APPENDIX 6.1-A

Drawdown Inyan Kara

ANALYTICAL DRAWDOWN IMPACT ANALYSIS OF THE INYAN KARA AQUIFER DEWEY-BURDOCK URANIUM PROJECT, FALL RIVER AND CUSTER COUNTIES, SOUTH DAKOTA

Topical Report RSI-2174

prepared for

Powertech (USA) Inc.
310 2nd Avenue
Edgemont, South Dakota 57735

November 2010

RESPEC
CONSULTING & SERVICES

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Topical Report RSI-2174

by

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1.0 INTRODUCTION

Calculations were conducted to estimate the drawdown impacts to the Inyan Kara Aquifer in the vicinity of the Dewey-Burdock in situ recovery project. These analytical calculations were prepared to supplement existing drawdown calculations.

This report is organized to optimize available information and understanding of the potential drawdown impacts. Chapter 2.0 provides information on the methods used to predict drawdown. Chapters 3.0 and 4.0 provide results of calculations for the Lakota Aquifer and the Fall River Aquifer, respectively. Conclusions are provided in Chapter 5.0 with references in Chapter 6.0. Information contained in other interrelated reports are referenced as appropriate.

2.0 DRAWDOWN PREDICTION METHODS

2.1 PREDICTION APPLICATIONS

Drawdown predictions for both the Lakota and Fall River Aquifers were calculated using two different applications, all using the Theis analytical solution for confined aquifers. Assumptions of the Theis solution (as presented in Powertech [2009a]) include:

- The aquifer is homogeneous and isotropic.
- The aquifer is confined with uniform thickness and has an infinite extent.
- No recharge to the aquifer occurs.
- The pumping well is fully penetrating and receives water from the full thickness of the formation.
- All water removed from the well comes from aquifer storage which is released instantaneously when the head is lowered.
- The piezometric surface is horizontal before pumping.
- The well is pumped at a constant rate.
- The pumping well diameter is small so wellbore storage is negligible.

Using both applications, drawdown was predicted at 22 Inyan Kara wells, 11 in each the Lakota and Fall River Aquifers. The locations of these wells are presented in Appendix A. These wells were chosen for their spatial distribution across the project site with special emphasis on selecting domestic water supply wells. Additional information about these wells is available in Appendix 2.2-A of the NRC Technical Report (TR) [Powertech, 2009b].

2.1.1 <u>Application 1</u>

The first application used in this study involves a simple calculation of drawdown using the Theis equation in a spreadsheet developed by the U.S. Geological Survey (USGS) [Halford and Kuniansky, 2002]; this method was used in the drawdown calculations provided to the Nuclear Regulatory Commission (NRC) in the Environmental Report (ER) Section 4.6.2.6 [Powertech, 2009a]. As in the ER, the outcrop was assumed to be a straight-line barrier boundary and was modeled with "image" pumping wells. The location of this barrier boundary is slightly shifted and rotated from the original calculations to best represent the outcrop locations across the site. Original outcrop boundaries follow more closely just the outcrop at the north end of the project area. The locations of the outcrop barrier boundaries are shown in Figures A-1 and A-2 in Appendix A. The Lakota boundary in this study is about 3,400 feet east of the Fall River boundary, compared to a 4,000-foot offset in the calculation used in the ER Section 4.6.2.6 [Powertech, 2009a].

This spreadsheet application was used for the purpose of mimicking the process used in drawdown estimates already presented in the NRC permit application. However, this method of analysis is limited and time consuming. The spreadsheet is not capable of rapidly predicting drawdown versus time curves in situations where multiple barrier boundaries and multiple pumping wells are present. For this reason, a second predictive application was chosen.

2.1.2 Application 2

The second application involved predicting drawdown using Theis' equation in AQTESOLV, Version 4.0 [HydroSOLVE, 2006], a software program used for analysis of aquifer tests. Final calculations in AQTESOLV used the same input information with the exception that both the outcrop and the Dewey Fault served as barrier boundaries. Most available hydrogeologic information indicates that the Dewey Fault acts as a barrier boundary to groundwater flow in the Inyan Kara Aquifers (Boggs [1983]; Powertech [2009b]). As a result of the fault boundary, predicted drawdown values would be more representative of actual conditions. Note that for this study, the barrier boundary along the Dewey Fault had to be rotated a few degrees from the exact fault orientation as AQTESOLV requires two barrier boundaries be orthogonal to one another.

2.2 AQUIFER PROPERTIES

Aquifer properties used in these calculations mirror those used in the ER. Transmissivity and storativity values were derived from aquifer tests conducted in 1979, 1982, and 2008. Values used in this analysis are provided in Table 2-1. These values represent the median (2008 tests) and average (1979 and 1982 tests) properties obtained from multiple observation wells; for a complete description of these tests and associated aquifer properties please refer to Tennessee Valley Authority (TVA) reports [Boggs and Jenkins, 1980], Boggs, 1983, and Powertech, 2009b]. Applications 1 and 2 calculate estimated drawdown using each of these aquifer property scenarios at pumping rates of 20 gallons per minute (gpm). Application 2 calculations done with higher pumping rates used only aquifer properties listed under Scenario 1 and 5 (Table 2-1), as these values are believed to be the most representative of the aquifer in proximity of proposed mining operations.

2.3 PUMPING RATES

Based on water consumption estimates, 99 percent of Inyan Kara water usage near Burdock will be derived from the Lakota Aquifer (Table 2-2). Near Dewey, about 75 percent of the Inyan Kara water usage will be derived from the Fall River Aquifer. For simplification, it is assumed that all pumping in the Lakota Aquifer occurs at the site of the May 2008 pump tests at the Burdock site, and pumping in the Fall River Aquifer occurs at the site of the May 2008 pump tests at the Dewey site. As a result of this simplifying assumption, predicted drawdown values for Lakota Aquifer wells may be slightly lower than expected, while predicted impacts to Fall River Aquifer wells will be conservatively higher.

Table 2-1. Transmissivity and Storativity Values Used in Drawdown Predictions

Scenario No.	Date/Conductor	Transmissivity (ft^2/day)	Storativity (ft/ft)
Lakota Aquifer Tests			
1	1979–TVA	190	1.8×10^{-4}
2	1982–TVA	590	1.0×10^{-4}
3	2008–Powertech	150	1.2×10^{-4}
Fall River Aquifer Tests			
4	1979–TVA	54	1.4×10^{-5}
5	2008–Powertech	255	4.6×10^{-5}

Table 2-2. Relative Quantities of Water by Site and Aquifer

Item	Units	Lakota		Fall River		Total	
		Value	%	Value	%	Value	%
Based on Number of Production Wells (PWs)							
Burdock	PWs	880	98.9	10	1.1	890	100.0
Dewey	PWs	153	27.9	395	72.1	548	100.0
Project Total	**PWs**	**1,033**	**71.8**	**405**	**28.2**	**1,438**	**100.0**
Average Water Usage							
Burdock			**99.0**		**1.0**		**100.0**
Dewey			**25.3**		**74.7**		**100.0**

In the AQTESOLV application, real-world coordinates for observation wells were used as input. To represent the initial well fields, a single pumping well was also used in this application; however, actual operating procedures will involve the extraction from a number of evenly distributed wells over the entire area of a wellfield (about 2,000 to 3,000 acres). In an effort to determine the effect that a single pumping well versus the multiple wells in a wellfield would have on drawdown values, a calculation was also ran where ten randomly placed wells would pump a total of 20 gpm. Preliminary data indicate that drawdown results at nearby domestic wells are at such a distance that the use of a single pumping well is sufficient to model a well field (Figure 2-1). Values for single versus multiple pumped wells were typically ± 0.3 feet. Note this simplifying assumption would not be adequate to determine drawdown in or within close proximity of an active well field.

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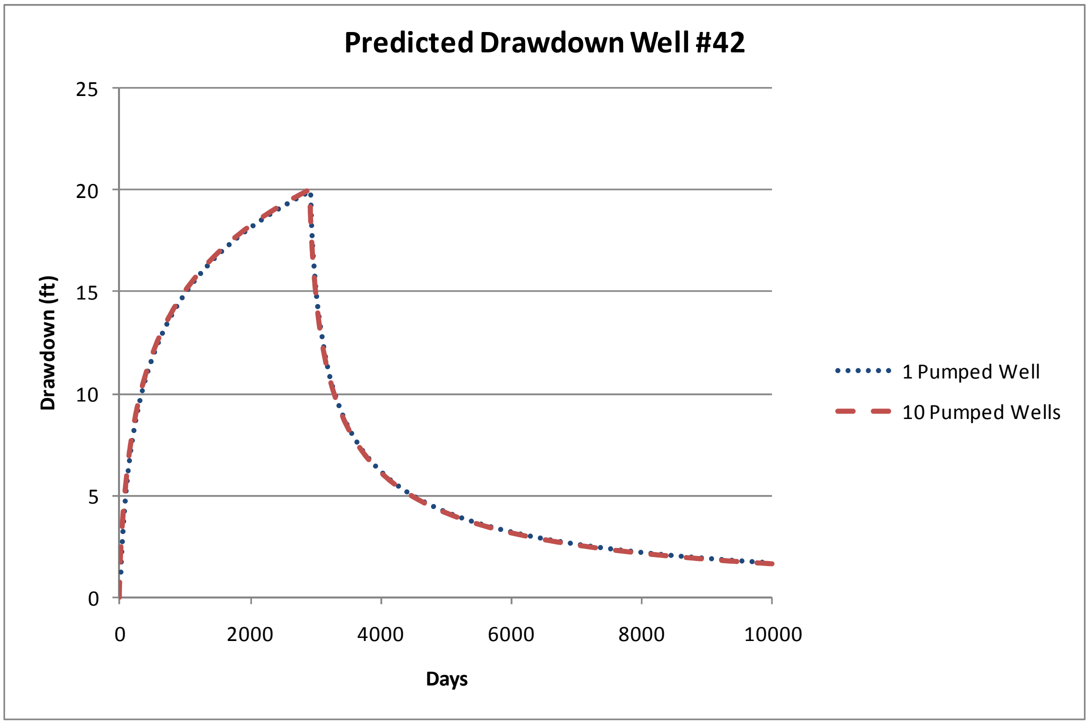

Figure 2-1. Comparison of Predicted Drawdown With One Versus Ten Pumped Wells in a Wellfield.

