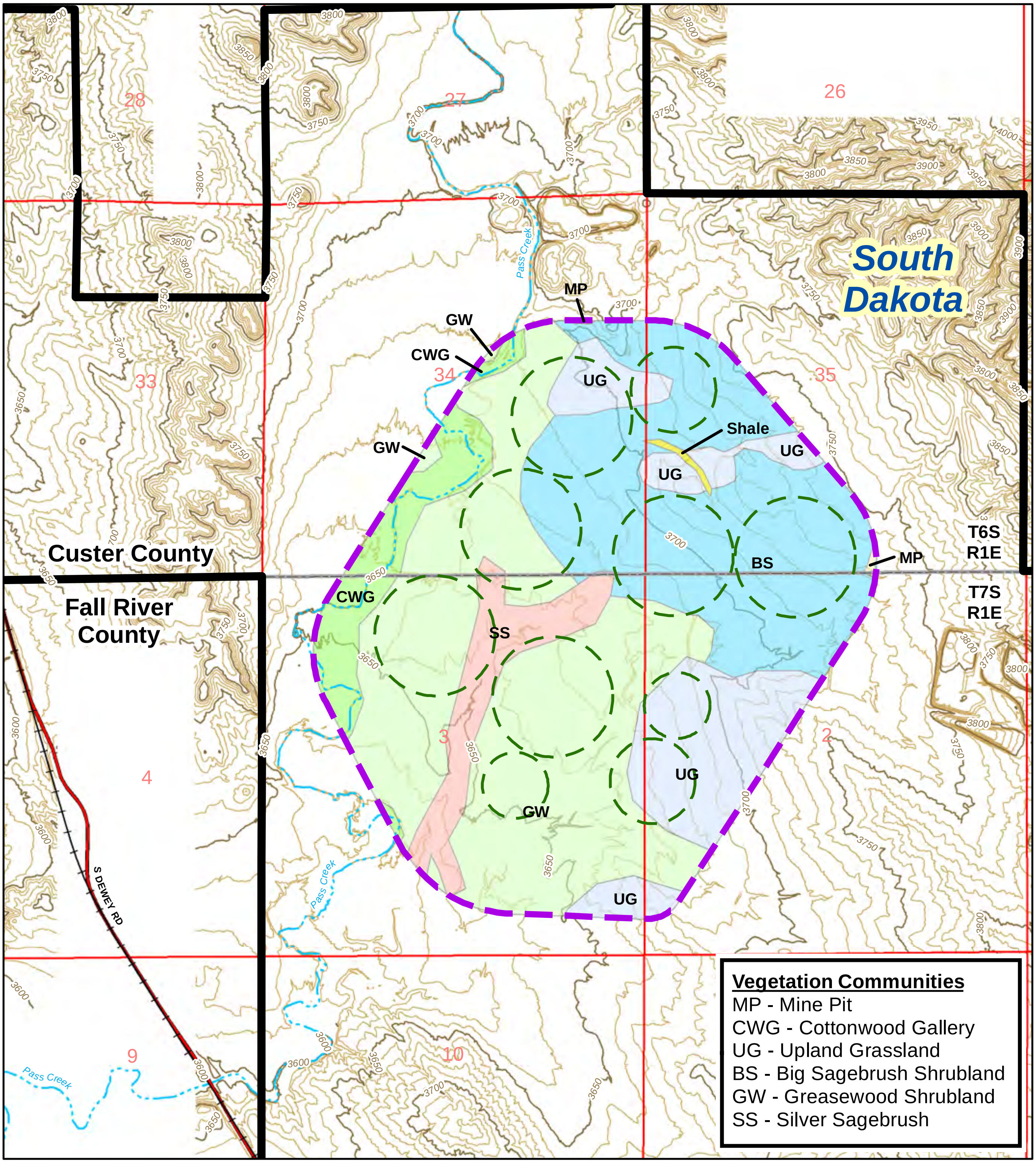
This section provides a general discussion of the affected environment for vertebrate terrestrial wildlife. Background information for terrestrial fauna in the vicinity of the project was obtained from several sources, including records from SDGF&P, BLM, the U.S. Fish and Wildlife Service (USFWS), the U.S. Forest Service (USFS), and the TVA DES for similar operations overlapping the proposed NRC license area. 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 the Dewey-Burdock Project.

3.4.2 Wildlife Survey Methodology

Wildlife sampling was conducted by ICF Jones & Stokes (formerly Thunderbird-Jones & Stokes) of Gillette, Wyoming from July 2007 through early August 2008.

Survey protocols and timing were developed collaboratively with SDGF&P to meet species-specific requirements. The survey area included the proposed NRC license area (project area) 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 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). In addition to these targeted


Wyoming
South Dakota
SS
PP
UG
D
AG
GW
UG
UG
SS
AG
S DEWEY RD
Beaver Creek
T41N R60W
T40N R60W
T6S R1E
T7S R1E
Custer County
Fall River County
Vegetation Communities
D - Disturbance
PP - Ponderosa Pine Woodland
AG - Agricultural Grassland
UG - Upland Grassland
GW - Greasewood Shrubland
SS - Silver Sagebrush Shrubland
Legend
Project Boundary
Dewey POP Zone
BNSF Railroad
County Roads
Perennial Streams
Proposed Land Application Areas
Feet
0 1,000 2,000
0 300 600
Meters
Note: 10' topographic contours generated by Merrick & Co., 2008 aerial topographic survey.
N
Figure 3.3-1
Vegetation Map for Proposed Dewey Land Application Area
Dewey-Burdock Project
DRAWN BY S. Hetrick
DATE 28-Feb-2012
FILENAME LandApp-VegMap-D.mxd
Powertech (USA) Inc.



Legend

- Project Boundary
- Burdock POP Zone
- BNSF Railroad
- County Roads
- Ephemeral Streams
- Proposed Land Application Areas

Feet: 0 — 1,000 — 2,000
Meters: 0 — 300 — 600

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

N

Figure 3.3-2

Vegetation Map for Proposed Burdock Land Application Area

Dewey-Burdock Project

DRAWN BY	S. Hetrick
DATE	28-Feb-2012
FILENAME	LandApp-VegMap-B.mxd

POWERTECH (USA) INC.

efforts, incidental observations of all vertebrate wildlife species were recorded during each site visit during the year-long baseline survey period. Surveys for black-footed ferrets (*Mustela nigripes*) were not required for the Dewey-Burdock Project due to a block clearance issued by the USFWS that includes the entire proposed NRC license area 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. Raptor nests, prairie dog colonies, and other features or observation points of special interest were mapped in the field using a hand-held GPS receiver to record the Universal Transverse Mercator (UTM, NAD27) coordinates.

3.4.3 Wildlife Survey Results

The following survey results are limited to big game, upland game birds, small mammals, and other species that could potentially graze in the land application areas. The results of the complete wildlife survey, including T&E species, raptors and other birds, aquatic life, and herptiles will be presented in the DENR LSM permit application.

No crucial big game habitats or migration corridors are recognized by SDGF&P in the project area 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 survey area, 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 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 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.

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 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 boundary. 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 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 survey area during the baseline survey period, predominantly in the cottonwood corridor along Pass Creek in the central portion of the project area. Most sightings of white-tailed deer were actually in the cottonwood corridor along the Cheyenne River, approximately 2-2.5 miles south of the project area. This species is considered an uncommon year-round resident in the survey area itself.

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. Both species are relatively common and occur in a variety of woodland and open habitats in the project area.

A variety of small and medium-sized mammalian species have the potential to occur in the survey area, although not all were observed within the study area 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 project area, 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 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 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 SDGF&P). The deer mouse (*Peromyscus maniculatus*) dominated the captures, with only seven individuals of other species recorded (Table 3.4-1). Deer mice are known for their ubiquitous presence and generalized habitat use, and these survey results are similar to those from recent trapping efforts in northwest South Dakota.

Table 3.4-1: Small Mammal Abundance during Trapping within the Project 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
Total	**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 3.4-2). 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 are available from the project area prior to 2007, its proximity to the annual survey area in Wyoming suggests that the population trend is similar in southwestern South Dakota.

Table 3.4-2: Total Lagomorphs Observed during Spotlight Surveys and Abundance Indices within the Project Area in September 2007

Parameter	Species		
	White-tailed jackrabbit	**Cottontail**	**Total**
Lagomorph Count[1]	**12**	**28**	**40**
Lagomorphs/Survey Mile[2]	**1.5**	**3.4**	**4.9**

1 Number given is highest count per species from two survey nights.
2 Survey route totaled 8.2 miles.

3.4.4 Livestock

As described in Section 3.5, lands within the project area are currently used for livestock grazing. Most land serves as grazing land for cattle that are consumed locally and sold as food. There are also a small number of horses grazed within the project area. Both cattle and horses have potential to graze within the proposed land application areas. A small number of pigs are grazed

south of the project area, but no pigs currently graze within the project area or within the proposed land application areas.

3.5 Land Use

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

There are five residences within the proposed NRC license boundary, including seasonal residences. There are two residences located within ¼ mile of the land application areas, but no residences are located within the proposed POP zones. Residences and drinking water wells are depicted on Figure 3.5-1 in relation to the proposed land application areas. The drinking water well number 43 near the Burdock area is associated with a former residence that is no longer inhabitable. Well 43 will be plugged and abandoned prior to operation of the Burdock land application system as described in Section 3.7.2.3.2.

Recreational use in and around the project area is limited primarily to large game hunting. Within the project area, hunting is currently open to the public on approximately 5,700 acres. Approximately 240 acres are public lands managed by BLM. In addition, SDGF&P leases around 3,000 acres annually of privately owned land that is designated as walk-in hunting areas. 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 land application areas in order to protect the public, protect workers, prevent damage to facilities, and provide security.

Within the eastern portion of the project area are historical surface and underground mine workings associated with shallow, underground uranium mines and open pits. All of the underground workings are associated with open-pit remnants that are clearly visible in the project area. There are no underground mines within the project area that are not associated with, adjacent to, or extensions of the open pits. These types of underground workings were common at historical surface mines and were considered to be extensions of the open pit mining operations. Based on historical TVA maps, an interview with a former underground mine worker, and an interview with the former Susquehanna-Western geologist who directed the

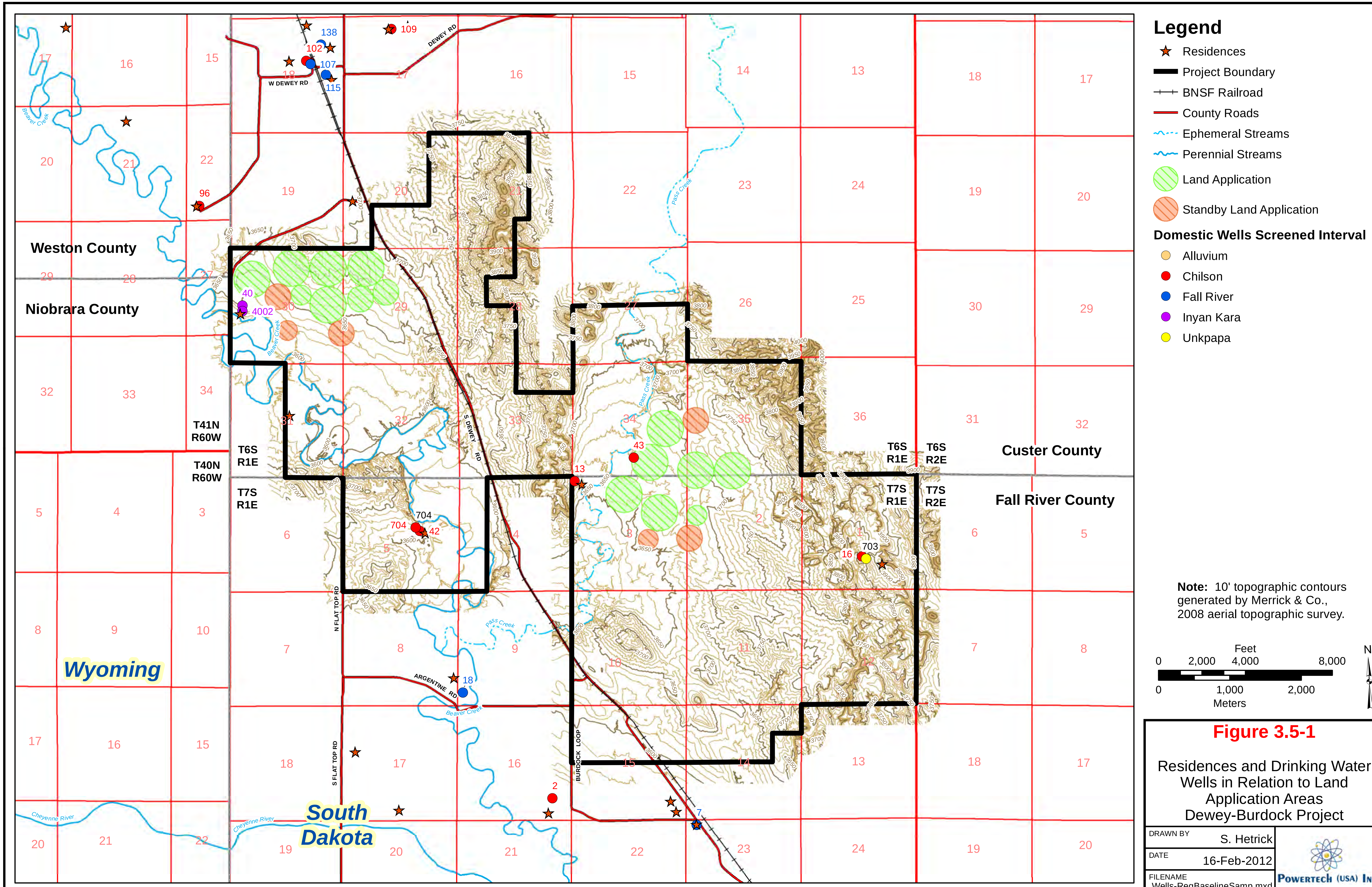


Figure 3.5-1

Residences and Drinking Water Wells in Relation to Land Application Areas Dewey-Burdock Project

delineation drilling for one of the primary surface mines, there are no underground mine workings within the proposed POP zones.

3.6 Geology

3.6.1 Regional Setting

The project area is located in the Great Plains Physiographic province on the southwestern flank of the Black Hills uplift in southwestern South Dakota. To the west of the project area is the Powder River Basin of Wyoming. The regional geologic map is shown in Figure 3.6-1.

3.6.1.1 Regional Structure

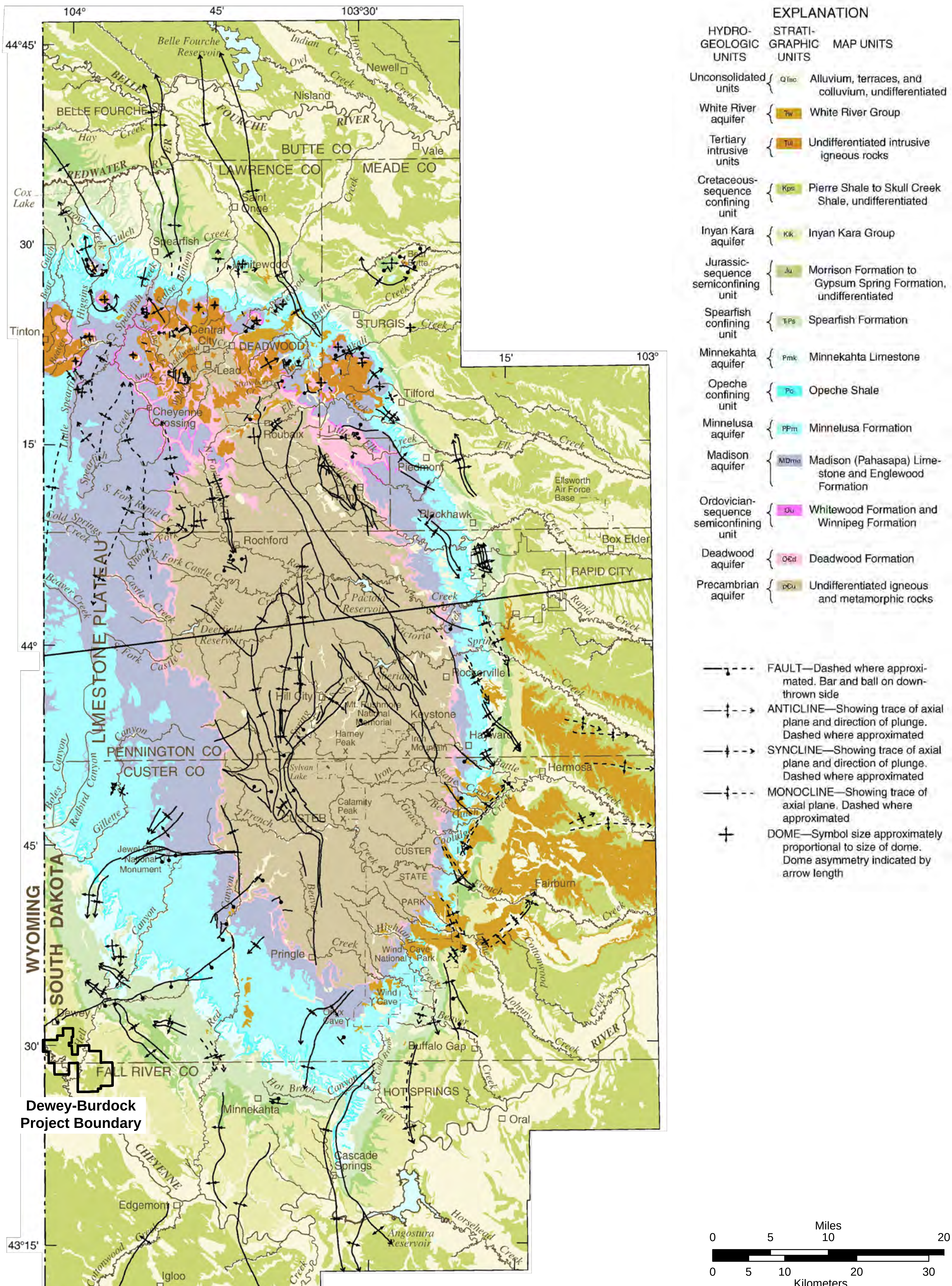
The dominant structural feature in this region is the Black Hills Uplift. This uplift is of Laramide age (65 million years ago) and is an elongate northwest trending dome about 125 miles long and 60 miles wide. Igneous and metamorphic Precambrian-age rock are exposed in the core of the uplift and are 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.

3.6.1.2 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 surface of this structural feature. Away from the center of the Black Hills uplift up to 2000-3000 feet of Paleozoic sediments overlie the crystalline rocks. This sedimentary sequence contains several regional aquifers, including the Deadwood Formation of Cambrian age, the Mississippian Madison Limestone and the Pennsylvanian/Permian-age Minnelusa Formation.

Mesozoic sediments include the Triassic age Spearfish Formation and the Sundance Formation, Unkpapa Sandstone, and Morrison Formation of Jurassic age. 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. The Inyan Kara Group is a transitional unit, exhibiting a change from



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 3.6-1

Geologic Map of the Black Hills

Dewey-Burdock Project

DRAWN BY Bonner, Hetrick

DATE 05-Dec-2011

FILENAME BlackHillsGeoMap.dwg

POWERTECH (USA) INC.

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 thick). These marine sediments are represented by the Skull Creek Shale, Newcastle Sandstone, Mowry Shale, Belle Fourche Shale, Greenhorn Formation, Carlile Shale, Niobrara Formation and Pierre Shale. In Late Cretaceous time, the modern Rocky Mountain Uplift began, forcing the retreat of the Cretaceous seaway.

Unconformably overlying the Cretaceous sediments in the Black Hills region is the Tertiary-age (Oligocene) 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.

Figure 3.6-2 shows a stratigraphic column of the Black Hills.

3.6.2 Site Geology

The site surface geology is shown in Figure 3.6-3. The Fall River Formation crops out across the eastern part of the project area and the Skull Creek Shale, Mowry Shale, and Belle Fourche Shale

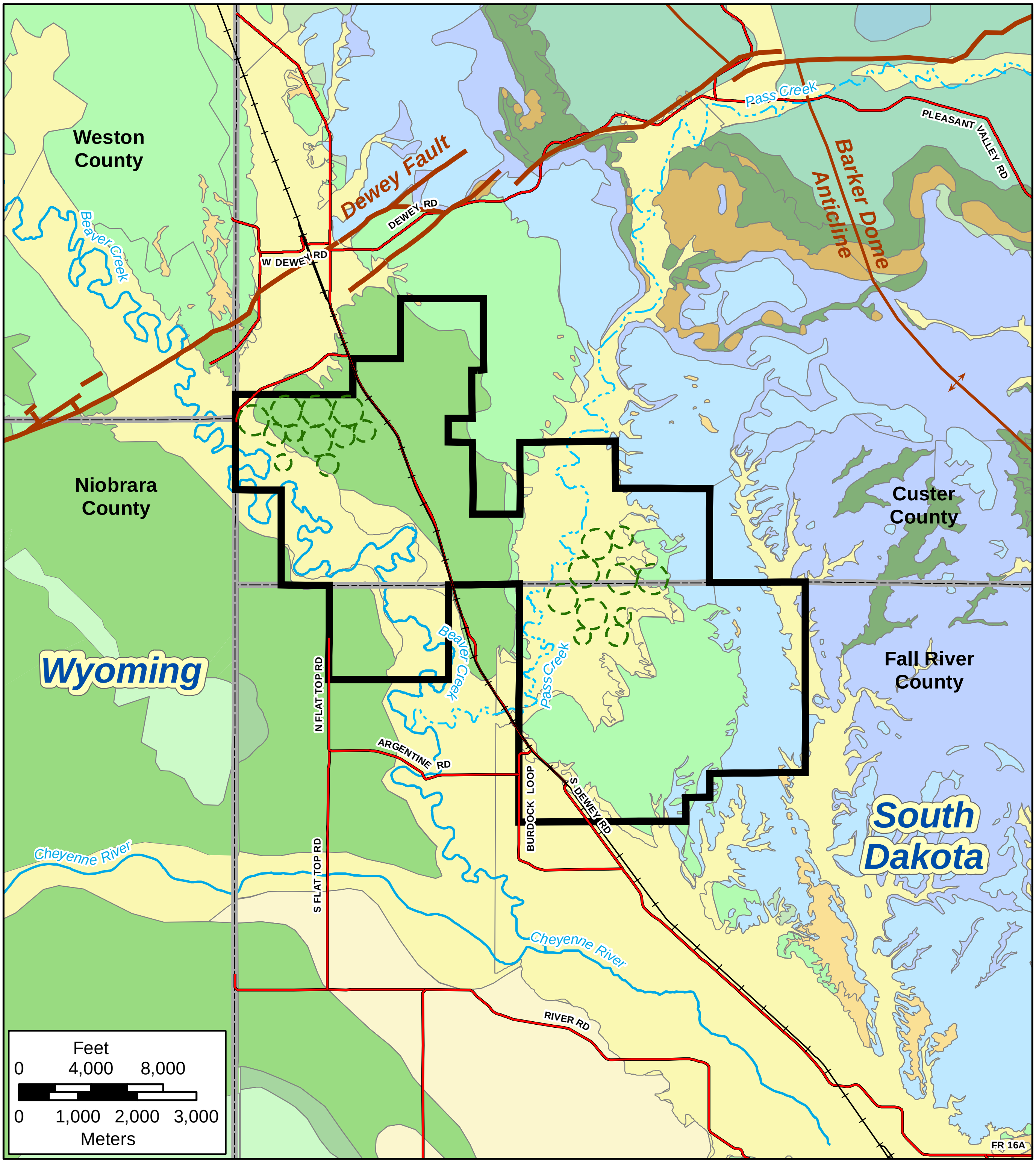
POWERTECH (USA) INC.

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	--	Includes 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	[1]80-300	Impure chalk and calcareous shale.
			CARLILE SHALE: Turner Sandy Member; Wall Creek Member	[1]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 Orman 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 FM: 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 SS	0-225	Massive fine-grained sandstone.
			SUNDANCE FORMATION: Redwater Member; Lak Member; Hulett Member; Stockade Beaver Mem.; 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	[1]25-65	Thin to medium-bedded, fine-grained, purplish gray laminated limestone.
		Po	OPECHE SHALE	[1]25-150	Red shale and sandstone.
	PERMIAN / PENNSYLVANIAN	PIPm	MINNELUSA FORMATION	[1]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	[1]<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.
	ORDOVICIAN	Ou	WHITEWOOD (RED RIVER) FORMATION	[1]0-235	Buff dolomite and limestone.
			WINNIPEG FORMATION	[1]0-150	Green shale with siltstone.
	ORDOVICIAN / CAMBRIAN	OЄd	DEADWOOD FORMATION	[1]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		pЄu	UNDIFFERENTIATED IGNEOUS AND METAMORPHIC ROCKS		Schist, slate, quartzite, and arkosic grit. Intruded by diorite, metamorphosed to amphibolite, and by granite and pegmatite.

[1]Modified based on drill-hole data

Source: Driscoll et al. (2002)

Figure 3.6-2: Stratigraphic Column of the Black Hills



- Alluvium
- 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
- Proposed Land Application Areas

N

Figure 3.6-3

Site Surface Geology

Dewey-Burdock Project

DRAWN BY	RESPEC, Hetrick
DATE	28-Feb-2012
FILENAME	SurfaceGeology.mxd

POWERTECH (USA) INC.

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

3.6.2.1 Site Structure

The structure across the project area is simple and shows sediments dipping gently 2 to 6 degrees to the southwest. This is illustrated by a structure contour map on the top of the Fall River Formation (Plate 3.6-1). Isopach maps are also provided for the Fall River Formation (Plate 3.6-2), Graneros Group (Plate 3.6-3) and alluvium (Plate 3.6-4).

The Dewey Fault, a northeast to southwest trending fault zone, is present approximately one mile north of the project area. The Dewey Fault is a steeply dipping to vertical normal fault with the north side uplifted approximately 500 feet by a combination of displacement and drag. The 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 Limestone, Minnelusa Formation or the Deadwood Formation. Despite the presence of faulting north and south of the site, there are no identified faults within the Dewy-Burdock project area.

3.6.2.2 Site Stratigraphy

The geologic units of primary interest to the GDP are the Quaternary alluvium and Cretaceous Graneros Group. These units are described below along with a description of the Fall River Formation, which contains the uppermost bedrock aquifer encountered beneath the land application areas.

Geologic cross sections through the proposed land application areas are provided as Plate 3.6-5 through Plate 3.6-9. The Dewey area cross sections (A-A' and B-B') show the presence of the Beaver Creek alluvium under a portion of the proposed land application area. This is underlain by 500 to 550 feet of Graneros Group shales, below which is the Fall River Formation. The Fall River Formation contains the uppermost bedrock aquifer beneath the land application areas.

The Burdock area cross sections (C-C' through E-E') show the presence of the Pass Creek alluvium and Graneros Group in relation to the proposed land application area. The thickness of the Graneros ranges from about 25 to 250 feet thick beneath the land application area. Below the Graneros Group is the Fall River Formation. Plate 3.6-3 shows the Graneros Group thickness in relation to all proposed land application areas.

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 Formation 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 Fall River Formation has a range of thickness of 120 to 160 feet. The thickening of the formation indicates the presence of channel sandstones. East of the proposed land application areas along the northeastern portion of the project area, this formation is exposed on the surface and erosion has taken place.

Graneros Group

The Cretaceous Graneros Group consists of several geologic units, including the Skull Creek Shale, Newcastle Sandstone (where present), Mowry Shale, and Belle Fourche Shale, which act as a single confining unit overlying the Fall River Formation. 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 project area based on the results of extensive exploration drilling. In the project area, the thickness of the Graneros Group ranges from zero at the outcrop of the Fall River Formation (east of the land application areas) to more than 500 feet (Plate 3.6-3). Following is a description of the geologic units that make up the Graneros Group within the project area.

Skull Creek Shale - The Skull Creek Shale directly overlies the Fall River Formation and consists of dark-gray to black shale, organic material, and some silt sized quartz grains. The Skull Creek Shale has a thickness of approximately 200 feet and is part of the Graneros Group. 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 area but is present everywhere under the land application areas.

Mowry Shale - At the project area the Skull Creek Shale is directly overlain by the Mowry shale, also considered to be part of the Graneros Group. 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. When present the Newcastle Sandstone is stratigraphically located between the Skull Creek Shale and the Mowry Shale. Drilling has encountered no Newcastle Sandstone on the surface or in the subsurface within the Dewey-Burdock project area.

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

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 are the Quaternary age alluvium deposits, which are present in the major drainages and their tributaries. The alluvium consists of silt, clay, sand and gravel. An isopach of the alluvium is presented as Plate 3.6-3. Cross sections of the Pass Creek alluvium are presented on Plate 3.6-10.

Powertech (USA) completed an alluvial geotechnical drilling program in May 2011 to further characterize the alluvium within the project area. Nineteen borings were drilled into the alluvium along Beaver Creek and Pass Creek, many of which were dry. Alluvial drilling logs indicating water levels (where present) are provided in Appendix 3.6-A. The alluvium in the Pass Creek drainage is up to 50 feet thick; in the Beaver Creek drainage, the alluvium is up to 30 feet thick. Only the bottom 0 to 15 feet of the alluvium typically contains gravel, and this is typically a mixture of silt, clay and sand with scattered gravel. The top of the alluvium contains a mixture of silt, clay and sand and may be better described as colluvium.

3.7 Hydrology

3.7.1 Surface Water

3.7.1.1 Regional Surface Water Hydrology

The project area is on the southwest flank of the Black Hills. The area 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

This page intentionally left blank.

compacted sedimentary rocks, which form a perimeter around an intrusion of Precambrian igneous and crystalline rocks. The sedimentary layers contain aquifer formations that typically have enough permeability to allow for the transportation and storage of water. Aquifers are usually separated by aquitard layers that restrict the vertical transport of water from one aquifer to the next. The aquifers generally receive most of their recharge from stream losses and infiltration along the outcrops which occur on the flanks of the Black Hills Uplift. The infiltration rates can vary greatly due to variations in slope and soil and can have a significant impact on the base flows of natural streams (Driscoll et al., 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 northwest to southeast in this vicinity toward the east-flowing Cheyenne River.

Precipitation incorporates both rainfall and snow which can differ greatly based on elevation and time of year. According to historical data, the upper elevations of the Black Hills can receive up to 24 inches of precipitation annually, while most of the lower plains receive significantly less (Driscoll et al., 2002).

3.7.1.2 Site Surface Water Hydrology

The project area 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 project area from the northwest to the southeast. The Pass Creek system flows south through the central portion of the project area and joins Beaver Creek southwest of the project area. Three miles south of this confluence, Beaver Creek converges with the Cheyenne River (Figure 3.7-1), which eventually flows into the Missouri River. The Beaver Creek Basin drainage area is 1,360 mi^2, excluding the Pass Creek subbasin. It extends from a few miles northwest of Upton, WY to about 8 miles southeast of Dewey, SD and lies within Weston, Niobrara and Crook counties in Wyoming and Pennington, Custer and Fall River counties in South Dakota. Beaver Creek is a perennial stream with ephemeral tributaries. 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 drainage area 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

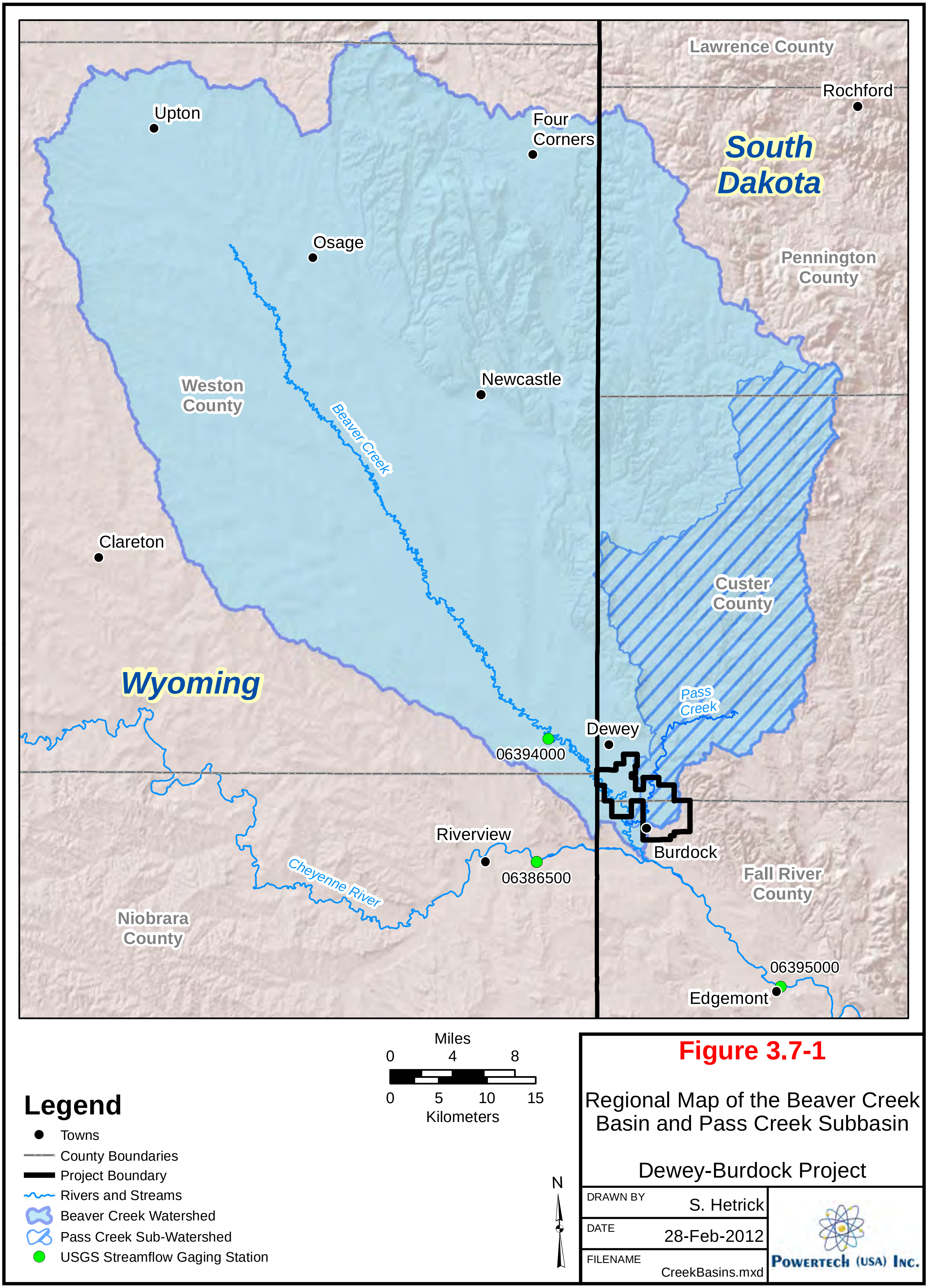


Figure 3.7-1

Regional Map of the Beaver Creek Basin and Pass Creek Subbasin

Dewey-Burdock Project

in Wyoming. Pass Creek is dry except for brief periods of runoff following major storms and snowmelt.

Several small impoundments exist within 1 mile of the proposed POP zones as shown on Figures 3.7-2 and 3.7-3. An inventory of impoundments within 1 mile of the proposed POP zones is provided in the surface water quality discussion in Section 4.1. These include stock dams and historical mine pits. Many of the impoundments only contain water temporarily following precipitation events or snowmelt. No springs have been identified within 1 mile of the proposed POP zones.

3.7.1.3 Flood Analysis

Powertech (USA) has evaluated flood inundation boundaries and will construct facilities outside of these boundaries to avoid potential impacts to facilities from flooding and potential impacts to Beaver Creek and Pass Creek in the event of any potential spills or leaks. Additional information is found in Section 8.2.

