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.

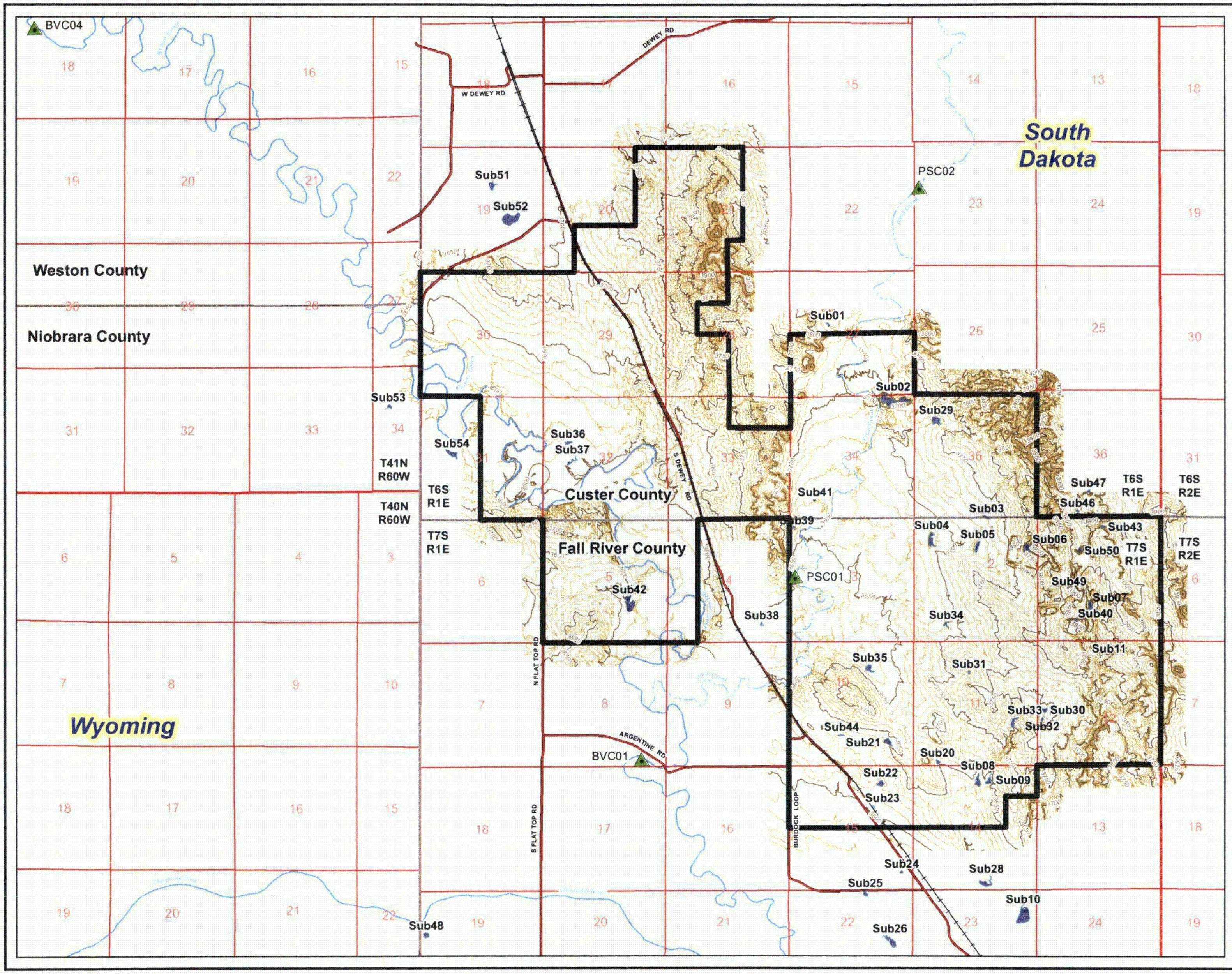


Figure 4.1-1

Baseline Surface Water Sampling Locations

Dewey-Burdock Project

DRAWN BY	S. Hetrick
DATE	28-Feb-2012
FILENAME	BaseSurfH2OSampLoc.mxd

POWERTECH (USA) INC.

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.