For calculations described under Application 1, the median bleed case of 1 percent of 2,000 gpm (20 gpm) was used. For Application 2 impact calculations, the bleed case was varied. For the Lakota Aquifer, impact calculations in this study were prepared for wellfield pumping rates of 20, 60, and 120 gpm cases. For the Fall River Aquifer, calculations were prepared for pumping rates of 20, 40, and 60 gpm.

Calculations for Application 1 were done for an active pumping period of 8 years. Application 2 calculations are performed for an active pumping period of 8, 14, and 20 years. It is anticipated that active mining will occur for 8 to 14 years. A time frame of 20 years was also included as restoration activities may be ongoing until that time as well as the fact that water rights permits are assigned on a 20-year basis. If operations were to continue longer than 20 years, drawdown impacts would need to be reevaluated in the future.

3.0 LAKOTA AQUIFER DRAWDOWN PREDICTIONS

3.1 APPLICATION 1

Drawdown estimates for 11 Lakota aquifer wells in the Dewey-Burdock area, based on the Theis spreadsheet analysis, are presented in Table B-1 of Appendix B. Distances from the pumping well range from 6,765 feet (Well # 619) to 32,075 feet (Well # 96).

Predicted drawdown values are greatest at wells closest to the pumping well and for the scenario using the 2008 pumping test aquifer properties (highest transmissivity). The highest drawdown value predicted at the end of 8 years of pumping is 18.3 feet (Well #16). The furthest well (# 96) has a maximum predicted drawdown of 7.6 feet.

In the ER Section 4.6.2.6, drawdown was predicted for only the nearest Lakota domestic well (# 13) at 8 years' time and using Application 1. Comparisons of results from the ER Section 4.6.2.6 [Powertech, 2009a] to results from this analysis are provided in Table 3-1. Results from this investigation are within about 10 percent of those from the previous investigation. Deviations are the result of differences in placement of the barrier boundary (outcrop) line. This comparison demonstrates that these drawdown predictions are consistent with those derived from previous investigations.

Table 3-1. Well # 13 Drawdown Comparison of Results in Environmental Report (ER) Versus Current Investigation

Test	ER	Current Investigation
1979	9.5 ft	10.4 ft
1982	4.9 ft	5.1 ft
2008	12.6 ft	13.9 ft

3.2 APPLICATION 2

A single drawdown-versus-time plot was generated for each set of aquifer properties using a 20 gpm pumping rate and period of 8 years (Figures C-1 to C-3 of Appendix C). The maximum drawdown values for all wells (other than the pumping well) are between 5 and 25 feet at 8 years of pumping 20 gpm.

The maximum predicted drawdown values for each of the selected wells at the specified time intervals and pumping rates are provided in Appendix D. Generally, predicted drawdown values increase with increases to the pumping rate and increased time of pumping. The maximum predicted drawdown values for the Lakota Aquifer occur after 20 years of pumping 120 gpm and are between 97 and 130 feet (Appendix D).

The most noticeable drawdown differences between applications are observed at wells closest to the Dewey Fault, notably Wells # 96 and # 615. The maximum drawdown observed on the AQTESOLV plots at these two wells in particular is about double the value calculated by Application 1. For example, the drawdown calculated using Application 1 with the 1979 aquifer test properties is 5.5 feet compared to about 10.1 feet. These differences indicate the simulation of the Dewey Fault as a barrier boundary does impact drawdown predictions, primarily increasing predicted drawdown at wells closest to the fault.

3.3 APPLICATION COMPARISON

For comparison of Applications 1 and 2, drawdown from three wells from each the Lakota and Fall River Aquifers were calculated using both the USGS spreadsheet and AQTESOLV (with and without the Dewey-Fault as a barrier boundary). The comparison results are all for a pumping rate of 20 gpm for a period of 8 years. Comparison graphs provided in Appendix E indicate that the USGS spreadsheet and AQTESOLV solution, both without the fault boundary, are nearly identical, as expected. Under similar pumping conditions and aquifer properties, predicted drawdown values from this calculation method are typically 25 to 100 percent greater than those determined from Application 1 (see Appendix E). Wells furthest from the fault show the least difference in drawdown, while wells closest to the fault have the greatest difference.

4.0 FALL RIVER AQUIFER PREDICTIONS

4.1 APPLICATION 1

Drawdown estimates for 11 Fall River Aquifer wells in the Dewey-Burdock area, based on the Theis spreadsheet analysis, are presented in Table B-2 of Appendix B. Distances from the pumping well range from 4,870 feet (Well # 695) to 29,710 feet (Well # 8).

Predicted drawdown values are greatest at wells closest to the pumping well and for the scenario using the 1979 pumping test aquifer properties (highest transmissivity). The highest drawdown value of 58.6 feet is predicted to occur at Well 695 after 8 years of pumping. The furthest well (# 8) has a maximum predicted drawdown of 35.6 feet.

In the ER, drawdown was predicted for only the nearest domestic well (# 18). Comparisons of results from the ER to results from this analysis are provided in Table 4-1. Results from this investigation are within about 10 percent of those from the previous investigation. Deviations are the result of differences in placement of the barrier boundary (outcrop) line. This comparison demonstrates that these drawdown predictions are consistent with those derived from previous investigations [Powertech, 2009b].

Table 4-1. Well # 18 Drawdown Comparison of Results in Environmental Report Versus Current Investigation

Test Year	ER	Current Investigation
1979	42.8 ft	43.8 ft
2008	9.9 ft	10.1 ft

4.2 APPLICATION 2

A single drawdown-versus-time plot was generated for each set of aquifer properties using a 20 gpm pumping rate and period of 8 years (Figures C-4 and C-5 of Appendix C). The maximum drawdown values for all wells (other than the pumping well), at a pumping rate of 20 gpm for a period of 8 years, are between 50 and 100 feet using the 1979 aquifer test properties and between 10 and 22 feet using the 2008 aquifer test properties. The significant range in predicted drawdown is the result of heterogeneities in the Dewey-Burdock area. It is important to note that the 1979 test was conducted near Burdock while the 2008 test was conducted near Dewey, the site of the first proposed mine units. For this reason, the drawdown results using aquifer properties from the 2008 Fall River test are more representative of anticipated results from mining in that area.

The maximum predicted drawdown values for each of the selected wells at the specified time intervals and pumping rates are provided in Appendix D. Generally, predicted drawdown values increase with increases to the pumping rate and increased time of pumping. The maximum predicted drawdown values for the Fall River Aquifer occur after 20 years of pumping 60 gpm and are between 55 and 80 feet (Appendix D).

Predicted drawdown values from the AQTESOLV calculation are typically 50 to 100 percent greater to those determined from Application 1 (see Appendix D). Unlike the calculations conducted for a Lakota wellfield near Burdock, the Fall River wellfield is much closer to the Dewey Fault barrier boundary, and hence, the effects of that boundary are much more apparent and play a greater role in increasing the amount of drawdown. Drawdown at wells closest to the fault are impacted the greatest by the fault boundary. Well # 622, for instance, is the closest well to the fault. Although Well # 622 is almost twice the distance from the pumping well as Well # 695, in less than a year's time and continuing through 8 years of pumping, it has a slightly greater drawdown than Well # 695 (Figure C-4 and Figure C-5 in Appendix C).

5.0 SUMMARY AND CONCLUSIONS

Analytical drawdown calculations were conducted using aquifer property values obtained from different aquifer pump tests. Predictions made from the USGS spreadsheet and in AQTESOLV with the use of only the outcrop boundary are comparable to previous calculations and indicate this study was conducted similarly. However, results from the AQTESOLV analysis indicate that the Dewey Fault barrier boundary does have significant impacts on drawdown calculations for wells in the project vicinity.

According to criteria for granting a water permit as set forth in South Dakota Codified Law) SDCL 46-2A-9, a proposed diversion will be approved only if it can be developed without unlawfully impairing existing rights. Existing Inyan Kara water rights (of which there are none in the immediate project area or vicinity) and domestic wells are protected from adverse impacts per rules SDCL 4:02:04 and 74:02:05; these rules provide that an adverse impact or impairment is one such that it inhibits the wells ability to produce water independent of artesian pressure. In other words, if water levels in the Inyan Kara Aquifer decline and the pump level can be lowered to below the top of the aquifer and still have the ability to produce water, the well is not considered impaired. In accordance with SDCL 46-1-4 and board-adopted findings, an increase in operating cost or decrease in production is not considered an adverse impact.