The potential for flood or erosion damage was evaluated by developing a design flood using statistical methods and a computer model for watershed hydrology. Peak discharge of the design flood was then transformed to a water level using a computer model for stream hydraulics. This approach provides a floodplain map that shows the maximum area inundated by the design flood, as well as detailed information on the depth and velocity of flood water at points of interest in the study area. The 100-year event was used for the design flood, since it represents an appropriate level of risk for the evaluation of flood potential near the facilities.

Hydrologic Analysis – Beaver Creek

USGS gage number 06394000 is located on Beaver Creek near Newcastle, WY (Figure 3.7-1). Statistical methods were used to estimate the design flows. Three software programs were used: National Flood Frequency (NFF) Program 3.2 (Ries and Crouse, 2002), PKFQWin 5.0 (Flynn et al., 2006), and a Matlab Flood Frequency Analysis program (Rao and Hamed, 2000).

The NFF program uses sub-watershed areas, geographical information, and precipitation averages to estimate flood events based on regional regression analyses. The PKFQWin and Matlab programs use the 55 years of historical peak flow at gage 06394000 to estimate flood events. The NFF and PKFQWin methods compute estimated floods ranging from 2- to 500-year frequencies.

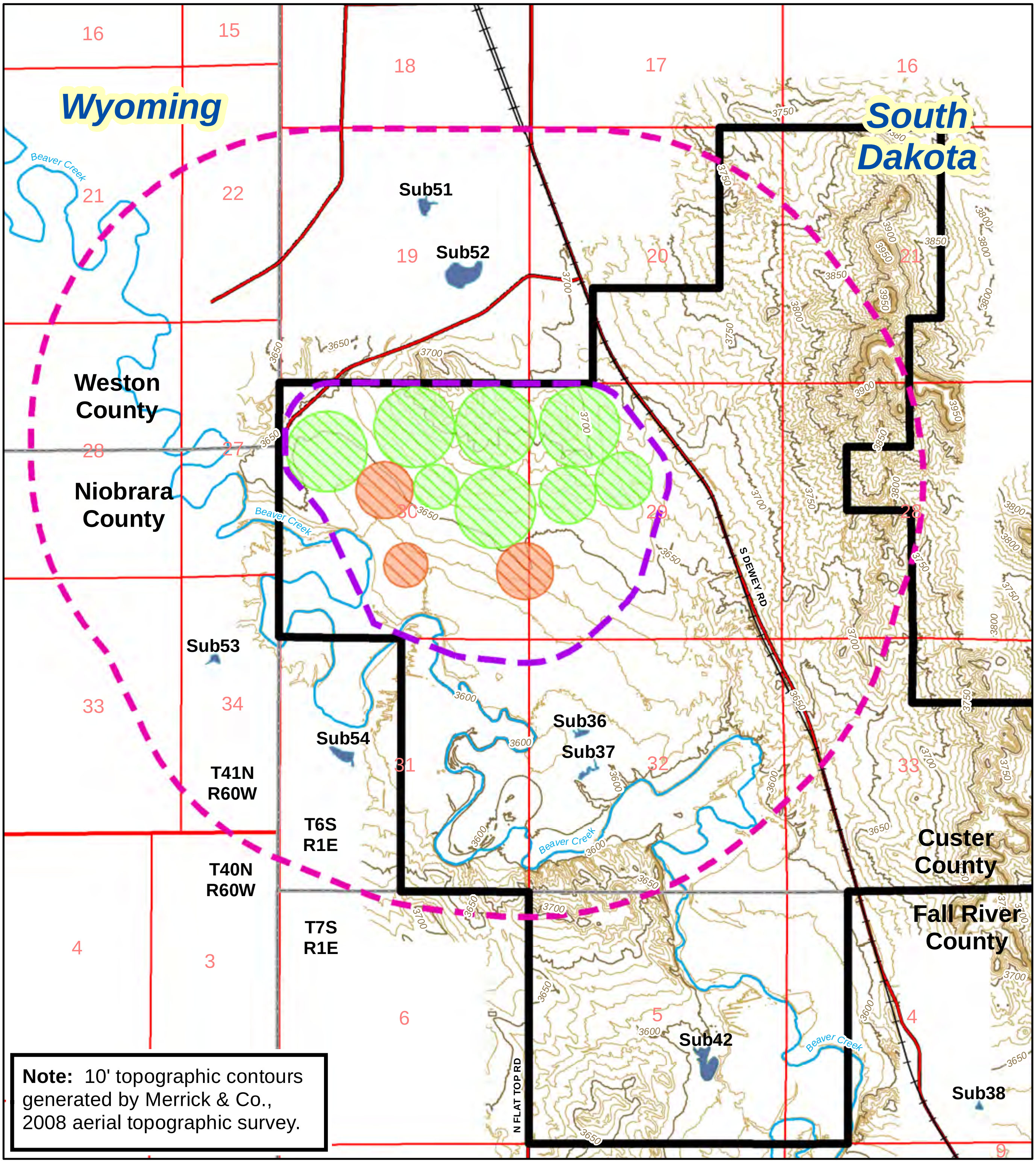


Figure 3.7-2

Surface Water Impoundments within 1 Mile of the Dewey POP Zone Dewey-Burdock Project

DRAWN BY	S. Hetrick
DATE	21-Feb-2012
FILENAME	LandApp-Imp1Mi-D.mxd

POWERTECH (USA) INC.

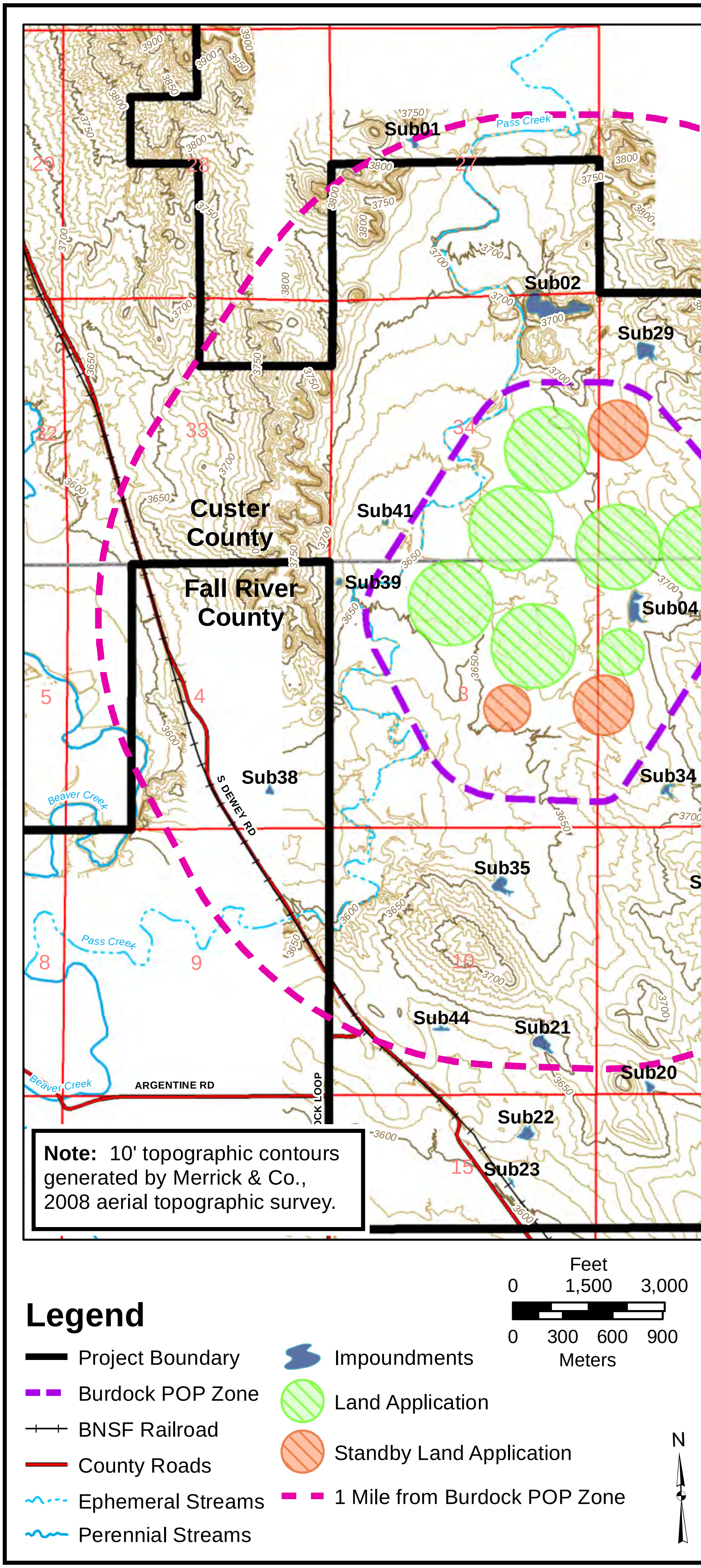


Figure 3.7-3

Surface Water Impoundments within 1 Mile of the Burdock POP Zone Dewey-Burdock Project

DRAWN BY	S. Hetrick
DATE	07-Dec-2011
FILENAME	LandApp-Imp1Mi-B.mxd

POWERTECH (USA) INC.

The flood estimates for Beaver Creek are summarized in Table 3.7-1. The flow value selected for the floodplain analysis of Beaver Creek was 7,990 cfs, representing the 100-year flood. This value was chosen because it represents the most conservative design flow estimate.

Table 3.7-1: Summary of Flood Estimates for Beaver Creek

Recurrence Interval (years)	PKFQWin Estimate (cfs)	NFF Estimate (cfs)	Matlab Estimate (cfs)
100	7,990	7,950	6,570

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 measured flow data. To obtain design flow values for the stream channel of Pass Creek, a rainfall runoff model was used 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.

The Hydrologic Modeling System (HEC-HMS) is designed to simulate the precipitation-runoff processes of dendritic watershed systems. HEC-HMS was used to estimate the 100-year flood event for Pass Creek using a HEC-GeoHMS basin model created from a high resolution digital elevation model (DEM) in ArcGIS.

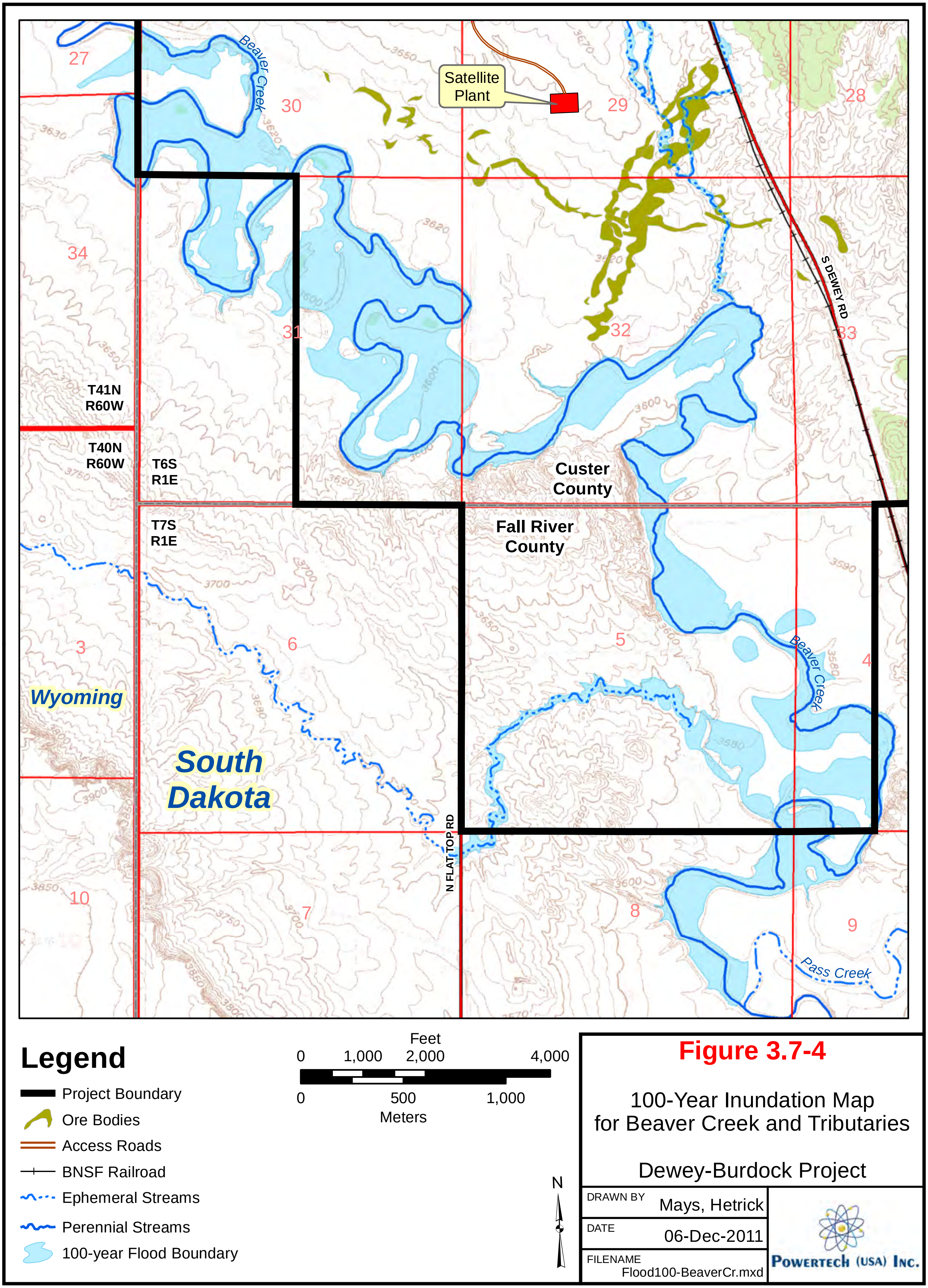
The output result from the HEC-HMS model of the Pass Creek watershed is shown in Table 3.7-2. The estimated 100-year peak discharge rate is 5,620 cfs.

Table 3.7-2: Discharge Results for the Single Basin Model of the Pass Creek Watershed

Recurrence Interval (years)	Peak Discharge (cfs)
100	5,620

Hydrologic Analysis – Beaver Creek and Pass Creek Tributaries

HEC-HMS models were used to calculate peak discharges for various storm events for minor 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 flood inundation boundaries on Beaver Creek and tributaries are depicted on Figure 3.7-4, and the flood inundation boundaries on Pass Creek and tributaries are depicted on Figure 3.7-5.


Satellite Plant
Beaver Creek
27
30
29
28
34
31
32
33
S DEWEY RD
T41N R60W
T40N R60W
T6S R1E
T7S R1E
Custer County
Fall River County
3
6
5
4
Wyoming
South Dakota
N FLAT TOP RD
10
7
8
9
Pass Creek
Legend
Project Boundary
Ore Bodies
Access Roads
BNSF Railroad
Ephemeral Streams
Perennial Streams
100-year Flood Boundary
Feet
0 1,000 2,000 4,000
0 500 1,000
Meters
N
Figure 3.7-4
100-Year Inundation Map for Beaver Creek and Tributaries
Dewey-Burdock Project
DRAWN BY Mays, Hetrick
DATE 06-Dec-2011
FILENAME Flood100-BeaverCr.mxd
POWERTECH (USA) INC.

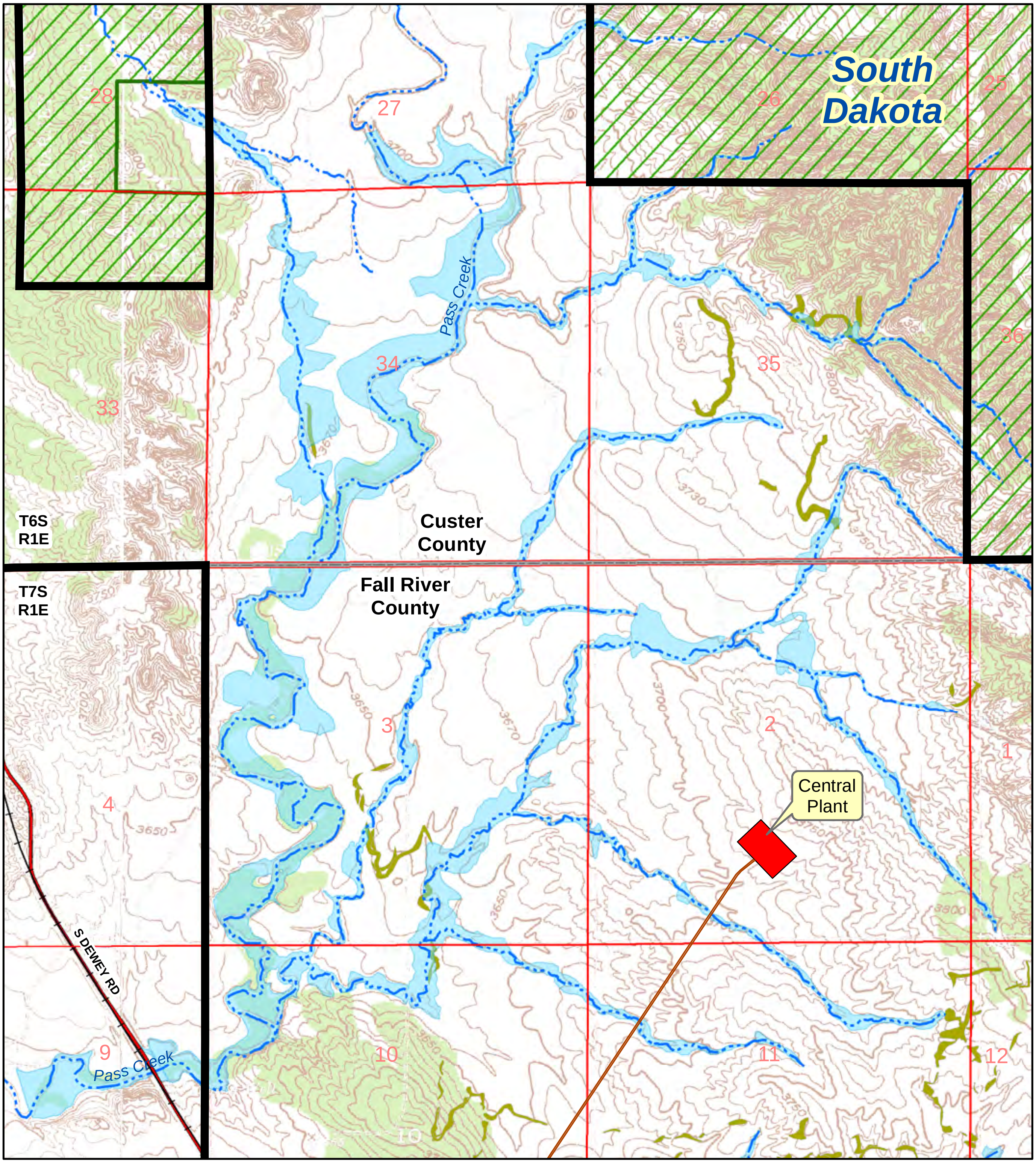


Figure 3.7-5

100-Year Inundation Map
for Pass Creek and Tributaries

Dewey-Burdock Project

DRAWN BY	Mays, Hetrick
DATE	06-Dec-2011
FILENAME	Flood100-PassCr.mxd

POWERTECH (USA) INC.

3.7.2 Groundwater

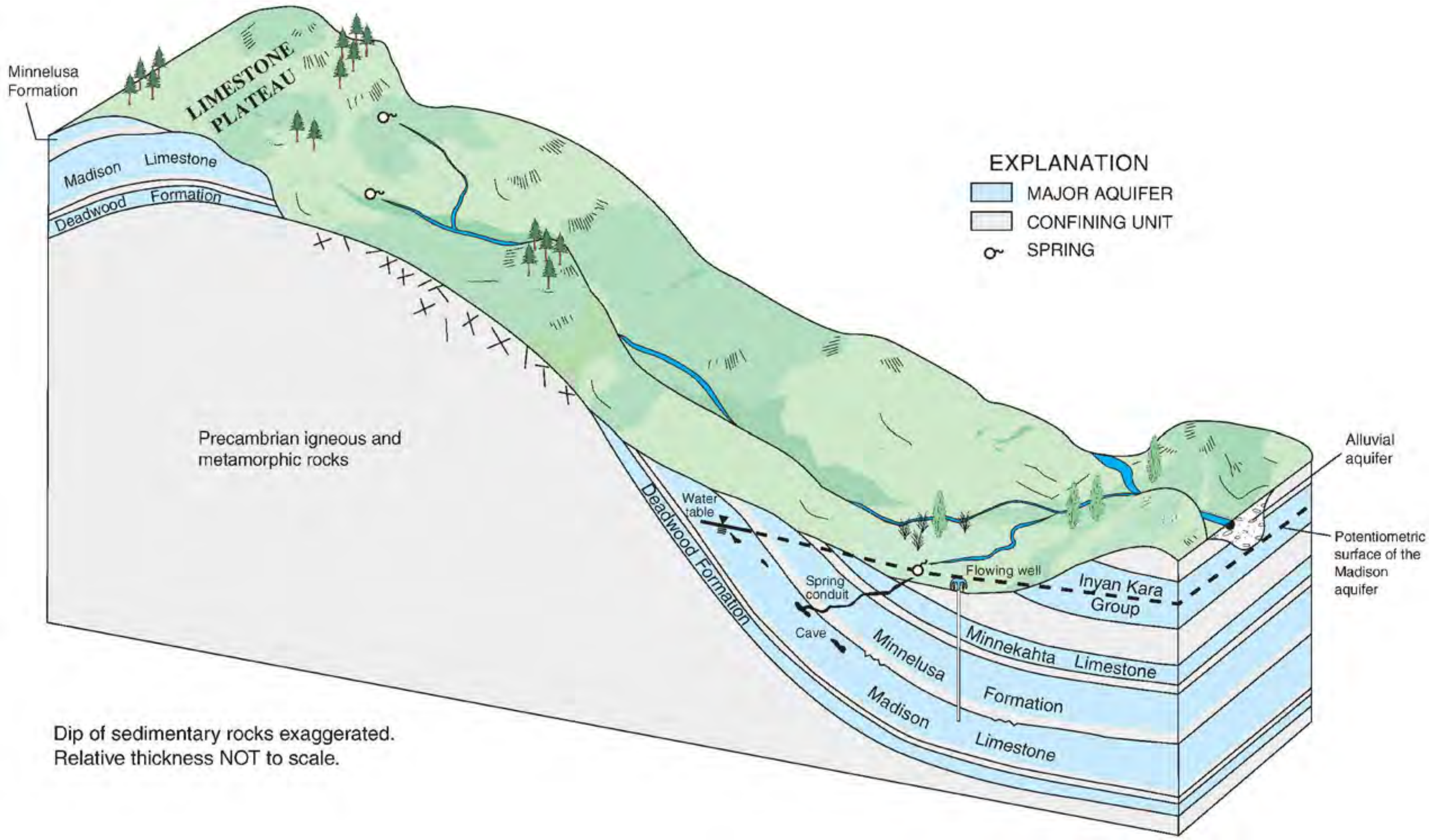
3.7.2.1 Regional Groundwater Hydrology

The Black Hills Uplift is the principal recharge area for the regional bedrock aquifer systems in southwestern South Dakota and northeastern Wyoming. The stratigraphy of the Black Hills area is summarized on Figure 3.6-2. Regionally, four principal aquifers are utilized as major sources of water supply. These are the Inyan Kara Group, Minnelusa Formation, Madison Limestone, and Deadwood Formation. 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 Dewey-Burdock project area, none of the deeper regional aquifers below the Sundance is used as a water supply, mainly because of the availability of shallower sources and 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.

Regional groundwater flow within the principal Black Hills aquifers is generally radially outward from the central Black Hills highlands toward the plains. All of the principal 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. Except near the outcrops, the potentiometric surface elevations in all principal aquifers are above the formation tops; the degree of this artesian condition increases with distance from the central Black Hills highlands. Locally, the potentiometric surface of the aquifers may be above land surface.

The primary source of recharge to the principal Black Hills aquifers is infiltration from precipitation and surface runoff at the outcrop areas. Other sources of recharge to individual units can occur from leakage between aquifers. 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.

Refer to Figure 3.7-6, which provides an overview of the hydrologic setting and general hydrogeologic flow within the Black Hills.



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 3.7-6
Diagram Showing a Simplified View of the Hydrogeologic Setting of the Black Hills Area

Dewey-Burdock Project

DRAWN BY	Mays, Hetrick
DATE	06-Dec-2011
FILENAME	Driscoll_L.dwg

POWERTECH (USA) INC.

3.7.2.2 Site Groundwater Hydrology

The main aquifers to be utilized during uranium recovery and aquifer restoration in the Dewey-Burdock Project (the Fall River Formation and Chilson Member of the Lakota Formation) 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.

3.7.2.2.1 Site Hydrostratigraphic Units

In the Dewey-Burdock 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 outcrop at the ground surface sequentially from east to west. The structure is illustrated by the structural contour map on top of the Fall River (Plate 3.6-1). Based on the logs for 3,900 exploration holes, no major faults or other structural features have been identified within the Dewey-Burdock project area.

Following is a description of the site hydrostratigraphic units of importance to the GDP. The discussion includes, from deepest to shallowest, the Fall River Formation, Graneros Group, and alluvium. The Fall River is confined below from the Chilson Member of the Lakota Formation by the Fuson Shale, which has been mapped by Powertech (USA) and consists of 20 to 80 feet of low-permeability shales and clays.

Fall River Formation

The Fall River Formation, along with the 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 uranium mineralization within the project area.

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 Fall River Formation 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 Fall River Formation, overlying alluvial aquifers, and the ground surface.

Graneros Group Confining Unit

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. Extensive exploration drilling has shown that the Newcastle Sandstone is not present within the project area. The Graneros Group shales have a thickness of zero at the Fall River Formation outcrop to more than 500 feet (Plate 3.6-3). Analyses of core samples of the Graneros Group clays (Skull Creek Formation) indicate low vertical permeability on the order of 6.8×10^{-9} cm/sec (0.007 millidarcies). This formation is present beneath all the land application areas proposed in this application.

Terrace Deposits and Quaternary Alluvium

The most recent sedimentary units within the Dewey-Burdock 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 3.6-4.

3.7.2.2.2 Groundwater Occurrence and Flow

Based on the regional and site-specific hydrogeological characterization, groundwater occurrence and flow in the Dewey-Burdock 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 Formation.

There are multiple deep regional groundwater flow systems within the Paleozoic section. These regional flow systems are associated with the permeable strata within the Deadwood Formation, Madison Limestone, and Minnelusa Formation. These deep regional flow systems and associated aquifers are isolated by low permeability layers, or confining beds, from the shallower formations that could potentially be impacted by the Dewey-Burdock Project, including the Fall River Formation, Chilson Member of the Lakota Formation, and alluvium.

An intermediate groundwater flow system exists within the Fall River Formation. This intermediate flow system has its origin in the areas within the eastern portion of the project area and immediately to the east and north of the project area where the Fall River Formation crops out at the land surface. The Fall River flow system is 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 dips gently to the southwest at 2 to 6 degrees away from its outcrop areas. As a result, groundwater flow generally occurs from the northeast to the southwest toward the Powder River Basin.

A potentiometric contour map for the Fall River Formation is shown on Figure 3.7-7. This map is based on representative water level measurements taken over a 5-day period from April 25 through April 29, 2011. The potentiometric contour map for the Fall River Formation shows a relatively uniform hydraulic gradient across the project area, with the potentiometric levels decreasing to the southwest.

A shallow, perched groundwater system exists within some of the alluvium associated with Beaver Creek, Pass Creek, and Bennett Canyon on the eastern edge of the project area. These alluvial systems are perched above the top of the Graneros Group on the portions of the project area where land application of water is proposed. 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 Formation. As such, the alluvial groundwater is a potential source of recharge to the underlying Chilson. The closest land application area, Burdock, is over 4,000 feet west of Bennett Canyon and will have no influence on Bennett Canyon alluvium or the Chilson Member.

A potentiometric surface contour map for the Pass Creek and Beaver Creek alluvium is shown on Figure 3.7-8. An isopach map for the alluvium is shown on Plate 3.6-4. The potentiometric surfaces within the alluvium show typical down-valley gradients paralleling the surface topography. The potentiometric surface in Figure 3.7-8 is based on water level measurements taken on November 5, 2012. The significant drop in the static water elevation between alluvial compliance well BC-2 and alluvial wells 708 and 713 is believed to be attributed to significant heterogeneity of the basal alluvial gravel material in this vicinity. This conclusion is supported by significant differences in water quality between wells BC-2 and 708.

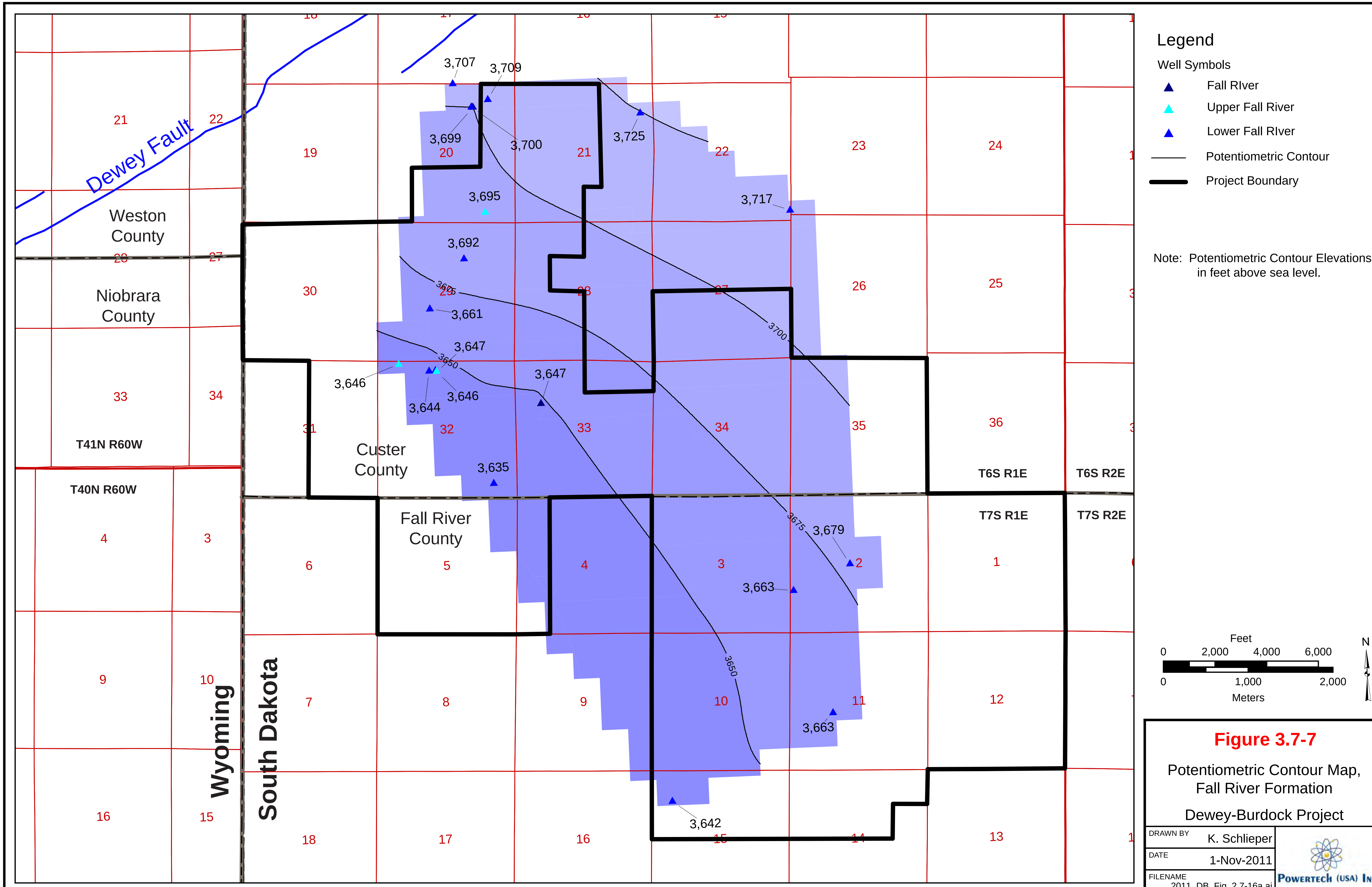


Figure 3.7-7

Potentiometric Contour Map, Fall River Formation

Dewey-Burdock Project

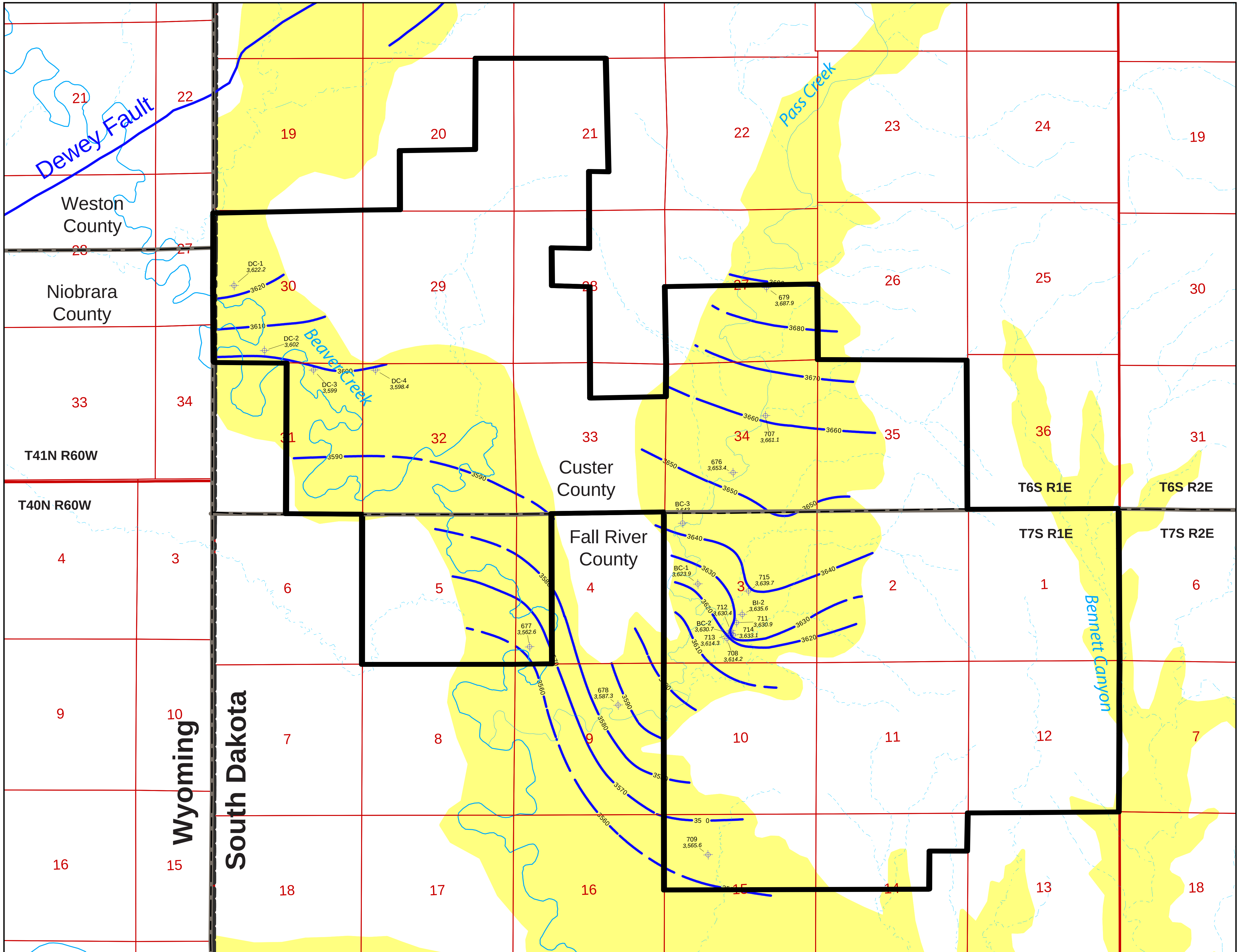


Figure 3.7-8

Potentiometric Contour Map, Pass Creek and Beaver Creek Alluvium

Dewey-Burdock Project

DRAWN BY	K. Schlieper
DATE	13-Nov-2012
FILENAME	2012_GDP_Fig_3.7-8.ai

Powertech (USA) Inc.