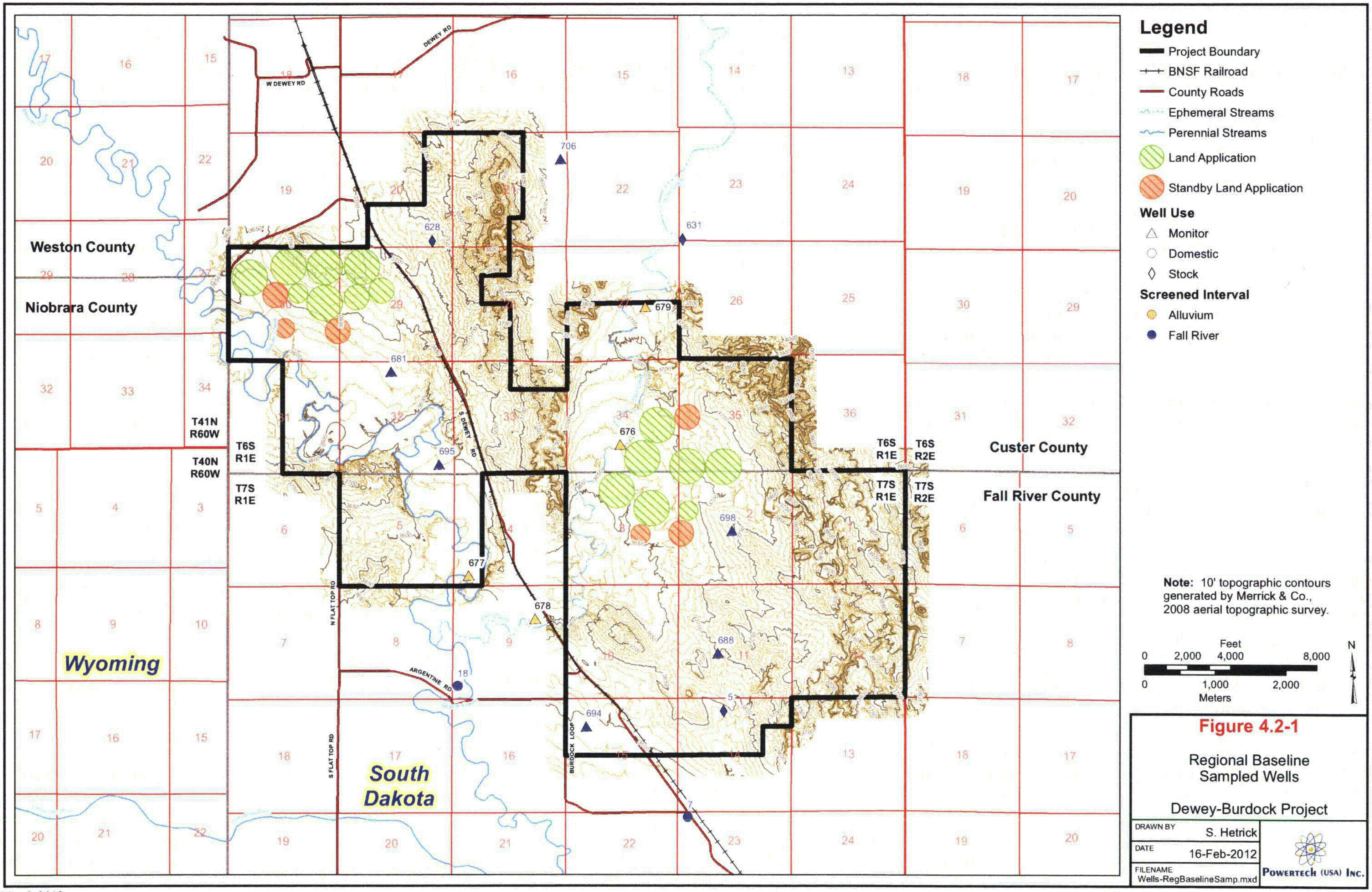


Figure 4.2-1
Regional Baseline Sampled Wells

- 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.