The maximum predicted drawdown within the Lakota Aquifer (Scenario 1 aquifer properties) occurs after 20 years of pumping 120 gpm with drawdown values between 77 and 130 feet. The maximum predicted drawdown within the Fall River Aquifer (Scenario 5 aquifer properties) occurs after 20 years of pumping 60 gpm with drawdown values between 55 and 80 feet. At the locality of existing wells, a maximum decrease of potentiometric head of 130 feet would not lower the water table below the top of the aquifer, and hence, these predicted drawdown values indicate any existing water use would not be lawfully impaired.

6.0 REFERENCES

Boggs, J. M. and A. M. Jenkins, 1980. *Analysis of Aquifer Tests Conducted at the Proposed Burdock Uranium Mine Site, Burdock, South Dakota*, Report No. WR28-1-520-109, prepared by the Tennessee Valley Authority.

Boggs, J. M., 1983. *Hydrogeologic Investigations at Proposed Uranium Mine Near Dewey, South Dakota*, Report No. WR28-520-128, prepared by the Tennessee Valley Authority.

Halford, K. J. and E. L. Kuniansky, 2002. *Documentation of Spreadsheets for the Analysis of Aquifer-test and Slug-test Data*, U.S. Geological Survey Open File Report 02-197.

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APPENDIX A

MAPS

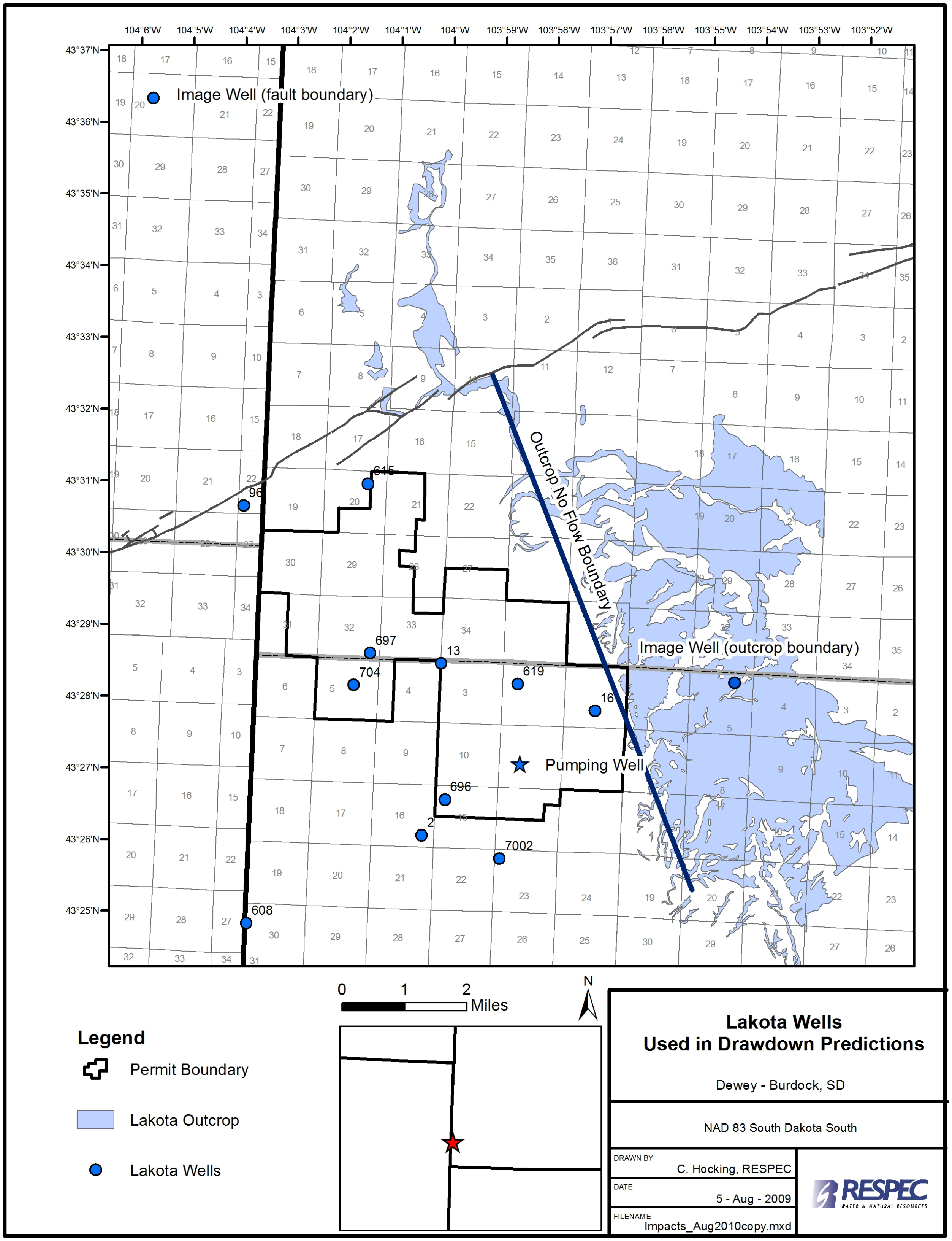


Figure A-1. Location of Lakota Wells Used in Drawdown Predictions.

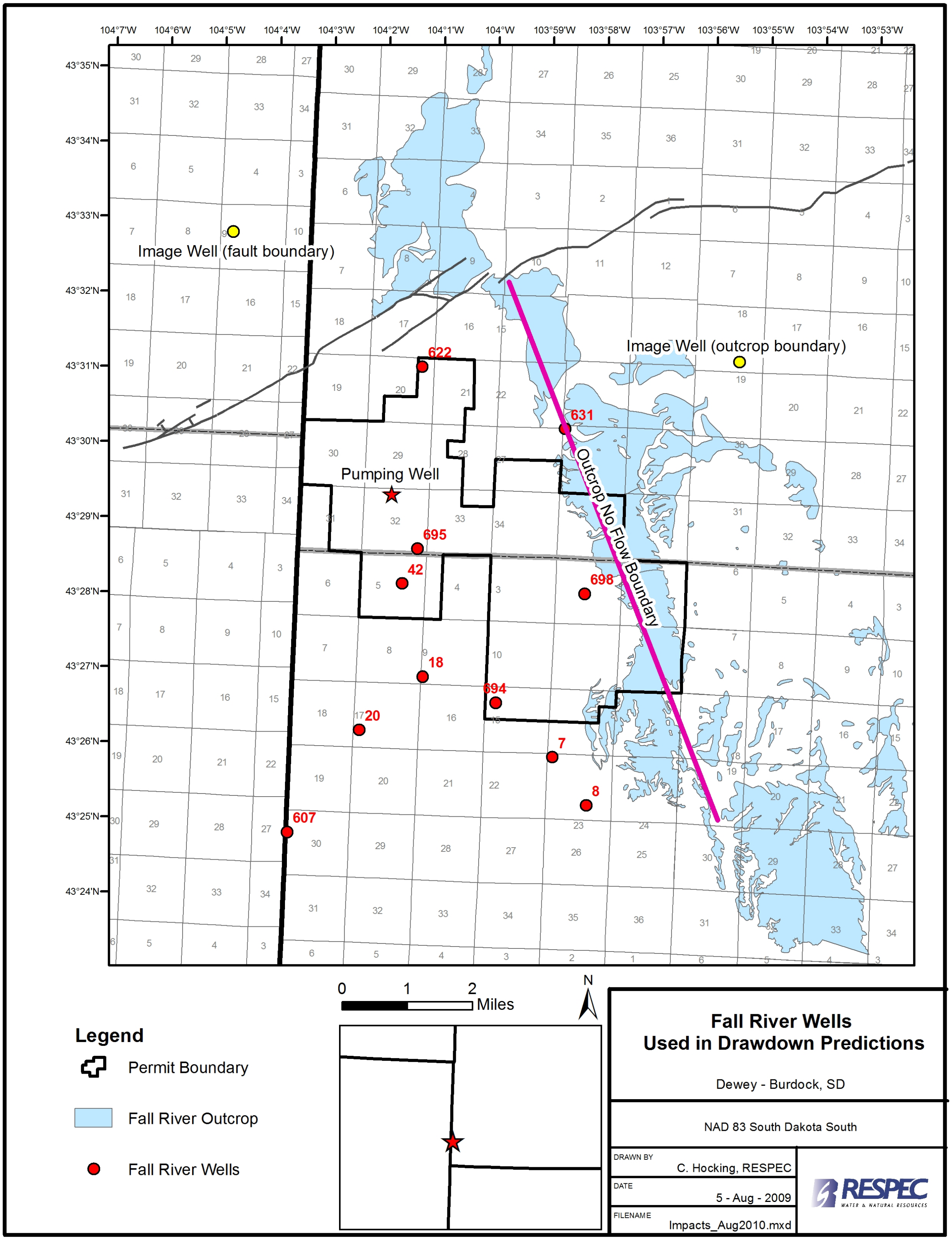


Figure A-2. Location of Fall River Wells Used in Drawdown Predictions.