3.7.2.3 Existing Wells

Historical records and field investigations of the project area and surrounding area were used to develop an inventory of existing wells within 1.2 miles (2 km) of the project area. An initial investigation of the wells was completed in 2007, and additional surveys were conducted in 2011 to evaluate the use and condition of the wells. The well inventory included existing wells, wells with historical records that are currently not present at the surface, and wells with historical records that have been visually confirmed as plugged and abandoned. Appendix 3.7-A contains well inventory summary tables and Appendix 3.7-B contains the detailed well inventory, well completion records and associated documentation. The following sections describe the well inventories for the areas within 1 mile of the proposed Dewey and Burdock POP zones.

Proposed wells include monitor wells and ISR injection and production wells. Monitor wells associated with the GDP are described in Section 6.1. Additional monitor wells and injection/production wells will be constructed within the project area as part of the ISR operations.

3.7.2.3.1 Dewey Area

Table 3.7-3 and Figure 3.7-9 present the well inventory within 1 mile of the proposed Dewey POP zone, which includes 26 existing wells. No wells with historical records that are currently not present or confirmed abandoned have been identified within 1 mile of the Dewey POP zone. Of the 26 existing wells, 3 are currently used for domestic use, 7 for stock watering, and 16 for monitor wells.

All existing domestic wells within the project area will be removed from private use prior to ISR operations, including wells 40 and 4002. Lease agreements for the entire project area currently allow Powertech (USA) to remove and replace the water supply wells as needed. Depending on the well construction, location and screen depth, Powertech (USA) may continue to use the former domestic wells for monitoring or plug and abandon the wells. The remaining domestic well within 1 mile of the proposed Dewey POP zone, well 96, is outside of the project area and will not be impacted by the proposed ISR operations.

Powertech (USA) will work with the owner of wells 40 and 4002 to determine a) whether water supply replacement is necessary, and b) the appropriate replacement water supply alternative, if needed. The two water supply replacement alternatives include drilling a new domestic well or extending a water supply pipeline to the residence. In the first option, Powertech (USA) would drill a new well near the residence. All replacement wells will be constructed in accordance with

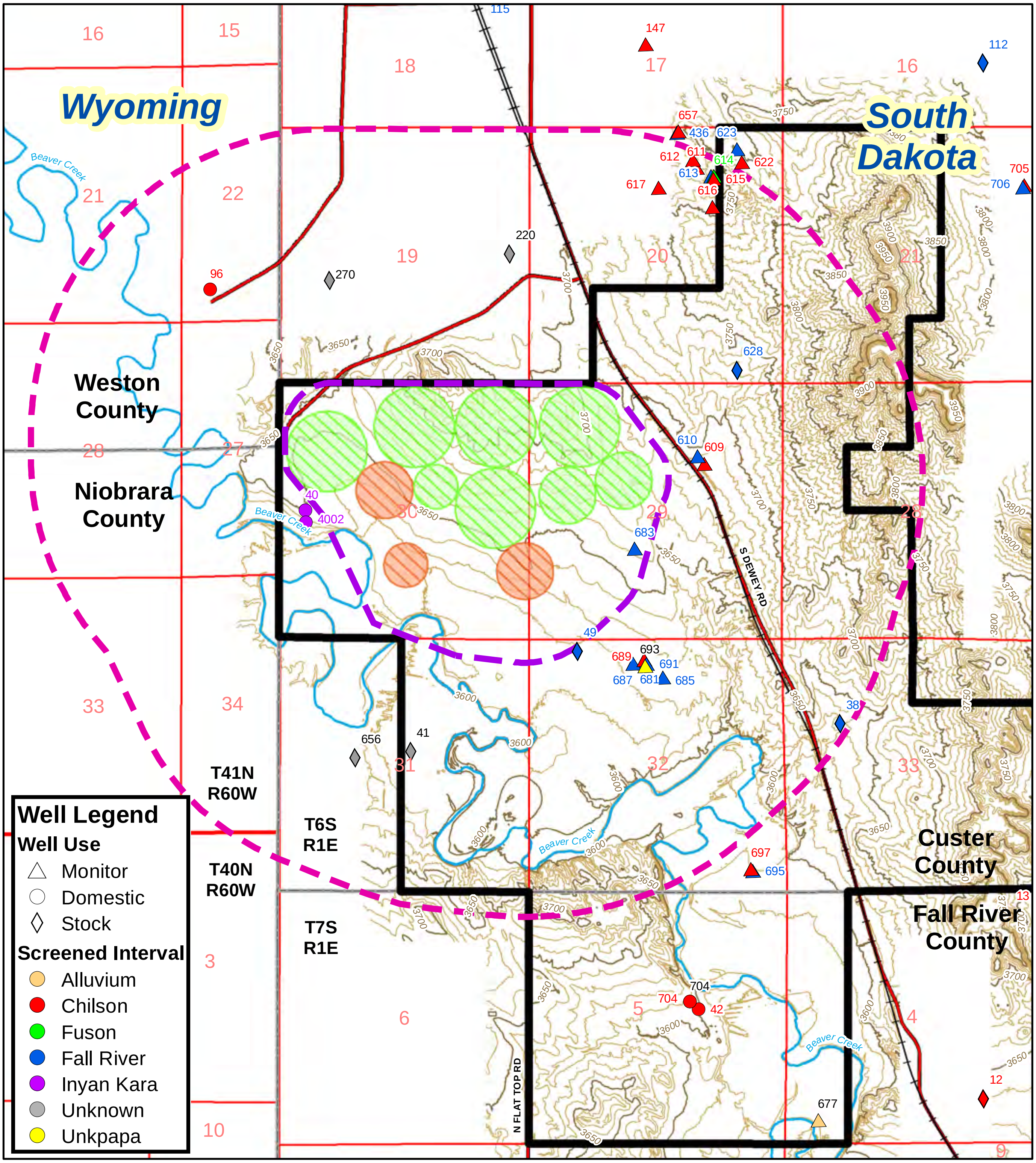
South Dakota well construction standards in ARSD 74:02:04. This will ensure that the wells will not create a pathway for vertical migration of potential contaminants. Further, all replacement wells will target formations outside of the ore zone of the nearest well fields, which will occur in the Fall River Formation and/or Chilson Member of the Lakota Formation. In the case of wells 40 and 4002, replacement wells, if required, will be further restricted to locations outside of the POP zone and formations outside of the alluvium in order to eliminate potential impacts from the proposed land application systems.

The second water supply replacement alternative is to extend a pipeline from one of the proposed Dewey-Burdock Project Madison aquifer supply wells to the residence. The Madison wells are currently being permitted through the Water Rights Program with the option to provide domestic and stock water to locations inside and near the project area.

Table 3.7-3: Wells within 1 Mile of Proposed Dewey POP Zone

Hydro ID	Township	Range	Section	1/4 - 1/4 Location	Coordinates East[1]	Coordinates North[1]	Screened Location[2]	Well Use
Existing Wells								
38	6S	1E	33	SWNW	1,024,328	442,289	Fall River	Stock
40	6S	1E	30	SWNW	1,013,415	447,182	Inyan Kara	Domestic[3]
41	6S	1E	31	SWNE	1,015,385	442,081	Unknown	Stock
49	6S	1E	32	NWNW	1,018,932	444,022	Fall River	Stock
96	41N	60W	22	SWSW	1,011,630	451,853	Chilson	Domestic[3]
220	6S	1E	19	SENE	1,017,872	452,334	Unknown	Stock
270	6S	1E	19	NWSW	1,014,108	451,942	Unknown	Stock
609	6S	1E	29	SWNE	1,021,735	447,808	Chilson	Monitor
610	6S	1E	29	SWNE	1,021,599	447,969	Fall River	Monitor
611	6S	1E	20	NWNE	1,021,835	453,954	Chilson	Monitor
612	6S	1E	20	NWNE	1,021,755	454,128	Chilson	Monitor
613	6S	1E	20	NWNE	1,022,125	453,775	Fall River	Monitor
614	6S	1E	20	NWNE	1,022,185	453,769	Fuson	Monitor
615	6S	1E	20	NWNE	1,022,172	453,708	Chilson	Monitor
616	6S	1E	20	SWNE	1,022,132	453,134	Chilson	Monitor
617	6S	1E	20	NENW	1,021,026	453,582	Chilson	Monitor
628	6S	1E	20	SESE	1,022,496	449,718	Fall River	Stock
656	6S	1E	31	SENW	1,014,230	442,000	Unknown	Stock
681	6S	1E	32	NENW	1,020,330	443,725	Fall River	Monitor
683	6S	1E	29	NESW	1,020,212	446,104	Fall River	Monitor
685	6S	1E	32	NWNE	1,020,690	443,409	Fall River	Monitor
687	6S	1E	32	NENW	1,020,081	443,724	Fall River	Monitor
689	6S	1E	32	NENW	1,020,316	443,789	Chilson	Monitor
691	6S	1E	32	NENW	1,020,364	443,698	Fall River	Monitor
693	6S	1E	32	NENW	1,020,327	443,661	Unkpapa	Monitor
4002	6S	1E	30	NWSW	1,013,414	446,931	Inyan Kara	Domestic

[1] Coordinate system is NAD 27 South Dakota State Plane South
[2] Inyan Kara indicates that screened interval includes both Chilson and Fall River
[3] To be removed from service and replaced if necessary prior to ISR operations



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

Feet: 0, 1,500, 3,000
Meters: 0, 300, 600, 900

N

Legend

- Project Boundary
- Dewey POP Zone
- BNSF Railroad
- County Roads
- Perennial Streams
- Land Application
- Standby Land Application
- 1 Mile from Dewey POP Zone

Figure 3.7-9

Existing Wells within 1 Mile of the Proposed Dewey POP Zone

Dewey-Burdock Project

DRAWN BY	S. Hetrick
DATE	07-Dec-2011
FILENAME	Wells-AllDewey1Mile.mxd

POWERTECH (USA) INC.

3.7.2.3.2 Burdock Area

Table 3.7-4 and Figure 3.7-10 present the well inventory within 1 mile of the proposed Burdock POP zone, which includes 25 existing wells and 7 wells with historical records that have been confirmed as plugged and abandoned. No wells with historical records that are currently not present have been identified within 1 mile of the Burdock POP zone. Of the 25 existing wells, 1 is currently used for domestic use, 1 was formerly used for domestic use, 8 are currently used for stock watering, and 15 are currently used for monitor wells.

All existing domestic wells within the project area will be removed from private use prior to ISR operations, including wells 13 and 43. As described in Section 3.5, well 43 is associated with a former residence that is no longer inhabitable. This well will be plugged and abandoned as described below. Well 13 will be replaced with a new domestic well or a water supply pipeline. Well replacement procedures are described in Section 3.7.2.3.1. In the case of well 13, a replacement well, if required, will be constructed in accordance with ARSD 74:02:04 well construction standards, targeting a formation outside of the ore zone of the nearest well fields and outside of the alluvium, and located outside of the POP zone in order to eliminate potential impacts from the proposed land application systems.

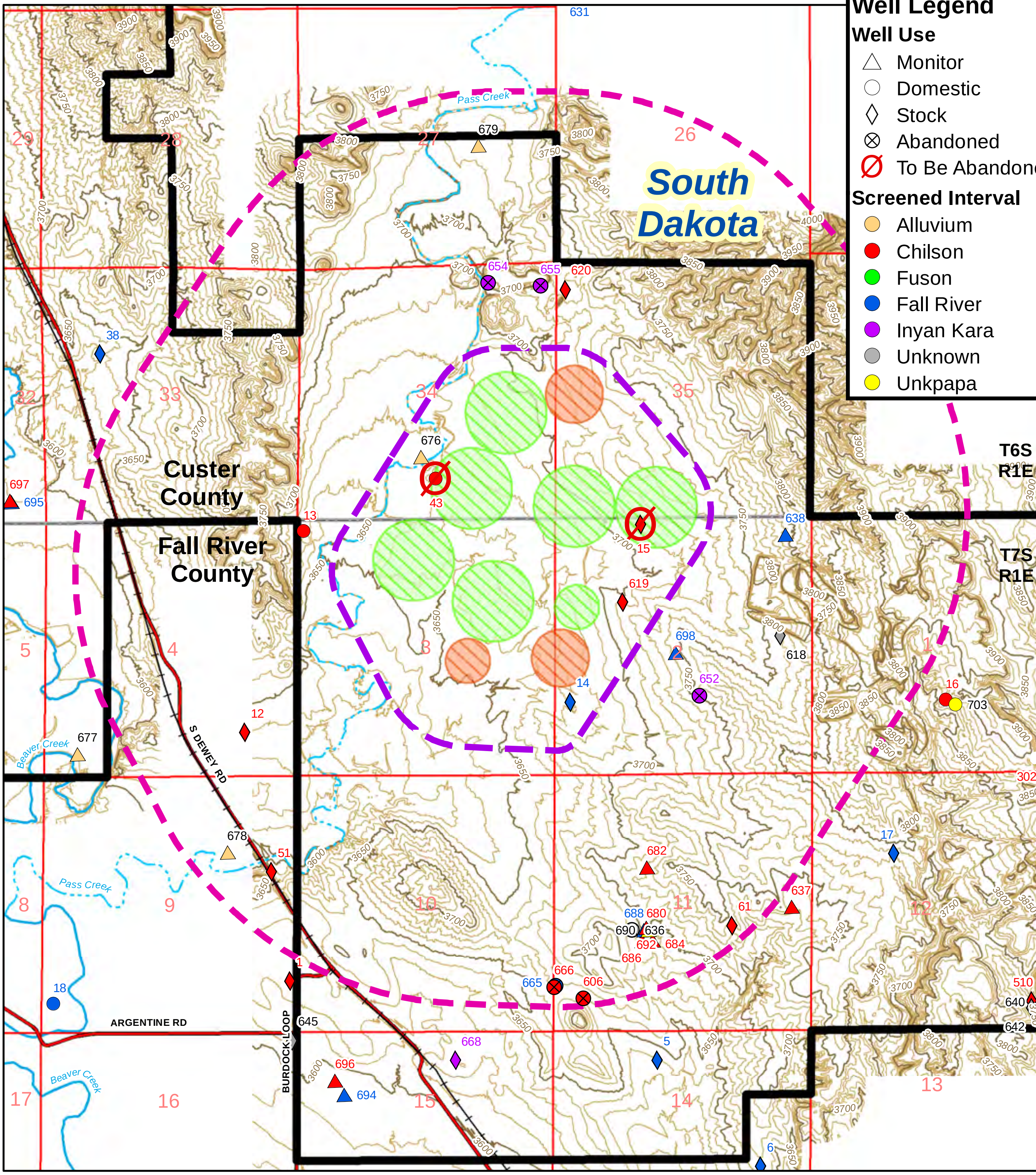
Wells 15 and 43 are both located within land application areas. Based on TVA records, both wells were constructed prior to 1977. Due to the uncertainty in the well construction methods and existing condition of these wells, Powertech (USA) will plug and abandon wells 15 and 43 prior to operation of the Burdock land application system. The wells will be plugged in accordance with ARSD 74:02:04:67 with bentonite or cement grout.

Seven wells are identified as abandoned in Table 3.7-4. Each well was visually inspected, and it has been determined that cement was placed within the well bore.

Table 3.7-4: Wells within 1 Mile of Proposed Burdock POP Zone

Hydro ID	Township	Range	Section	1/4 - 1/4 Location	Coordinates East[1]	Coordinates North[1]	Screened Location[2]	Well Use
Existing Wells								
12	7S	1E	4	SESE	1,026,978	434,378	Chilson	Stock
13	7S	1E	3	NWNW	1,028,360	438,470	Chilson	Domestic
14	7S	1E	2	NWSW	1,033,704	434,723	Fall River	Stock
15[3]	7S	1E	2	NENW	1,035,304	438,317	Chilson	Stock
43[3]	6S	1E	34	SWSE	1,031,123	439,436	Chilson	Domestic[4]
51	7S	1E	9	SENE	1,027,411	431,487	Chilson	Stock
61	7S	1E	11	NWSE	1,036,832	429,987	Chilson	Stock
618	7S	1E	2	SENE	1,038,074	435,906	Unknown	Stock
619	7S	1E	2	SENW	1,034,866	436,729	Chilson	Stock
620	6S	1E	35	NWNW	1,033,951	443,209	Chilson	Stock
638	7S	1E	2	NENE	1,038,269	437,976	Fall River	Monitor
662	7S	1E	11	SESW	1,035,381	428,928	Unknown	Monitor
676	6S	1E	34	SESW	1,030,846	439,891	Alluvial	Monitor
678	7S	1E	9	SWNE	1,026,522	431,925	Alluvial	Monitor
679	6S	1E	27	NWSE	1,032,294	446,245	Alluvial	Monitor
680	7S	1E	11	NESW	1,035,078	429,969	Chilson	Monitor
682	7S	1E	11	SENW	1,035,139	431,257	Chilson	Monitor
684	7S	1E	11	NESW	1,035,191	429,744	Chilson	Monitor
686	7S	1E	11	NESW	1,034,970	429,749	Chilson	Monitor
688	7S	1E	11	NESW	1,035,027	429,974	Fall River	Monitor
690	7S	1E	11	NESW	1,035,114	429,970	Unkpapa	Monitor
692	7S	1E	11	NESW	1,035,075	430,014	Chilson	Monitor
698	7S	1E	2	NESW	1,035,909	435,651	Fall River	Monitor
707	6S	1E	34	SWNE	1,031,935	441,809	Alluvial	Monitor
708	7S	1E	3	SESW	1,030,254	434,094	Alluvial	Monitor
Abandoned Wells								
606	7S	1E	11	SWSW	1,033,713	428,609	Chilson	None
636	7S	1E	11	NESW	1,034,774	429,982	Unknown	None
652	7S	1E	2	NWSE	1,036,360	434,742	Inyan Kara	None
654	6S	1E	34	NWNE	1,032,372	443,410	Inyan Kara	None
655	6S	1E	34	NENE	1,033,454	443,307	Inyan Kara	None
665	7S	1E	11	SWSW	1,033,153	428,901	Fall River	None
666	7S	1E	11	SWSW	1,033,128	428,870	Chilson	None

1 Coordinate system is NAD 27 South Dakota State Plane South
2 Inyan Kara indicates screened interval includes both Chilson and Fall River
3 To be plugged and abandoned prior to operation of the Burdock land application system
4 Formerly used as a domestic well; former residence is uninhabitable



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

Feet: 0, 1,500, 3,000
Meters: 0, 300, 600, 900

Legend

- Project Boundary
- BNSF Railroad
- County Roads
- Ephemeral Streams
- Perennial Streams
- Land Application
- Standby Land Application
- Burdock POP Zone
- 1 Mile from Burdock POP Zone

N

Figure 3.7-10

Existing and Abandoned Wells within 1 Mile of the Proposed Burdock POP Zone
Dewey-Burdock Project

DRAWN BY	S. Hetrick
DATE	14-Jun-2012
FILENAME	Wells-AllBurd1Mile.mxd

POWERTECH (USA) INC.

4.0 WATER QUALITY

This section describes the regional baseline surface water and groundwater sampling that relates to the proposed land application systems. Surface water quality sample results are provided for the project area streams (Beaver Creek and Pass Creek) and for impoundments within 1 mile of the proposed POP zones. Groundwater quality sample results are provided for the alluvium and Fall River Formation. Additional ambient surface water and groundwater sampling will occur prior to land application system operation as described in Section 6.

4.1 Surface Water Quality

4.1.1 Streams

4.1.1.1 Stream Sampling

As part of the baseline monitoring program for the NRC license and LSM permit applications, Powertech (USA) established stream sampling sites on Beaver Creek and Pass Creek. The baseline monitoring program included monthly visits to each site, the locations of which are depicted on Figure 4.1-1. Grab samples were collected from the sites on Beaver Creek, when available, while automated samplers were installed at the sites on Pass Creek. Table 4.1-1 describes which sites were sampled during each sampling event and provides a reason why samples could not be collected at some locations.

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

Field methods for sampling surface waters followed DENR *Standard Operating Procedures for Field Samplers, Volume I* (DENR, 2003).

- Field methods included measuring and recording field water-quality parameters dissolved oxygen, turbidity, pH, specific conductance, and temperature with a water-quality probe.
- Sample bottles and preservative were supplied by EPA-certified Energy Laboratories in Rapid City. Bottles not containing preservative were rinsed three times with sample water before sample collection. Bacteriological sample bottles were not rinsed prior to filling.
- Samples were field-preserved (where required) and immediately placed on ice and delivered within 24 hours to Energy Laboratories in Rapid City along with proper chain-of-custody forms.

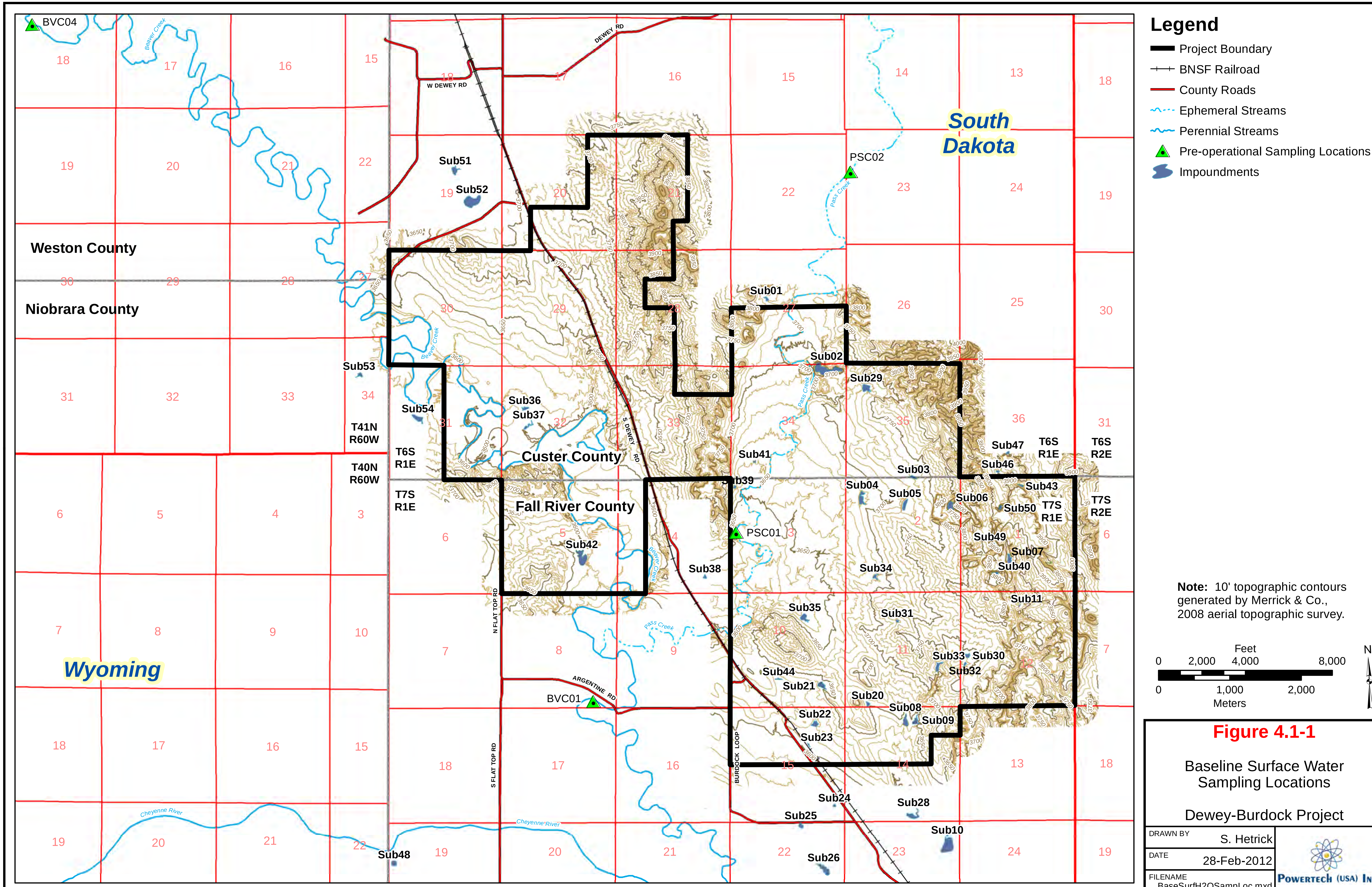


Figure 4.1-1

Baseline Surface Water Sampling Locations

Dewey-Burdock Project

Table 4.1-1: 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
PSC01	Pass Creek Downstream	Passive Sampler	X	2	2	2	2	2	2	2	2	2	2	X
PSC02	Pass Creek Upstream	Passive Sampler	X	2	2	2	2	2	2	2	2	2	2	X

Notes:

X – sample collected

1-2 – no sample collected due to:

1 – Ice

2 – Passive sampler did not indicate precipitation event

– A replicate and a blank sample were collected for every 10 water quality samples collected.

4.1.1.2 Stream Sampling Results

Table 4.1-2 summarizes the results of baseline stream sampling on Beaver Creek and Pass Creek. Appendix 4.1-A contains summaries of the sample results from each surface water sampling point, and Appendix 4.1-B contains analytical data. The Beaver Creek field parameters varied significantly seasonally, with temperature ranging from about 0 to 28°C (32 to 82°F), conductivity ranging from about 680 to 7,700 µmhos/cm, and turbidity ranging from about 2 to 1,800 NTU. Fecal coliform bacteria ranged from non-detect to nearly 6,000 CFU/100 mL.

Salinity (as TDS) in Beaver Creek ranged from 620 to 6,100 mg/L. This was made up predominantly of sodium and sulfate, with significant contributions from calcium and chloride. Chloride concentrations were notably high in many of the Beaver Creek samples. The chloride concentration was above 500 mg/L in 50% of the samples (11 of 22) and above 1,000 mg/L in 23% of samples (5 of 22). This high chloride concentration suggests potential anthropogenic influence such as produced water discharge from oil and gas operations upstream from the project area.

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

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

Only four water quality samples were collected on Pass Creek, all of which were collected in July 2007 and July 2008. Table 4.1-2 demonstrates less variability in Pass Creek water quality than Beaver Creek. This is attributed at least in part to the limited number of samples. Field temperature ranged from about 13 to 17°C (55 to 63°F), conductivity was approximately 1,750 µmhos/cm, and turbidity was approximately 1,750 NTU.

Pass Creek salinity (as TDS) ranged from 1,100 to 1,700 mg/L, which was almost entirely made up of calcium and sulfate. Magnesium, sodium and bicarbonate concentrations were much lower

Table 4.1-2: Stream Water Quality

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

Table 4.1-2: Stream Water Quality (cont'd)

Constituent	Units	Beaver Creek	Pass Creek
Metals - Dissolved			
Silver	mg/L	<0.005	<0.005
Thorium-232	mg/L	<0.005	<0.005
Uranium	mg/L	0.002 - 0.027	0.0007 - 0.005
Vanadium	mg/L	<0.1	<0.1
Zinc	mg/L	<0.01	<0.01
Metals – Dissolved – Speciated			
Selenium-IV	mg/L	<0.001 - 0.002	<0.001
Selenium-VI	mg/L	<0.001 - 0.004	<0.001
Metals – Suspended			
Thorium-232	mg/L	<0.001 - 0.013	<0.001 - 0.002
Uranium	mg/L	<0.0003 - 0.003	0.0004 - 0.0009
Metals - Total			
Aluminum	mg/L	<0.1 - 99.3	58.7 - 85.9
Arsenic	mg/L	<0.001 - 0.048	0.003 - 0.031
Barium	mg/L	<0.1 - 1.1	0.2 - 0.8
Boron	mg/L	<0.1 - 0.6	<0.1 - 0.3
Cadmium	mg/L	<0.005	<0.005
Chromium	mg/L	<0.05 - 0.19	<0.05 - 0.17
Copper	mg/L	<0.01 - 0.11	<0.01 - 0.1
Iron	mg/L	0.05 - 137	0.28 - 128
Lead	mg/L	<0.001 - 0.088	0.002 - 0.074
Manganese	mg/L	0.05 - 1.82	0.12 - 2.55
Mercury	mg/L	<0.001	<0.001
Molybdenum	mg/L	<0.1	<0.1
Nickel	mg/L	<0.05 - 0.15	<0.05 - 0.15
Selenium	mg/L	<0.001 - 0.004	<0.001 - 0.003
Silver	mg/L	<0.005	<0.005
Thorium-232	mg/L	<0.005 - 0.04	0.012 - 0.02
Uranium	mg/L	0.003 - 0.026	0.0012 - 0.025
Vanadium	mg/L	<0.1 - 0.4	<0.1 - 0.1
Zinc	mg/L	<0.01 - 0.54	0.02 - 0.34
Metals – Total – Speciated			
Selenium-IV	mg/L	<0.001 - 0.001	<0.001
Selenium-VI	mg/L	<0.001 - 0.004	<0.001
Radionuclides - Dissolved			
Lead-210	pCi/L	<1 - 26	1.7 - 2.2
Polonium-210	pCi/L	<1 - 3	0.2 - 0.7
Radium-226	pCi/L	<0.2 - 2	0 - 0.1
Thorium-230	pCi/L	<0.2 - 1.7	0

Table 4.1-2: Stream Water Quality (cont'd)

Constituent	Units	Beaver Creek	Pass Creek
Radionuclides - Suspended			
Lead-210	pCi/L	<1 - 15.3	-0.8 - 0.9
Polonium-210	pCi/L	<1 - 3.7	0.3
Radium-226	pCi/L	<0.2 - 3.1	-0.2 - 0.1
Thorium-230	pCi/L	<0.2 - 3.4	0.2 - 0.5
Radionuclides - Total			
Gross Alpha	pCi/L	2.3 - 65.8	1.9 - 8.8
Gross Beta	pCi/L	<2 - 48.1	-7 - 15.1
Gross Gamma	pCi/L	<20 - 1,310	0
Lead-210	pCi/L	<1 - 35	0 - 3
Polonium-210	pCi/L	<1 - 4.4	0.5 - 1
Radium-226	pCi/L	<0.2 - 5.1	<0.2 - 0.7
Thorium-230	pCi/L	<0.2 - 3.4	0.2 - 0.5

than calcium and sulfate, and sodium and chloride were very low (typically less than 5 mg/L). Dissolved metal concentrations were low or non-detectable. Notable total metal detections included aluminum, arsenic, barium, iron, lead, manganese, nickel, uranium and zinc.

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

4.1.2 Impoundments

4.1.2.1 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 4.1-3. The table includes 27 impoundments within 1 mile of the proposed POP zones. During the regional baseline monitoring program, 6 of the 27 impoundments were visited on a quarterly basis. Table 4.1-3 illustrates which of these impoundments were sampled during each quarterly sampling event or provides a reason why a sample could not be collected.

As described in Section 6.2, Powertech (USA) proposes to sample three impoundments during operation of the land application systems. These are the only impoundments within 1 mile of the proposed land application systems, downgradient from the proposed land application systems,

Table 4.1-3: Regional Baseline Impoundment Sampling

Site	Type/Name	Baseline Sampling				Down-Gradient of Proposed Land Application Systems*
		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	No
Sub06	Darrow Mine Pit Northwest	X	X	X	X	No
Sub21	Stock Pond					No
Sub29	Stock Pond					No
Sub31	Stock Pond					No
Sub34	Stock Pond					No
Sub35	Stock Pond					No
Sub36	Stock Pond					Yes
Sub37	Stock Pond					Yes
Sub38	Stock Pond					No
Sub39	Stock Pond					No
Sub40	Darrow Mine Pit Southeast					No
Sub41	Stock Pond					No
Sub43	Stock Pond					No
Sub44	Stock Pond					No
Sub46	Stock Pond					No
Sub47	Stock Pond					No
Sub49	Darrow Mine Pit					No
Sub50	Darrow Mine Pit					No
Sub51	Stock Pond					No
Sub52	Stock Pond					No
Sub53	Stock Pond					No
Sub54	Stock Pond					No

* Including center pivots, catchment areas and land application system pipelines.
Notes: X – Sample collected
1 – No sample collected due to impoundment being dry during quarterly visit

and not downgradient from other impoundments that will be included in the operational monitoring program. Prior to operation, Powertech (USA) will collect additional baseline samples from these impoundments as necessary.

4.1.2.2 Impoundment Sampling Results

Table 4.1-4 summarizes the baseline sampling results for two of the three impoundments proposed for operational monitoring: Sub03 and Sub04. As described in Section 6.2, impoundments proposed for operational monitoring include those within 1 mile and

Table 4.1-4: Impoundment Water Quality

Constituent	Units	Sub03	Sub04
Field Parameters			
Field Temperature	°C	10.9 - 31.9	9.5 - 27.1
Field pH	s.u.	6.1 - 6.5	4.7 - 7.2
Field Dissolved Oxygen	mg/L	8.9 - 10.2	9.5 - 9.8
Field Conductivity	umhos/cm	1,023 - 1,225	562 - 1,868
Field Turbidity	NTU	6.6 - 12.7	1.4 - 37.3
Microbiological			
Bacteria, Fecal Coliform	CFU/100 mL	<2	<2
Physical Properties			
Conductivity @ 25°C	umhos/cm	975 - 1,080	692 - 1,650
pH	s.u.	4.4 - 4.6	4.7 - 4.9
Sodium Adsorption Ratio (SAR)	unitless	<0.1 - 0.15	<0.1 - 0.25
Solids, Total Dissolved (TDS) @ 180 °C	mg/L	820 - 970	450 - 1,700
Solids, Total Suspended(TSS) @ 105 °C	mg/L	6 - 26	<5 - 23
Common Elements and Ions			
Alkalinity, Total as $CaCO_3$	mg/L	<5	<5
Bicarbonate as HCO_3	mg/L	<5	<5
Carbonate as CO3	mg/L	<5	<5
Calcium	mg/L	128 - 130	64.8 - 201
Chloride	mg/L	2 - 9	2 - 18
Fluoride	mg/L	0.2 - 0.4	0.4 - 0.6
Magnesium	mg/L	47 - 53	27.3 - 99.5
Nitrogen, Ammonia as N	mg/L	0.1	<0.1 - 0.3
Nitrogen, Nitrate as N	mg/L	<0.1	<0.1
Potassium	mg/L	16 - 35	14 - 46
Sodium	mg/L	4 - 8.2	2.9 - 17.1
Sulfate	mg/L	510 - 699	291 - 1,200
Silica	mg/L	2.1 - 7.5	3.7 - 16.2
Metals - Dissolved			
Aluminum	mg/L	0.6	0.4 - 1.2
Arsenic	mg/L	<0.001	<0.001
Barium	mg/L	<0.1	<0.1
Boron	mg/L	<0.1 - 0.2	<0.1 - 0.1
Cadmium	mg/L	<0.005	<0.005 - 0.008
Chromium	mg/L	<0.01	<0.01
Copper	mg/L	<0.01	<0.01
Iron	mg/L	0.12 - 0.24	<0.03 - 1.48
Lead	mg/L	<0.001	<0.001 - 0.001
Manganese	mg/L	8.4 - 11.6	5.2 - 20.4
Mercury	mg/L	<0.001	<0.001
Molybdenum	mg/L	<0.1	<0.1
Nickel	mg/L	0.17 - 0.23	0.09 - 0.43
Selenium	mg/L	<0.005	<0.005

Table 4.1-4: Impoundment Water Quality (cont'd)

Constituent	Units	Sub03	Sub04
Metals - Dissolved			
Silver	mg/L	<0.005	<0.005
Thorium-232	mg/L	<0.005	<0.005
Uranium	mg/L	0.0014 - 0.0023	0.0006 - 0.0021
Vanadium	mg/L	<0.1	<0.1
Zinc	mg/L	0.1 - 0.16	0.07 - 0.37
Metals – Dissolved – Speciated			
Selenium-IV	mg/L	<0.001	<0.001
Selenium-VI	mg/L	<0.001	<0.001
Metals – Suspended			
Thorium-232	mg/L	<0.001	<0.001
Uranium	mg/L	0.0004 - 0.0008	<0.0003 - 0.0014
Metals - Total			
Aluminum	mg/L	0.7 - 1.2	0.5 - 1.5
Arsenic	mg/L	<0.001 - 0.002	<0.002
Barium	mg/L	<0.1	<0.1
Boron	mg/L	<0.1 - 0.1	<0.1
Cadmium	mg/L	<0.005	<0.005 - 0.008
Chromium	mg/L	<0.05	<0.05
Copper	mg/L	<0.01	<0.01
Iron	mg/L	0.16 - 1.1	0.18 - 3.73
Lead	mg/L	<0.001	<0.001
Manganese	mg/L	8.4 - 12.2	5.2 - 21.3
Mercury	mg/L	<0.001	<0.001
Molybdenum	mg/L	<0.1	<0.1
Nickel	mg/L	0.17 - 0.23	0.1 - 0.44
Selenium	mg/L	<0.001	<0.001 - 0.001
Silver	mg/L	<0.005	<0.005
Thorium-232	mg/L	<0.005	<0.005
Uranium	mg/L	0.0014 - 0.0031	0.0007 - 0.0024
Vanadium	mg/L	<0.1 - 0.2	<0.1
Zinc	mg/L	0.08 - 0.17	0.06 - 0.41
Metals – Total – Speciated			
Selenium-IV	mg/L	<0.001	<0.001
Selenium-VI	mg/L	<0.001	<0.001 - 0.001
Radionuclides - Dissolved			
Lead-210	pCi/L	<1	<1
Polonium-210	pCi/L	<1	0.2 - 2.2
Radium-226	pCi/L	2.6 - 4.5	3.1 - 3.4
Thorium-230	pCi/L	<0.2	0 - 0.9
Radionuclides - Suspended			
Lead-210	pCi/L	<1	<1 - 6.7
Polonium-210	pCi/L	<1	<1
Radium-226	pCi/L	<0.2	<2
Thorium-230	pCi/L	0.4 - 1.3	0.2 - 0.5

Table 4.1-4: Impoundment Water Quality (cont'd)

Constituent	Units	Sub03	Sub04
Radionuclides - Total			
Gross Alpha	pCi/L	16.6 - 19.9	3 - 13.6
Gross Beta	pCi/L	21.8 - 38.8	13 - 51.3
Gross Gamma	pCi/L	1,080 - 1,270	<20
Lead-210	pCi/L	<1	<1
Polonium-210	pCi/L	0.5 - 2.5	0.4 - 3.4
Radium-226	pCi/L	2.5 - 4	2.7 - 3.5
Thorium-230	pCi/L	<0.2 - 0.3	<0.2 - 0.2

downgradient from the land application systems. Baseline sampling results for other impoundments within 1 mile but not downgradient from the land application systems are provided in Appendices 4.1-A and 4.1-B. The final impoundment proposed for operational monitoring (Sub36) was not sampled in the original baseline sampling program. As described in Section 6.2, Powertech (USA) will sample Sub36 to establish baseline conditions prior to land application system operation.