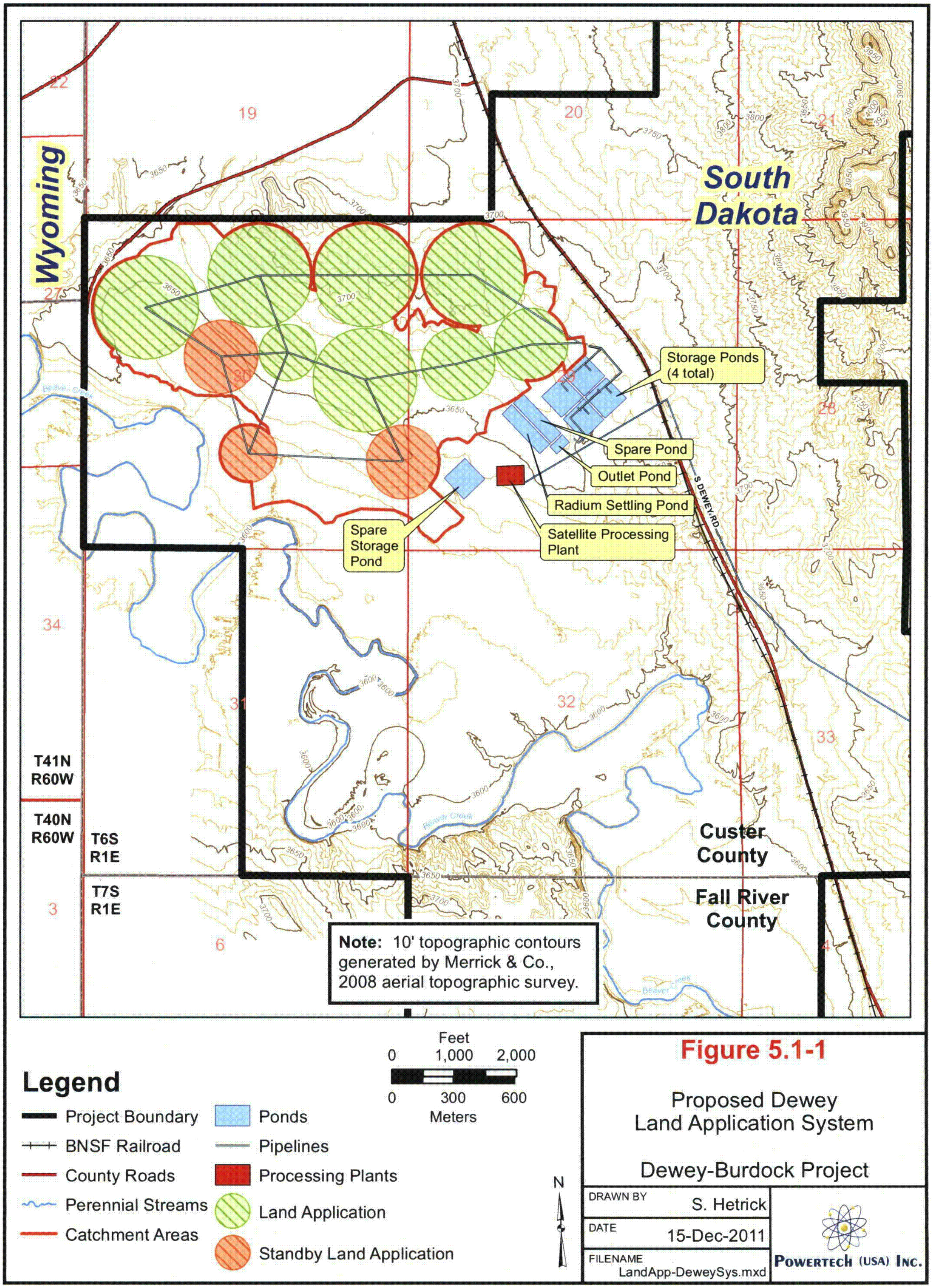
5.1 Dewey Land Application System Design

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.

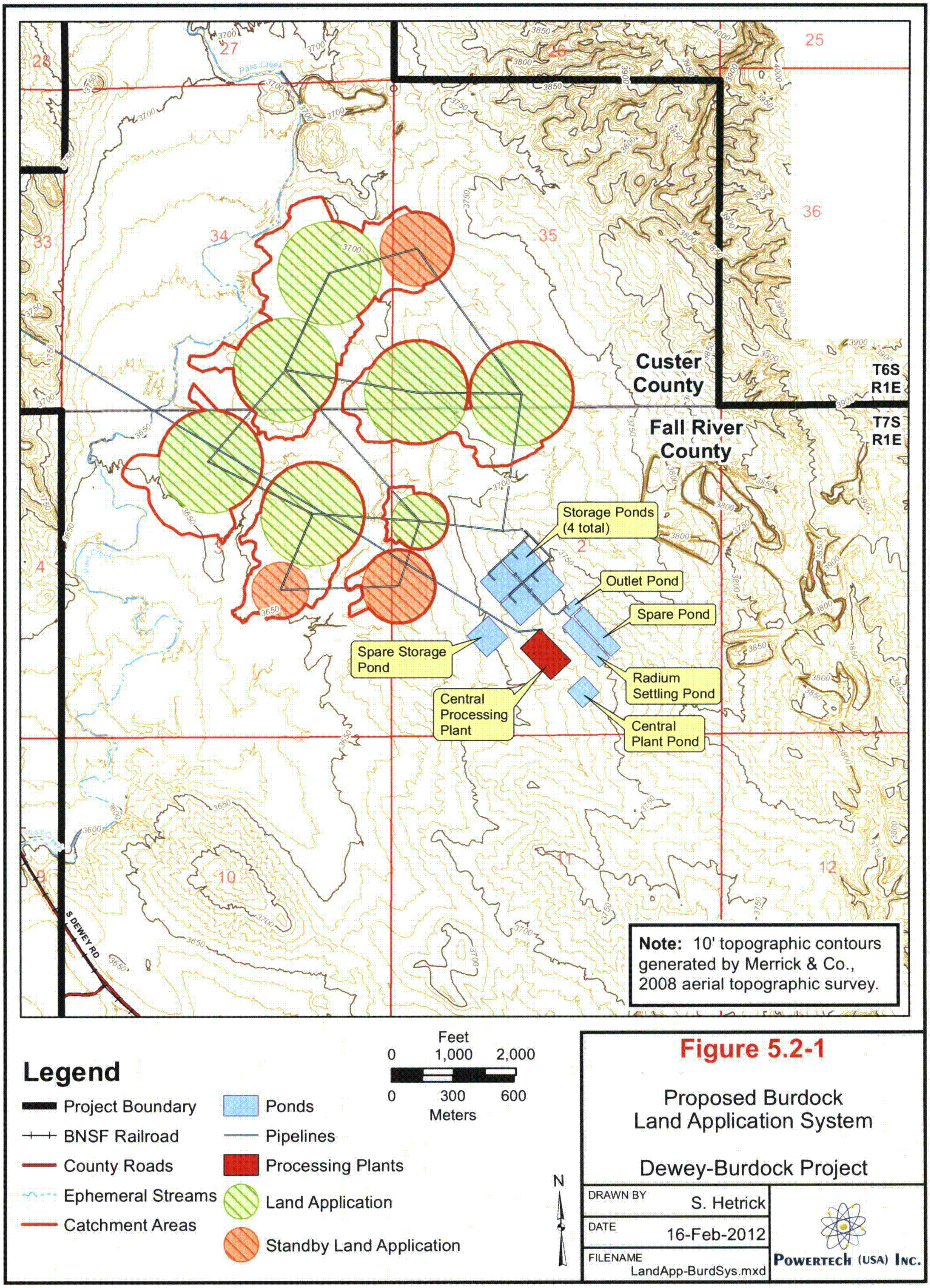
5.2 Burdock Land Application System Design