APPENDIX B

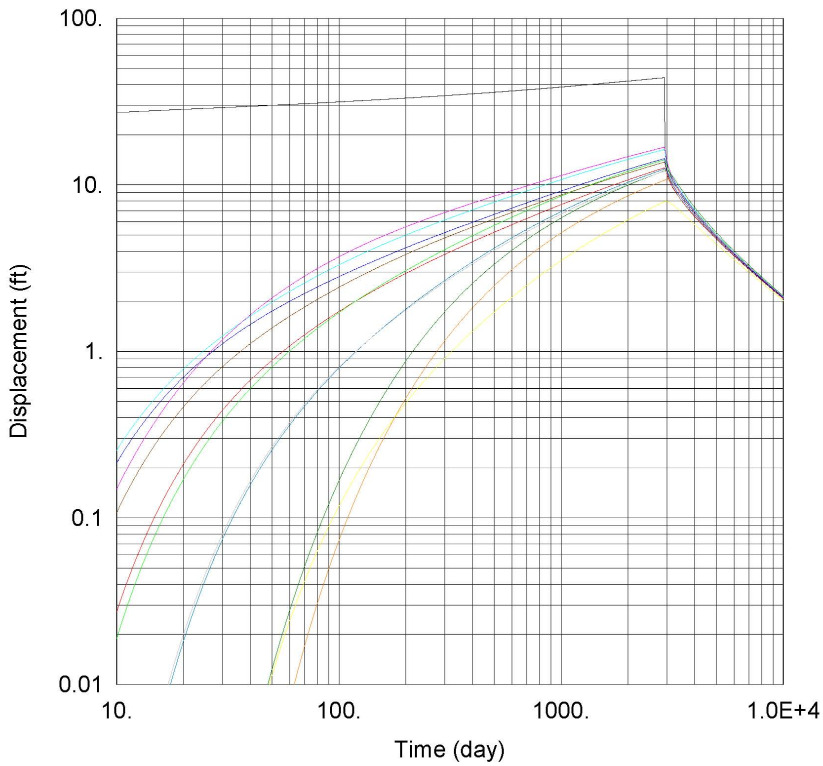
APPLICATION 1: U.S. GEOLOGICAL SURVEY SPREADSHEET DRAWDOWN PREDICTIONS

Table B-1. Burdock Well Field (Lakota Aquifer) Drawdown Estimates for Select Wells (All Values in Feet)

Scenario		Well No.										
		2	13	16	96	608	615	619	696	697	705	7002
1	1 yr	4.3	4.4	7.4	0.9	1.2	1.5	6.6	5.6	3.0	2.9	5.3
	2 yrs	6.1	6.3	9.5	2.0	2.4	2.9	8.7	7.5	4.7	4.6	7.2
	3 yrs	7.2	7.4	10.8	2.9	3.3	3.9	9.9	8.7	5.8	5.7	8.4
	4 yrs	8.1	8.3	11.7	3.6	4.0	4.7	10.8	9.6	6.6	6.5	9.3
	5 yrs	8.8	9.0	12.4	4.2	4.6	5.3	11.5	10.3	7.3	7.2	10.0
	6 yrs	9.3	9.5	13.0	4.7	5.1	5.8	12.1	10.8	7.8	7.7	10.6
	7 yrs	9.8	10.0	13.5	5.1	5.5	6.2	12.6	11.3	8.3	8.2	11.0
	8 yrs	10.2	10.4	13.9	5.5	5.9	6.6	13.0	11.7	8.7	8.6	11.4
2	1 yr	2.9	3.0	4.1	1.4	1.6	1.8	3.8	3.4	2.4	2.4	3.3
	2 yrs	3.6	3.7	4.8	2.1	2.2	2.5	4.5	4.1	3.1	3.1	4.0
	3 yrs	4.0	4.1	5.2	2.5	2.6	2.9	5.0	4.5	3.5	3.5	4.4
	4 yrs	4.3	4.4	5.5	2.8	2.9	3.2	5.2	4.8	3.8	3.8	4.7
	5 yrs	4.6	4.6	5.8	3.0	3.1	3.4	5.5	5.1	4.1	4.0	5.0
	6 yrs	4.7	4.8	6.0	3.2	3.3	3.6	5.7	5.2	4.3	4.2	5.2
	7 yrs	4.9	5.0	6.1	3.3	3.5	3.7	5.8	5.4	4.4	4.4	5.3
	8 yrs	5.0	5.1	6.3	3.5	3.6	3.9	6.0	5.5	4.5	4.5	5.5
3	1 yr	5.9	6.1	10.0	1.4	1.8	2.2	9.0	7.7	4.2	4.2	7.3
	2 yrs	8.3	8.5	12.7	3.0	3.5	4.2	11.7	10.2	6.5	6.4	9.8
	3 yrs	9.8	10.1	14.3	4.2	4.7	5.5	13.2	11.7	7.9	7.8	11.3
	4 yrs	10.9	11.2	15.5	5.1	5.6	6.5	14.4	12.8	9.0	8.9	12.4
	5 yrs	11.8	12.0	16.4	5.9	6.4	7.3	15.3	13.7	9.9	9.8	13.3
	6 yrs	12.5	12.7	17.1	6.5	7.1	8.0	16.0	14.4	10.6	10.5	14.0
	7 yrs	13.1	13.4	17.8	7.1	7.6	8.5	16.6	15.0	11.2	11.1	14.6
	8 yrs	13.6	13.9	18.3	7.6	8.1	9.1	17.2	15.5	11.7	11.6	15.2

APPENDIX C

APPLICATION 2: AQTESOLV DRAWDOWN CURVES BY AQUIFER PROPERTY SCENARIO (20 GALLONS PER MINUTE PUMPING RATE)



WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
BurdockLAK	1003477	429969

Observation Wells

Well Name	X (ft)	Y (ft)
BurdockLAK	1003477	429969
2	995123	423923
96	980028	451854
615	990571	453709
697	990748	439347
705	989365	436648
13	996759	438470
619	1003265	436729
16	1009828	434447
696	997086	426946
7002	1001731	421931
608	980229	416455

SOLUTION

Aquifer Model: Confined

Solution Method: Theis

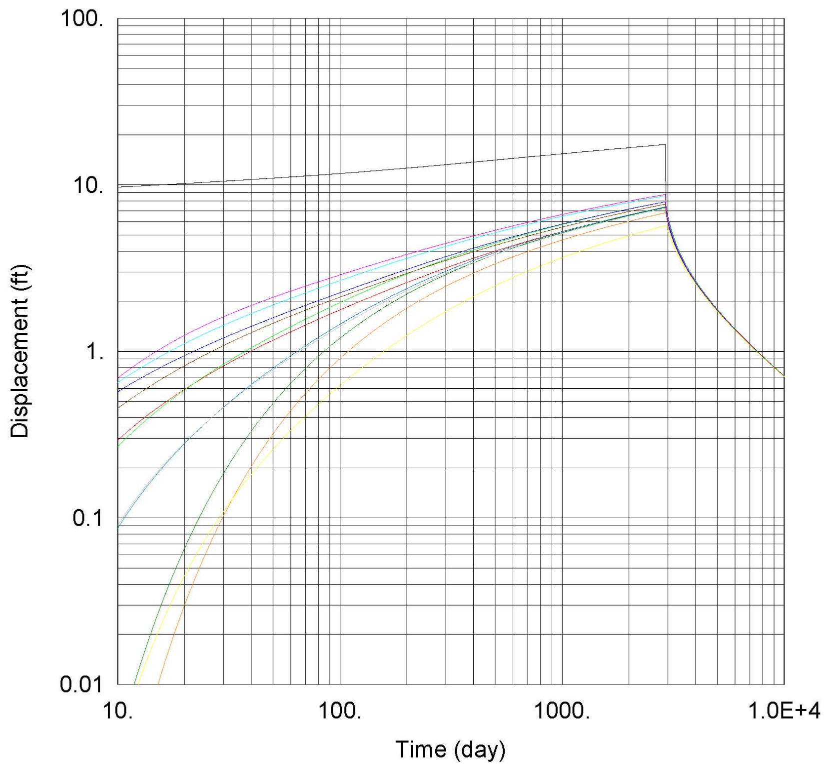
T = 190. ft^2/day

S = 0.00018

Kz/Kr = 1.

b = 100. ft

Figure C-1. Lakota Aquifer Drawdown Predictions for Nearby Wells Based on Aquifer Properties From Scenario 1 (1979 TVA Pump Test).



WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
BurdockLAK	1003477	429969

Observation Wells

Well Name	X (ft)	Y (ft)
BurdockLAK	1003477	429969
2	995123	423923
96	980028	451854
615	990571	453709
697	990748	439347
705	989365	436648
13	996759	438470
619	1003265	436729
16	1009828	434447
696	997086	426946
7002	1001731	421931
608	980229	416455

SOLUTION

Aquifer Model: Confined

Solution Method: Theis

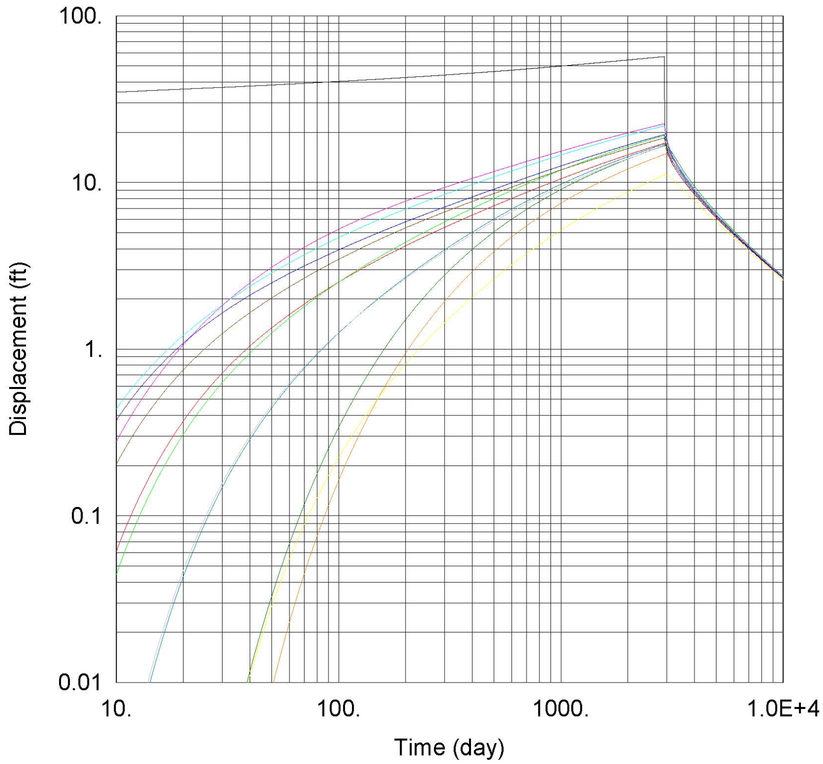
T = 590. ft^2/day

S = 0.0001

Kz/Kr = 1.

b = 100. ft

Figure C-2. Lakota Aquifer Drawdown Predictions for Nearby Wells Based on Aquifer Properties From Scenario 2 (1982 TVA Pump Test).



WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
BurdockLAK	1003477	429969

Observation Wells

Well Name	X (ft)	Y (ft)
□ BurdockLAK	1003477	429969
□ 2	995123	423923
□ 96	980028	451854
□ 615	990571	453709
□ 697	990748	439347
□ 705	989365	436648
□ 13	996759	438470
□ 619	1003265	436729
□ 16	1009828	434447
□ 696	997086	426946
□ 7002	1001731	421931
□ 608	980229	416455

SOLUTION

Aquifer Model: Confined

Solution Method: Theis

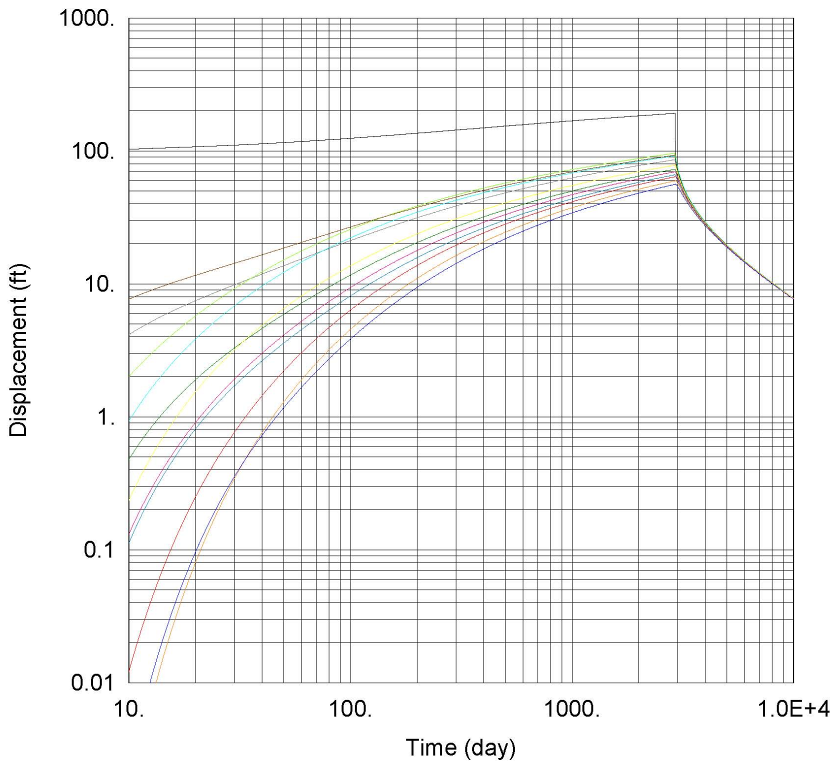
T = 150. ft^2/day

S = 0.00012

Kz/Kr = 1.

b = 100. ft

Figure C-3. Lakota Aquifer Drawdown Predictions for Nearby Wells Based on Aquifer Properties From Scenario 3 (2008 Powertech Pump Test).



WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
DeweyFR	988728	443725

Observation Wells

Well Name	X (ft)	Y (ft)
DeweyFR	988728	443725
7	1001703	422417
8	1004451	418515
18	991211	428960
20	986071	424628
42	989543	436481
607	980219	416378
622	991175	454034
631	1002734	448993
694	997116	426836
695	990783	439313
698	1004308	435651

SOLUTION

Aquifer Model: Confined

Solution Method: Theis

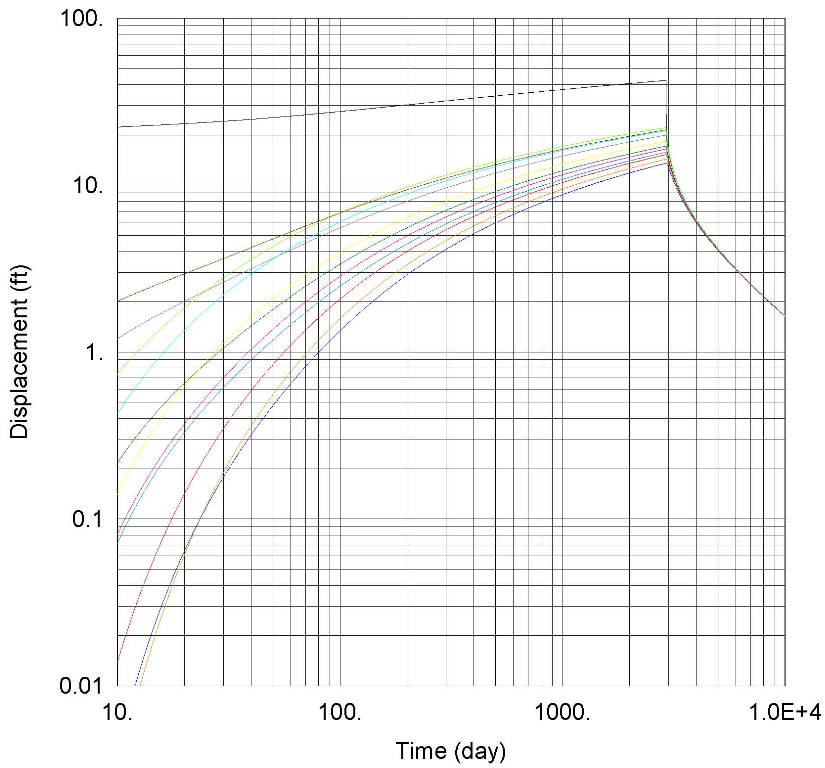
T = 54. ft^2/day

S = 1.4E-5

Kz/Kr = 1.

b = 100. ft

Figure C-4. Fall River Aquifer Drawdown Predictions for Nearby Wells Based on Aquifer Properties From Scenario 4 (1979 TVA Pump Test).



WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
DeweyFR	988728	443725

Observation Wells

Well Name	X (ft)	Y (ft)
DeweyFR	988728	443725
7	1001703	422417
8	1004451	418515
18	991211	428960
20	986071	424628
42	989543	436481
607	980219	416378
622	991175	454034
631	1002734	448993
694	997116	426836
695	990783	439313
698	1004308	435651

SOLUTION

Aquifer Model: Confined

Solution Method: Theis

T = 255. ft^2/day

S = 4.6E-5

Kz/Kr = 1.

b = 100. ft

Figure C-5. Fall River Aquifer Drawdown Predictions for Nearby Wells Based on Aquifer Properties From Scenario 5 (2008 Powertech Pump Test).