The water quality in Sub03 and Sub04 is similar in terms of physical properties and major ion chemistry. The laboratory pH ranged from 4.4 to 4.9 and TDS ranged from 820 to 1,700 mg/L. Major ions are dominated by calcium and sulfate, with significant concentrations of magnesium but low to non-detectable concentrations of sodium, chloride, and bicarbonate. Notable dissolved metal concentrations above detection limits included aluminum, iron, manganese, nickel, and uranium. Total metal concentrations tended to be similar to dissolved concentrations, indicating that most of the metals were present as dissolved species rather than associated with sediment or precipitates. Gross alpha and beta were moderate in both impoundments. Gross gamma was relatively high in Sub03 but non-detectable in Sub04.

4.2 Groundwater Quality

4.2.1 Groundwater Sampling

Regional baseline groundwater sampling was conducted in accordance with NRC regulatory guidance as appropriate to ISR operations. The wells were selected based on type of use, aquifer, and location. The subset includes wells within the Fall River Formation and alluvium. Initial baseline sampling of these wells was conducted quarterly from July 2007 through June 2008, with additional monthly samples collected from select wells between March 2008 and February 2009. The regional baseline wells are listed in Table 4.2-1. The well locations are presented on Figure 4.2-1.

Table 4.2-1: Regional Baseline Alluvial and Fall River Wells

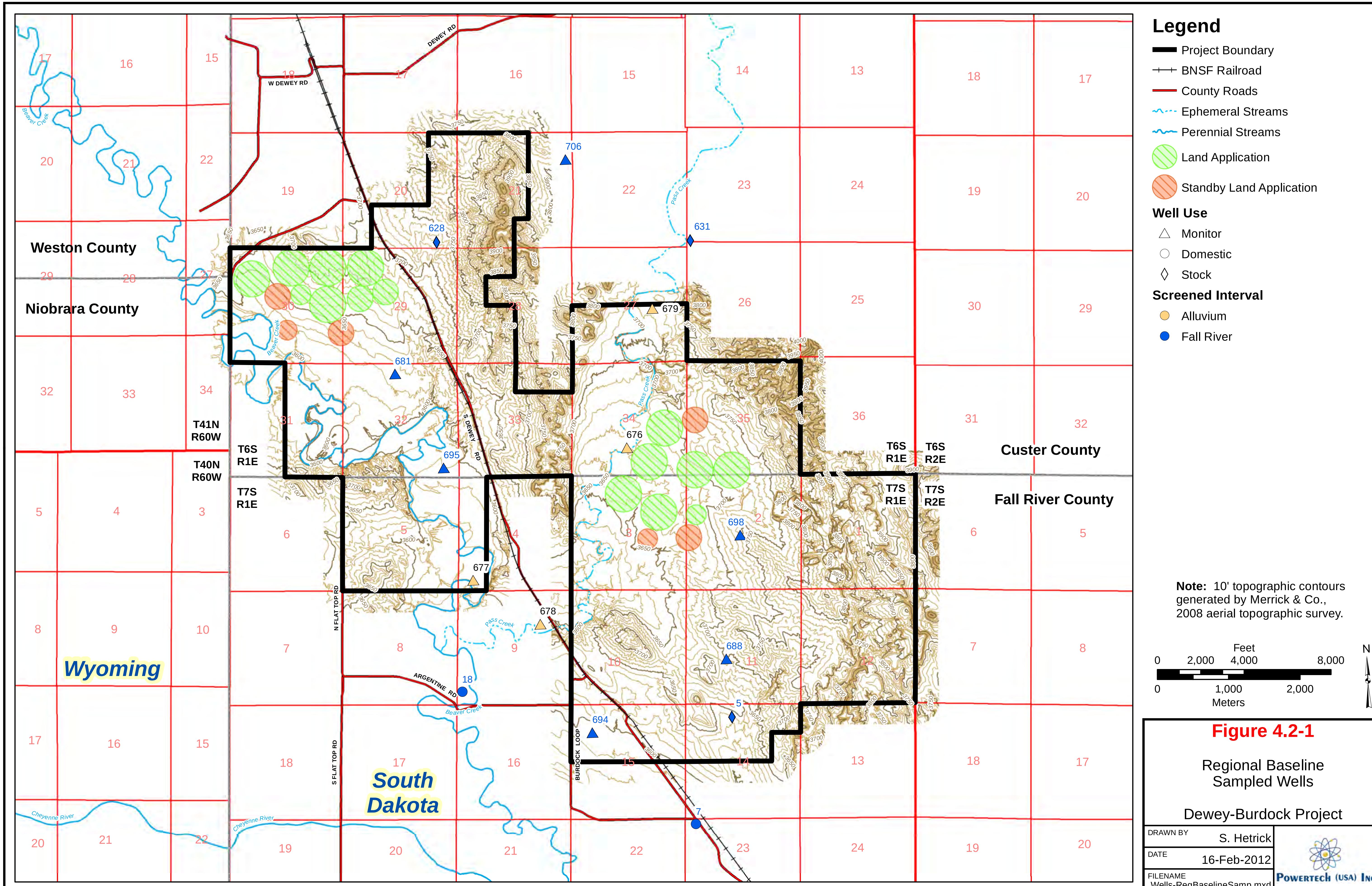
Hydro ID	Township (S)	Range (E)	Section	1/4 - 1/4 Location	Coordinates East	Coordinates North	Screened Location	Well Use
5	7	1	14	NENW	1035181	427284	Fall River	Stock
7	7	1	23	NWNW	1033304	422417	Fall River	Domestic
8	7	1	23	SWSE	1036052	418515	Fall River	Domestic
18	7	1	9	SWSW	1022812	428960	Fall River	Domestic
628	6	1	20	SESE	1022496	449718	Fall River	Stock
631	6	1	23	SWSW	1034177	449309	Fall River	Stock
676	6	1	34	SESW	1030846	439891	Alluvial	Monitor
677	7	1	4	SWSW	1023527	434077	Alluvial	Monitor
678	7	1	9	SWNE	1026522	431925	Alluvial	Monitor
679	6	1	27	NWSE	1032294	446245	Alluvial	Monitor
681	6	1	32	NENW	1020330	443725	Fall River	Monitor
688	7	1	11	NESW	1035027	429974	Fall River	Monitor
694	7	1	15	NWNW	1028717	426836	Fall River	Monitor
695	6	1	32	SESE	1022385	439312	Fall River	Monitor
698	7	1	2	NESW	1035909	435651	Fall River	Monitor
706	6	1	21	NENE	1028589	453276	Fall River	Monitor

Note: Coordinate system is NAD 27 South Dakota Sate Plane South (feet)

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

Additional steps taken during groundwater sampling include the following:

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


Legend
Project Boundary
BNSF Railroad
County Roads
Ephemeral Streams
Perennial Streams
Land Application
Standby Land Application
Well Use
Monitor
Domestic
Stock
Screened Interval
Alluvium
Fall River
Note: 10' topographic contours generated by Merrick & Co., 2008 aerial topographic survey.
Feet
0 2,000 4,000 8,000
0 1,000 2,000
Meters
N
Weston County
Niobrara County
Custer County
Fall River County
Wyoming
South Dakota
T41N R60W
T40N R60W
T6S R1E
T7S R1E
T6S R2E
T7S R2E
W DEWEY RD
DEWEY RD
S DEWEY RD
N FLAT TOP RD
S FLAT TOP RD
ARGENTINE RD
BURDOCK LOOP
Beaver Creek
Pass Creek
Cheyenne River
706
628
631
681
695
679
676
698
677
678
688
18
5
694
7
Figure 4.2-1
Regional Baseline Sampled Wells
Dewey-Burdock Project
DRAWN BY S. Hetrick
DATE 16-Feb-2012
FILENAME Wells-RegBaselineSamp.mxd
POWERTECH (USA) INC.

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

The groundwater sampling constituent list was developed based on NRC guidance and a constituent list review with DENR.

4.2.2 Groundwater Sampling Results

Table 4.2-2 summarizes the groundwater sampling results for the alluvium and Fall River Formation. Appendix 4.2-A contains summaries of the sample results from each well, and Appendix 4.2-B contains analytical data. The data in Table 4.2-2 represent the range of the average concentration for the well in each monitoring zone. Note that the maximum value represents the maximum detected value for each parameter.

The alluvial water quality is characterized by moderate pH (7.2 - 7.6), moderate to high TDS (2,525 - 9,325 mg/L), and variable turbidity (3.8 - 799 NTUs). Major cation chemistry is 50% calcium dominant (2 of 4 wells), 25% sodium dominant (1 of 4 wells) and 25% incomplete dominance, with significant contributions from sodium, calcium and magnesium. Major anion chemistry is 100% sulfate dominant. Bicarbonate concentrations were low in all alluvial wells and chloride concentrations were low in 75% of wells (3 of 4). A notable exception is Well 677, which had an average chloride concentration of 1,625 mg/L.

A comparison between the alluvial water quality and ARSD 74:54:01:04 human health standards shows that 75% of the alluvial wells (3 of 4) exceed the uranium standard of 0.03 mg/L, 25% (1 of 4) exceed the arsenic standard of 0.01 mg/L, and 100% (4 of 4) exceed the gross alpha standard of 15 pCi/L.

The water quality in the Fall River Formation is distinguished from that in the alluvium by lower TDS (the maximum Fall River TDS is lower than the minimum alluvial TDS), less variability in major ion chemistry, and higher radionuclide concentrations. Sodium is the dominant cation in 75% of wells (9 of 12). Two wells exhibited calcium dominance and one well had incomplete cation dominance. All of the Fall River baseline wells exhibited strong sulfate dominance, with sulfate accounting for 73% to 92% of the anion concentration (in meq/L). 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 in the Fall River Formation were much higher than those measured in the alluvium. For example, gross alpha was measured up to 1,505 pCi/L and radon-222 up to about 280,000 pCi/L. Appendix 4.2-A compares sample results with EPA primary and secondary drinking water standards. Note that

Table 4.2-2: Summary of Water Quality by Formation

Constituent	Units	Alluvial	Fall River
Field Parameters			
Water Level Elevation	ft AMSL	3561.7 - 3685.5	3574.6 - 3725.1
Field Temperature	°C	10.1 - 11.1	11.1 - 14.9
Field pH	s.u.	6.8 - 7.4	6.7 - 8.4
Field Dissolved Oxygen	mg/L	0.8 - 9.4	0.07 - 5.4
Field Conductivity	umhos/cm	2,666 - 11,256	1,223 - 2,623
Field Turbidity	NTU	3.8 - 799	0.1 - 13.1
Physical Properties			
Conductivity @ 25°C	umhos/cm	2,460 - 11,375	1,201 - 2,870
Oxidation-Reduction Potential	mV	193 - 253	129 - 258
pH	s.u.	7.2 - 7.6	7.1 - 8.5
Sodium Adsorption Ratio (SAR)	unitless	0.8 - 16.3	1.0 - 11.4
Solids, Total Dissolved (TDS) @ 180 °C	mg/L	2,525 - 9,325	774 - 2,250
Common Elements and Ions			
Alkalinity, Total as $CaCO_3$	mg/L	145 - 497	117 - 197
Carbonate as CO3	mg/L	<5	<5 - 7.9
Bicarbonate as HCO_3	mg/L	177 - 606	143 - 240
Calcium	mg/L	426 - 515	30 - 368
Chloride	mg/L	12 - 1,625	9.5 - 47
Fluoride	mg/L	0.2 - 0.6	0.3 - 0.5
Magnesium	mg/L	98 - 442	10.5 - 134
Nitrogen, Ammonia as N	mg/L	<0.1 - 0.09	<0.1 - 0.4
Nitrogen, Nitrate as N	mg/L	0.06 - 1.2	<0.1
Nitrogen, Nitrite as N	mg/L	<0.1	<0.1
Potassium	mg/L	11.3 - 19.2	7.1 - 16
Sodium	mg/L	77 - 1,965	87 - 503
Sulfate	mg/L	1,485 - 4,425	425 - 1,443
Silica	mg/L	8.5 - 13.6	5.2 - 11.2
Metals - Dissolved			
Aluminum	mg/L	<0.1	<0.1
Arsenic	mg/L	<0.001 - 0.001	<0.001 - 0.002
Barium	mg/L	<0.1	<0.1
Boron	mg/L	0.4 - 1.43	<0.1 - 0.43
Cadmium	mg/L	<0.005	<0.01
Chromium	mg/L	<0.05	<0.05
Copper	mg/L	<0.01	<0.01
Iron	mg/L	<0.03	<0.03 - 2.58
Lead	mg/L	<0.001	<0.001
Manganese	mg/L	0.01 - 2.8	0.03 - 2.41
Mercury	mg/L	<0.001	<0.001
Molybdenum	mg/L	<0.1	<0.1
Nickel	mg/L	<0.05	<0.05 - 0.03
Selenium	mg/L	0.001 - 0.013	<0.001 - 0.001
Silver	mg/L	<0.005	<0.01

Table 4.2-2: Summary of Water Quality by Formation (cont'd)

Constituent	Units	Alluvial	Fall River
Metals - Dissolved			
Thorium-232	mg/L	<0.005	<0.005
Uranium	mg/L	0.014 - 0.055	<0.0003 - 0.11
Vanadium	mg/L	<0.1 - 0.088	<0.1
Zinc	mg/L	<0.01 - 0.013	<0.01 - 0.0125
Metals – Dissolved – Speciated			
Selenium-IV	mg/L	<0.001	<0.001
Selenium-VI	mg/L	<0.001 - 0.012	<0.001 - 0.001
Metals – Suspended			
Uranium	mg/L	0.001 - 0.020	<0.0003 - 0.0031
Metals - Total			
Antimony	mg/L	<0.003	<0.003
Arsenic	mg/L	0.001 - 0.011	0.0008 - 0.0038
Barium	mg/L	<0.1 - 0.28	<0.1
Beryllium	mg/L	<0.001 - 0.002	<0.005
Boron	mg/L	0.2 - 1.5	<0.1 – 0.45
Cadmium	mg/L	<0.001	<0.005
Chromium	mg/L	<0.05 - 0.038	<0.05
Copper	mg/L	<0.01 - 0.063	<0.01
Iron	mg/L	0.028 - 33.3	0.04 - 4.8
Lead	mg/L	<0.001 - 0.03	<0.001 - 0.002
Manganese	mg/L	0.46 - 2.7	0.03 - 2.49
Mercury	mg/L	<0.0001 - 0.0002	<0.001
Molybdenum	mg/L	<0.01 - 0.03	<0.01 - 0.03
Nickel	mg/L	<0.05 - 0.063	<0.05
Selenium	mg/L	0.003 - 0.014	<0.001 - 0.001
Silver	mg/L	<0.005	<0.02
Strontium	mg/L	7.6 - 10.8	0.65 - 6.2
Thallium	mg/L	<0.001	<0.001
Uranium	mg/L	0.016 - 0.064	<0.0003 - 0.11
Zinc	mg/L	<0.01 - 0.16	<0.01 - 0.01
Radionuclides - Dissolved			
Gross Alpha	pCi/L	18.5 - 63.0	5.6 - 1,505
Gross Beta	pCi/L	-7.5 - 18.1	3.2 - 484
Gross Gamma	pCi/L	528 - 697	216 - 4,994
Lead-210	pCi/L	0.9 - 3.7	-1.9 - 29.7
Polonium-210	pCi/L	0.9 - 1.4	0.02 - 2.36
Radium-226	pCi/L	0.1 - 1.2	1.2 - 388
Thorium-230	pCi/L	0.08 - 0.18	0.01 - 0.13
Radionuclides - Suspended			
Lead-210	pCi/L	-2 - 0	-1.5 - 11.8
Polonium-210	pCi/L	0.3 - 0.8	0.03 - 2.2
Radium-226	pCi/L	0.4 - 3.9	-0.2 - 7.9
Thorium-230	pCi/L	0.1 - 1.1	-0.07 - 1.29

Table 4.2-2: Summary of Water Quality by Formation (cont'd)

Constituent	Units	Alluvial	Fall River
Radionuclides - Total			
Lead-210	pCi/L	<1	<1
Polonium-210	pCi/L	<1	<1 - 6.4
Radium-226	pCi/L	<0.2 - 2.5	<0.2 - 15.2
Radon-222	pCi/L	522 - 1,413	277 - 278,030
Thorium-230	pCi/L	<0.2 - 1.9	<0.2

for uranium, arsenic, and gross alpha, the ARSD 74:54:01:04 human health standards are the same as the EPA MCLs.

4.2.3 Groundwater Classification

According to ARSD 74:54:01:03, groundwater which has an ambient TDS concentration of 10,000 mg/L or less is classified as having the beneficial use of drinking water supplies. Thus, although both the alluvial groundwater and Fall River Formation groundwater exceed ARSD 74:54:01:04 human health standards for various constituents, the groundwater is classified as having the beneficial use of drinking water supplies.

The regional baseline alluvial water quality is described in Table 4.2-2. As described in Section 6.1, Powertech (USA) proposes to install additional alluvial monitor wells to serve as compliance wells and interior wells for the proposed POP zones. The ambient water quality in those wells will be used to determine the water quality standards at the point of compliance. Table 4.2-3 compares the existing alluvial water quality data with the human health standards (Tables 1 and 2) in ARSD 74:54:01:04. According to ARSD 74:54:01:03, if the groundwater quality does not meet the standards in ARSD 74:54:01:04 as a result of natural causes or conditions, no degradation of the groundwater beyond the ambient concentration may be allowed. Based on available alluvial water quality data, there is potential that the ambient water quality will exceed the human health standards for uranium, gross alpha, and radon-222.

Table 4.2-3: Comparison of Alluvial Water Quality with Human Health Standards

Constituent	Units	Alluvial Water Quality	Human Health Standards in ARSD 74:54:01:04
Common Elements and Ions			
Chloride	mg/L	12 - 1,625	250
Cyanide (free)	mg/L	NM	0.2
Cyanide (week acid soluble)	mg/L	NM	0.75
Fluoride	mg/L	0.2 - 0.6	4
Nitrogen, Nitrate as N	mg/L	0.06 - 1.2	10
Nitrogen, Nitrite as N	mg/L	<0.1	1
pH	s.u.	7.2 - 7.6	6.5 - 8.5
Sulfate	mg/L	1,485 - 4,425	500
TDS	mg/L	2,525 - 9,325	1,000
Inorganics[1]			
Antimony	mg/L	NM	0.006
Arsenic	mg/L	<0.001 - 0.001	0.01
Asbestos	MFL	NM	7
Barium	mg/L	<0.1	2
Beryllium	mg/L	NM	0.004
Bromate	mg/L	NM	0.01
Cadmium	mg/L	<0.005	0.005
Chlorite	mg/L	NM	1
Chromium	mg/L	<0.05	0.1
Copper	mg/L	<0.01	1.0
Lead	mg/L	<0.001	0.015
Mercury	mg/L	<0.0001 - 0.0002	0.002
Selenium	mg/L	0.001 - 0.013	0.05
Silver	mg/L	<0.005	0.1
Thallium	mg/L	NM	0.002
Uranium	mg/L	0.014 - 0.055	0.03
Radionuclides			
Gross Beta	varied	-7.5 - 18.1 pCi/L	4 mrem/yr
Gross Alpha	pCi/L	18.5 - 63.0	15
Radium-226 + Radium-228[2]	pCi/L	0.13 - 1.2	5
Radon-222	pCi/L	522 - 1,413	300

[1]Applies to dissolved portion of each constituent except mercury
[2]Range shown for alluvial water quality represents radium-226 only

5.0 DESCRIPTION OF DISCHARGE FACILITY

Each land application system will consist of irrigation center pivots, associated pumps and piping, and catchment areas. The land application systems will also include various failure detection systems to detect and control potential leaks. The instrumentation and control systems are discussed in further detail in Section 6.3.3. Associated facilities include lined radium settling ponds and lined storage ponds. Following is a description of the proposed Dewey and Burdock area land application system designs, operating plans and results of hydrologic modeling used to size the land application areas and pond capacities. In order to satisfy the ARSD 74:54:02:06 (10) requirement to submit plans and specifications related to the construction of the land application systems, Powertech (USA) proposes to submit detailed as-constructed drawings and specifications for the land application system center pivots, catchment areas, pumps, piping, and monitoring systems after construction but prior to operation of the land application systems.

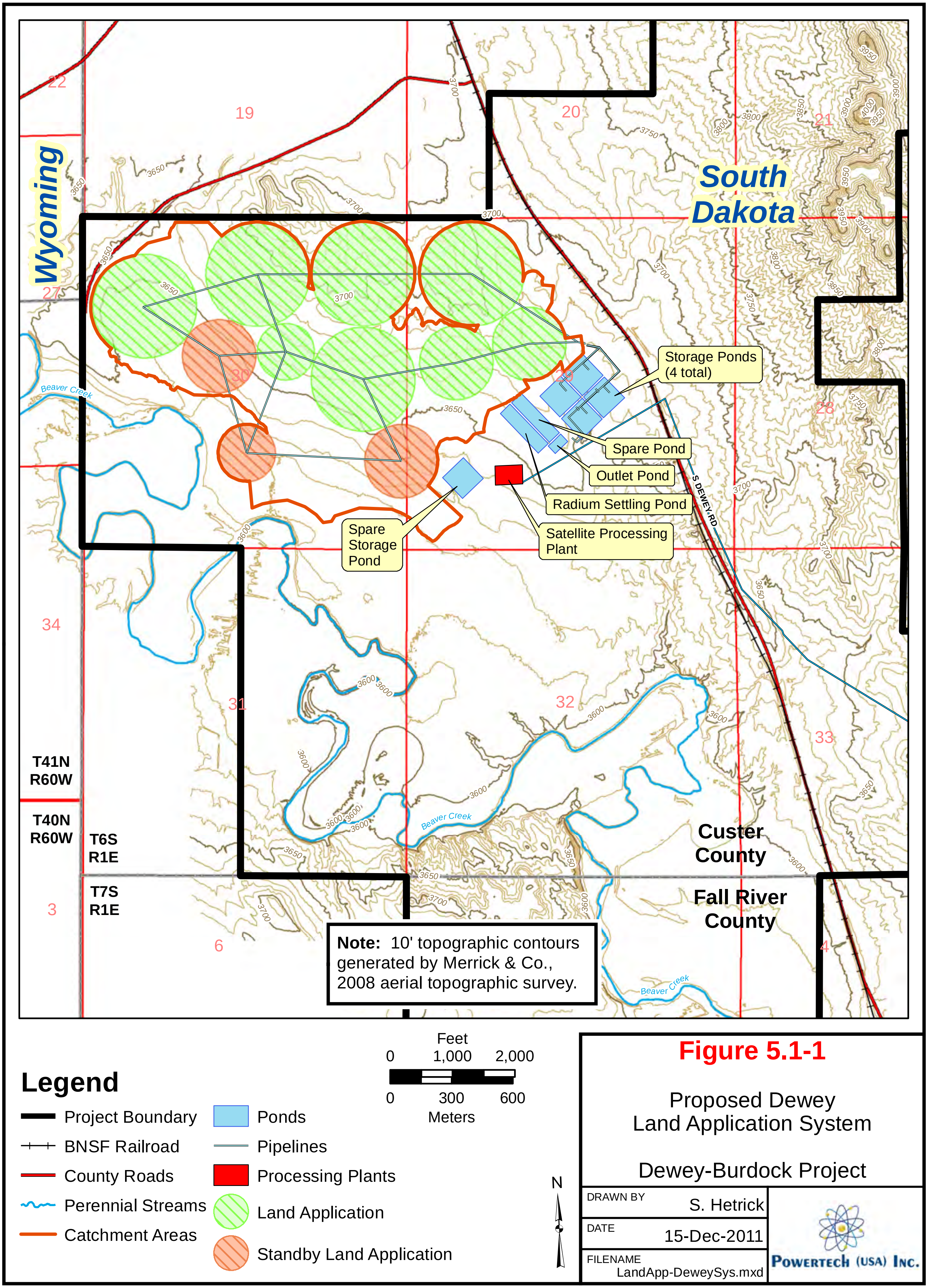
5.1 Dewey Land Application System Design

The proposed Dewey land application system is depicted on Figure 5.1-1. It will be located in Sections 29 and 30, T6S, R1E, in Custer County. Access will be provided from S. Dewey Road. The land application system will have 315 acres of irrigated area consisting of individual 50-, 25- and 15-acre center pivots. In addition, it will have 65 acres of center pivots on standby, which can be used during repairs and maintenance of other center pivots or on a rotating basis. Table 5.1-1 summarizes the capacities of the Dewey land application system and storage ponds.

Table 5.1-1: Dewey Land Application System Design

Parameter	Units	Design Value
Center Pivots		
No. of 50-acre primary pivots	---	5
No. of 25-acre primary pivots	---	2
No. of 15-acre primary pivots	---	1
Primary pivot area	ac	315
Standby pivot area	ac	65
Total pivot area	ac	380
Design application rate, Mar 29 - May 10	gpm	297
Design application rate, May 11 - Sep 24	gpm	653
Design application rate, Sep 25 - Oct 31	gpm	297
Design average annual application rate[1]	gpm	310
Design average annual application volume[1]	ac-ft	500
Storage Ponds		
No. of primary storage ponds	---	4
No. of spare storage ponds	---	1
Operating capacity of each storage pond	ac-ft	61.8
Primary storage pond capacity	ac-ft	247.2
Total storage pond capacity	ac-ft	309.0

[1] Includes 0 gpm typical land application rate during approximately Nov 1 through Mar 28.


Wyoming
South Dakota
Storage Ponds (4 total)
Spare Pond
Outlet Pond
Radium Settling Pond
Satellite Processing Plant
Spare Storage Pond
S DEWEY RD
Beaver Creek
T41N R60W
T40N R60W
T6S R1E
T7S R1E
Custer County
Fall River County
Note: 10' topographic contours generated by Merrick & Co., 2008 aerial topographic survey.
Legend
Project Boundary
BNSF Railroad
County Roads
Perennial Streams
Catchment Areas
Ponds
Pipelines
Processing Plants
Land Application
Standby Land Application
Feet
0 1,000 2,000
0 300 600
Meters
N
Figure 5.1-1
Proposed Dewey Land Application System
Dewey-Burdock Project
DRAWN BY S. Hetrick
DATE 15-Dec-2011
FILENAME LandApp-DeweySys.mxd
Powertech (USA) Inc.

5.2 Burdock Land Application System Design

The proposed Burdock land application system is depicted on Figure 5.2-1. It will be located in Sections 34 and 35, T6S, R1E, in Custer County and in Sections 2 and 3, T7S, R1E, in Fall River County. Access will be provided from S. Dewey Road. The land application system will have 315 acres of irrigated area consisting of individual 50-, 25- and 15-acre center pivots. In addition, it will have 65 acres of center pivots on standby, which can be used during repairs and maintenance of other center pivots or on a rotating basis. Table 5.2-1 summarizes the capacities of the Burdock land application system and storage ponds.

Table 5.2-1: Burdock Land Application System Design

Parameter	Units	Design Value
Center Pivots		
No. of 50-acre primary pivots	---	6
No. of 25-acre primary pivots	---	0
No. of 15-acre primary pivots	---	1
Primary pivot area	ac	315
Standby pivot area	ac	65
Total pivot area	ac	380
Design application rate, Mar 29 - May 10	gpm	297
Design application rate, May 11 - Sep 24	gpm	653
Design application rate, Sep 25 - Oct 31	gpm	297
Design average annual application rate[1]	gpm	310
Design average annual application volume[1]	ac-ft	500
Storage Ponds		
No. of primary storage ponds	---	4
No. of spare storage ponds	---	1
Operating capacity of each storage pond	ac-ft	61.8
Primary storage pond capacity	ac-ft	247.2
Total storage pond capacity	ac-ft	309.0

[1] Includes 0 gpm typical land application rate during approximately Nov 1 through Mar 28.

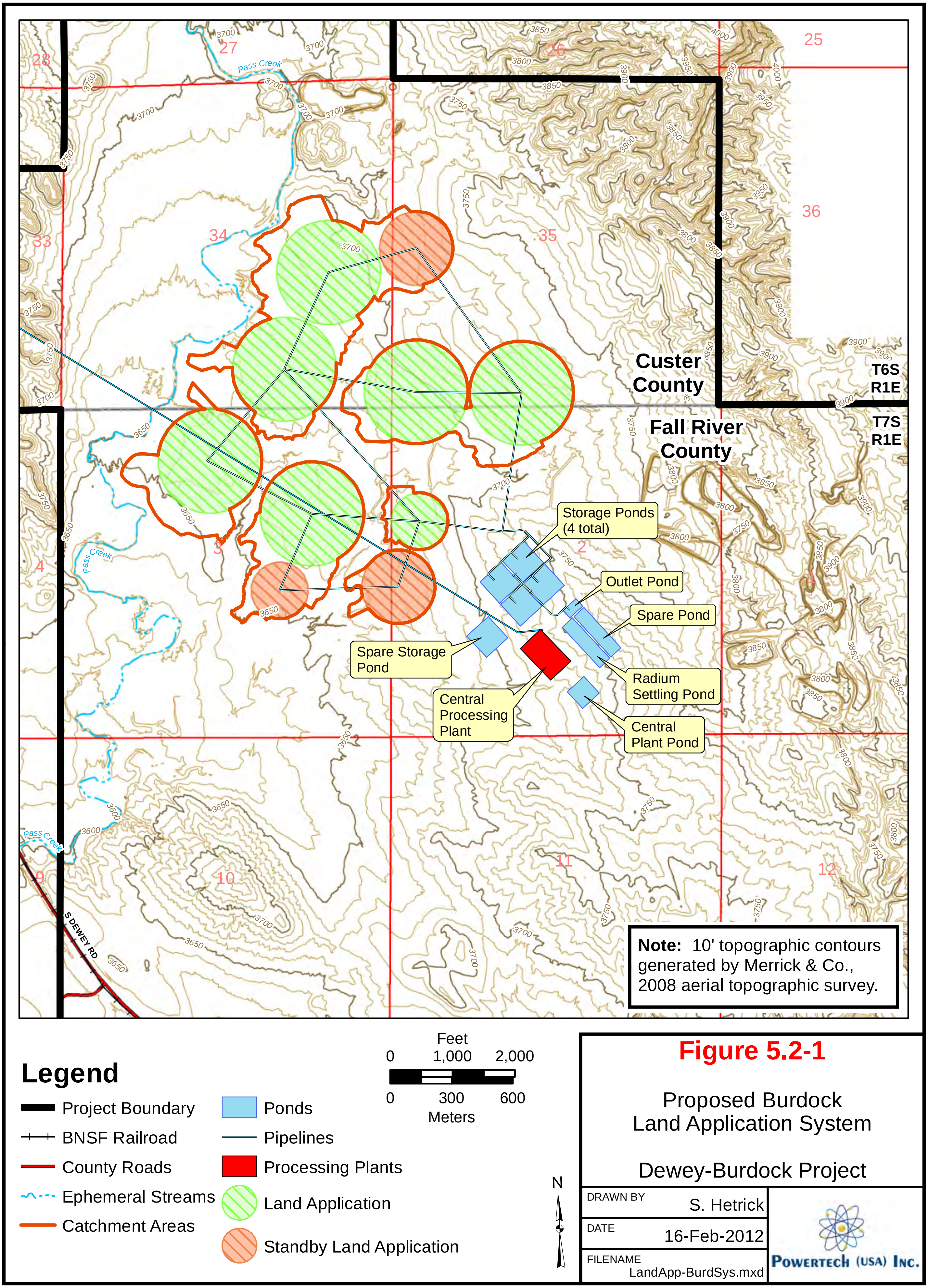


Figure 5.2-1

Proposed Burdock Land Application System

Dewey-Burdock Project

5.3 Pond Design

The storage ponds will be used to store treated water during the times when the land application systems are not operating. These ponds will include a single geosynthetic liner underlain by a 1-foot minimum thickness clay liner. The total estimated capacity per storage pond is 63.8 ac-ft, with 2.0 ac-ft reserved for containment of the 100-year, 24-hour storm event while maintaining 3 feet of freeboard. The available capacity of each pond is therefore 61.8 ac-ft. The storage pond dimensions will be approximately 465 feet x 465 feet x 30 feet deep.

Additional ponds at each site will include outlet ponds, radium settling ponds, and spare ponds designed to be used as either radium settling ponds or in the same capacity as the central plant pond. One central plant pond will also be provided at the Burdock CPP. The central plant pond capacity allows for adequate storage for CPP liquid waste during the initial project startup period when uranium recovery is occurring, but before aquifer restoration activities have started. During this time, CPP liquid waste will need to be stored for approximately 18 months until groundwater sweep water is available for blending with the CPP liquid waste. This capacity will provide flexibility for blending the liquid wastes during normal operation. The central plant pond capacity will allow storage of up to 660 days of CPP liquid water production at 12 gpm. Design information for these ponds is found within the Technical Report prepared for the NRC license application for the Dewey-Burdock Project.