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.


Custer County
Fall River County
T6S R1E
T7S R1E
Storage Ponds (4 total)
Outlet Pond
Spare Pond
Spare Storage Pond
Radium Settling Pond
Central Processing Plant
Central Plant Pond
S DEWEY RD
Note: 10' topographic contours generated by Merrick & Co., 2008 aerial topographic survey.
Legend
Project Boundary
BNSF Railroad
County Roads
Ephemeral Streams
Catchment Areas
Ponds
Pipelines
Processing Plants
Land Application
Standby Land Application
Feet
0 1,000 2,000
0 300 600
Meters
N
Figure 5.2-1
Proposed Burdock Land Application System
Dewey-Burdock Project
DRAWN BY S. Hetrick
DATE 16-Feb-2012
FILENAME LandApp-BurdSys.mxd
POWERTECH (USA) INC.

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.

All of the ponds will be lined with a primary geosynthetic liner and secondary clay liner as described above. The radium settling, spare and central plant ponds will include two geosynthetic liners, a compacted clay liner, and a leak detection system. 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.

5.4 Catchment Areas

Runoff from significant precipitation events or snowmelt on the land application areas will be conveyed to collection areas downgradient from the land application 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 runoff from the center pivot areas to 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. The catchment areas will be constructed with berms and will be graded to prevent any runoff from applied water and rainfall on the land

application areas from reaching surface water. Berms surrounding the land application areas and catchment areas will also prevent any surface water from entering or leaving the land application areas. Catchment area capacities were estimated using the SPAW model as described below.

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 5.1-2. 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 5.1-2 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 5.1-2, 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

<u>5.7.2.1 Meteorological Parameters</u>

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 3.2-4. 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. 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. 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

6.1.1.1 Alluvial Monitor Wells

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
Interior wells	BI-1	SENW	3	7S	1E	Proposed
	BI-2	NWSE	3	7S	1E	Proposed
	BI-3	NWNE	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