APPENDIX D

APPLICATION VARIABLE RATE AND DURATION DRAWDOWN PREDICTIONS

Table D-1. Burdock Well Field Drawdown Estimates for Select Lakota Aquifer Wells Using Scenario 1 Aquifer Properties (All Values in Feet)

Rate	Year	Well No.										
		2	13	16	96	608	615	619	696	697	705	7002
20	8	12.6	14.1	16.8	10.7	7.9	12.1	16.3	14.4	12.4	12.1	13.7
	14	15.8	17.4	20.1	13.9	10.8	15.5	19.6	17.5	15.7	15.3	16.8
	20	17.9	19.6	22.2	16.1	12.9	17.7	21.7	19.6	17.9	17.5	18.9
60	8	37.9	42.4	50.5	32.0	23.7	36.4	48.9	43.1	37.3	36.3	41.1
	14	47.3	52.2	60.2	41.8	32.5	46.4	58.7	52.6	47.1	46.0	50.4
	20	53.6	58.7	66.6	48.3	38.6	53.0	65.2	58.9	53.6	52.4	56.6
120	8	75.9	84.8	100.9	64.0	47.5	72.7	97.8	86.2	74.6	72.6	82.1
	14	94.6	104.4	120.3	83.6	65.0	92.8	117.4	105.2	94.2	92.0	100.7
	20	107.1	117.4	133.2	96.6	77.1	106.0	130.3	117.8	107.1	104.9	113.2

Table D-2. Dewey Well Field Drawdown Estimates for Select Fall River Aquifer Wells Using Scenario 5 Aquifer Properties (All Values in Feet)

Rate	Year	Well No.										
		7	8	18	20	42	607	622	631	694	695	698
20	8	15.2	14.3	17.1	15.7	19.9	13.5	22.1	21.2	16.5	21.4	18.3
	14	17.9	16.9	19.8	18.4	22.6	16.2	24.8	23.9	19.1	24.1	20.9
	20	19.6	18.6	21.5	20.0	24.3	17.8	26.5	25.6	20.8	25.8	22.6
40	8	30.5	28.6	34.3	31.4	39.9	27.1	44.3	42.4	32.9	42.9	36.6
	14	35.8	33.9	39.6	36.7	45.2	32.3	49.6	47.8	38.2	48.2	41.9
	20	39.1	37.2	43.0	40.1	48.6	35.7	53.0	51.2	41.6	51.6	45.3
60	8	45.7	42.9	51.4	47.2	59.8	40.6	66.4	63.6	49.4	64.3	54.9
	14	53.6	50.8	59.4	55.1	67.8	48.5	74.4	71.6	57.3	72.3	62.8
	20	58.7	55.8	64.4	60.1	72.9	53.5	79.5	76.8	62.4	77.4	67.9

APPENDIX E

APPLICATION 1 AND 2 COMPARISONS (20 GALLONS PER MINUTE PUMPING RATE)

RSI-1853-10-081

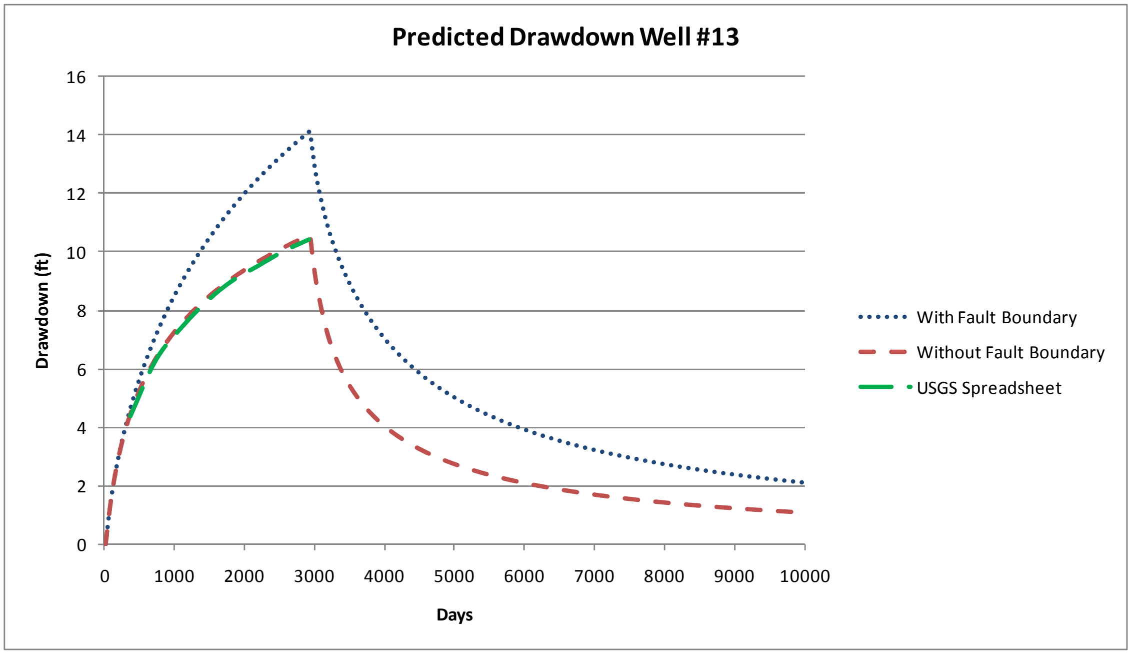


Figure E-1. Application Drawdown Comparison for Well # 13. Lakota Aquifer properties same as Scenario 1.

RSI-1853-10-082

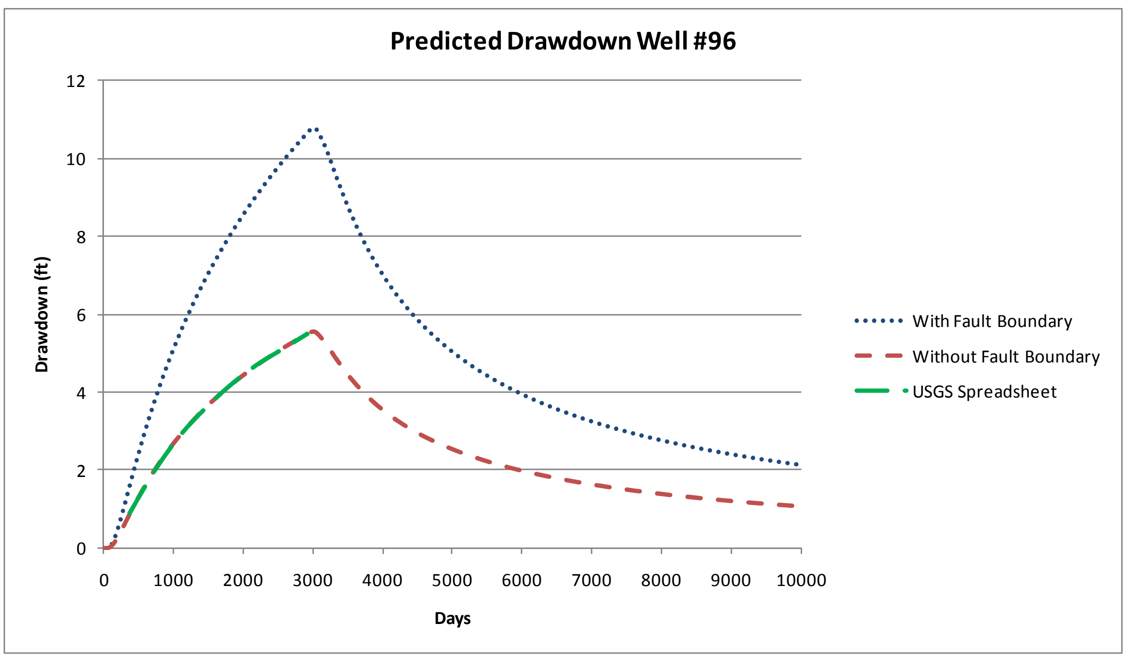


Figure E-2. Application Drawdown Comparison for Well # 96. Lakota Aquifer properties same as Scenario 1.

RSI-1853-10-083

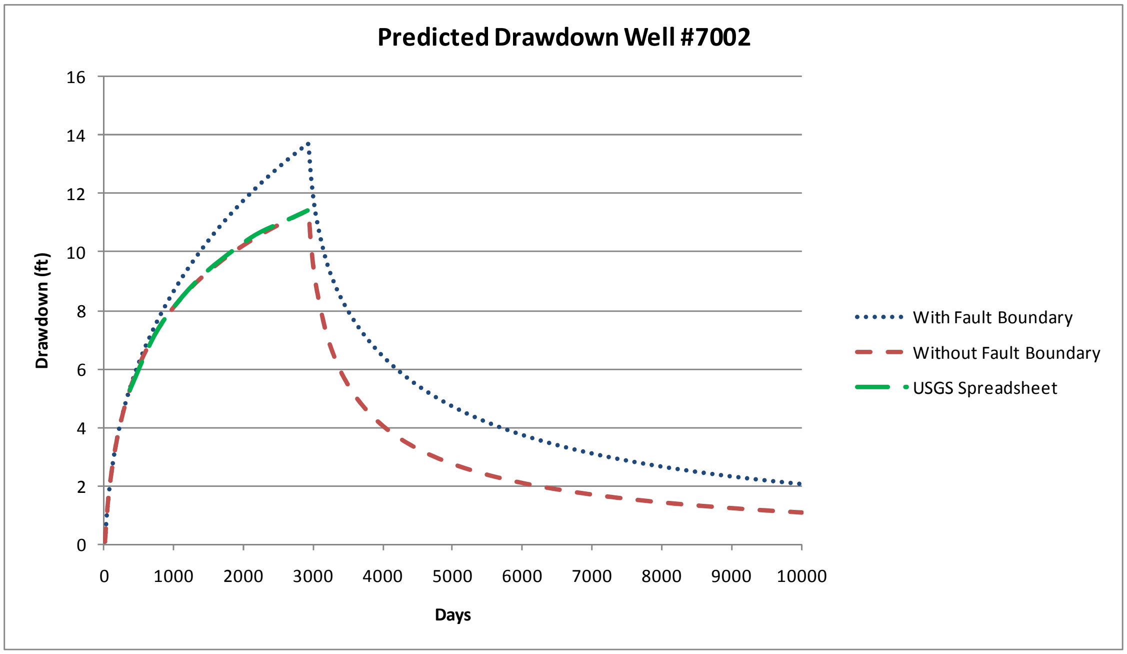


Figure E-3. Application Drawdown Comparison for Well # 7002. Lakota Aquifer properties same as Scenario 1.