Several ponds are located either wholly or partially within the proposed POP zones. In the Dewey area these include some of the storage ponds, the radium settling pond, the spare radium settling pond, the outlet pond, and the spare storage pond. In the Burdock area these include some of the storage ponds. Following is a description of the pond liners, leak detection systems, and inspection programs that will prevent potential groundwater impacts. Since the ponds will be lined they are not proposed as sources of discharge for the Groundwater Discharge Plan and are not considered in the designation of the proposed POP zones.

The storage ponds and outlet ponds will store treated water and will therefore pose minimal risk to groundwater. Nevertheless, each of these ponds will contain a single geosynthetic liner underlain by a 1-foot minimum thickness clay liner. These ponds will not include leak detection systems but will be inspected routinely as described in Section 10.

The radium settling ponds, spare ponds, and central plant pond will each contain a dual geosynthetic liner with a leak detection system, with a 1-foot minimum thickness clay liner beneath the secondary geosynthetic liner. The primary and secondary liners will be separated by

a geonet, which will provide a physical separation and allow any fluid to flow between the two liners. A minimum grade of 2 percent will be maintained across the bottom of the pond toward a leak detection sump. Any potential leakage from the primary liner will be contained by the secondary liner and collected in the leak detection sump. The sump will be routinely monitored for the presence of fluid as described below. Should a leak occur, the pond will be removed from service and dewatered by transferring the contents to a spare pond.

Routine inspections for all ponds will be conducted in accordance with NRC license requirements as discussed in Section 10. In addition, routine inspections for ponds with leak detection systems will include daily checks for water accumulation in leak detection systems and monthly inspections of the functionality of leak detection systems.

5.4 Catchment Areas

Runoff from significant precipitation events or snowmelt on the land application areas will be conveyed to catchment areas within or adjacent to the pivot areas and allowed to evaporate or infiltrate. The minimum collection area will be 35 acres at each of the Dewey and Burdock sites, and the capacity will be sufficient to contain the estimated 100-year runoff event from each center pivot area. The application rate will be maintained at an agronomic rate that will prevent water from accumulating in the catchment areas during normal operation. The application rate will be adjusted as necessary including temporary shutdown if needed to prevent excessive ponding in the catchment areas. Following is a description of the conceptual catchment area design and operating plan. Prior to operation of the land application systems, Powertech (USA) will submit final designs of the catchment areas as indicated below.

Conceptual Catchment Area Design

Plates 5.4-1 and 5.4-2 present the conceptual designs of the Dewey and Burdock catchment areas, respectively. The final designs may vary from those shown on the plates but will include a minimum surface area of 35 acres at each of the Dewey and Burdock sites and sufficient capacity to contain the estimated 100-year, 24-hour runoff event from all center pivot areas and contributing drainage areas.

The conceptual designs include multiple catchment areas for each of the Dewey and Burdock sites. Earthen catchment berms typically will be constructed at the downgradient edges of the pivot areas or in common locations downgradient of multiple pivot areas. Catchment berms typically will be less than 6 feet high or will have an impounding capacity (excluding incised capacity) less than or equal to 15 acre-feet. Therefore, they are anticipated to be classified as

"barriers" according to ARSD 74:02:08:01(7) and not require consideration of dam safety requirements in ARSD 74:02:08. Only one of the conceptual designs includes a capacity greater than 15 acre-feet and berm height greater than 6 feet (B-15 in the Burdock area). In this case the catchment area will be incised sufficiently such that the impounding capacity will be 15 acre-feet or less.

For each catchment area, the runoff volume resulting from the 100-year, 24-hour precipitation event was calculated. The 100-year, 24-hour general storm runoff was estimated using the Natural Resource Conservation Service triangular hydrograph method, a parametric method of estimating flood peaks and volumes from drainage area, relief, soil type, vegetative cover and stream length. The precipitation value (4.8 inches) for the 100-year, 24-hour storm event was obtained from the national depth-duration frequency map. This is the same value used for the flood analysis of Pass Creek and ephemeral tributaries within the project area described in Section 3.7.1.3.

Summary tables are presented on each plate describing the individual and combined area and volume of the conceptual catchment areas and the estimated 100-year, 24-hour storm runoff volumes. In the conceptual design, the combined area is about 70 acres for each site, which is about twice the minimum area of 35 acres described in Section 5.4. The combined capacity is 141 to 167 acre-feet, which is approximately 18 to 50% more than the total estimated 100-year, 24-hour runoff volume.

In most cases, the catchment areas will have excess capacity beyond the minimum required to contain the 100-year, 24-hour runoff event. The elevation corresponding to the excess capacity volume, where applicable, is designated on each area capacity table on Plates 5.4-1 and 5.4-2. This is termed "inactive capacity" on the plates and represents the normal operating level for each catchment area. As described below, a dewatering program will be initiated if the catchment areas fill above the normal operating level.

In a few cases, two or more catchment areas will be used to contain the 100-year, 24-hour storm runoff volume from multiple drainage areas. In these cases, overflow from upgradient catchment areas will be routed to a downgradient catchment area as indicated on the plates. The overflow will be conveyed in pipelines and/or ditches sized to convey the excess runoff at non-erosive velocities during the 100-year, 24-hour runoff event. In one or more cases berms with catchment ditches will be constructed at the edges of pivot areas to convey the runoff within the pivot areas to the catchment areas (i.e., the pivot area associated with Catchment D-13 in the Dewey land application area).

Typical cross sections are provided on the plates traversing multiple pivot and catchment areas. The plates also depict the relationship between the conceptual catchment area designs and the general catchment area boundaries depicted on other figures and plates in this application (e.g., Figure 2.3-2 and Plates 3.6-5 through 3.6-10). The conceptual designs are within the general boundaries. The actual extents of the catchment areas also will be within or very close to the general catchment area boundaries depicted in this application. The actual extents will be determined during final design as described below.

Conceptual Catchment Area Operating Plan

Powertech (USA) will operate the catchment areas to maintain adequate freeboard capacity for the estimated 100-year, 24-hour storm runoff. This will be accomplished by marking the elevation of the normal operating level in each catchment area, or, in the case of multiple catchment areas operated in series, marking the elevation of the normal operating level in the most downgradient catchment area. The normal operating level will be delineated with a clearly visible marker such as a post. Each catchment area will be routinely monitored, including after significant precipitation events.

The land application water will be applied at an agronomic rate to prevent runoff into the catchment areas except during significant precipitation or snowmelt events. If a catchment area fills above the normal operating level, a dewatering program will be initiated. The catchment area will be dewatered through pumping or gravity discharge. The excess water will be conveyed to another catchment area with excess operating capacity, pumped to the storage ponds, or pumped to a land application pivot area (primary or standby area).

The conceptual catchment area design includes sufficient excess capacity such that dewatering would not be required frequently. This is demonstrated by the calculated 2-year, 24-hour runoff volumes listed on the summary tables on Plates 5.4-1 and 5.4-2. These runoff volume estimates are provided to illustrate how the catchment areas would be operated during a more frequent precipitation event. In each case, the total 2-year, 24-hour runoff volume is approximately equal to or less than the excess capacity, which is calculated as the total catchment capacity less the designated freeboard volume for the 100-year, 24-hour storm event. In the Dewey area, the conceptual catchment capacity is approximately 167 acre-feet and the 100-year, 24-hour runoff volume is approximately 111 acre-feet. The excess capacity is therefore about 56 acre-feet, or about 300% of the 2-year, 24-hour runoff volume of about 18 acre-feet. In the Burdock area, the excess capacity is about 22 acre-feet, which is approximately equal to the 2-year, 24-hour runoff volume of 23 acre-feet. This shows that the frequency at which the normal operating level would

be exceeded for the combined catchment areas would typically be less than or equal to every 2 years. In this case the excess water would be pumped to a pivot area (likely a standby pivot area) or to the storage ponds. The final operating plan described below will include standard operating procedures to ensure that there will be adequate storage pond excess capacity or standby pivot areas such that dewatering could be accomplished in a reasonable amount of time.

The calculation of 2-year, 24-hour runoff volumes for the catchment areas also demonstrates that the quantity of water evaporating or infiltrating in the catchment areas will be much smaller than the quantity of water applied to the land application areas. As described in Tables 5.1-1 and 5.2-1, the design average annual application volume is 500 acre-feet for each land application system. By comparison, the calculated 2-year, 24-hour runoff volume for the catchment areas is about 18 to 23 acre-feet. This shows that the volume of runoff captured during a storm event that is predicted to occur every other year will only be about 4 to 5% of the design land application volume each year. This supports the conclusion that the catchment areas will have minimal potential groundwater impacts compared to the land application areas.

Final Design and Operation and Maintenance Plan

Prior to operating the land application systems, Powertech (USA) will provide the following information to DENR for review and approval:

1) Final catchment area designs, including hydrologic calculations for the 100-year, 24-hour runoff volumes, catchment area capacities and areas, normal operating levels, berm dimensions, overflow hydraulic designs, and dewatering systems;
2) As-constructed drawings showing the surveyed staged storage capacity, berm dimensions and elevations of the normal operating levels (which will be identified in the field by highly visible markers with the location shown on the as-constructed drawings);
3) Demonstration that water rights have been obtained for all catchment areas, if applicable;
4) Demonstration of catchment area compliance with Safety of Dams regulations in ARSD 74:02:08; and
5) An operation and maintenance (O&M) plan for the Dewey and Burdock sites that includes:
    a. Inspection procedures, including operating level monitoring frequency and berm inspection frequency;
    b. An operation plan describing the overflow and dewatering procedures; and
    c. A dewatering plan describing how each catchment area will be dewatered in the event that the water level exceeds the normal operating level.

5.5 Irrigated Crops

Irrigated crops may include one or more of the following: native vegetation (primarily warm season perennial grasses, cool season perennial grasses, and perennial shrubs), alfalfa, or salt-tolerant wheatgrass.

5.6 Land Application System Operation

The center pivot irrigation systems will typically operate 24 hours per day during the normal frost-free season, which is approximately April through October. The land application systems will have variable operation schedules to allow for adjustments due to weather conditions and other site-specific conditions. The land application system design will allow for instantaneous shutdown of any one or more center pivots as needed. Temporary shutdowns would occur in the event of a piping leak, for maintenance activities, during significant precipitation events, due to excessive ponding in a catchment area, or due to cold temperature. The land application systems will not be used when water cannot infiltrate due to frozen ground. During times when land application will not be used, the treated liquid waste stream will be temporarily stored in ponds. As discussed in Section 5.7.4, the storage ponds will have significant surplus capacity. This will provide contingency to allow for a late spring startup or an early fall stoppage of operations. In addition, Section 5.3 describes how the central plant pond will provide additional capacity for blending of process water to keep the land application water quality relatively consistent.

The land application schedule will follow the project schedule shown in Figure 2.4-1. Land application will occur during production and restoration, the total duration of which is expected to be approximately 9.25 years. During the initial production period prior to restoration, which is expected to last approximately 1.5 to 2 years, the land application rate will be relatively low. During this phase the CPP liquid waste will be stored in the central plant pond and the land application solutions will consist almost entirely of production bleed. The average annual production bleed will be less than 100 gpm, or less than one-third the design average annual application rate of 310 gpm shown in Tables 5.1-1 and 5.2-1. The land application rate will be highest during concurrent production and restoration, which is expected to last approximately 6 years. The design application rates shown in Table 5.1-1 and 5.2-1 are based on this period of operation. The final project phase will be restoration without concurrent production. The land application rate during this relatively brief phase (approximately 0.25 year) will be slightly less

than the values shown in Tables 5.1-1 and 5.2-1, since there will not be disposal of production bleed.

5.7 Hydrologic Land Application and Pond Simulations

Disposal capacity for the land application system was estimated using the SPAW (Soil-Plant-Atmosphere-Water) model, which is described below. In addition to estimating the water budget for agricultural landscapes, the SPAW model also was used to estimate the water budget for the storage ponds and catchment areas.

5.7.1 SPAW Model Description

The SPAW (Soil-Plant-Atmosphere-Water) model was developed by the USDA (Saxton and Willey, 2006) to simulate the daily hydrologic water budgets of agricultural landscapes by two connected routines, one for farm fields and one for impoundments such as irrigation ponds. The field hydrology simulation is represented by: 1) daily climatic descriptions of precipitation, temperature, and evaporation, 2) a soil profile of interacting layers each with unique water holding characteristics, and 3) annual crop growth with management options for rotations, irrigation, and fertilization. The model output for the field hydrology routine includes a daily vertical, one-dimensional water budget depth for all major hydrologic processes such as runoff, infiltration, evapotranspiration, soil water profiles, and percolation. Water volumes for each component of the water balance are estimated by multiplying the water budget depth times the associated field area.

Pond hydrology simulations provide water budgets by multiple input and depletion processes for impoundments whose water source is runoff from agricultural fields and/or water produced by wells or other sources. Model outputs for the pond hydrology routine include daily values of depth, volume, precipitation, evaporation, and change in storage for the period of simulation. The version of the SPAW model used was Version 6.02.75. The model has been extensively tested by the developers using research data and real-world applications.

5.7.2 Model Input Parameters

5.7.2.1 Meteorological Parameters

The local climate at the project site is continental, with hot summers, cold winters, and an average annual precipitation of 16 to 17 inches. The wettest months are from May to July. May and June are the months of highest average precipitation, with occasional thunderstorms that can be severe. Typical average daily temperatures range from 23 °F in January to 73 °F in July.

Daily maximum temperatures are typically 10 to 15 °F above the average temperatures, and daily minimum temperatures are typically 10 to 15 °F below the average daily temperatures.

Because of limited on-site climatic data, 28 years of daily precipitation and temperature values (from 1980 to 2007) from the nearest available meteorological station at Edgemont, South Dakota were downloaded from the National Climatic Data Center and used as input data for the SPAW model. The Edgemont station is approximately 13 miles southeast of the site at an elevation of 3460 feet above mean sea level (amsl). The project plant site is at 3720 feet amsl. As described in Section 3.1, the Edgemont station best represents the long-term precipitation and temperature of the project area. Table 5.7-1 shows the average monthly air temperature data at the Edgemont station for the 28-year period of record.

Table 5.7-1: Average Monthly and Annual Air Temperature at Edgemont, SD (°F)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
22.6	26.8	36.6	46.7	56.9	66.4	74.3	72.5	61.3	47.8	33.0	22.6	47.3

5.7.2.1.1 Precipitation

Daily precipitation values for the 28-year period of record from the Edgemont station were used as input data for the SPAW model. Where daily data were absent in the record, the daily average for that month from the 28-year record was used. No adjustments were made to the precipitation values for the 260-foot elevation difference between the Edgemont station and the project site. Table 5.7-2 shows the average monthly precipitation at the Edgemont station for the 28-yr period of record.

Table 5.7-2: Average Monthly and Annual Precipitation at Edgemont, SD (inches)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0.33	0.50	1.09	1.87	2.48	2.60	2.17	1.59	1.38	1.31	0.69	0.43	16.44

5.7.2.1.2 Potential Evapotranspiration

The SPAW model requires daily potential evapotranspiration (PET) data. Lake evaporation is a close estimate of PET, and is similar to PET values estimated using the Penman method. The mean annual lake evaporation (PET equivalent) at the site was determined to be 44 inches using the Evaporation Atlas for the Contiguous 48 United States (Farnsworth and Thompson, 1982). The monthly PET was calculated by applying the values for the monthly distribution of evaporation for the north central United States that are contained in the SPAW model. The daily

PET for each month was then calculated by dividing the monthly PET by the number of days in the month. Table 5.7-3 shows the estimated average monthly and annual potential evapotranspiration at the site calculated using this method.

Table 5.7-3: Average Monthly and Annual Potential Evapotranspiration at Project Site (inches)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0.92	1.23	1.98	3.30	4.40	5.76	7.08	6.95	5.50	3.74	2.02	1.10	44.0

5.7.2.2 Material Properties

To characterize the soils at the site, eleven test pits were excavated on July 11 and 12, 2008. Samples were collected at various depths and analyzed for particle size distribution, dry bulk density, permeability, and other geotechnical parameters. Test pits 1 through 5 were excavated at the Dewey land application area, and test pits 6 through 11 were excavated in and near the Burdock land application area. The test pit locations are shown on Figure 3.2-1. Section 3.2.5 provides a summary of the soil properties.

5.7.3 Modeling Approach

The general assumptions for the SPAW model include the following:

1. The model is a one-dimensional vertical model.
2. The model assumes that the modeled area is spatially uniform in soil, crop and climate characteristics.
3. Model inputs and outputs are based on daily values.
4. The model does not does not include flow routing or channel descriptors.
5. Daily runoff is estimated as an equivalent depth over the simulation field by the USDA/SCS Curve Number method.
6. The field budget utilizes a one-dimensional vertical system beginning above the plant canopy and proceeding downward through the soil profile to a depth sufficient to represent the complete root penetration and subsurface hydrologic processes (lateral soil water flow is not simulated).

Specific assumptions related to this project are as follows:

1. Daily precipitation and temperature data used in the model are based on 28 years of record from the Edgemont, South Dakota station.
2. SPAW modeling was done for two land application and pond areas, the Dewey site and the Burdock site.

3. Soils data used in the modeling of the Dewey site were based on a composite of soils data from Test Pits 1, 2 and 5.
4. Soils data used in the modeling of the Burdock site were based on a composite of soils data from Test Pits 8, 9 and 10.
5. The 24/7 year-round inflow rate from process water and bleed water at each site is 310 gpm.
6. The irrigation season is from March 29 to October 31 each year (217 days).
7. Model runs were conducted assuming no crop (bare soil). This assumption ensures that the results will be conservative in terms of the resulting evapotranspiration and runoff, since it is difficult to model the response to alfalfa or other crops to the quality of the applied irrigation water and to the soil conditions present at the site.
8. The irrigation water will be applied at a rate that balances the total amount of process inflow water. The modeled application rate is 297 gpm from March 29 to May 10, 653 gpm from May 11 to September 24, and 297 gpm from September 25 to October 31.
9. Irrigation tailwater and runoff from the land application areas will be conveyed to catchment areas at the edges of the land application areas and allowed to evaporate and seep into the soil.
10. The storage impoundments are designed to contain the 1 percent exceedance probability event (100-year event) plus 3 feet of freeboard.
11. All storage impoundments have side slopes of 3 to 1 (H:V) and are 30 feet deep.

The objective of the SPAW modeling was to help design a land application system that: (1) maximizes evapotranspiration; (2) minimizes surface runoff; (3) minimizes percolation below the rooting zone; (4) minimizes the irrigated acreage required; and (5) minimizes the required volume of the storage ponds while maintaining a 1 percent probability that the design pond volume will be exceeded during the operating life of the facility.

SPAW modeling was performed by Knight-Piésold at both the Dewey and Burdock sites. A composite of the soil properties at each site was created for use in the model using analytical data from three test pits from each site. Test pits 1, 2 and 5 were used for the Dewey site and test pits 8, 9 and 10 were used for the Burdock site. The composites were created by taking the averages of the gravel, sand and clay fractions and the dry bulk densities for each depth interval for the three test pits at each site.

The SPAW modeling assumed that the facility will operate on a year-round basis for 15 years. Year-round operation includes the storage of water during the non-irrigation season, which is approximately November through the end of March. Twenty-eight years of daily precipitation, temperature and evaporation data from January 1, 1980 to December 31, 2007 were used to

create 28 unique and equally likely simulations of the process water balance. Each simulation used 15 years of sequential climatic data corresponding to the 15 years of operation of the facility. The climatic data intervals used for each of the 28 simulations are shown in Table 5.7-4. Additional SPAW model simulations used to estimate potential postclosure impacts are described in Section 8.1.3.

Field simulations using the SPAW model were run using each of the 28 climatic data intervals shown in Table 5.7-4. The results of these field simulations were used as the input to pond simulations for the same 28 climatic intervals. The result was a daily pond volume for each day of the year for each of the 28 15-year simulations.

The pond volume with a 1 percent exceedance probability during a 15-year operating period was estimated as follows. First, the average pond volume for each day during the 15-year operating period for the 28 simulations was calculated. Then, the pond volume for each day of the 15-year period with a 1 percent exceedance probability was calculated using the Gumbel Extreme Value distribution, which resulted in 5,475 possible values. The greatest of these 5,475 values was then selected as the maximum possible volume with a 1 percent exceedance probability during a 15-year period.

5.7.4 Model Results

<u>Field Model Results</u>

The estimated daily water budgets obtained from SPAW modeling indicate that each land application area will be capable of disposing approximately 297 gpm from March 29 to May 10, 653 gpm from May 11 to September 24, and 297 gpm from September 25 to October 31. The actual land application season will depend on climatic conditions. Weather permitting, the land application systems may operate any time of year.

The annual summaries of the SPAW field modeling results for the twenty-eight 15-year simulations at the Dewey and Burdock sites are shown in Table 5.7-5 and Table 5.7-6, respectively. The SPAW model output for all simulations is provided in Appendix 5.7-A. The following terms are used in Tables 5.7-5, 5.7-6 and Appendix 5.7-A. These terms have been derived from Saxton and Willey, 2006.

Table 5.7-4: Sequential Water Balance Simulations

Simulation No.	15-Year Climatic Data Interval
1	01/01/1980 to 12/31/1994
2	01/01/1981 to 12/31/1995
3	01/01/1982 to 12/31/1996
4	01/01/1983 to 12/31/1997
5	01/01/1984 to 12/31/1998
6	01/01/1985 to 12/31/1999
7	01/01/1986 to 12/31/2000
8	01/01/1987 to 12/31/2001
9	01/01/1988 to 12/31/2002
10	01/01/1989 to 12/31/2003
11	01/01/1990 to 12/31/2004
12	01/01/1991 to 12/31/2005
13	01/01/1992 to 12/31/2006
14	01/01/1993 to 12/31/2007
15	01/01/1994 to 12/31/2007; 01/01/1980 to 12/31/1980
16	01/01/1995 to 12/31/2007; 01/01/1980 to 12/31/1981
17	01/01/1996 to 12/31/2007; 01/01/1980 to 12/31/1982
18	01/01/1997 to 12/31/2007; 01/01/1980 to 12/31/1983
19	01/01/1998 to 12/31/2007; 01/01/1980 to 12/31/1984
20	01/01/1999 to 12/31/2007; 01/01/1980 to 12/31/1985
21	01/01/2000 to 12/31/2007; 01/01/1980 to 12/31/1986
22	01/01/2001 to 12/31/2007; 01/01/1980 to 12/31/1987
23	01/01/2002 to 12/31/2007; 01/01/1980 to 12/31/1988
24	01/01/2003 to 12/31/2007; 01/01/1980 to 12/31/1989
25	01/01/2004 to 12/31/2007; 01/01/1980 to 12/31/1990
26	01/01/2005 to 12/31/2007; 01/01/1980 to 12/31/1991
27	01/01/2006 to 12/31/2007; 01/01/1980 to 12/31/1992
28	01/01/2007 to 12/31/2007; 01/01/1980 to 12/31/1993

PET - Atmospheric potential evapotranspiration (inches): estimated using mean annual lake evaporation (PET equivalent) at the site from the Evaporation Atlas for the Contiguous 48 United States (Farnsworth and Thompson, 1982).

AET - Actual evapotranspiration (inches): estimated by beginning with daily atmospheric potential evapotranspiration (PET), then estimating and combining the major AET components: interception evaporation (INT), soil water evaporation (EVAP), and plant transpiration (TRAN).

EVAP - Soil water evaporation (inches): evaporation from the soil surface; represented by a thin (1.0 inch) upper boundary layer (evaporation layer) of the soil profile, from which water is

Table 5.7-5: SPAW Field Modeling Simulation Results - Dewey

Simulation No.	Dewey Land Application													
	PET (in)	AET (in)	EVAP (in)	TRAN (in)	INT (in)	PRECIP (in)	IRRIG (in)	RUNOFF (in)	INFIL (in)	PERC (in)	DEEPDRN (in)	DLT-SM (in)	STRESS	YLDRED
1	44.01	29.83	18.02	0.00	11.81	16.29	19.07	5.03	18.52	0.08	0.00	0.42	0.00	0.00
2	44.04	29.95	18.15	0.00	11.80	16.42	19.07	5.05	18.64	0.08	0.00	0.41	0.00	0.00
3	44.04	30.24	18.42	0.00	11.83	16.70	19.07	4.99	18.95	0.09	0.00	0.45	0.00	0.00
4	44.04	30.08	18.28	0.00	11.80	16.42	19.07	4.91	18.78	0.09	0.00	0.42	0.00	0.00
5	44.04	30.23	18.43	0.00	11.80	16.88	19.07	5.21	18.94	0.08	0.00	0.42	0.00	0.00
6	44.04	30.17	18.36	0.00	11.81	16.98	19.07	5.42	18.82	0.08	0.00	0.38	0.00	0.00
7	44.04	30.17	18.34	0.00	11.83	17.06	19.07	5.47	18.83	0.08	0.00	0.41	0.00	0.00
8	44.04	29.97	18.14	0.00	11.83	16.80	19.07	5.39	18.65	0.08	0.00	0.42	0.00	0.00
9	44.04	30.02	18.21	0.00	11.81	16.82	19.07	5.40	18.69	0.08	0.00	0.39	0.00	0.00
10	44.04	30.13	18.32	0.00	11.82	16.90	19.07	5.34	18.82	0.08	0.00	0.42	0.00	0.00
11	44.04	30.16	18.36	0.00	11.80	16.84	19.07	5.11	19.00	0.08	0.00	0.56	0.00	0.00
12	44.04	30.11	18.31	0.00	11.80	16.90	19.07	5.24	18.94	0.08	0.00	0.54	0.00	0.00
13	44.04	30.04	18.24	0.00	11.79	16.79	19.07	5.17	18.89	0.08	0.00	0.56	0.00	0.00
14	44.04	29.93	18.15	0.00	11.78	16.92	19.07	5.26	18.84	0.08	0.00	0.61	0.00	0.00
15	44.04	29.77	17.98	0.00	11.79	16.43	19.07	5.08	18.64	0.08	0.00	0.57	0.00	0.00
16	44.04	29.82	18.07	0.00	11.74	16.52	19.07	5.14	18.70	0.08	0.00	0.54	0.00	0.00
17	44.04	29.80	18.06	0.00	11.75	16.77	19.07	5.38	18.71	0.08	0.00	0.57	0.00	0.00
18	44.04	29.68	17.93	0.00	11.75	16.74	19.07	5.39	18.66	0.08	0.00	0.65	0.00	0.00
19	44.04	29.75	17.97	0.00	11.78	16.61	19.07	5.29	18.61	0.08	0.00	0.55	0.00	0.00
20	44.04	29.37	17.61	0.00	11.76	15.78	19.07	4.84	18.25	0.08	0.00	0.56	0.00	0.00
21	44.04	29.53	17.77	0.00	11.76	16.21	19.07	5.06	18.45	0.08	0.00	0.60	0.00	0.00
22	44.04	29.63	17.88	0.00	11.75	16.13	19.07	4.87	18.58	0.08	0.00	0.61	0.00	0.00
23	44.04	29.43	17.68	0.00	11.75	15.78	19.07	4.78	18.31	0.08	0.00	0.55	0.00	0.00
24	44.04	29.48	17.71	0.00	11.77	15.94	19.07	4.87	18.37	0.09	0.00	0.57	0.00	0.00
25	44.04	29.56	17.81	0.00	11.75	16.24	19.07	5.09	18.46	0.08	0.00	0.56	0.00	0.00
26	44.04	29.61	17.83	0.00	11.78	16.27	19.07	5.21	18.35	0.08	0.00	0.44	0.00	0.00
27	44.04	29.53	17.76	0.00	11.77	15.86	19.07	4.92	18.24	0.08	0.00	0.40	0.00	0.00
28	44.04	29.81	18.03	0.00	11.79	16.47	19.07	5.19	18.56	0.09	0.00	0.45	0.00	0.00
Maximum	44.04	30.24	18.43	0.00	11.83	17.06	19.07	5.47	19.00	0.09	0.00	0.65	0.00	0.00
Minimum	44.01	29.37	17.61	0.00	11.74	15.78	19.07	4.78	18.24	0.08	0.00	0.38	0.00	0.00

Table 5.7-6: SPAW Field Modeling Simulation Results - Burdock

Simulation No.	Burdock Land Application													
	PET (in)	AET (in)	EVAP (in)	TRAN (in)	INT (in)	PRECIP (in)	IRRIG (in)	RUNOFF (in)	INFIL (in)	PERC (in)	DEEPDRN (in)	DLT-SM (in)	STRESS	YLDRED
1	44.04	30.39	18.58	0.00	11.81	16.29	19.07	4.45	19.10	0.13	0.00	0.39	0.00	0.00
2	44.04	30.56	18.76	0.00	11.80	16.42	19.07	4.42	19.28	0.13	0.00	0.39	0.00	0.00
3	44.04	30.78	18.96	0.00	11.83	16.70	19.07	4.45	19.49	0.13	0.00	0.40	0.00	0.00
4	44.04	30.59	18.79	0.00	11.80	16.42	19.07	4.39	19.30	0.13	0.00	0.39	0.00	0.00
5	44.04	30.73	18.93	0.00	11.80	16.88	19.07	4.68	19.47	0.13	0.00	0.41	0.00	0.00
6	44.04	30.74	18.93	0.00	11.81	16.98	19.07	4.83	19.41	0.12	0.00	0.36	0.00	0.00
7	44.04	30.74	18.91	0.00	11.83	17.06	19.07	4.89	19.41	0.13	0.00	0.38	0.00	0.00
8	44.04	30.53	18.70	0.00	11.83	16.80	19.07	4.84	19.21	0.13	0.00	0.38	0.00	0.00
9	44.04	30.54	18.73	0.00	11.81	16.82	19.07	4.86	19.22	0.12	0.00	0.37	0.00	0.00
10	44.04	30.76	18.95	0.00	11.82	16.90	19.07	4.71	19.45	0.13	0.00	0.38	0.00	0.00
11	44.04	30.72	18.92	0.00	11.80	16.84	19.07	4.53	19.58	0.13	0.00	0.53	0.00	0.00
12	44.04	30.67	18.87	0.00	11.80	16.90	19.07	4.66	19.51	0.12	0.00	0.52	0.00	0.00
13	44.04	30.59	18.80	0.00	11.79	16.79	19.07	4.61	19.46	0.12	0.00	0.54	0.00	0.00
14	44.04	30.51	18.73	0.00	11.78	16.82	19.07	4.66	19.44	0.13	0.00	0.59	0.00	0.00
15	44.04	30.28	18.49	0.00	11.79	16.43	19.07	4.56	19.15	0.13	0.00	0.53	0.00	0.00
16	44.04	30.27	18.52	0.00	11.74	16.52	19.07	4.68	19.16	0.12	0.00	0.52	0.00	0.00
17	44.04	30.32	18.57	0.00	11.75	16.77	19.07	4.85	19.24	0.13	0.00	0.54	0.00	0.00
18	44.04	30.27	18.51	0.00	11.75	16.74	19.07	4.82	19.24	0.13	0.00	0.60	0.00	0.00
19	44.04	30.32	18.54	0.00	11.78	16.61	19.07	4.72	19.18	0.12	0.00	0.52	0.00	0.00
20	44.04	29.82	18.06	0.00	11.76	15.78	19.07	4.37	18.71	0.12	0.00	0.53	0.00	0.00
21	44.04	30.13	18.37	0.00	11.76	16.21	19.07	4.47	19.04	0.13	0.00	0.54	0.00	0.00
22	44.04	30.13	18.38	0.00	11.75	16.13	19.07	4.37	19.08	0.12	0.00	0.58	0.00	0.00
23	44.04	29.93	18.17	0.00	11.75	15.78	19.07	4.28	18.81	0.12	0.00	0.52	0.00	0.00
24	44.04	29.93	18.16	0.00	11.77	15.94	19.07	4.41	18.83	0.13	0.00	0.55	0.00	0.00
25	44.04	30.08	18.33	0.00	11.75	16.24	19.07	4.57	18.99	0.13	0.00	0.53	0.00	0.00
26	44.04	30.09	18.31	0.00	11.78	16.27	19.07	4.74	18.83	0.12	0.00	0.39	0.00	0.00
27	44.04	29.99	18.22	0.00	11.77	15.86	19.07	4.44	18.72	0.12	0.00	0.37	0.00	0.00
28	44.04	30.41	18.63	0.00	11.79	16.47	19.07	4.58	19.17	0.13	0.00	0.42	0.00	0.00
Maximum	44.04	30.78	18.96	0.00	11.83	17.06	19.07	4.89	19.58	0.13	0.00	0.60	0.00	0.00
Minimum	44.04	29.82	18.06	0.00	11.74	15.78	19.07	4.28	18.71	0.12	0.00	0.36	0.00	0.00

readily evaporated and limited only by that portion of the PET not intercepted by the overlying plant canopy.

TRAN - Plant transpiration (inches): transpiration from plants; estimated as the combined effect of PET, root density distribution, and soil water content and distribution.

INT - Interception (inches): free water on plant and soil surfaces which readily evaporates with minimal surface interaction or vapor resistance.

PRECIP - Precipitation (inches): input from meteorological data.

IRRIG - Irrigation (inches): input from land application system design.

RUNOFF - Runoff (inches): computed by the USDA/SCS Curve Number method as a percent of daily rainfall from parameters of soil type, antecedent soil moisture, vegetation, surface conditions and frozen soil.

INFIL - Infiltration (inches): a daily amount based on rainfall minus estimated runoff and stored in the uppermost soil layers as available capacity permits.

PERC - Percolation (inches): Water leaving the bottom layer of the described soil profile. Percolated water is considered to be temporarily stored in an “image” layer just below the profile and is upward retrievable.

DEEPDRN - Deep drainage (inches): drainage beneath the image layer; deep drainage to groundwater or interflow occurs when the image layer achieves near saturation and additional percolation occurs.

DLT-SM - Change in soil moisture (inches): the SPAW model uses a Darcy tension-conductivity method to provide downward and upward flow estimates for redistribution of moisture within the soil profile.

STRESS - Vegetative stress (percentage): daily plant stress is defined as

$$\text{Stress} = 1 - (AT/PT)$$

where: AT = actual transpiration and PT = potential temperatures.

YLDRED - Yield reduction (percentage): reduction in crop yield due to vegetative stress.

The results of the SPAW model simulations show that for both land applications, the quantity of percolation was estimated to be less than 0.1 inch, which is the simulated percolation of water beneath a depth of 6 feet below ground surface. The estimated deep drainage, which is the simulated percolation of water beneath a depth of 8 feet below ground surface, was zero for all 28 simulations for both land application areas. It is important to note that not only did the average SPAW model results for each of the 15-year simulation periods (Tables 5.7-5 and 5.7-6) demonstrate no deep percolation, but in no case did one year of any of the modeled simulations indicate that water would percolate below a depth of 8 feet below ground surface.

Pond Model Results

Based on the assumptions listed above, the model results showed that the total required irrigation storage pond volume having a 1-percent exceedance probability is 216 acre-feet at both the Dewey and Burdock sites. An additional 31 acre-feet of active capacity was added to the ponds at each site, for a total primary storage capacity of 247 acre-feet. This additional capacity acts as contingency storage for days at the beginning of the irrigation season when weather conditions may limit land application. In addition, a spare storage pond will be provided with 61.8 acre-feet usable capacity. The total available capacity is therefore about 43 percent greater than the capacity required for a 1-percent exceedance probability. The surplus capacity would allow the land application season to be reduced by at least 2 months if needed (e.g., during an abnormally wet year or late spring). Pond model results are provided in Appendix 5.7-A

Catchment Area Results

Runoff from irrigation return flows and from rainfall falling on the land application areas will be conveyed to catchment areas at the edges of the land application areas and allowed to evaporate and/or infiltrate. As described in Section 5.4, an agronomic land application rate will be maintained to prevent runoff from the center pivot areas to the catchment areas during normal operations. Therefore, the actual irrigation runoff is anticipated to be less than the modeled runoff, which assumed fixed application rates during various phases of each land application season. The quantity of this runoff was calculated by the SPAW model and entered into a monthly water balance to determine the required volume of these collection areas. The following equation summarizes the monthly water balance:

$$S = RO + P - E - I$$

where:

S = storage required

RO = runoff from the 315-acre land application area due to irrigation and precipitation

P = precipitation falling directly on the catchment area

E = evaporation from the collection area

I = seepage from the collection area

The water balance was determined using a spreadsheet model that calculates the cumulative storage required at the end of each month during the 15-year operating life of the facility. Water balances for five potential 15-year operating periods were simulated for both the Dewey and Burdock sites, using the five 15-year periods with the highest annual precipitation amounts from the 28 years of available climatic data.