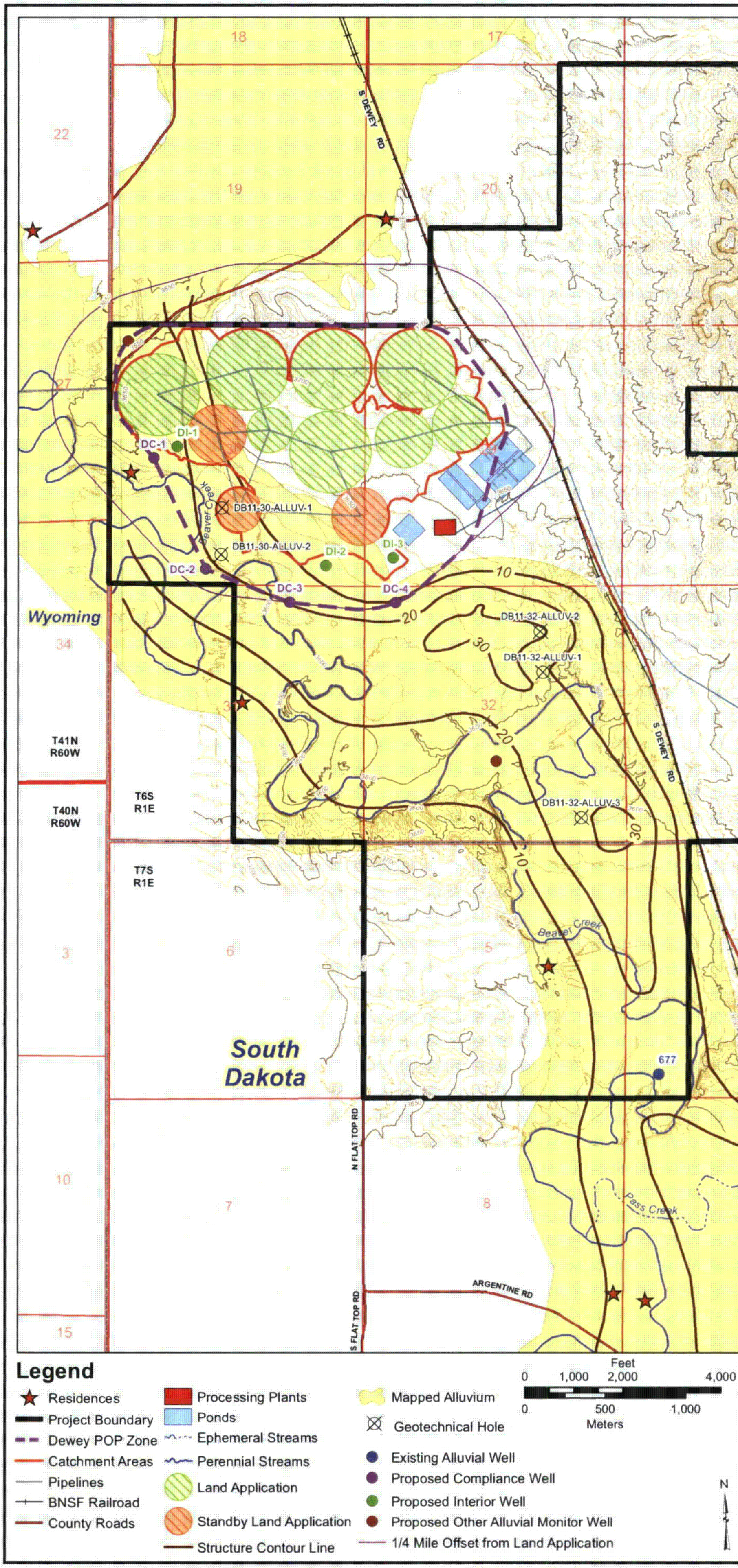


Figure 6.1-1

Proposed Alluvial Monitor Wells
Dewey Land Application Area

Dewey-Burdock Project

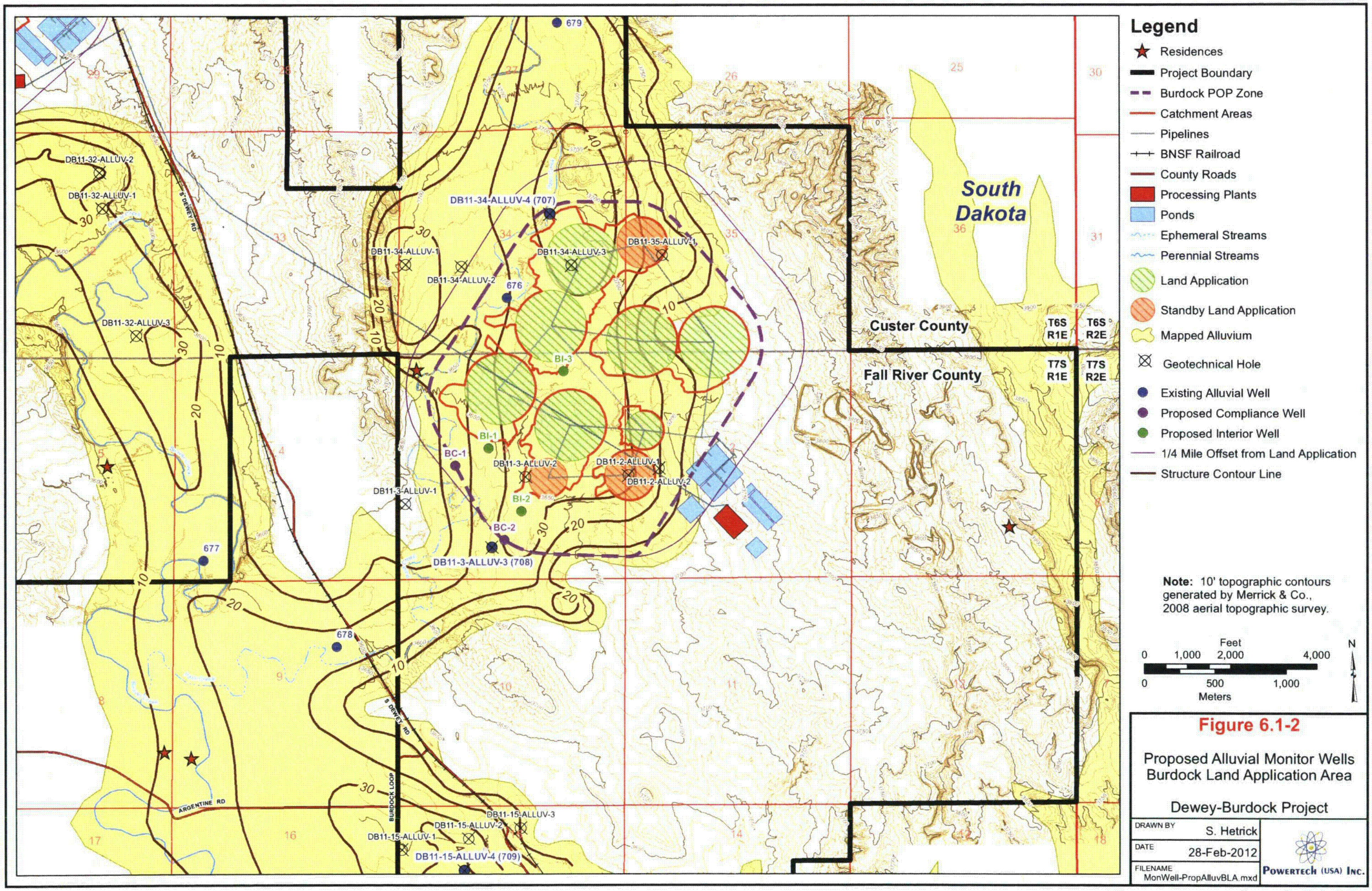


Figure 6.1-2

Proposed Alluvial Monitor Wells
Burdock Land Application Area

Dewey-Burdock Project

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DATE	28-Feb-2012
FILENAME	MonWell-PropAlluvBLA.mxd

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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

Table 6.1-3: Water Quality Parameter List

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

≠ Field and Laboratory
+ Laboratory only