RSI-1853-10-084

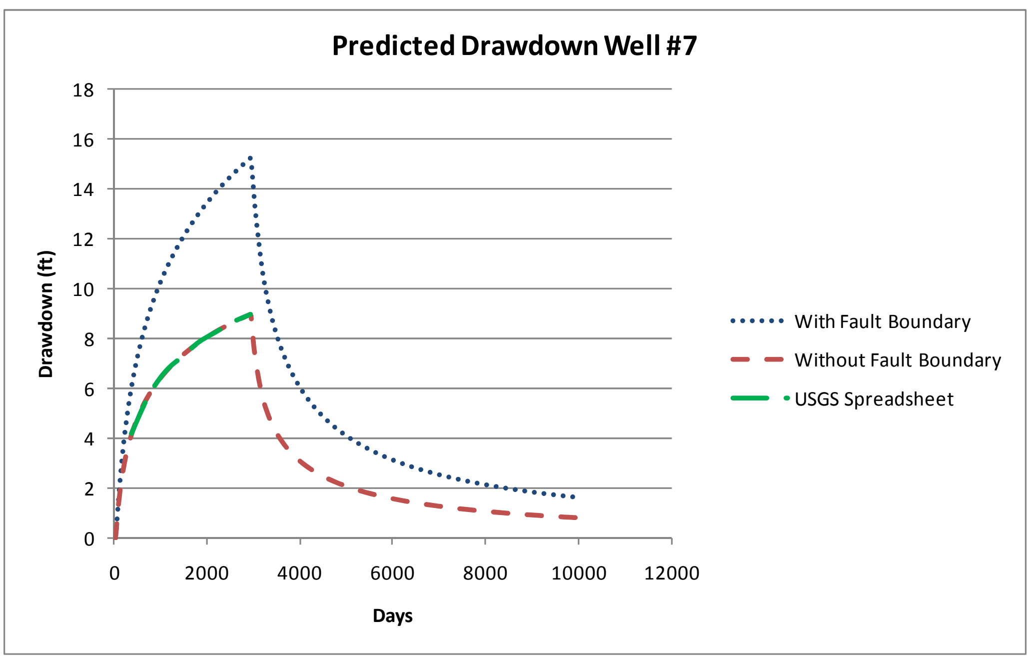


Figure E-4. Application Drawdown Comparison for Well # 7. Fall River Aquifer properties same as Scenario 5.

RSI-1853-10-085

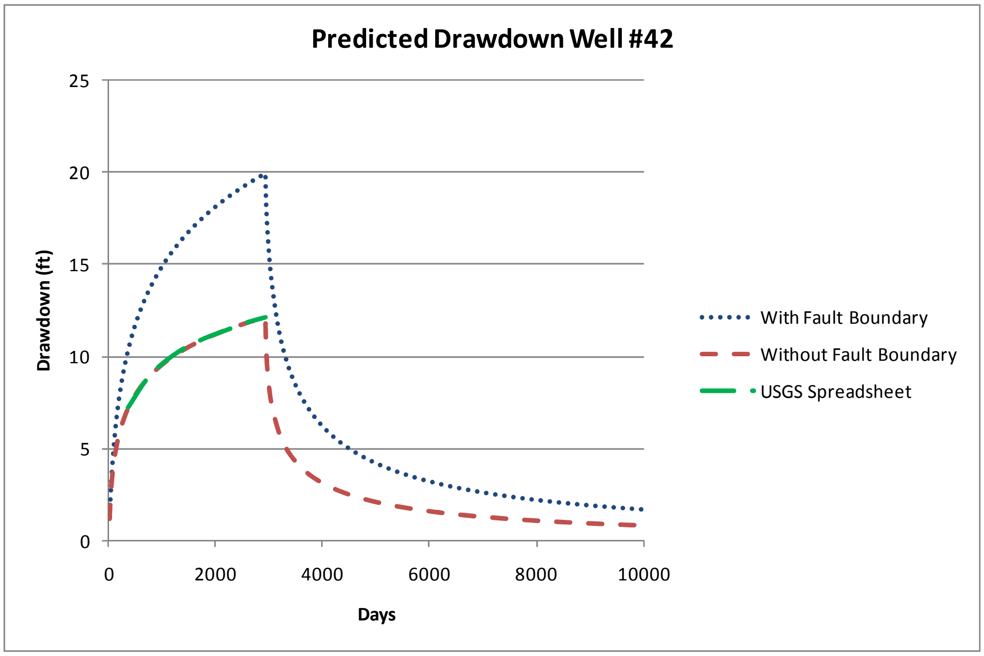


Figure E-5. Application Drawdown Comparison for Well # 42. Fall River Aquifer properties same as Scenario 5.

RSI-1853-10-086

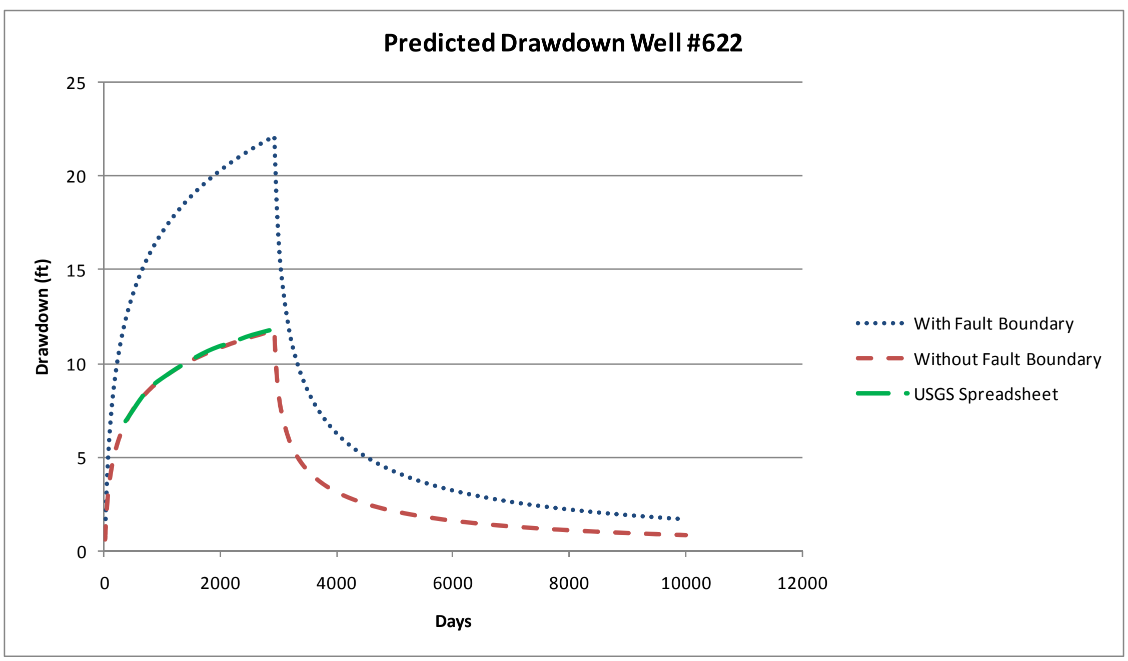


Figure E-6. Application Drawdown Comparison for Well # 622. Fall River Aquifer properties same as Scenario 5.

APPENDIX 6.6-A

Financial Assurance Estimate

Dewey-Burdock Project Financial Assurance - Appendix 6.6-A
Table of Contents

Summary of Costs by Year
Dewey-Burdock Project
Powertech (USA), Inc.

Dewey-Burdock - Restoration and Reclamation Costs - Deep Well Disposal Option

		Project Year	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
		Operation Phase	**Construction**	**Production**	**Restoration + Stability**		**Decommissioning**		
		Production (lbs U3O8)	**-**	**1,000,000**	**2,588**	**-**	**-**	**-**	
No.		Description							
1		Facility Decommissioning							
	A	Salvageable Equipment					**121,000**	**121,000**	**242,000**
	B	Non-salvageable bldg. & equipment disposal					**355,040**	**355,040**	**710,080**
	C	11e.(2) byproduct material disposal			**4,400**		**231,105**	**231,105**	**466,609**
	D	Restore contaminated areas						**570,300**	**570,300**
2		O&M - Aquifer restoration and stability monitoring							**-**
	A	Method: RO treatment with permeate injection			**448,937**	**448,937**			**897,873**
	B	Method: groundwater sweep with Madison injection							
3		Well field reclamation							**-**
	A	Well plugging & closure					**375,650**	**375,650**	**751,300**
	B	Remove surface equipment & reclaim					**487,525**	**487,525**	**975,050**
4		Radiological Survey						**10,300**	**10,300**
5		Project Management Costs & Miscellaneous			**268,400**	**242,300**	**229,500**	**228,500**	**968,700**
6		Labor incl. 35% overhead + 10% contractor profit			**534,000**	**398,000**	**270,000**	**135,000**	**1,337,000**
7		Contingency @ 15%			**188,360**	**163,385**	**310,473**	**377,163**	**1,039,382**
		Total Financial Assurance Amount	**-**	**-**	**1,444,097**	**1,252,622**	**2,380,293**	**2,891,583**	**7,968,594**

Summary of Costs by Year
Dewey-Burdock Project
Powertech (USA), Inc.