The results of the catchment area modeling are presented in Appendix 5.7-A. The results showed that a 35-acre catchment area at the Burdock site would have an average of 1.3 inches of standing water at month end during each month of the 15-year operating life of the facility, and a maximum of 30.5 inches of standing water, which occurred during a single month over the 15 years. As stated previously, Powertech (USA) will operate the land application systems at agronomic rates to avoid runoff and ponding in the catchment areas.

At the Dewey site, a 35-acre collection area would have an average of 0.1 inch of standing water at month end during each month of the 15-year operating life of the facility, and a maximum of 8.8 inches of standing water, which occurred during a single month over the 15 years. The difference in storage required at the two sites is due to the higher permeability of the soils at the Dewey site. The soil permeabilities used in the water balance were based on permeability values determined from laboratory testing of the soils from the on-site test pits.

5.8 Land Application Water Properties

The types of liquid waste that will be disposed in the proposed land application system include production bleed, groundwater generated during aquifer restoration, affected groundwater generated during well development, and liquid process waste such as resin transfer water and the brine generated during uranium processing. Of these, the largest contributors will be the production bleed and groundwater generated during aquifer restoration. Production bleed is

excess production solution withdrawn to maintain a cone of depression so native groundwater continually flows to the center of the production zone.

Table 5.8-1 presents the estimated end-of-production water quality in the ISR well fields. This represents the untreated water quality extracted from the ore zone at the end of uranium recovery and at the beginning of aquifer restoration. This table represents the worst-case water quality encountered in the well fields, and it was used to estimate the range of concentrations of the treated effluent proposed for land application after accounting for treatment and blending.

The typical water quality during land application will be better than that shown in Table 5.8-1, since the water quality will be continually improving during aquifer restoration. Table 5.8-2 presents the anticipated land application water quality. The upper values shown in this table represent the estimated worst-case water quality to be land applied. The typical land application water quality will be better than the upper values, since multiple well fields will typically be in various stages of production and aquifer restoration at one time, with water quality gradually degrading toward the worst case during production and gradually improving to approximately baseline water quality during restoration. In addition, Madison water may be used at any time to improve the land application water quality. It is anticipated that trace metal concentrations will be at or below ARSD 74:54:01:04 human health standards. In addition, the effluent concentration limits will be met for the release of radionuclides to the environment as defined in 10 CFR Part 20, Appendix B. This will be accomplished through treating the water as follows.

Prior to discharge to the storage ponds, Powertech (USA) will treat all land application water to meet the requirements of 10 CFR 20, Appendix B, Table 2, Column 2, which are the established limits for discharge of radionuclides to the environment and include limits for natural uranium, radium-226, lead-210 and thorium-230. This will be accomplished by ion exchange for uranium removal followed by radium removal through co-precipitation with barium sulfate in radium settling ponds. It is not anticipated that thorium-230 and lead-210 will be present at concentrations above the limits. If concentrations in the storage ponds are above the release limits, the effluent will be treated as necessary to satisfy the Appendix B limits.

As stated in Section 2.2.1 the land application water will not contain any domestic (septic) waste water.

The values shown in Tables 5.8-1 and 5.8-2 were estimated by Powertech (USA) based on results of laboratory-scale leach tests conducted on ore samples from the project sandstones, as well as from historical end-of-production water quality data from other ISR facilities in

Wyoming and Nebraska, with adjustments as necessary to account for planned post-production water treatment(s).

The primary source of land application water, production and restoration bleed, will result from multiple well fields undergoing differing phases of production and restoration. During production, the concentrations of dissolved constituents in each well field will gradually increase from the baseline quality to the post-production quality estimated in Table 5.8-1. During restoration, the water quality will be returned to approximately baseline water quality. The water from multiple well fields will be combined in the storage ponds, where increasing concentrations from producing well fields will be offset by decreasing concentrations from well fields undergoing restoration. This, combined with adequate pond capacity, will ensure that the land

Table 5.8-1: SAR, ESP and RSC Calculations for Dewey and Burdock End-of-Production Ground Water Quality

Constituent	Dewey					Burdock				
	(mg/L)	**(meq/L)**	**ESP**	**RSC**	**SAR**	**(mg/L)**	**(meq/L)**	**ESP**	**RSC**	**SAR**
CO_3	0.5	0.02				0.50	0.02			
HCO_3	25	0.41				25.00	0.41			
Cl	1,300	36.67				1,300	36.67			
SO_4	1,000	20.82				1,800	37.48			
Na	270	11.74				190	8.26			
Ca	730	36.43				970	48.40			
Mg	120	9.87	2.29	-45.87	2.44	220	18.09	0.85	-66.07	1.43
K	20	0.51				10	0.26			
Total Ion Bal.		0.54					0.29			
SAR (measured)	4.9					2.8				
pH (s.u.)	6.5-7.5					6.5-7.5				
TDS (mg/L)	4,500					4,500				
Spec. Cond. (µS/cm)	5,000					5,000				
As	0.01					0.01				
V	<10					6				

Table 5.8-2: Estimated Land Application Water Quality

Analyte	Units	Land Application Water Estimate
Physical Properties		
pH	s.u.	6.5 - 7.5
Total dissolved solids (TDS)	mg/L	1,000 - 5,000
Electrical conductivity	umhos/cm	1,500 - 6,000
Common Elements and Ions		
Bicarbonate	mg/L	50 - 300
Calcium	mg/L	200 - 1,000
Carbonate	mg/L	<1
Chloride	mg/L	300 - 1300
Magnesium	mg/L	50 - 300
Potassium	mg/L	10
Sodium	mg/L	100 - 500
Sulfate	mg/L	500 - 2,000
Sodium adsorption ratio (SAR)	unitless	2 - 6
Minor Ions and Trace Elements		
Arsenic	mg/L	0.01
Barium	mg/L	0.4
Cadmium	mg/L	0.3
Chromium	mg/L	0.4
Copper	mg/L	0.3
Iron	mg/L	0.2
Molybdenum	mg/L	<0.1
Nickel	mg/L	0.3
Selenium	mg/L	<0.2
Vanadium	mg/L	<10
Radiological Parameters		
Lead-210	pCi/L	<10
Radium-226	pCi/L	<60
Thorium-230	pCi/L	<100
U-natural	pCi/L	<300

Note: Estimates of land application water quality were based on the results of laboratory scale leach tests conducted on ore samples from the Dewey (Fall River) and Burdock (Chilson) sites, as well as from historical end-of-production water quality data from other ISR sites in Wyoming and Nebraska, with adjustments as necessary to account for planned post-production water treatments.

application water has relatively consistent water quality throughout the project duration. With an available storage capacity (excluding spare storage ponds) of 247.2 ac-ft at each site and a typical pumping rate of 297 to 653 gpm, the ponds will provide 86 to 188 days of storage during land application system operation. As described in Section 5.3, the central plant pond will also have sufficient capacity to store all of the relatively high TDS CPP liquid waste until the first well fields begin restoration. Over time, the land application water quality will gradually improve as the final well fields are restored to baseline water quality.

Some of the parameters important to irrigation water quality include exchangeable sodium percentage (ESP), residual sodium carbonate (RSC), and sodium adsorption ratio (SAR). These are defined as follows:

ESP = Exchangeable Sodium Percentage. Empirical relationship from Withers and Vipond (1980).

$$ESP = \frac{100(-0.0126 + 0.01475 * SAR)}{1 + (-0.0126 + 0.01475 * SAR)}$$

RSC = Residual Sodium Carbonate (meq/L).

$$RSC = ([CO_3] + [HCO_3]) - ([Ca] + [Mg])$$

SAR = Sodium Adsorption Ratio.

$$SAR = \frac{[Na]}{\sqrt{([Ca] + [Mg]) / 2}}$$

6.0 MONITORING PLAN

The following operational monitoring plan was prepared to meet the requirements of ARSD 74:54:02:06(9). This monitoring will be performed to evaluate potential environmental impacts and to track system performance. Implementation of the proposed monitoring plan will ensure beneficial uses will not be impaired and there will be no hazard to human health as required by ARSD 74:54:02:09(3). The following types of samples will be collected for laboratory analysis:

- Groundwater
- Surface water
- Land application water (effluent)
- Soil
- Vegetation
- Livestock

Following is a description of the operational monitoring plan including sampling frequency, parameters, and analytical techniques. Proposed maximum allowable metal accumulation values and proposed criteria for determining if and when land application should be initiated or discontinued are presented in Section 8.

6.1 Groundwater

The groundwater monitoring program will include alluvial monitor wells located hydrologically upgradient, within and downgradient of the proposed land application systems. The monitoring program has been designed to provide a comprehensive evaluation of potentially affected groundwater quality within and near the proposed POP zones. In addition to alluvial groundwater monitoring, Powertech (USA) will provide DENR the results of monitoring in the shallowest bedrock aquifer, the Fall River Formation. Powertech (USA) also proposes to install suction lysimeters to monitor the vadose groundwater quality beneath the land application systems.

6.1.1 Alluvial Groundwater Monitoring

<u>*6.1.1.1 Alluvial Monitor Wells*</u>

Monitor wells will be constructed in accordance with ARSD 74:54:02:06(9)(f) requirements. Three types of alluvial monitor wells are proposed to assess baseline conditions and potential impacts to alluvial water quality:

Compliance wells are proposed hydrologically down-gradient from the land application systems at the POP zone boundaries. These wells will serve as compliance monitoring locations for potential impacts to alluvial water quality outside of the POP zone.

Interior wells are proposed within each POP zone to measure potential changes in alluvial water quality within the POP zones. Per ARSD 74:54:02:06(9)(a), the interior wells will be positioned approximately 1/3 the distance between the point of application (pivot areas) and the compliance monitoring points.

Other wells are proposed to measure ambient alluvial water quality within the project area. These include wells located upgradient of the proposed land application systems and downgradient wells outside of the POP zones. Many of these wells will be monitored as a condition of the NRC license and are not directly associated with the GDP. Nevertheless, Powertech (USA) will provide the monitoring results for these other wells to DENR.

Tables 6.1-1 and 6.1-2 present the proposed alluvial monitor wells. The wells are depicted on Figures 6.1-1 and 6.1-2.

Table 6.1-1: Proposed Alluvial Monitor Wells, Dewey Land Application System

Category	Well ID	Qtr-Qtr	Section	Township	Range	Status
Compliance wells	DC-1	NWSW	30	6S	1E	Proposed
	DC-2	SESW	30	6S	1E	Proposed
	DC-3	NENW	31	6S	1E	Proposed
	DC-4	NWNW	32	6S	1E	Proposed
Interior wells	DI-1	SWNW	30	6S	1E	Proposed
	DI-2	SESE	30	6S	1E	Proposed
	DI-3	SWSW	29	6S	1E	Proposed
Other wells	TBD	NWNW	30	6S	1E	Proposed
	TBD	NWSE	32	6S	1E	Proposed
	677	SWSW	4	6S	1E	Existing

Table 6.1-2: Proposed Alluvial Monitor Wells, Burdock Land Application System

Category	Well ID	Qtr-Qtr	Section	Township	Range	Status
Compliance wells	BC-1	NWSW	3	7S	1E	Proposed
	BC-2	SESW	3	7S	1E	Proposed
	BC-3	NWNW	4	7S	1E	Proposed
Interior wells	BI-1	SENW	3	7S	1E	Proposed
	BI-2	NWSE	3	7S	1E	Proposed
	BI-3	NWNE	3	7S	1E	Proposed
	BI-4	NWNW	3	7S	1E	Proposed
Other wells	676	SESW	34	6S	1E	Existing
	678	SWNE	9	7S	1E	Existing
	679	NWSE	27	6S	1E	Existing
	707	SWNE	34	6S	1E	Existing
	708	SESW	3	7S	1E	Existing

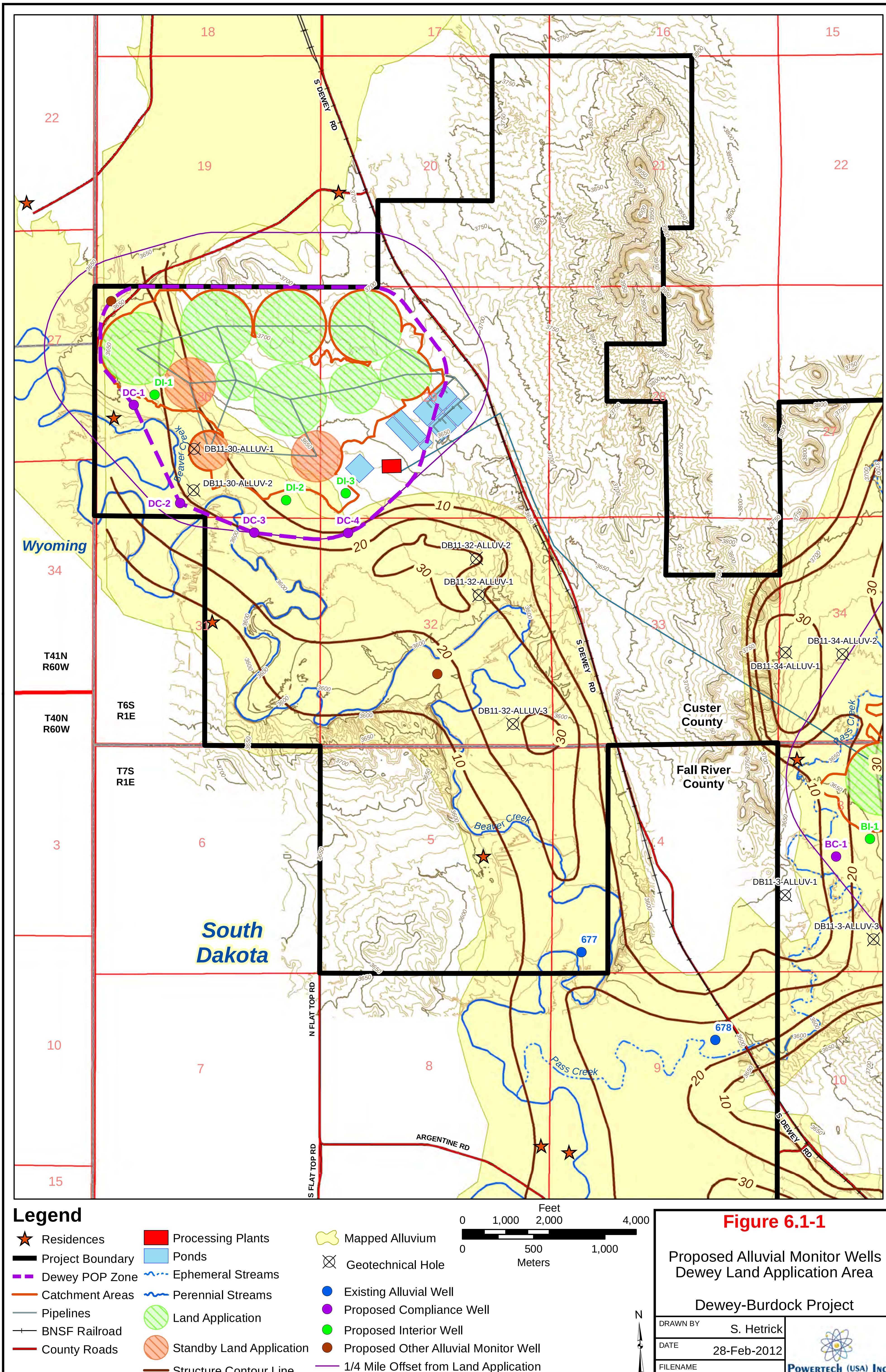


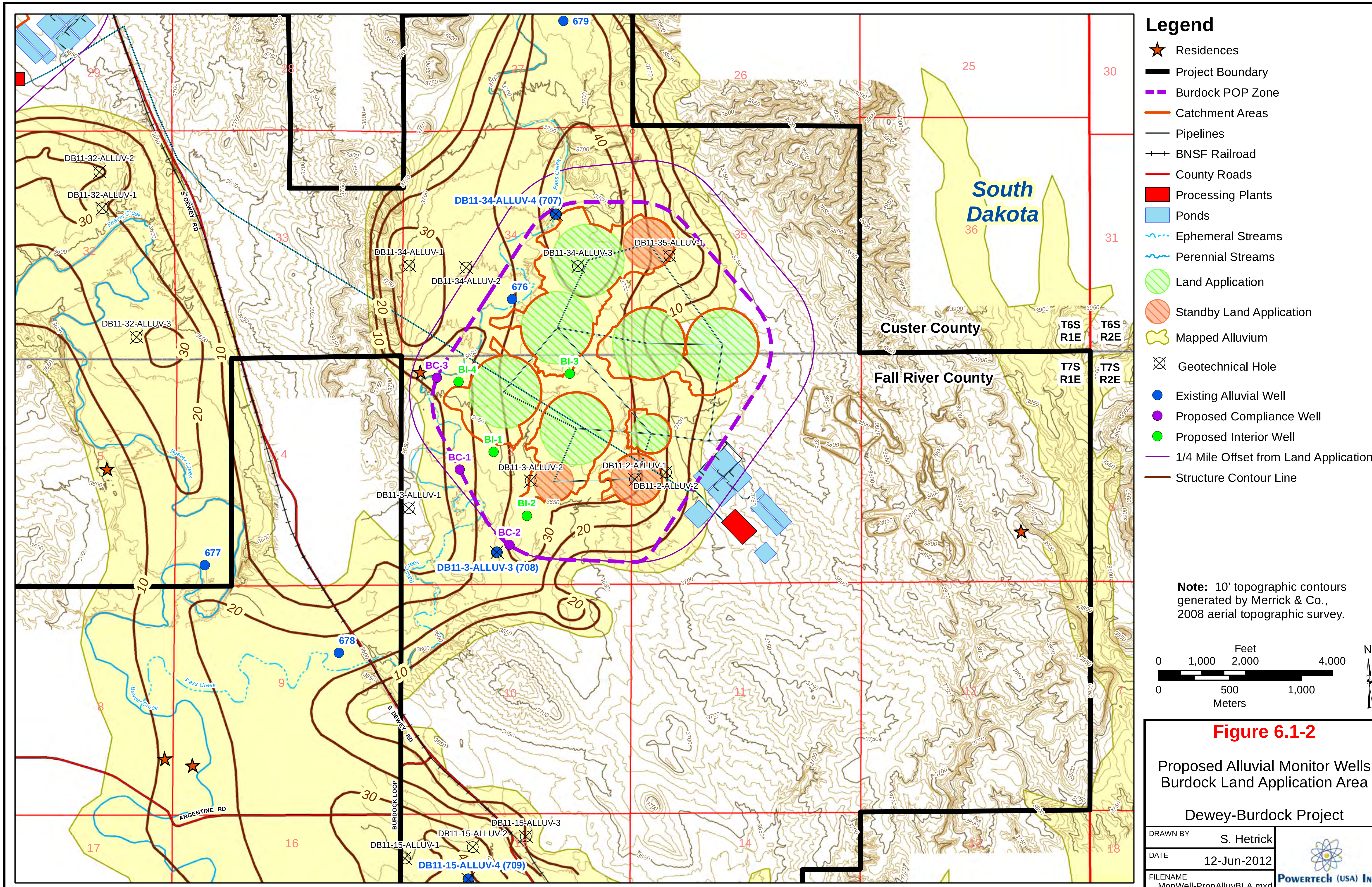
Figure 6.1-1

Proposed Alluvial Monitor Wells
Dewey Land Application Area

Dewey-Burdock Project

DRAWN BY	S. Hetrick
DATE	28-Feb-2012
FILENAME	MonWell-PropAlluvDLA.mxd

POWERTECH (USA) INC.


Legend
Residences
Project Boundary
Burdock POP Zone
Catchment Areas
Pipelines
BNSF Railroad
County Roads
Processing Plants
Ponds
Ephemeral Streams
Perennial Streams
Land Application
Standby Land Application
Mapped Alluvium
Geotechnical Hole
Existing Alluvial Well
Proposed Compliance Well
Proposed Interior Well
1/4 Mile Offset from Land Application
Structure Contour Line
South Dakota
Custer County
Fall River County
T6S R1E
T6S R2E
T7S R1E
T7S R2E
DB11-32-ALLUV-2
DB11-32-ALLUV-1
DB11-32-ALLUV-3
DB11-34-ALLUV-4 (707)
DB11-34-ALLUV-1
DB11-34-ALLUV-2
DB11-34-ALLUV-3
DB11-35-ALLUV-1
DB11-3-ALLUV-1
DB11-3-ALLUV-2
DB11-3-ALLUV-3 (708)
DB11-2-ALLUV-1
DB11-2-ALLUV-2
DB11-15-ALLUV-1
DB11-15-ALLUV-2
DB11-15-ALLUV-3
DB11-15-ALLUV-4 (709)
BC-1
BC-2
BC-3
BI-1
BI-2
BI-3
BI-4
676
677
678
679
S DEWEY RD
BURDOCK LOOP
ARGENTINE RD
Beaver Creek
Pass Creek
Note: 10' topographic contours generated by Merrick & Co., 2008 aerial topographic survey.
Feet
0 1,000 2,000 4,000
0 500 1,000
Meters
N
Figure 6.1-2
Proposed Alluvial Monitor Wells
Burdock Land Application Area
Dewey-Burdock Project
DRAWN BY S. Hetrick
DATE 12-Jun-2012
FILENAME MonWell-PropAlluvBLA.mxd
Powertech (USA) Inc.

6.1.1.2 Sample Collection and Analysis Methods

Static water level will be measured before sample collection. Measurement techniques will include pressure transducers, a portable electronic water level meter, or an ultrasonic water level sensor. Three casing volumes will be purged prior to sample collection. Field parameters will be measured and recorded and samples will not be collected until field pH, conductivity and temperature have stabilized. The criterion used to assess stability will be three consecutive measurements of each of the field parameters with values for each parameter within 10% of each other.

All groundwater samples will be collected in clean sample containers and field preserved, where required. The sample containers will be kept cool (less than 4°C) until delivery to the contract laboratory. Samples will be analyzed for the parameters in Table 6.1-3.

6.1.1.3 Sample Frequency

Prior to operation of the land application systems, all compliance wells, interior wells, and other wells designated in Tables 6.1-1 and 6.1-2 will be sampled to determine ambient water quality. Per ARSD 74:54:02:18, each compliance and interior well will be sampled a minimum of four times within a 6-month period with no two samples taken in the same month.

During operation of each land application system, the designated compliance, interior, and other wells will be sampled quarterly. All baseline and operational water samples will be analyzed for the parameters in Table 6.1-3.

6.1.1.4 Compliance Limits

For each interior and compliance well, ambient water quality will be established as the arithmetic mean of baseline water samples plus one standard deviation of the sample data for each constituent in accordance with ARSD 74:54:02:18. Where non-detect values occur, one-half the detection limit will be used in calculating the arithmetic mean and standards deviation. The same procedure will be followed to establish ambient water quality for the other alluvial wells described in Section 6.1.1.1, including up-gradient wells.

Compliance limits will be established on a well-by-well basis for each constituent in each compliance monitor well as the human health standards in Table 4.2-3 or ambient water quality, whichever is greater. As described in Section 8.1.1, out-of-compliance status will be defined in accordance with ARSD 74:54:02:28 as two consecutive samples which exceed the permitted allowable limit by two standard deviations. Interior wells will not have established compliance

POWERTECH (USA) INC.

Table 6.1-3: Water Quality Parameter List

Test Analyte/Parameter	Units	Analytical Method
Physical Properties		
pH ǂ	pH units	A4500-H B
Total Dissolved Solids (TDS) +	mg/L	A2540 C
Conductivity	µmhos/cm	A2510 B
Common Elements and Ions		
Alkalinity (as $CaCO_3$)	mg/L	A2320 B
Bicarbonate Alkalinity (as $CaCO_3$)	mg/L	A2320 B (as HCO_3)
Calcium	mg/L	E200.7
Carbonate Alkalinity (as $CaCO_3$)	mg/L	A2320 B
Chloride, Cl	mg/L	A4500-Cl B; E300.0
Magnesium, Mg	mg/L	E200.7
Nitrate, NO_3^- (as Nitrogen)	mg/L	E300.0
Potassium, K	mg/L	E200.7
Sodium, Na	mg/L	E200.7
Sulfate, SO_4	mg/L	A4500-SO4 E; E300.0
Trace and Minor Elements[1]		
Arsenic, As	mg/L	E200.8
Barium, Ba	mg/L	E200.8
Boron, B	mg/L	E200.7
Cadmium, Cd	mg/L	E200.8
Chromium, Cr	mg/L	E200.8
Copper, Cu	mg/L	E200.8
Fluoride, F	mg/L	E300.0
Iron, Fe	mg/L	E200.7
Lead, Pb	mg/L	E200.8
Manganese, Mn	mg/L	E200.8
Mercury, Hg	mg/L	E200.8
Molybdenum, Mo	mg/L	E200.8
Nickel, Ni	mg/L	E200.8
Selenium, Se	mg/L	E200.8, A3114 B
Silver, Ag	mg/L	E200.8
Uranium, U	mg/L	E200.7, E200.8
Vanadium, V	mg/L	E200.7, E200.8
Zinc, Zn	mg/L	E200.8
Radiological Parameters[1,2]		
Gross Alpha††	pCi/L	E900.0
Gross Beta	pCi/L	E900.0
Radium, Ra-226	pCi/L	E903.0

ǂ Field and laboratory
+ Laboratory only
††Excluding radon, radium, and uranium
[1] For alluvial compliance and interior well sampling, the concentrations of trace and minor elements and radiological parameters will be the dissolved portion, except mercury, which will be the total, unfiltered concentration in accordance with ARSD 74:54:01:04.
[2] The parameter list for alluvial compliance and interior wells also will include radon-222 and radium-228.

Limits; however, as described in Section 8.1.1, a contingency plan will be implemented if the monitored constituents concentrations begin to increase.

6.1.2 Bedrock Aquifer Groundwater Monitoring

Due to the thickness and confining properties of the Graneros Group shales, which separate the proposed land application systems from bedrock aquifers, Powertech (USA) does not propose to establish POP zones or compliance monitor wells in the bedrock aquifers (Section 3.6.2 discusses the site geology in further detail, and Plates 3.6-3 and 3.6-5 through 9 show that the thickness of the Graneros Group is never less than 25 feet in the land application areas). However, Powertech (USA) proposes to provide DENR with monitoring results from operational monitor wells in the shallowest bedrock aquifer, which occurs in the Fall River Formation. Figure 6.1-3 depicts the Fall River monitor wells currently proposed to be included in the operational monitoring program for the NRC license. The wells designated as operational Fall River monitoring locations may change throughout the course of well field development. Powertech (USA) commits to providing DENR with results of monitoring for all Fall River monitor wells designated as operational monitor wells in the NRC license.

Prior to ISR operations, each of the Fall River monitor wells will be sampled quarterly for one year (including samples already collected). During ISR operations, the Fall River monitor wells will be sampled quarterly and analyzed for the parameters in Table 6.1-3.

6.1.3 Vadose Zone Groundwater Monitoring

Suction lysimeters will be placed in each of the center pivot circles and catchment areas at both the Dewey and Burdock areas to obtain pore water samples from unsaturated soil beneath the land application systems. The suction lysimeters will be installed at a depth appropriate to verify the assumption that land application water will not percolate below a depth of 8 feet, as demonstrated by the SPAW model results.

One suction lysimeter will be installed in each center pivot circle and catchment area at a depth of 8 to 12 feet. Prior to operation of the land application systems, pore samples will be collected from each suction lysimeter a minimum of four times within a 6-month period with no two samples taken in the same month. If insufficient water is available to obtain a sample, it will be noted on the field sampling form. Sample collection techniques will be in accordance with lysimeter manufacturer specifications. Samples will be analyzed for the physical properties and common elements and ions listed in Table 6.1-3.

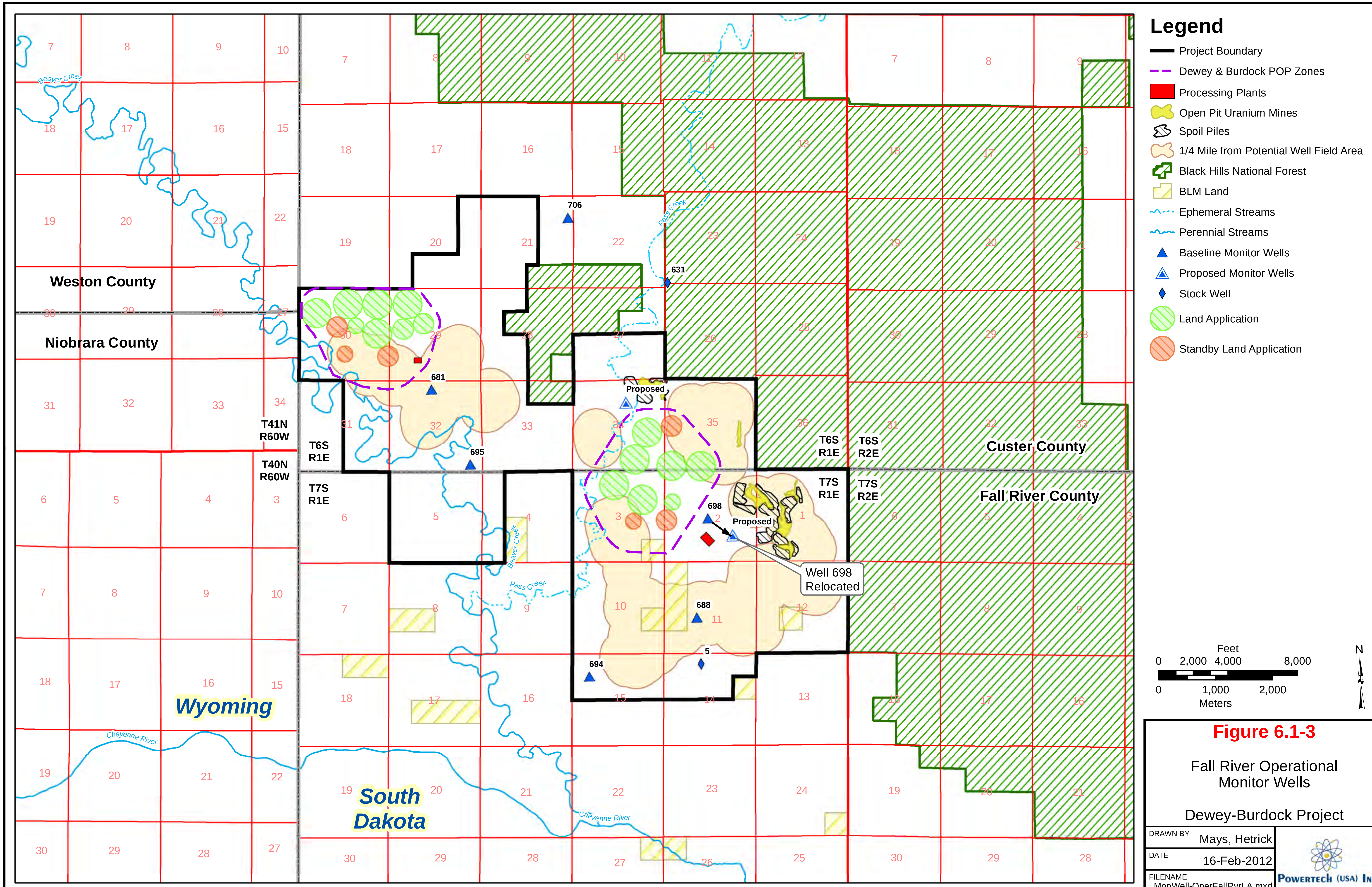


Figure 6.1-3

Fall River Operational Monitor Wells

During operation of the land application systems, pore water samples will be collected once prior to each irrigation season, once during each irrigation season (for lysimeters installed beneath operational pivots and catchment areas only), and once after each irrigation season. Samples will be analyzed for the same parameters as pre-operational monitoring.

6.1.4 Domestic Wells

Domestic wells within 1.2 miles (2 km) of the project area will be monitored prior to and during ISR operations, including operation of the proposed land application systems. In accordance with NRC license conditions, samples will be collected quarterly for four quarters prior to operations and annually during operations. Samples will be analyzed for the constituents in Table 6.1-3. To demonstrate protection of drinking water wells during operation of the proposed land application systems, Powertech (USA) will provide the sample results to DENR.

6.2 Surface Water

6.2.1 Streams

Prior to ISR operations, Powertech (USA) will establish upstream and downstream sampling sites on Beaver Creek and Pass Creek. The locations of the stream sampling sites are listed in Table 6.2-1 and depicted on Figure 6.2-1. These locations are different from those described in Section 4.1. The new stream sampling sites better meet NRC regulatory guidance. The upstream sites on each creek will be positioned approximately at the upstream boundaries of the NRC license area and will represent ambient water quality. The downstream location on Beaver Creek is downstream of the Dewey land application system, and the downstream location on Pass Creek is downstream of the Burdock land application system.

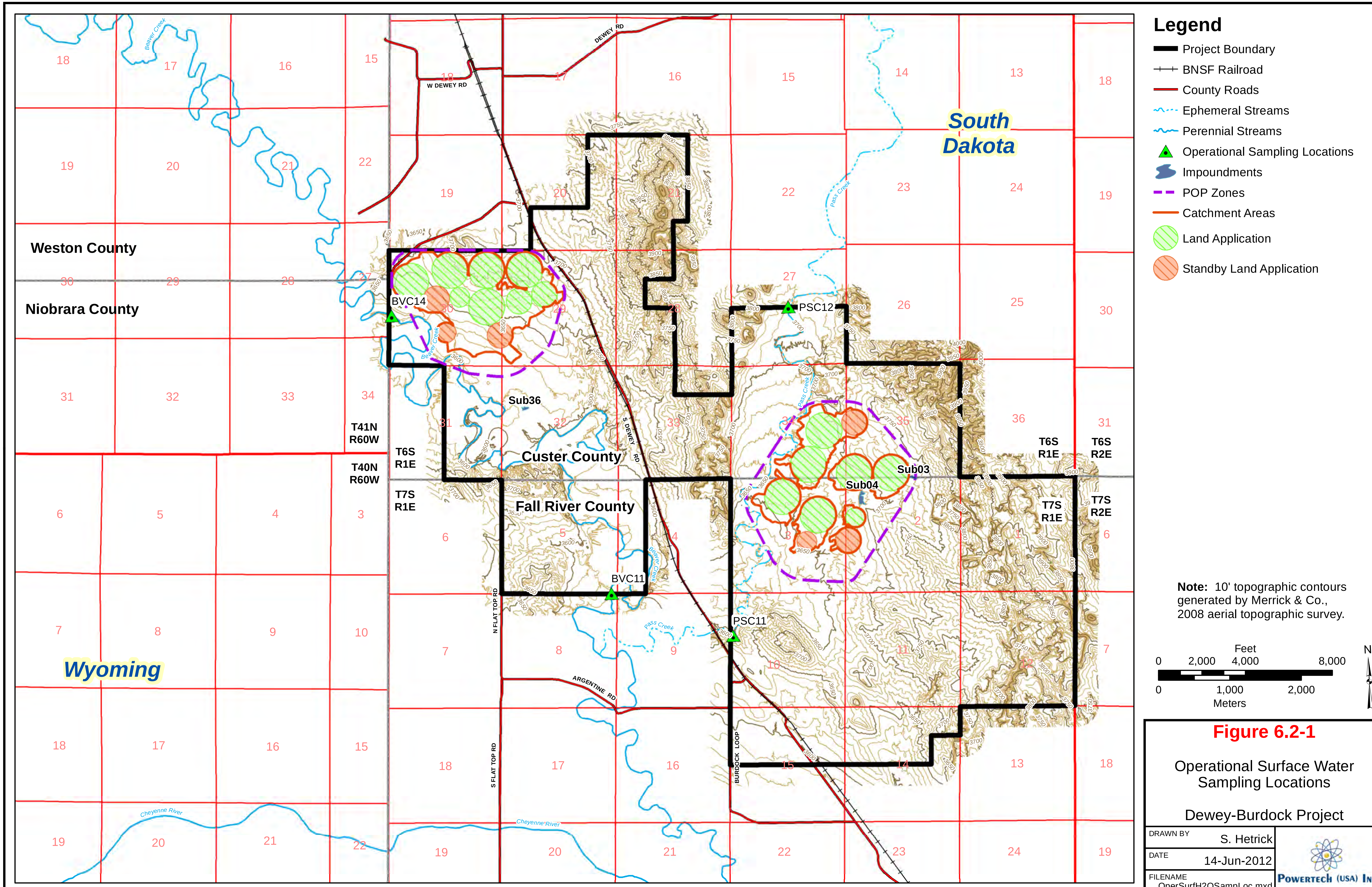
Table 6.2-1: Operational Stream Sampling Locations

Site ID	Name	Sample Type	Location (feet)[1]	
			Northing	Easting
BVC11	Beaver Creek Downstream	Grab	433,638	1,022,546
BVC14	Beaver Creek Upstream	Grab	446,829	1,012,976
PSC11	Pass Creek Downstream	Passive sampler	431,452	1,028,064
PSC12	Pass Creek Upstream	Passive sampler	446,470	1,031,222

[1]Coordinate system is NAD 27, South Dakota State Plane South

Prior to ISR operations, Powertech (USA) will sample each stream sampling site monthly for 12 consecutive months. Grab samples will be collected from sites BVC11 and BVC14. Passive samplers will be installed at sites PSC11 and PSC12 to collect samples during ephemeral flow events. Water samples will be analyzed for constituents listed in Table 4.1-2.