††Excluding radon, radium, and uranium
§ If initial analysis indicates presence of Th-232, then Ra-228 will be considered within the baseline sampling program or an alternative may be proposed.

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

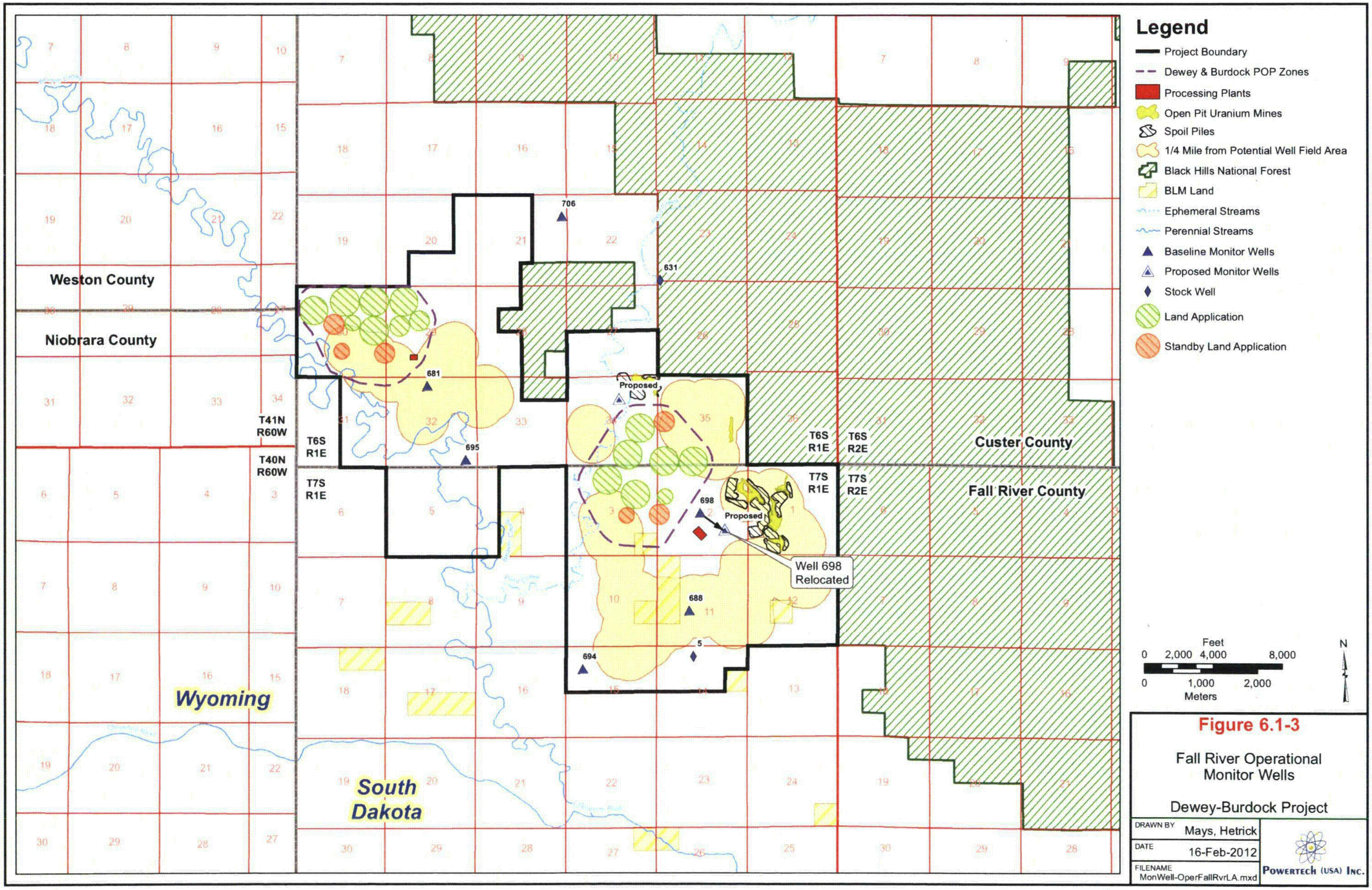
Due to the thickness and confining properties of the Graneros Group shales, which separate the proposed land application systems from bedrock aquifers, Powertech (USA) does not propose to establish POP zones or compliance monitor wells in the bedrock aquifers (Section 3.6.2 discusses the site geology 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.