During ISR operations, including operation of the land application systems, streams will be sampled by grab sampling or with automatic samplers. Grab samples will be collected quarterly from the perennial stream sampling locations on Beaver Creek. Passive samplers (single-stage samplers) will be installed at Pass Creek sampling sites from April through October. These will automatically collect samples when the flow rate in the channel reaches a field-adjustable minimum depth threshold. Following the runoff event the water will be manually transferred



Legend
Project Boundary
BNSF Railroad
County Roads
Ephemeral Streams
Perennial Streams
Operational Sampling Locations
Impoundments
POP Zones
Catchment Areas
Land Application
Standby Land Application
Note: 10' topographic contours generated by Merrick & Co., 2008 aerial topographic survey.
Feet
0 2,000 4,000 8,000
0 1,000 2,000
Meters
N
South Dakota
Wyoming
Weston County
Niobrara County
Custer County
Fall River County
T41N R60W
T40N R60W
T6S R1E
T7S R1E
T6S R2E
T7S R2E
BVC14
BVC11
PSC12
PSC11
Sub36
Sub04
Sub03
W DEWEY RD
DEWEY RD
S DEWEY RD
N FLAT TOP RD
S FLAT TOP RD
ARGENTINE RD
BURDOCK LOOP
Beaver Creek
Pass Creek
Cheyenne River
Figure 6.2-1
Operational Surface Water Sampling Locations
Dewey-Burdock Project
DRAWN BY S. Hetrick
DATE 14-Jun-2012
FILENAME OperSurfH2OSampLoc.mxd
Powertech (USA) Inc.

from the temporary sample container to clean sample bottles and submitted to the contract laboratory for analysis.

Water representative of that collected in the grab samples will be analyzed in the field for pH, conductivity and temperature. Stream samples will be analyzed for the parameters presented in Table 6.2-2, which has been prepared according to NRC regulatory guidance to monitor potential impacts to surface water from uranium ISR facilities.

Table 6.2-2: Operational Surface Water Monitoring Parameter List and Analytical Methods

Parameter	Units	Analytical Method
Uranium, dissolved	mg/L	E200.8
Uranium, suspended	mg/L	E200.8
Ra-226, dissolved	pCi/L	E903.0
Ra-226, suspended	pCi/L	E903.0
Th-230, dissolved	pCi/L	E907.0
Th-230, suspended	pCi/L	E907.0
Pb-210, dissolved	pCi/L	E909.0M
Pb-210, suspended	pCi/L	E909.0M
Po-210, dissolved	pCi/L	RMO-3008
Po-210, suspended	pCi/L	RMO-3008

6.2.2 Impoundments

In the operational surface water monitoring program for ISR operations, Powertech (USA) will monitor all impoundments within and adjacent to the project area that are down-gradient of proposed ISR activity (e.g., well fields, plants, pipelines, and land application systems). Impoundments downstream of the land application areas for the Dewey and Burdock sites are summarized in Table 6.2-3 and 6.2-4, respectively. Powertech (USA) will provide DENR with results of operational monitoring of the impoundments designated to be included in the operational monitoring program in Tables 6.2-3 and 6.2-4.

Table 6.2-3: Impoundments Included in Operational Monitoring Program, Dewey Area

Site	Type	Down-Gradient of Proposed Land Application System	Included in Operational Monitoring Program	Justification for Not Including in Operational Monitoring Program
Sub36	Stock Pond	Yes	Yes	---
Sub37	Stock Pond	Yes	No	Downstream of Sub36

Table 6.2-4: Impoundments Included in Operational Monitoring Program, Burdock Area

Site	Type	Down-Gradient of Proposed Land Application System	Included in Operational Monitoring Program	Justification for Not Including in Operational Monitoring Program
Sub03	Mine Dam	Yes	Yes	---
Sub04	Stock Pond	Yes	Yes	---

All impoundments identified for operational monitoring will be visited on a quarterly basis throughout construction and operation. In addition, Powertech (USA) will visit all of the impoundments included in the operational monitoring program four times (including pre-operational samples already collected) prior to operations.

Prior to operation of the land application systems or ISR operations, ambient water samples will be collected, when available, and analyzed for constituents listed in Table 4.1-4. Operational monitoring will include the parameters listed in Table 6.2-2.

6.3 Land Application Discharge Water (Effluent)

6.3.1 Flow Rate

Flow rate will be measured using flow meters installed in the discharge piping from the pumps that deliver water from the storage ponds to the land application systems. Every day Powertech (USA) personnel will record the average daily flow rate of the cumulative flow to each land application system. Personnel will also note which of the center pivots were active during that day, and whether any water is ponded in the catchment areas. The flow rate will be adjusted to prevent excessive ponding in the catchment areas. As described in Section 8.2, Powertech (USA) will adjust the land application rate or pump water from catchment areas if the freeboard capacity limits are approached.

6.3.2 Effluent Water Quality

Powertech (USA) proposes the following effluent monitoring plan to comply with ARSD 74:54:02:06(13), which requires "provisions for sampling of effluent and for flow monitoring, to determine the volume and chemistry of the discharge onto or below the surface of the ground …." Powertech (USA) will collect effluent grab samples monthly during operation of each land application system and have them analyzed for the parameters listed in Table 6.1-3. In addition to the parameters in Table 6.1-3, monthly effluent samples will be analyzed for compliance with

the anticipated NRC effluent limits in Table 6.3-1. These anticipated effluent limits are the 10 CFR Part 20, Appendix B, Table 2, Column 2 established limits for discharge of radionuclides to the environment. Table 6.3-1 also lists the ARSD 74:54:01:04 human health standards for groundwater.

Table 6.3-1: Anticipated NRC Effluent Limits for Land Application Effluent

Radionuclide	Anticipated NRC Effluent Limits		ARSD 74:54:01:04 Human Health Standards	Analytical Method
	µCi/ml	pCi/L		
Lead-210	1E-8	10	No standard	E903.0
Radium-226	6E-8	60	5 pCi/L*	E908.0
Uranium-natural	3E-7	300	0.03 mg/L	E907.0
Thorium-230	1E-7	100	No standard	E905.0

Source: 10 CFR 20, Appendix B, Table 2, Column 2

* Includes Ra-226 and Ra-228

6.3.3 Instrumentation and Control

In accordance with ARSD 74:54:02:06(9)(b), Powertech (USA) will install automated control and data recording systems at the Dewey Satellite Facility and the Burdock CPP which will provide centralized monitoring and control of the land application systems. The systems will include alarms and automated shutoffs to detect and control a potential release or spill.

Pressure and flow sensors will be installed, for the purpose of leak detection, on the main pipelines that connect the lined storage ponds to the land application areas. Measurements will be collected and transmitted to both the CPP and Satellite Facility control systems. Should pressures or flows fluctuate outside of normal operating ranges, alarms will provide immediate warning to operators which will result in a timely response and appropriate corrective action.

If a pipeline leak were to occur, procedures will be in place to address and correct it. Daily visual inspections will be conducted of land application facilities, including all visible pipes, connections, and fittings. In the event of visual confirmation of a pipeline leak or confirmation through the automated control system, Powertech (USA) will take immediate corrective action, including shutting down the affected pipeline, repairing the leak, and cleaning up the affected area in accordance with the requirements of the NRC license and LSM permit.

6.4 Soil

Prior to operation of the land application systems, two baseline soil samples will be collected from each quadrant of each center pivot (eight total samples per pivot). Samples will be collected from two depth intervals (0-18 inches and 18-36 inches) and analyzed for the parameters in Table 6.4-1.

During operation, a minimum of two soil samples will be collected each year from each land application pivot active during that year, one from 0-18 inches and one from 18-36 inches. Samples will be analyzed for the parameters in Table 6.4-1.

Table 6.4-1: Soil Sampling Parameters

Parameter	Units	Reporting Limit
Conductivity, paste extract	umhos/cm	0.01
pH, paste extract	s.u.	0.1
Sodium	mg/kg-dry	1
Sodium adsorption ratio (SAR)	unitless	0.1
Chloride, soluble	mg/kg-dry	1
Chloride	mg/kg-dry	10
Sulfate	mg/kg-dry	10
Arsenic	mg/kg-dry	0.6
Barium	mg/kg-dry	0.6
Boron	mg/kg-dry	0.1
Cadmium	mg/kg-dry	0.6
Chromium	mg/kg-dry	0.6
Lead	mg/kg-dry	0.6
Mercury	mg/kg-dry	1
Selenium	mg/kg-dry	0.6
Silver	mg/kg-dry	0.6
Vanadium	mg/kg-dry	0.6
Nitrate as N, KCl extract	mg/kg-dry	1
Uranium-natural	mg/kg-dry	0.5
Radium-226	pCi/g-dry	0.1
Thorium-230	pCi/g-dry	0.1
Lead-210	pCi/g-dry	0.1
Polonium-210	pCi/g-dry	0.1

6.5 Vegetation

Samples of the crops grown on three of the land application areas from each of the Dewey and Burdock sites will be collected at the end of each irrigation season during operations. If crops are not grown, samples of existing vegetation will be collected and analyzed. Samples will be analyzed for the parameters in Table 6.5-1.

Table 6.5-1: Vegetation Sampling Parameters

Constituent	Units
Uranium-natural	mg/kg
Radium-226	pCi/g
Thorium-230	pCi/g
Lead-210	pCi/g
Polonium-210	pCi/g
Selenium	mg/kg
Arsenic	mg/kg

6.6 Livestock

Section 8.5 describes how Powertech (USA) will work with affected landowners to prevent livestock grazing during operation of the land application systems. Should livestock graze on the land application areas or consume crops grown on the land application areas, livestock samples will be collected during operation of the land application systems. Powertech (USA) will collect one grab sample each year taken at the time of harvest or slaughter and have it analyzed for the parameters in Table 6.6-1.

Powertech (USA) does not propose to sample wild game due to the migratory nature and relatively large home range of game animals in relation to the size of the land application areas.

Table 6.6-1: Livestock Sampling Parameters

Constituent	Units
Uranium-natural	mg/kg
Radium-226	pCi/g
Thorium-230	pCi/g
Lead-210	pCi/g
Polonium-210	pCi/g
Selenium	mg/kg
Arsenic	mg/kg

7.0 PROPOSED PERIMETER OF OPERATIONAL POLLUTION (POP)

The POP zones for the Dewey and Burdock land application areas are proposed to provide protection of groundwater resources in the respective areas in accordance with ARSD 74:54:02:17. Each of the proposed POP zones is within one-quarter mile of the respective land application areas and within the property boundaries of the permitted facility (NRC license boundary). The proposed POP zones in the Dewey and Burdock areas are shown on Figures 6.1-1 and 6.1-2, respectively. No residences or drinking water wells are located within either zone.

ARSD 74:54:02:06(8) requires the applicant to provide, "If applicable, the description of the POP, including the dimensions and hydrologic and geologic data to determine the dimensions, the proposed compliance monitoring point, and justification of necessary economic or social development for the POP." Each of these requirements is addressed below.

<u>Dimensions and Hydrologic and Geologic Data to Determine the Dimensions</u>

The areal extents and configuration of the proposed Dewey area POP zone are shown on Figure 6.1-1. The western, northern and northeastern edges of the proposed POP zone are topographically upgradient of the land application areas. These edges also are hydrologically upgradient of the land application areas based on the results of the 2011 alluvial drilling program described in Sections 3.6.2.2 and 8.1.1. The POP zone is proposed just outside of the catchment areas in these areas, since there is no potential for surface water or groundwater flow to the west, north or northeast based on hydrologic and topographic data and therefore no need to extend the POP zone further in these directions. The proposed POP zone was further constrained to the north and west by the NRC license boundary/LSM permit boundary. To the south of the land application areas, the proposed POP zone is up to ¼ mile from the land application areas in the downgradient (topographic and hydrologic) directions, which are southwest, south, and southeast. In the vicinity of compliance well DC-2, the proposed POP zone is less than ¼ mile from the nearest land application area due to an oxbow in Beaver Creek, which would make it impractical to perform compliance monitoring further south. In the vicinity of DC-1, the proposed POP zone is less than ¼ mile from the nearest land application area in order to avoid placing a compliance monitoring well across Beaver Creek from the land application areas and to avoid a residence and domestic wells in the NWSW Sec. 30, T6S, R1E (refer to Figures 6.1-1 and 3.7-9 for the locations of the residence and domestic wells). As shown on Figure 3.6-3, the Dewey land application areas overlay the Graneros Group and Beaver Creek alluvium. As discussed in Section 3.7.2.2, the Graneros Group has a very low permeability; therefore, lateral movement of water is expected to be negligible within the Graneros Group. The proposed POP

zone extends to the south in the alluvium, since the alluvium is the first and only hydrogeologic unit potentially impacted by land application.

In the Burdock area, the topographic and hydrologic downgradient directions from the land application areas are south and west. Since there is no potential for groundwater flow to the north or east, the northern and eastern edges of the proposed POP zone are near the catchment areas. The southern and southwestern edges of the proposed POP zone are up to ¼ mile from the land application areas. In the vicinity of BC-1, the POP zone is less than ¼ mile from the nearest land application area due to an oxbow in Pass Creek, which makes it impractical to perform compliance monitoring further west. To the north of BC-1, the proposed POP zone is less than ¼ mile from the nearest land application area to avoid including a residence and domestic well in the NWNW Sec. 3, T7S, R1E (refer to Figures 6.1-2 and 3.7-10 for the locations of the residence and domestic well). As shown on Figure 3.6-3, the Burdock land application areas overlay the Graneros Group and the Pass Creek alluvium. As with the Dewey area, the proposed POP zone was extended in the downgradient direction in the alluvium, since the alluvium is the first and only hydrogeologic unit potentially impacted by land application.

<u>Proposed Compliance Monitoring Points</u>

Refer to Section 6.1.1.1, which describes the locations of the proposed compliance wells.

<u>Justification of Necessary Economic or Social Development</u>

Support for the Dewey-Burdock Project as benefitting the State of South Dakota is found in SDCL 45-6B-2, which states, "Every effort should be used to promote and encourage the development of mining as an industry, but to prevent the waste and spoilage of the land and the improper disposal of tailings which would deny its future use and productivity." Powertech (USA)'s commitment to adhering to best professional practices, NRC license conditions and EPA and DENR permit conditions will ensure that facility construction, operation, decommissioning and reclamation will protect DENR-approved postmining land use(s). As required by the NRC license, LSM permit and EPA Class III Underground Injection Control permit, Powertech (USA) will be required to post financial assurance for all aspects of the Dewey-Burdock Project. This will ensure that resources will be available for decommissioning and reclamation such that the site will be released for unrestricted (i.e., DENR-approved postmining) use.

Support for ISR uranium recovery to be considered a mining beneficial use is found in SDCL 45-6B-3(11), which includes *in situ* mining in the definition of "mining operation."

The Dewey-Burdock Project NRC license application (Powertech, 2009) describes how the project benefits include its potential to create approximate 250 new jobs during construction and approximately 150 new jobs during operation, which will contribute direct and indirect benefits to the local economy. In addition, Powertech (USA) estimates that the project will generate some $35 million in state and local tax revenue and approximately $187 million in value added benefits over the life of the project.

8.0 MITIGATION OF POTENTIAL IMPACTS

The following sections describe the mitigation measures that will be used to minimize the potential impacts to groundwater, surface water, soil, vegetation, livestock and wildlife.

8.1 Groundwater

8.1.1 Alluvial Groundwater

Mitigation measures used to protect alluvial groundwater quality are described below and include:

- Siting the land application areas at locations where natural conditions make it highly unlikely that the land application water will reach the alluvium,
- Plugging and abandoning existing wells within the land application areas,
- Design and construct well fields and land application systems to avoid any potential conflicts and minimize potential risks,
- Applying the water at agronomic rates,
- Treating the land application water to remove radionuclides,
- Providing sufficient pond storage capacity to stabilize the water quality over long periods of time,
- Implementing an extensive monitoring program, and
- Implementing a contingency plan to address increasing trends in groundwater quality constituents within the POP zones in order to avoid potential impacts to groundwater outside of the POP zones.

<u>Natural Conditions</u>

Potential impacts to alluvial groundwater will be minimized by natural conditions that make it highly unlikely that the land application water will reach the alluvial groundwater. Plate 3.6-10 depicts shallow geologic cross sections drawn through the Burdock land application area. The figure shows that the depth to the top of the alluvial gravel ranges from about 12 to 33 feet and is typically 15 to 25 feet. The depth to alluvial groundwater, where encountered, is typically 13 to 35 feet. By comparison, the SPAW model simulations predict that the land application water will not percolate deeper than 8 feet.

In the Dewey area, groundwater was not typically encountered in the alluvial drilling program completed in May 2011. The primary reason is the composition of the clay-rich alluvial material along Beaver Creek in the project area, which generally contains less gravel than the alluvium along Pass Creek. Many of the Beaver Creek alluvial characterization holes encountered no gravel from the surface to the well-defined contact with the Granerous Group shales. Due to the limited occurrence of gravel and water within the Beaver Creek alluvium, there is even less potential to impact alluvial groundwater from the proposed land application system.

The soil hydraulic properties beneath the land application areas will help prevent the migration of water into the alluvial groundwater. Table 3.2-3 shows that the soils sampled from test pits in and around the land application areas predominantly contain clay and silt, with lesser amounts of sand and virtually no gravel to a depth of 7 to 10 feet. The primary mapped soil units in the Dewey land application area are Arvada fine sandy loam, Pierre clay, and slickspots. The permeability of each of these units is very slow as described in Appendix 3.2-A. The primary mapped soil units in the Burdock land application area include some with very low permeability (Arvada and Hisle silt loam) and others with moderate permeability (Barnum very fine sandy loam, Tilford silt loam, and Cushman very fine sandy loam).

Soil permeability was measured on samples from three test pits at each of the land application areas. Table 3.2-3 shows the permeability in the Dewey area ranged from 3.2×10^{-5} to 8.3×10^{-5} cm/sec (TP-01, TP-03 and TP-05). The permeability in the Burdock area was lower on average, ranging from 1.6×10^{-7} to 5.7×10^{-4} cm/sec. The differences in permeability for the two land application areas were taken into account in the SPAW model simulations.

The results of the May 2011 alluvial drilling program (Appendix 3.6-A) show similar soils as those sampled from the test pits to greater depths. Only the bottom 0 to 15 feet of the alluvium typically contains gravel, and this is typically a mixture of silt, clay and sand with scattered gravel. The top of the alluvium contains a mixture of silt, clay and sand as described in Section 3.6.2.2.

Plugging and Abandoning Existing Wells within Land Application Areas

Powertech (USA) has not identified any existing wells within the proposed Dewey land application area. Within the proposed Burdock land application area, there are two existing wells. As described in Section 3.7.2.3.2, these include one former domestic well (well 43) and one stock well (well 15). Both of these wells will be plugged and abandoned prior to operation of the Burdock land application system. The wells will be plugged in accordance with ARSD

74:02:04:67 with bentonite or cement grout. This will eliminate the potential for vertical migration of land application solutions through these existing wells.

Design and Construction of Well Fields and Land Application Systems to Avoid Potential Conflicts and Minimize Potential Risks

The potential well field areas are shown on Figure 2.3-2 along with the proposed land application areas. The figure shows limited overlap between the potential well field areas and the proposed land application systems. In the Dewey area, the only land application areas that will potentially overlap with well fields are designated for standby operation. These standby areas generally will not be used at the same time as the underlying well fields, but there is potential for simultaneous operation of the standby land application systems and overlapping well fields. Potential impacts will be mitigated as described below.

In the Burdock area, there will be very limited potential overlap between the proposed land application systems and potential well field areas. In this case overlap will likely be limited to perimeter monitor wells, which are shown as rings 400 feet from the ore bodies on Figure 2.3-2.

Although overlap between active land application areas and potential well field areas will be limited, there may be times that production, injection and monitor wells are operated within active land application areas. Powertech (USA) will design and construct the well fields and land application systems to avoid any potential conflicts and minimize potential risks. The irrigation nozzles will be suspended above the well head covers, and wells and fences will be positioned to avoid the center pivot wheel pathways. Injection, production and monitor wells will have sealed well heads to prevent entry of the land application water. The well heads also will have sufficient aboveground casing to ensure that surface water cannot enter the wells. Injection and production pipelines will be buried and will not conflict with land application systems. Perimeter monitor wells will have pressure transducers that will allow remote monitoring of water levels. If necessary, discharge piping and pressure transducer cable will be installed from the monitor wells to remote sampling locations outside of the land application area. This would allow Powertech personnel to measure water levels and sample monitor wells without traveling through active land application areas.

Water Application Rate

The land application rate has been specifically designed to minimize percolation below the rooting zone. The typical seasonal application rate over each of the land application areas will be

about 19 inches of water, which is a typical agronomic application rate for growing alfalfa and grasses in this region. The instantaneous rate will be adjusted as needed to avoid excessive ponding in the catchment areas. Section 8.2 also describes how Powertech (USA) will pump water from the catchment areas if necessary. Infiltration from the catchment areas will only occur sporadically. The annual average infiltration rate from the catchment areas is expected to be much lower than that from the center pivot areas, and thus potential alluvial groundwater impacts from catchment area infiltration will be lower than those from the center pivot areas. Due to the extensive monitoring system available within each land application area, including

suction lysimeters beneath each center pivot, Powertech (USA) will be able to monitor the movement of water through the subsoil and adjust the application rates to various pivots to further avoid potential impacts to alluvial groundwater.

Water Treatment

Prior to discharge to the storage ponds, Powertech (USA) will treat all land application water as described in Section 5.8. Treatment will include ion exchange for uranium removal, radium removal through co-precipitation with barium sulfate, and, if needed, specific treatment for thorium-230 and lead-210.

Storage Ponds

The storage ponds will have an operating capacity of 247.2 ac-ft at each land application area, which equates to about 3 to 6 months storage capacity at the typical application rate of 297 to 653 gpm. This large capacity will stabilize the water quality over long periods of time and minimize potential impacts to groundwater quality from changes in land application water quality.

The other ponds at each facility will provide further operational flexibility to minimize changes in water quality. The central plant pond at the Burdock area is sized sufficiently to temporarily store liquid waste originating from the CPP during initial production until the CPP liquid waste can be blended with restoration liquid waste and treated to meet discharge standards. See Section 5.3 for additional information.

The flow rate of the CPP liquid waste from the central plant pond to the radium settling ponds will be adjusted according to the concentration of dissolved solids in the CPP liquid waste stream. When well field liquid waste has relatively low concentrations of dissolved solids, for example when restoration is nearly complete in a particular well field, the percentage of CPP liquid waste in the waste disposal stream can be higher.

Monitoring

Implementation of the groundwater monitoring program described in Section 6.1 will minimize potential impacts to alluvial groundwater. Soil moisture measurements from the suction lysimeters will be used to track the potential vertical migration of land application water. This tracking will be enhanced by vadose zone water quality samples collected from the lysimeters. Interior monitor wells will be used to track changes in water quality within the POP zones and provide adequate warning to initiate mitigation measures such as adjusting the land application

rate within a specific area or initiating a pump and treat system. In the unlikely event that a non-compliance event occurs at a compliance well, Powertech (USA) will initiate the groundwater retrieval system described below.

The alluvial groundwater monitoring program described in Section 6.1 will also detect any potential impacts to Cheyenne River alluvium. Figure 3.6-3 shows that the mapped Beaver Creek and Pass Creek alluvium are contiguous with the Cheyenne River alluvium. The position of the interior and compliance alluvial monitor wells depicted in Figures 6.1-1 and 6.1-2 will ensure that any land application solutions entering the Beaver Creek or Pass Creek alluvium from the land application systems will be detected. There is no pathway for land application solutions to eventually reach the Cheyenne River alluvium without first passing through a compliance well. Further, Figure 6.1-1 shows that Powertech (USA) will also monitor other alluvial wells further downgradient in the Beaver Creek and Pass Creek alluvium (e.g., wells 677 and 678). These wells will be monitored as required by the NRC license, and the results will be provided to DENR as described in Section 6.1.1.1. Periodic monitoring of these downgradient alluvial wells will allow detection of any potential impacts from the Dewey-Burdock Project on Cheyenne River alluvium via Beaver Creek or Pass Creek alluvium.

Contingency Plan

Should the water quality in interior monitor wells indicate an increasing trend in constituent concentrations that could potentially trigger a permit limit violation at a compliance well, Powertech (USA) will implement a contingency plan, which will include the following actions:

- A preliminary investigation will be completed to determine the probable cause and the area affected.
- Affected wells will be analyzed for the full suite of parameters in Table 6.1-3.
- An assessment will be performed to determine what actions, if any, should be taken to protect the groundwater outside of the POP zone. If sufficient data to make such a determination are not available, additional wells may be installed to fill in the data gaps.
- If it is determined that the groundwater outside of the POP zone has potential to be impacted, Powertech (USA) will initiate a corrective action plan that will include one or more of the following actions:
    - Change operating parameters of the associated land application system, including reducing land application rate in a specified area or throughout the affected land application system.
    - Initiate a pump back or pump and treat plan to recover the alluvial groundwater. Affected water will be pumped back into the ponds and treated as necessary prior

to land application in other areas or disposal in an alternate, appropriately permitted facility such as a Class V UIC well.

Should the concentration of any one or more parameter in any compliance well exceed the permit limit, Powertech (USA) will implement the following contingency plan:

- Verify probable out-of-compliance status, which will be defined in accordance with ARSD 74:54:02:26, which states: “Determination of probable out-of-compliance status shall be based on the sample value for any one groundwater contaminant that exceeds the permitted allowable limit, within the established laboratory quality assurance.”
- Upon determination of probable out-of-compliance status, accelerate the monitoring schedule in accordance with ARSD 74:54:02:27, which states: “The accelerated schedule requires monthly sampling in addition to quarterly sampling of the compliance monitoring point for the water contaminant which as met the criteria of § 74:54:02:26 for two months or until the facility is brought into compliance.”
- Out-of-compliance status will be defined by ARSD 74:54:08:28, which states:

  “Out-of-compliance status shall be based upon two consecutive samples which exceed the permitted allowable limit by two standard deviations as calculated for the groundwater contaminant at the compliance monitoring point or statistically higher concentrations in the compliance monitoring point over that of the permitted allowable limit determined as follows:

  (1) Statistical significance shall be determined using the one-tailed Mann-Whitney U Test at the 0.10 level of significance;
  (2) Compliance testing shall use data from the two analyses immediately preceding accelerated monitoring and all accelerated monitoring data to date, with a minimum of four accelerated sample data values, from the compliance monitoring point paired against the permitted allowable limit.”

- The following contingency plan will be initiated for a compliance well determined to be out-of-compliance:
  - Immediately notify the secretary of the DENR or a representative authorized to act for the secretary by phone within 24 hours.
  - Submit a written statement confirming the oral report within 30 days.
  - Initiate a pump back or pump and treat plan to recover the groundwater from within the POP zone in the vicinity of the compliance well. Affected water will be pumped back into the ponds and treated as necessary prior to land application in other areas or disposal in an alternate, appropriately permitted facility such as a Class V UIC well.
  - Accelerate the monitoring schedule to weekly until the facility is brought into compliance and three consecutive weekly samples are within compliance limits.

8.1.2 Bedrock Groundwater

Bedrock groundwater quality will be protected from potential impacts from the land application systems by the thickness and confining properties of the Graneros Group shales, which separate the proposed land application systems from bedrock aquifers.

8.1.3 Domestic Wells

Powertech (USA) will protect domestic wells in and near the project area throughout all phases of the Dewey-Burdock Project. As described in Section 3.7.2.3.1, Powertech (USA) will remove all domestic wells within the project area from private use prior to ISR operations. Domestic well replacement procedures are described in Section 3.7.2.3.1 will include drilling a new domestic well or extending a Madison water supply pipeline to the residence. Replacement wells will be protected from potential impacts by locating wells outside of the POP zones, constructing them in accordance with ARSD 74:02:04, and completing them in formations outside of the ore zone targeted in the nearest well fields. This will ensure that there is no plausible pathway for contamination of domestic wells from the proposed land application systems. This will be verified through operational monitoring as described in Section 6.1.4.

8.1.4 Modeling Potential Postclosure Impacts

The SPAW model was used to estimate the potential postclosure impacts of the land application system. The objective of the postclosure modeling was to determine if there would be a potential for continuing downward migration of water and salts after cessation of land application operations. In order to conservatively estimate potential operational and postclosure impacts, the wettest 15-year period of record was modeled during operations and repeated for two cycles after operations (30-year postclosure modeling period). The wettest 15-year period of record was 1986 to 2000. This period of record yielded the deepest penetration of the water during the operational land application modeling simulations.

During the 15 years of operational monitoring, the irrigation parameters described in Section 5.7.3 were used. The SPAW model was continued for 30 additional years by repeating the 15-year precipitation and temperature inputs. During the 30-year postclosure modeling period, no irrigation water was input.

Table 8.1-1 presents the 15-year modeling results for the Dewey land application area during operations. The average input and output values match those shown in Table 5.7-5 for simulation number 7. Table 8.1-2 presents the 30-year postclosure modeling results for the Dewey land

application area. The results show lower average annual runoff during the postclosure period (4.3 versus 5.5 inches), lower annual average infiltration (9.3 versus 18.8 inches), lower annual average percolation (-0.01 versus 0.08 inch), no deep percolation, and a reversal of the change in soil moisture (-0.02 versus 0.42 inch).

Table 8.1-3 presents the 15-year modeling results for the Burdock land application area during operations. The average input and output values match those shown in Table 5.7-5 for simulation number 7. Table 8.1-4 presents the 30-year postclosure modeling results for the Burdock land application area. As with the Dewey model, the results show similar decreases during the postclosure period in average annual runoff, infiltration, percolation, and soil moisture.

The results of the postclosure modeling show that using the wettest 15-year period of record for climatic inputs, there would be no net downward movement of water beneath the land

Table 8.1-1: Operational SPAW Field Modeling Results using Wettest 15-Year Period of Record - Dewey

YEAR	PET in	AET in	EVAP in	TRAN in	INT in	PRECIP in	IRRIG in	RUNOFF in	INFIL in	PERC in	DEEPDRN in	DLT-SM in	STRESS	YLDRED
1986	44.04	28.79	17.04	0	11.76	22.03	19.07	7.94	21.4	0.05	0	4.32	0	0
1987	44.04	28.36	16.48	0	11.87	12.36	19.07	2.2	17.36	0.56	0	0.32	0	0
1988	44.04	27.40	15.59	0	11.81	13.79	19.07	4.63	16.41	0.27	0	0.55	0	0
1989	44.04	28.91	17.06	0	11.85	15.58	19.07	4.75	18.06	0.21	0	0.79	0	0
1990	44.04	30.99	19.33	0	11.65	19.14	19.07	6.8	19.76	0.18	0	0.24	0	0
1991	44.04	29.21	17.29	0	11.92	15.03	19.07	4.53	17.65	0	0	0.37	0	0
1992	44.04	29.28	17.64	0	11.63	14.08	19.07	4.34	17.18	-0.01	0	-0.45	0	0
1993	44.04	32.92	20.93	0	11.99	22.31	19.07	7.7	21.69	0.01	0	0.75	0	0
1994	44.04	29.31	17.39	0	11.92	12.01	19.07	2.2	16.96	-0.01	0	-0.43	0	0
1995	44.04	32.03	20.22	0	11.81	18.32	19.07	5.49	20.1	0	0	-0.13	0	0
1996	44.04	31.28	19.54	0	11.74	17.6	19.07	4.9	20.02	0	0	0.48	0	0
1997	44.04	31.29	19.75	0	11.54	17.73	19.07	5.93	19.32	0	0	-0.43	0	0
1998	44.04	33.11	21.15	0	11.96	24.28	19.07	10.17	21.22	0	0	0.07	0	0
1999	44.04	30.28	18.37	0	11.91	17.17	19.07	6.54	17.78	-0.01	0	-0.57	0	0
2000	44.04	29.27	17.19	0	12.07	14.51	19.07	3.97	17.53	-0.04	0	0.37	0	0
Average	**44.04**	**30.16**	**18.33**	**0**	**11.83**	**17.06**	**19.07**	**5.47**	**18.83**	**0.08**	**0**	**0.42**	**0**	**0**

Table 8.1-2: Postclosure SPAW Field Modeling Results - Dewey

YEAR	PET in	AET in	EVAP in	TRAN in	INT in	PRECIP in	IRRIG in	RUNOFF in	INFIL in	PERC in	DEEPDRN in	DLT-SM in	STRESS	YLDRED
2001	44.04	14.91	10.95	0	3.96	22.03	0	6.92	11.15	0.01	0	0.20	0	0
2002	44.04	11.20	8.26	0	2.93	12.36	0	2.05	7.38	-0.05	0	-0.83	0	0
2003	44.04	9.73	7.36	0	2.37	13.71	0	4.23	7.11	-0.07	0	-0.18	0	0
2004	44.04	11.41	8.03	0	3.38	15.66	0	4.01	8.27	-0.05	0	0.29	0	0
2005	44.04	13.90	10.48	0	3.41	19.14	0	5.25	10.48	0.02	0	-0.03	0	0
2006	44.04	11.72	8.25	0	3.47	15.03	0	3.33	8.23	-0.02	0	0.00	0	0
2007	44.04	11.45	8.22	0	3.23	14.08	0	2.92	7.93	-0.02	0	-0.27	0	0
2008	44.04	16.00	11.74	0	4.26	22.31	0	5.54	12.51	0.01	0	0.76	0	0
2009	44.04	10.31	7.33	0	2.98	12.01	0	2.04	6.99	0.01	0	-0.35	0	0
2010	44.04	14.64	10.41	0	4.24	18.32	0	3.71	10.37	0.01	0	-0.05	0	0
2011	44.04	13.05	9.38	0	3.66	17.38	0	4.09	9.61	0.01	0	0.21	0	0
2012	44.04	14.17	10.45	0	3.72	17.93	0	4.03	10.2	0.03	0	-0.28	0	0
2013	44.04	16.58	12.53	0	4.05	24.28	0	7.33	12.9	0.02	0	0.34	0	0
2014	44.04	12.65	9.07	0	3.58	17.17	0	5.17	8.42	-0.02	0	-0.63	0	0
2015	44.04	10.67	7.41	0	3.25	14.51	0	3.82	7.44	-0.08	0	0.11	0	0
2016	44.04	14.46	10.50	0	3.96	22.03	0	6.92	11.15	0.05	0	0.60	0	0
2017	44.04	11.05	8.11	0	2.93	12.36	0	2.05	7.38	0	0	-0.73	0	0
2018	44.04	9.64	7.27	0	2.37	13.71	0	4.23	7.11	-0.04	0	-0.12	0	0
2019	44.04	11.27	7.89	0	3.38	15.66	0	4.01	8.27	-0.03	0	0.41	0	0
2020	44.04	13.89	10.51	0	3.38	19.11	0	5.25	10.48	0.04	0	-0.07	0	0
2021	44.04	11.69	8.22	0	3.47	15.03	0	3.33	8.23	-0.01	0	0.02	0	0
2022	44.04	11.43	8.20	0	3.23	14.08	0	2.92	7.93	-0.01	0	-0.26	0	0
2023	44.04	15.91	11.67	0	4.24	22.29	0	5.54	12.51	0.02	0	0.83	0	0
2024	44.04	10.37	7.42	0	2.95	12.03	0	2.04	7.03	0.01	0	-0.40	0	0

Table 8.1-2: Postclosure SPAW Field Modeling Results – Dewey (cont.)

YEAR	PET in	AET in	EVAP in	TRAN in	INT in	PRECIP in	IRRIG in	RUNOFF in	INFIL in	PERC in	DEEPDRN in	DLT-SM in	STRESS	YLDRED
2025	44.04	14.64	10.40	0	4.24	18.32	0	3.71	10.37	0.02	0	-0.05	0	0
2026	44.04	13.04	9.38	0	3.66	17.38	0	4.09	9.61	0.01	0	0.21	0	0
2027	44.04	14.13	10.40	0	3.72	17.95	0	4.03	10.2	0.03	0	-0.23	0	0
2028	44.04	16.68	12.62	0	4.06	24.28	0	7.33	12.9	0.02	0	0.26	0	0
2029	44.04	12.62	9.03	0	3.58	17.17	0	5.17	8.42	-0.02	0	-0.59	0	0
2030	44.04	10.66	7.41	0	3.25	14.51	0	3.82	7.44	-0.08	0	0.11	0	0
Average	**44.04**	**12.80**	**9.30**	**0.00**	**3.50**	**17.06**	**0.00**	**4.30**	**9.27**	**-0.01**	**0.00**	**-0.02**	**0.00**	**0.00**

Table 8.1-3: Operational SPAW Field Modeling Results using Wettest 15-Year Period of Record - Burdock

YEAR	PET in	AET in	EVAP in	TRAN in	INT in	PRECIP in	IRRIG in	RUNOFF in	INFIL in	PERC in	DEEPDRN in	DLT-SM in	STRESS	YLDRED
1986	44.04	26.83	15.07	0	11.76	22.03	19.07	6.92	22.42	1.77	0	5.58	0	0
1987	44.04	29.21	17.33	0	11.87	12.36	19.07	2.23	17.32	0.04	0	-0.05	0	0
1988	44.04	28.55	16.74	0	11.81	13.79	19.07	4.28	16.76	-0.01	0	0.03	0	0
1989	44.04	29.93	18.08	0	11.85	15.58	19.07	4.14	18.67	0.10	0	0.49	0	0
1990	44.04	31.85	20.19	0	11.65	19.14	19.07	6.58	19.97	0.00	0	-0.23	0	0
1991	44.04	29.52	17.60	0	11.92	15.03	19.07	4.59	17.59	-0.03	0	0.02	0	0
1992	44.04	30.27	18.64	0	11.63	14.08	19.07	3.06	18.46	-0.04	0	-0.14	0	0
1993	44.04	33.76	21.77	0	11.99	22.31	19.07	6.86	22.53	0.11	0	0.66	0	0
1994	44.04	29.49	17.58	0	11.92	12.01	19.07	2.04	17.12	-0.03	0	-0.43	0	0
1995	44.04	32.59	20.78	0	11.81	18.32	19.07	4.81	20.78	0.02	0	-0.02	0	0
1996	44.04	31.74	19.99	0	11.74	17.6	19.07	4.7	20.23	-0.01	0	0.24	0	0
1997	44.04	32.11	20.57	0	11.54	17.73	19.07	5.02	20.24	-0.05	0	-0.28	0	0
1998	44.04	34.14	22.18	0	11.96	24.28	19.07	8.76	22.63	0.14	0	0.31	0	0
1999	44.04	31.54	19.62	0	11.91	17.17	19.07	5.57	18.75	-0.18	0	-0.69	0	0
2000	44.04	29.37	17.30	0	12.07	14.51	19.07	3.82	17.69	0.04	0	0.35	0	0
Average	**44.04**	**30.73**	**18.90**	**0**	**11.83**	**17.06**	**19.07**	**4.89**	**19.41**	**0.12**	**0**	**0.39**	**0**	**0**

Table 8.1-4: Postclosure SPAW Field Modeling Results - Burdock

YEAR	PET in	AET in	EVAP in	TRAN in	INT in	PRECIP in	IRRIG in	RUNOFF in	INFIL in	PERC in	DEEPDRN in	DLT-SM in	STRESS	YLDRED
2001	44	18.64	14.69	0	3.96	22.03	0	3.21	14.86	0.08	0	0.09	0	0
2002	44	12.93	10	0	2.93	12.36	0	0.05	9.37	-0.17	0	-0.46	0	0
2003	44	11.81	9.45	0	2.37	13.71	0	1.89	9.46	-0.01	0	0.02	0	0
2004	44.04	13.46	10.08	0	3.38	15.66	0	1.6	10.68	0.11	0	0.49	0	0
2005	44	16.91	13.49	0	3.41	19.14	0	2.26	13.47	0.05	0	-0.07	0	0
2006	44	14.11	10.64	0	3.47	15.03	0	1.07	10.49	-0.07	0	-0.08	0	0
2007	44	14.33	11.1	0	3.23	14.08	0	0.03	10.81	-0.07	0	-0.22	0	0
2008	44.04	18.15	13.89	0	4.26	22.31	0	3.29	14.77	0.16	0	0.72	0	0
2009	44	12.5	9.53	0	2.98	12.01	0	0	9.03	-0.06	0	-0.43	0	0
2010	44	17.17	12.94	0	4.24	18.32	0	1.11	12.97	0.03	0	0	0	0
2011	44	15.92	12.26	0	3.66	17.38	0	1.39	12.31	-0.01	0	0.07	0	0
2012	44.04	16.82	13.1	0	3.72	17.93	0	1.36	12.87	-0.06	0	-0.18	0	0
2013	44	19.94	15.89	0	4.05	24.28	0	3.8	16.43	0.15	0	0.39	0	0
2014	44	15.65	12.06	0	3.58	17.17	0	2.41	11.18	-0.18	0	-0.7	0	0
2015	44	12.34	9.09	0	3.25	14.51	0	1.95	9.31	0	0	0.22	0	0
2016	44.04	18.48	14.52	0	3.96	22.03	0	3.2	14.87	0.12	0	0.23	0	0
2017	44	12.92	9.99	0	2.93	12.36	0	0.05	9.37	-0.16	0	-0.45	0	0
2018	44	11.81	9.45	0	2.37	13.71	0	1.89	9.46	-0.01	0	0.02	0	0
2019	44	13.39	10.01	0	3.38	15.66	0	1.6	10.68	0.11	0	0.56	0	0
2020	44.04	16.95	13.56	0	3.38	19.11	0	2.26	13.47	0.05	0	-0.14	0	0
2021	44	14.11	10.64	0	3.47	15.03	0	1.07	10.49	-0.06	0	-0.08	0	0
2022	44	14.33	11.1	0	3.23	14.08	0	0.03	10.81	-0.07	0	-0.22	0	0
2023	44	18.1	13.86	0	4.24	22.29	0	3.26	14.79	0.14	0	0.78	0	0
2024	44.04	12.58	9.63	0	2.95	12.03	0	0	9.08	-0.05	0	-0.5	0	0
2025	44	17.17	12.93	0	4.24	18.32	0	1.11	12.97	0.03	0	0.01	0	0

Table 8.1-4: Postclosure SPAW Field Modeling Results – Burdock (cont.)

YEAR	PET in	AET in	EVAP in	TRAN in	INT in	PRECIP in	IRRIG in	RUNOFF in	INFIL in	PERC in	DEEPDRN in	DLT-SM in	STRESS	YLDRED
2026	44	15.92	12.26	0	3.66	17.38	0	1.39	12.31	-0.01	0	0.07	0	0
2027	44	16.78	13.06	0	3.72	17.95	0	1.36	12.87	-0.05	0	-0.13	0	0
2028	44.04	20.06	16	0	4.06	24.28	0	3.78	16.45	0.15	0	0.31	0	0
2029	44	15.61	12.03	0	3.58	17.17	0	2.4	11.18	-0.18	0	-0.66	0	0
2030	44	12.34	9.09	0	3.25	14.51	0	1.95	9.31	0	0	0.22	0	0
Average	**44.01**	**15.37**	**11.88**	**0**	**3.50**	**17.06**	**0.00**	**1.69**	**11.87**	**0.00**	**0**	**0.00**	**0**	**0**

application areas following cessation of land application system operation. These model results demonstrate lack of potential to impact groundwater quality from the land application systems.

8.2 Surface Water

The two primary means of avoiding potential impacts to surface water quality are protection from flooding and containment of land application solutions. Specific mitigation measures are described below.

Flood Protection

The primary means of preventing impacts from flooding is siting the land application areas to avoid the floodplains of Pass Creek, Beaver Creek, and ephemeral tributaries. Figures 8.2-1 and 8.2-2 depict the location of the proposed land application facilities in relation to the modeled 100-year floodplains for Beaver Creek, Pass Creek, and ephemeral tributaries. These figures show that nearly all of the center pivots and catchment areas will be constructed to avoid potential flooding.

In cases where flood inundation areas cannot be avoided, Powertech (USA) will implement engineering controls to prevent impacts to the land application systems from flooding. These will include constructing diversion channels and berms. These engineering controls will be permitted through the DENR Minerals and Mining Program as part of the LSM permit. Other engineering controls used to minimize potential impacts to surface water quality will include stormwater best management practices (BMPs) that will be implemented as part of a construction NPDES permit that will be required through DENR. Example stormwater BMPs that may be used to minimize potential impacts to surface water quality from construction of the land application systems include silt fence, sediment logs, and straw bale check dams.

Containment of Land Application Solutions

Powertech (USA) will provide containment for all land application solutions by constructing catchment areas around each center pivot. As described in Section 5.4, runoff from significant precipitation events or snowmelt on the land application areas will be conveyed to catchment areas within or adjacent to the pivot areas and allowed to evaporate or infiltrate. Sufficient catchment area capacity will be provided to contain the runoff from the 100-year, 24-hour storm. Powertech (USA) will monitor the catchment areas daily to ensure that there is not excessive ponding and that adequate capacity is available for containment of rainfall/runoff from the 100-year, 24-hour storm. Powertech (USA) will adjust the land application rate or

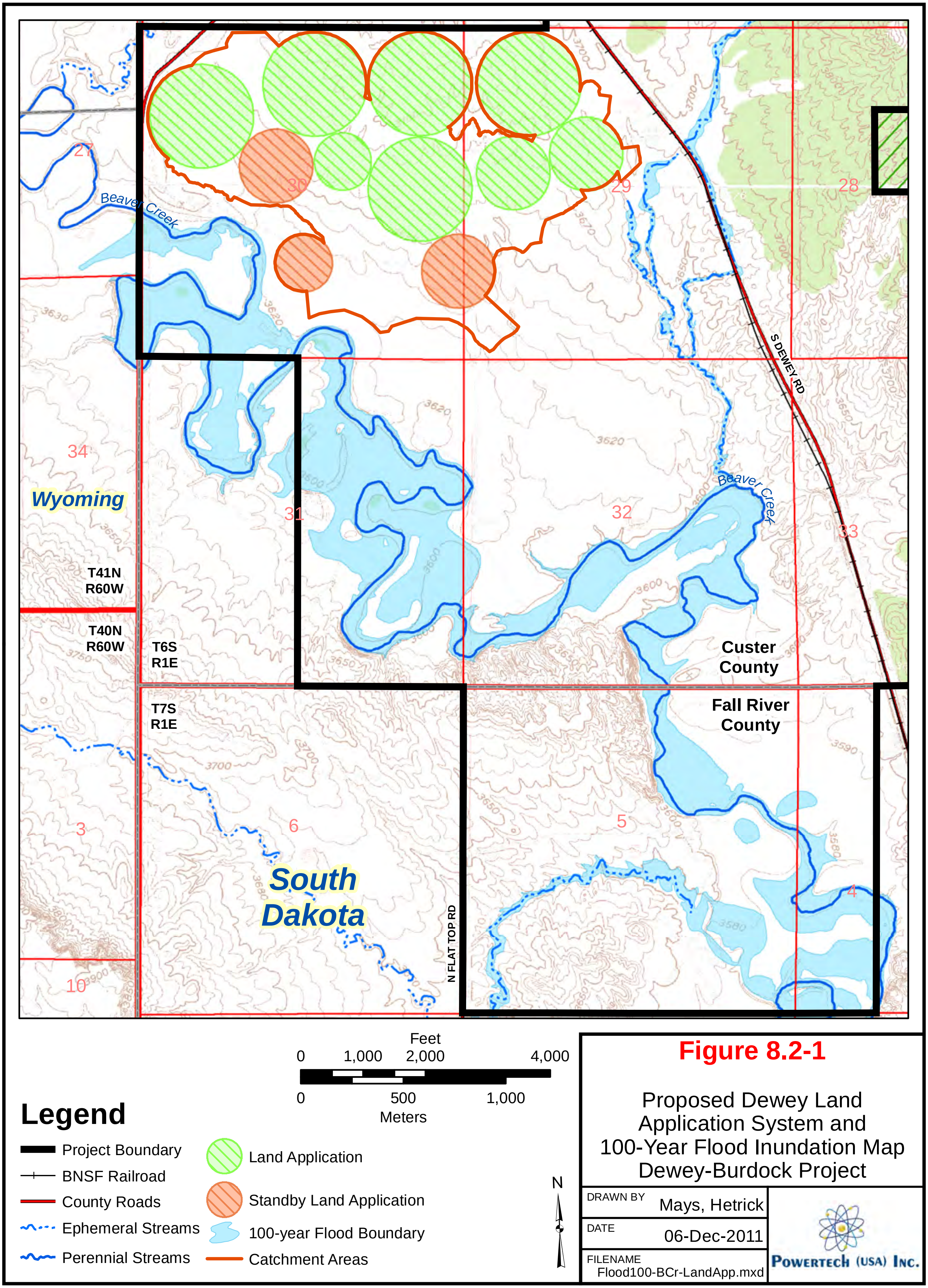


Figure 8.2-1

Proposed Dewey Land Application System and 100-Year Flood Inundation Map Dewey-Burdock Project

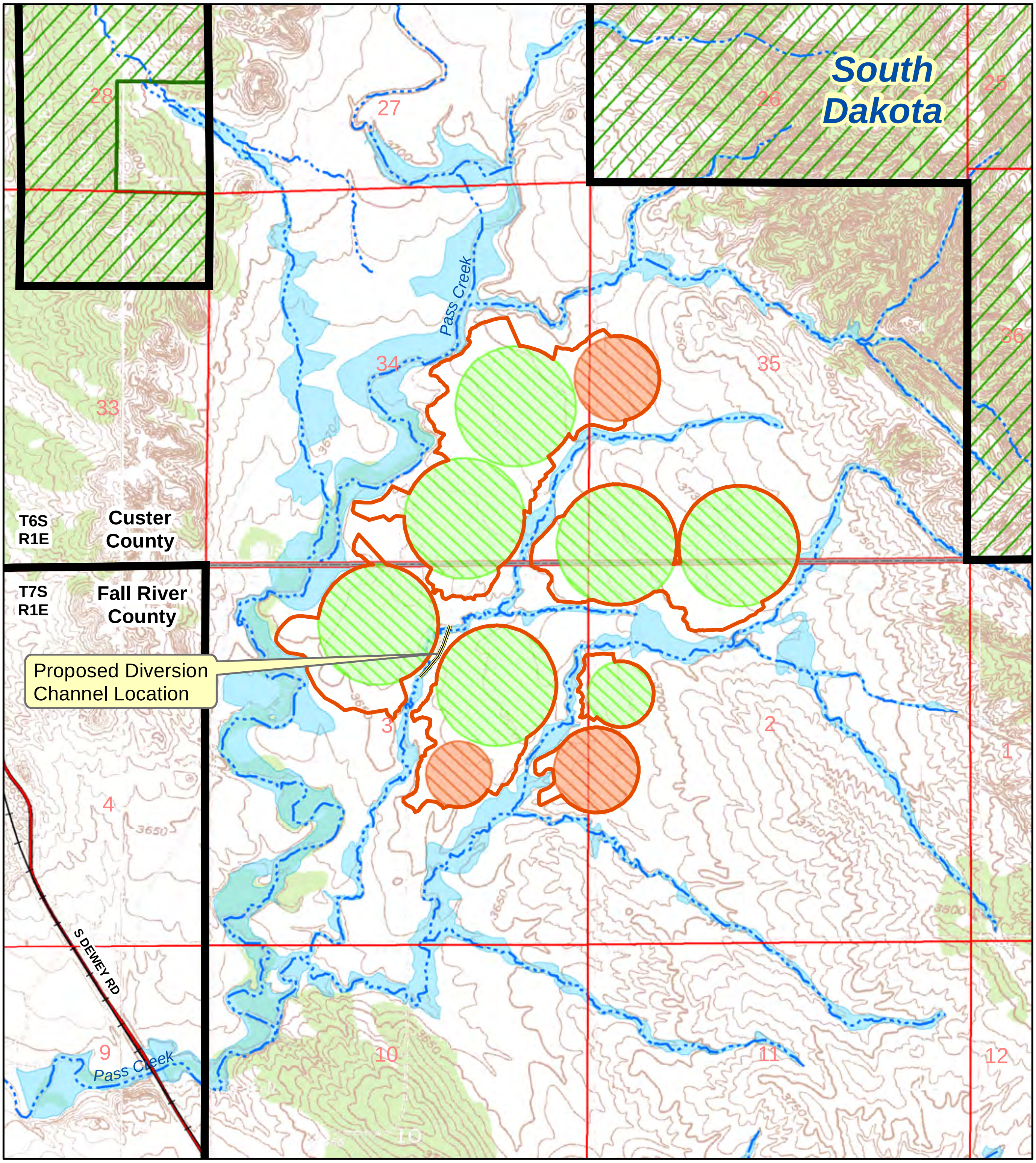


Figure 8.2-2

Proposed Burdock Land Application System and 100-Year Flood Inundation Map Dewey-Burdock Project

DRAWN BY	Mays, Hetrick
DATE	16-Feb-2012
FILENAME	Flood100-PCr-LandApp.mxd

POWERTECH (USA) INC.

dewater the catchment areas if the freeboard capacity limits are approached. The excess water will be conveyed to another catchment area with excess operating capacity, pumped to the storage ponds, or pumped to a land application pivot area. Powertech (USA) also will record daily precipitation totals and use this information along with the daily catchment area monitoring results to evaluate whether the catchment areas accumulate water during normal operations (i.e., dry conditions). If water accumulates in the catchment areas during dry conditions, Powertech (USA) will implement a dewatering program. The accumulated water will be conveyed to the storage ponds or pumped to a land application pivot area (primary or standby area).

8.3 Soil

During land application, there could be potential impacts to the soil from the buildup of salts, changes in SAR, buildup of radionuclides, buildup of metals and metalloids, and decrease in soil fertility. Mitigation of each of these potential impacts is described below.

Salinity and EC

The expected land application water quality is described in Section 5.8. With an anticipated TDS concentration of 1,000 to 5,000 mg/L, the water will pose a low to moderate risk to the growth of moderately sensitive crops such as alfalfa. Soil salinity levels will be controlled by blending the land application water in the ponds and by leaching salts below the root zone during land application. Powertech (USA) will operate the land application systems to balance the downward migration of water, which has potential alluvial groundwater impacts, with the leaching that will be used to control salt buildup in the root zone.

The anticipated SAR levels are 2 to 6, which should pose a low risk to soil infiltration rates. Should soil SAR increase and pose a risk to soil infiltration, Powertech (USA) will use amendments as necessary such as sulfur or gypsum.

Radionuclides

Since Powertech (USA) will treat the land application water to meet the 10 CFR Part 20, Appendix B, Table 2, Column 2 standards for release of radionuclides to the environment, it is unlikely that radionuclides will build up to potentially harmful levels. This will be verified through operational soil monitoring and additional surveys during decommissioning. Powertech (USA) has evaluated potential uranium chemical toxicity through various exposure pathways and determined that these concentrations should not result in chemical toxicity effects. These

concentrations will be the trigger levels for operational monitoring, at which the contingency plan described below will be implemented

During decommissioning, Powertech (USA) will conduct land cleanup in accordance with 10 CFR Part 40, Appendix A, Criterion 6(6) and DENR requirements. This includes cleaning up surface soils to standards for radium-226 and natural uranium that will be established as conditions in the NRC license as protective of human health and the environment.

Decommissioning will begin with a gamma survey to determine if there are areas requiring soil cleanup. Areas exhibiting contamination will be excavated and the affected soil disposed at an appropriately permitted facility. Compliance with cleanup standards will be verified through radiological gamma surveys and soil sampling with laboratory analysis. Upon completion of decommissioning activities, the NRC will release the site for unrestricted (i.e., any) use.

Metals and Metalloids

The concentrations of metals and metalloids, including arsenic and selenium, are anticipated to be low as shown in Table 5.8-2. Nevertheless, there is potential for buildup of metals and metalloids over time in the land application areas. Potential impacts will be mitigated by monitoring soil concentrations during operations and implementing a contingency plan if concentrations approach trigger values. Table 8.3-1 presents the proposed trigger values for arsenic and selenium in surface and subsurface soil.

Table 8.3-1: Trigger Values for Arsenic and Selenium in Soil

Parameter	Units	Trigger Value
Arsenic	mg/kg-dry	Baseline average concentration plus 2 standard deviations
Selenium	mg/kg-dry	Baseline average concentration plus 2 standard deviations

Powertech (USA) has evaluated the baseline concentrations of arsenic and selenium within the project area and determined that significant natural variability occurs in these parameters. Therefore, Powertech (USA) proposes to base the arsenic and selenium trigger values on the baseline concentration and natural variability. Specifically, Powertech (USA) proposes to collect four samples from each of two sample depths in each center pivot area as described in Section 6.4. For each sampling depth within each center pivot area, the trigger value will be established as the average baseline concentration plus two standard deviations.

Recognizing the potential for buildup of metals and metalloids other than arsenic and selenium, Powertech (USA) commits to sample an extensive list of metals and other trace elements as described in Section 6.4. Powertech (USA) will analyze the results of monitoring for all soil parameters in Table 6.4-1 and propose additional trigger values if increasing trends are observed. This analysis will be completed annually and provided in the written report submitted to DENR following each land application cycle described in Section 11.

Soil Fertility

Powertech (USA) may apply fertilizer to the land application areas to maximize crop production and maintain adequate soil fertility. Fertilizer will contain one or more of the three primary nutrients of nitrogen (N), phosphate (P_2O_5), and potash (K_2O). The alluvial water quality parameter list in Table 6.1-3 includes nitrate and potassium and will be adequate to detect any potential impacts to alluvial water quality from the use of fertilizer. These parameters are better indicators of potential impacts from fertilizer than phosphorus, which tends to adsorb to soil surfaces.

Contingency Plan

In the event that soil monitoring trigger values are exceeded, Powertech (USA) will implement a contingency plan consisting of one or more of the following action items:

- Verify sample results and precisely delineate affected areas through additional soil sampling and analysis.
- Modify land application system operating parameters to reduce the discharge rate in specific pivots or throughout the land application area.
- Implement water treatment if necessary for radionuclides, metals or metalloids.
- Implement a phytoremediation plan to control buildup of selenium in soil.
- Excavate soil contaminated above the reclamation standards established in the NRC license and LSM permit and dispose excavated soil in an appropriately permitted disposal facility.

8.4 Vegetation

Potential vegetation impacts include plant stress from increased salinity and toxicity from specific ions. The expected land application water quality is described in Section 5.8. With an anticipated TDS concentration of 1,000 to 5,000 mg/L, the water will pose a low to moderate risk to the growth of moderately sensitive crops such as alfalfa. Salinity can stunt plant growth by forcing the plant to work harder to extract water from the soil (Hanson et al., 1999). Salinity impacts will be mitigated by controlling the concentration of salinity in the land application water through blending in the ponds and through leaching the irrigation water and salts below the root zone as appropriate.

Three specific ions commonly associated with plant toxicity are sodium, chloride and boron. As indicated in Table 5.8-2, the concentration of sodium in land application water is expected to be about 100 to 500 mg/L, and the concentration of chloride about 300 to 1,300 mg/L. According to Hanson et al. (1999), alfalfa has a sodium chloride susceptibility level of 10 to 20 meq/L, primarily due to foliar injury from sprinkler irrigation. This is equivalent to a sodium concentration of 230 to 460 mg/L and a chloride concentration of 355 to 710 mg/L. Mitigation measures that will be used as needed to prevent sodium or chloride toxicity include controlling the land application water salinity as described above and selecting crops less susceptible to foliar damage. Boron is not anticipated to be present at significant concentrations, but the soil concentration will be monitored during operations to detect any build up. Boron in soil was sampled at varying depths at four locations within the proposed Dewey POP zone (Holes 72-75) and four locations within the proposed Burdock POP zone (Holes 39-42) during baseline soil

sampling. The boron concentration in the Dewey samples ranged from 0.2 to 2.5 mg/kg, and the boron concentration in the Burdock samples ranged from 0.2 to 7.7 mg/kg. Additional baseline characterization will occur prior to land application as described in Section 6.4.

Although the concentration of selenium is expected to be low in the land application water, selenium could build up in the land application soils. Selenium is also naturally found in the land application soils and has the potential to accumulate in the land application area vegetation during and after operations. Selenium in soil was sampled at varying depths at 22 locations within the proposed Dewey POP zone (highlighted in Appendix 3.2-A) and 16 locations within the proposed Burdock POP zone (highlighted in Appendix 3.2-A) during baseline soil sampling. The selenium concentration in the Dewey samples ranged from <0.01 to 3.0 mg/kg, and the selenium concentration in the Burdock samples ranged from <0.01 to 2.1 mg/kg. Additional baseline characterization will occur prior to land application as described in Section 6.4.

During operations Powertech (USA) will monitor the potential buildup of metals, metalloids, and radionuclides in irrigated vegetation as described in Section 6.5. Should routine monitoring indicate an increasing trend in constituent concentrations, a contingency plan will be implemented that will include one or more of the following action items:

- Verify sample results and precisely delineate affected areas through additional vegetation sampling and analysis.
- Modify land application system operating parameters to reduce the discharge rate in specific pivots or throughout the land application area.
- Implement water treatment if necessary for radionuclides, metals or metalloids.
- Implement a phytoremediation plan to control buildup of selenium in soil.
- Plant alternate crops that have increased tolerance to the specific ions of concern.

8.5 Livestock and Wildlife

Potential impacts to livestock and wildlife include potential toxicity impacts from consuming vegetation grown in the land application areas and potential impacts to humans resulting from the consumption of livestock that consume vegetation from the land application areas. Mitigation of each of these potential impacts is discussed below.

Powertech (USA) will work with affected landowners to prevent grazing on land application areas during land application. Potential mitigation measures include fencing and pasture rotation.

As described in Section 6.6, Powertech (USA) will collect annual samples of livestock if they have grazed within the land application areas or been fed crops grown in the land application areas. Livestock tissue samples will be analyzed for selenium and arsenic to detect the potential accumulation of metals and metalloids. Based on the low expected concentration of these parameters in the land application water, there is a low potential for impacts. As such, Powertech (USA) may request to have the livestock sampling frequency reduced following demonstration of no potential impacts to DENR.

Based on modeling of the potential radiological impacts from the Dewey-Burdock Project presented in the NRC license application, Powertech (USA) does not anticipate that livestock grazed anywhere within the project area will represent a potentially significant exposure pathway (an exposure pathway should be considered significant if the predicted dose to an individual would exceed 5% of the applicable radiation protection standard per NRC guidance). This will be verified through livestock tissue sampling collected during the first year of operation for comparison to baseline. A grab sample taken at the time of harvest or slaughter will be analyzed for natural uranium, radium-226, thorium-230, lead-210 and polonium-210.

Powertech (USA) does not propose to sample wild game. The migratory nature and relatively large home range of game animals in relation to the size of the land application areas make the potential impacts very low.

9.0 POSTCLOSURE MONITORING

Surface reclamation postclosure monitoring will be conducted as part of the LSM permit, which will include land application area disturbance.

Following is the postclosure monitoring plan proposed specifically for the Groundwater Discharge Plan in accordance with ARSD 74:54:02:06 (9) (d) and (e). In order to demonstrate that groundwater outside of the POP zones remains unaffected after operations, Powertech (USA) will sample interior wells and compliance wells annually for 30 years following operations, or until release of this requirement has been granted by DENR. Monitor wells will be sampled according to the procedures described in Section 6.1 and analyzed for the parameters in Table 6.1-3. Results will be reported in an annual report to DENR as described in Section 11.

The contingency plan described in Section 8.1.1 will be followed if the water quality in interior monitor wells exhibits an increasing trend in constituent concentrations that could potentially trigger a compliance limit violation at a compliance well or if the concentration of any parameter in a compliance well exceeds the compliance limit.

Bonding for postclosure monitoring associated with the Groundwater Discharge Plan will be incorporated into the postclosure bond for the LSM permit.

10.0 INSPECTIONS

The following inspection procedures will be followed to verify facility operations and to detect potential failure of any component of the land application systems in accordance with ARSD 74:54:02:06. Inspections will be performed on the storage ponds, pumps and piping systems, land application pivot areas, and catchment areas.

Storage Ponds

All ponds associated with the Dewey-Burdock Project will be inspected as required by the NRC license. Inspection procedures for the storage ponds will include:

- Daily inspections of the liner, liner slopes, and other earthwork features
- Daily inspections of pond freeboard to ensure adequate containment capacity is available for the 100-year, 24-hour storm
- Quarterly inspections of embankment settlement and slope stability. Unscheduled inspections will be performed after occurrence of significant earthquakes, tornadoes, intense local rainfall, or other unusual events.

Pumps and Piping Systems

The land application pumps and aboveground pipe, connections and fittings will be inspected daily by field personnel. Operating pressures of the buried piping systems will also be monitored during these visits. In addition, the flow rate of the water pumped to the land application systems will be monitored. Should the pressure/flow fluctuate outside of normal operating ranges, the affected line will be shut down.

Land Application Pivots

Areas of surface disturbance within the land application sites will be stabilized and revegetated following surface disturbance. During operation of the land application systems, each center pivot will be inspected by field personnel daily during periods of solution application for any unplanned effects such as erosion, sedimentation, and damage to vegetation or wildlife.

Additionally, any stormwater control BMPs will be inspected in accordance of the requirements of the construction and industrial stormwater control NPDES permits.

Catchment Areas

Field personnel will inspect the catchment area berms weekly for signs of erosion or other damage. Daily inspections will be required of the water level in each catchment area to ensure that adequate freeboard is maintained for the 100-year, 24-hour storm.

Postclosure Inspections

Postclosure inspection of reclaimed surface disturbance will be conducted as required by the LSM permit.

11.0 REPORTING

Powertech (USA) will establish and maintain records and prepare and submit reports in accordance with the requirements of SDCL 34A-2-44 and ARSD 74:54:02.

In accordance with ARSD 74:54:02:19, Powertech (USA) will verbally notify DENR upon commencement of operation of the land application system. Written notice of the start-up will follow within 30 days. DENR will also be notified of the discontinuance of land application and the reason for the stoppage within 10 days with written notice within 30 days. If stoppage is due to an upset condition, such as spill or leak, DENR will be notified immediately.

Per ARSD 74:54:02:20, Powertech (USA) will submit a written report to the DENR following each land application cycle. Prior to the end of each year, Powertech (USA) will prepare and submit a written report including the following information for each of the land application systems (Dewey and Burdock):

1) The total amount of land application solution applied
2) The total hydraulic loading rate per acre
3) The total metals loading rate per acre, including all of the trace and minor elements and radiological parameters in Table 6.1-3
4) All sampling data, including alluvial groundwater, Fall River Formation groundwater, streams and impoundments, domestic wells, land application discharge water, soil, vegetation, and livestock
5) An analysis of potential increasing trends in the concentration of all soil sampling parameters in Table 6.4-1 and proposed additional trigger values, if applicable
6) The results of daily catchment area monitoring to ensure that water does not accumulate in the land application areas during normal operations (i.e., dry conditions) and that freeboard capacity limits are not exceeded
7) Description of any catchment area dewatering activities
8) A general discussion of the success of the system

Powertech (USA) will notify DENR by phone of any out-of-compliance conditions, including groundwater sample results, soil or vegetation sampling results, or release of land application solutions outside of the ponds, center pivot areas, or catchment areas within 24 hours. This includes reporting within 24 hours any spill, leak, or accidental release which threatens waters of the State in accordance with ARSD 74:54:02:25. A written statement confirming the oral report will be submitted to DENR within 30 days.

Records of all sampling activities and laboratory analyses will be maintained as hard copy originals or stored electronically. All records will be stored in a manner to prevent loss from fire, flood, or other unforeseen events beyond the control of Powertech (USA). All records will be maintained both on-site and at an off-site location until Groundwater Discharge Permit termination, except postclosure monitoring reports, which will be maintained off-site until the postclosure monitoring is terminated.

12.0 REFERENCES

Dorn, R.D., 2001, "Vascular Plants of Wyoming, 3rd Edition", Mountain West Publishing, Cheyenne, Wyoming. 289 pp.

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.

Farnsworth, R.K. and Thompson, E.S., 1982. "*Evaporation Atlas for the Contiguous 48 United States. NOAA Technical Report NWS 33"*, National Weather Service. Washington, DC.

Fitzgerald, J.P., C.A. Meaney, and D.M. Armstrong, 1994 "*Mammals of Colorado*" Denver Museum of Natural History, Denver, Colorado.

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.

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.

Hanson, B., S.R. Grattan and A. Fulton, 1999, Agricultural Salinity and Drainage, University of California Irrigation Program, UC Davis, Revised 1999.

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/

IML Air Science, 2011, hourly average data from the Wyoming Refining Company Meteorological Monitoring Station, Newcastle, Wyoming, 2002-2011.

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.

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

Powertech (USA) Inc., 2009, Dewey-Burdock Project Application for NRC Uranium Recovery License, Fall River and Custer Counties, South Dakota, Technical Report, August 2009.

Rao, A.R., and Hamed, K.H., 2000, "*Flood Frequency Analysis*", CRC Press.

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.

Saxton, K.E. and P.H Willey, 2006, "*The SPAW Model for Agricultural Field and Pond Hydrologic Simulation*, Chapter 17 in *Mathematical Modeling of Watershed Hydrology"*, V.P. Singh and D. Frevert, Editors; CRC Press, pp 401-435.

Saxton, K.E., 2006, "*SPAW (Soil-Plant-Air-Water) Field and Pond Hydrology Computer Model"*, Version 6.02.75. U.S.D.A. Agricultural Research Service.

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.

South Dakota Department of Game, Fish & Parks (SDGF&P), Undated, "*Prairie Stream Sampling, Region 1*", 2 pages.

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

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.

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

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