Legend
Project Boundary
Dewey & Burdock POP Zones
Processing Plants
Open Pit Uranium Mines
Spoil Piles
1/4 Mile from Potential Well Field Area
Black Hills National Forest
BLM Land
Ephemeral Streams
Perennial Streams
Baseline Monitor Wells
Proposed Monitor Wells
Stock Well
Land Application
Standby Land Application
Weston County
Niobrara County
Custer County
Fall River County
Wyoming
South Dakota
T41N R60W
T40N R60W
T6S R1E
T7S R1E
T6S R2E
T7S R2E
Proposed
Well 698 Relocated
706
631
681
695
698
688
694
5
Feet
0 2,000 4,000 8,000
0 1,000 2,000
Meters
N
Figure 6.1-3
Fall River Operational Monitor Wells
Dewey-Burdock Project
DRAWN BY Mays, Hetrick
DATE 16-Feb-2012
FILENAME MonWell-OperFallRvrLA.mxd
POWERTECH (USA) INC.

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.

6.2 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. 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

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
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.

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,
- 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. Figure 3.4-6 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 25 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.

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 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 5.7, runoff from irrigation return flows and from rainfall on the land application areas will be conveyed to catchment areas at the downgradient edges of the land application areas and allowed to evaporate and 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

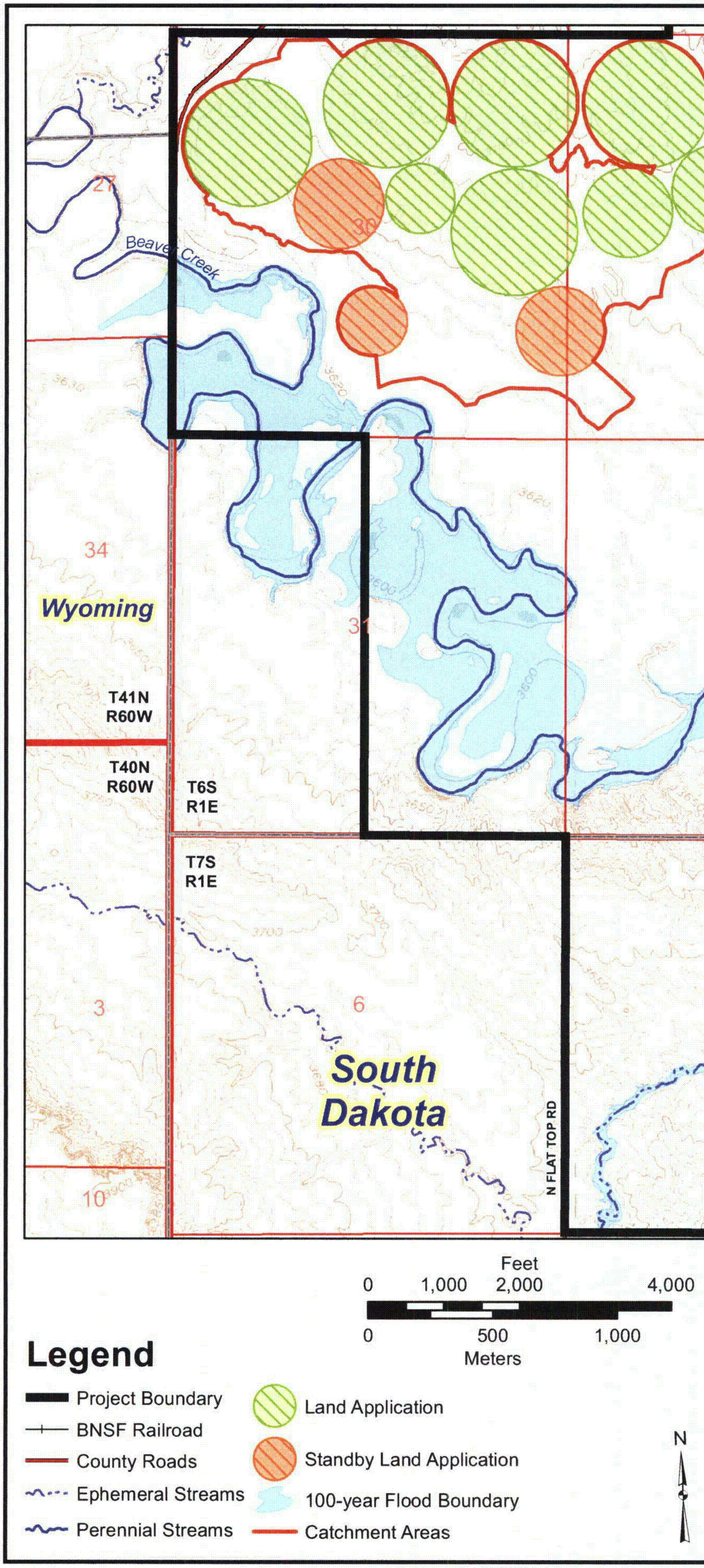


Figure 8.2-1

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

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

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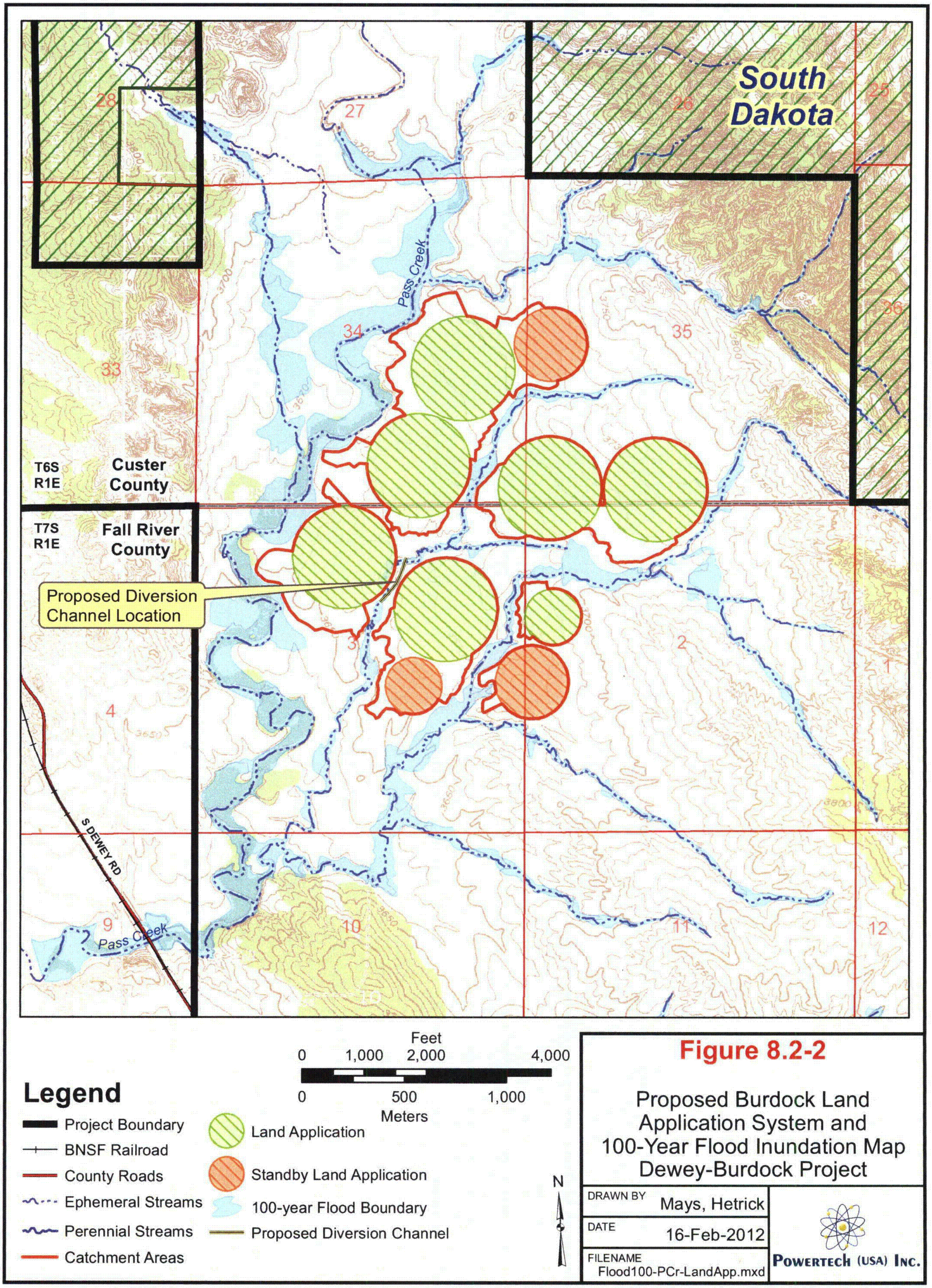

Figure 8.2-2

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

pump water from catchment areas if the freeboard capacity limits are approached. Berms surrounding the land application areas and catchment areas will prevent surface water from entering the land application areas.

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.

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, land application discharge water, soil, vegetation, and livestock
5) 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.

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