Dewey-Burdock - Restoration and Reclamation Costs - Land Application Option

		Project Year	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
		Operation Phase	**Construction**	**Production**	**Restoration+ stability**		**Decommissioning**		
		Production (lbs U3O8)	**-**	**1,000,000**	**2,588**	**-**	**-**	**-**	
No.		Description							
1		Facility Decommissioning							
	A	Salvageable Equipment					**121,000**	**121,000**	**242,000**
	B	Non-salvageable bldg. & equipment disposal					**561,790**	**561,790**	**1,123,580**
	C	11e.(2) Byproduct material disposal			**4,400**		**261,716**	**261,716**	**527,831**
	D	Restore contaminated areas						**1,429,100**	**1,429,100**
2		O&M - Aquifer restoration and stability monitoring							
	A	Method: RO treatment with permeate injection							
	B	Method: groundwater sweep with Madison injection			**277,850**	**277,850**			**555,700**
3		Well field reclamation							**-**
	A	Well plugging & closure					**375,650**	**375,650**	**751,300**
	B	Remove surface equipment & reclaim					**487,525**	**487,525**	**975,050**
4		Radiological Survey						**24,400**	**24,400**
5		Project Management Costs & Miscellaneous			**268,400**	**242,300**	**229,500**	**228,500**	**968,700**
6		Labor incl. 35% overhead + 10% contractor profit			**534,000**	**398,000**	**270,000**	**135,000**	**1,337,000**
7		Contingency @ 15%			**162,698**	**137,723**	**346,077**	**543,702**	**1,190,199**
		Total Financial Assurance Amount	**-**	**-**	**1,247,348**	**1,055,873**	**2,653,258**	**4,168,383**	**9,124,861**

Notation

Abbrev.	Definition
ac	acres
ac-ft	acre-feet
BSW	baseline sampling well
CF	cubic feet
CPP	Central Processing Plant
CY	cubic yards
d	days
DDW	deep disposal well
est.	estimated
ft	feet
ft^3	cubic feet
gpm	US gallons/minute
HH	header house
IMW	internal monitor wells
IW	injection wells
IX	ion exchange
kgal	thousand gallons
kW	kiloWatt
kWh	kiloWatt-hour
L	liter
LA	land application
lb	pounds mass
lf	linear foot
M#	million pounds
MET	meteorological
mg	milligrams
Mgal	million gallons
MW	monitor wells
MWh	megaWatt-hour
PMW	perimeter monitor wells
ppm	parts per million
PV	pore volumes
PW	production wells
RC	restoration composite
R/T	round trips
SF	Satellite Facility
TDH	total dynamic head
U3O8	uranium oxide product
WF	well field
y	year

Assumptions
Dewey-Burdock Project

Table 1: Assumptions
Dewey-Burdock Project
Powertech USA, Inc.

Description		Quantity	Units
Producton phase parameters			
1	Production objective	1,000,000	lb/y U3O8
2	Ore zone mass per unit area (Total resource/total ore body area)	1.59	lb/sq ft
3	ISR recovery efficiency	0.75	
4	Ore body area in active ISR (1Mlb/y U3O8/0.75/(1.59 lb/ft^2)	836,050	sq. ft
5	Ratio of actual pattern area/ ore body area	1.04	
6	Active ISR wellfield area	869,493	sq ft
7	Active ISR wellfield area	20.0	acres
8	Area per 70' x 70' pattern, mean	4,450	sq ft/pattern
9	Design flow rate of production composite	4000	gpm
10	Design flow rate of production composite per production well	20	gpm
11	Mean grade of extracted water (ppm U3O8) (design)	60	mg/L U3O8
12	Number of online patterns to meet production goal (active area/(area/pattern))	195	patterns
13	Ratio of injection wells to production wells (design)	2.1	IJ/PW
14	Number of online injection wells required to meet objective	411	IW
15	Number of online production wells per header house (design)	18	PW/HH
16	Number of HH required to meet production objective (PW/18)	11	HH
17	Number of perimeter monitor wells in Burdock WF#1 and Dewey WF#1	70	PMW
19	Number of overlying internal mon. wels in active production zone @ 1 per 4 ac.	5	MW
20	Number of underlying internal monitor wells in active prod. zone @ 1 per 8 ac.	2	MW
21	Total number of active internal monitor wells in Burd. WF#1 and Dew. WF#1	7	Int. MWs;
22	Number of internal monitor wells per HH	1	Int. MW/HH
24	Baseline sampling wells in active production area (1 per 4 acres)	5	BSW
26	Length of large (10' wide) pipeline trench	10,000	ft
28	Length of medium (5' wide) pipeline trench	5,050	ft
30	Length of small (2' wide) pipeline trench	2,000	ft
Summary of active wells for production phase			
1	Production wells	195	PW
2	Injection wells	411	IW
3	Perimeter ring wells	70	PMW
4	Internal monitor wells	7	IMW
5	Baseline sampling wells	5	BSW
6	Header houses	11	HH
7	Total # monitor wells per 1MM lb/y produced during production	77	MW
8	WF access roads	17,000	ft

Assumptions
Dewey-Burdock Project

Assumptions - continued

Description		Quantity	Units
Well field equipment in place at end of 1st year production			
1	Total wells to be plugged & abandoned	683	wells
2	Wellhead covers to be heated during aquifer restoration (PW + IW + MW)	683	wells
3	Header houses	11	HH
4	Overhead electric lines	101,000	ft
5	Facility access roads (24') (Burd. - 7,975 ft., Dew. - 8,550 ft.)	16,525	ft
6	Well field access roads (12') (Burd. - 11076 ft., Dew. - 11,710 ft.)	22,786	ft
General aquifer restoraton assumptions			
1	Restoration flow rate	500	gpm
2	Restoration operating days	365	day/y
3	Ore zone porosity	0.30	
4	Ore zone thickness	4.6	ft
5	Flare factor, volumetric	1.44	
6	Pore volumes required for restoration	6.0	PV
Restoration parameters			
1	Pore volume affected in year 1 = (ore body area/1M pounds U3O8 recovered) x thickness x porosity x flare factor	12,924,359	gallons/M# recovered
2	Total volume restoration composite, including excess wellfield area, for 6 PV	77,546,156	gallons
3	Months to restore a pattern (6 PV @ 20 gpm)	0.5	month
4	Years to restore aquifer for 1M lbs of U3O8 recovered (total vol RC/500 gpm)	0.30	years
Well plugging parameters			
1	Mean well depth (Inj., Prod., Monitoring) (Burd.-450', Dew.-600')	525	ft
2	Inside diameter	4.91	inch
3	Volume per foot (for plugging)	0.131	ft^3/ft
4	Volume to be plugged per well	69	ft^3
Pipeline disposal			
1	HDPE pipe density, SG	0.95	
2	Void volume in chipped pipe	10%	
Pond solids			
1	Addition rate of barium chloride to restoration composite	20	mg/L
2	Percent solids	40%	
3	Specific gravity	1.4	
4	Pond sludge density	87.2	lb/CF

Assumptions
Dewey-Burdock Project

Assumptions - continued

Description		Units	Disposal Option	
Flow rates during restoration period (gpm)			**DDW**	**LA**
1	Madison water (gpm)	gpm	150	500
2	Well field wastewater to disposal system (gpm)	gpm	150	500
Pond inventories at beginning of financial assurance period				
1	CPP pond capacity	ac-ft	15.9	36.2
2	CPP pond - 50% capacity	Mgal	3	6
3	Storage ponds - 50% capacity of 8 ponds @ 63.8 ac-ft	Mgal		83
4	Surge ponds - 50% capacity of 2 ponds @ 8.4 ac-ft	Mgal	3	
5	Radium settling & outlet ponds 100% capacity	Mgal	14	29
6	Total inventory at beginning of financial assurance period	Mgal	20	118
Wastewater disposal				
1	Volume of restoration wastewater (Mgal)	Mgal	23	78
2	Total wastewater (Mgal)	Mgal	43	196
3	Volume to DDW (Mgal)	Mgal	43	
4	Volume to land application (Mgal)	Mgal		196
Madison water required				
1	Volume of Madison water required	Mgal	23	78
Stability Period				
1	Length of stability period		12	
2	Number of sampling events		5	
Pump/motor parameters				
1	Pump efficiency - variable frequency drive		0.90	

Unit Costs
Dewey-Burdock Project

Unit Costs

Cost factors presented here and elsewhere in this Appendix are from vendor quotes, from the 2009 RS Means cost estimating handbooks, from recent ISR license applications, and from calculations as described.

		Unit	Price
1	**Energy costs**	**Unit**	**Price**
	Electrical power	$/kWh	0.07
	Propane	$/gal	2.15
2	**Chemical Costs**	**unit**	**$/unit**
	Hydrogen peroxide - 50% solution	lb	0.30
	Sulfuric acid - 93%	lb	0.135
	Sodium hydroxide - 50% solution	lb	0.145
	Sodium chloride	lb	0.09
	Sodium carbonate	lb	0.135
	Barium chloride dihydrate	lb	0.67
3	**Well plugging costs**		
	Cost of plugging mix.	$/CF	9.00
	Cost of plugging cement per well	$/well	621.29
	Contract labor w/ equipment, 4 crew-hr/well @ $125/hr	$/well	500.00
	Total plugging cost per well	$/well	1121.29
4	**11e.(2) byproduct material disposal cost**		
	Transportation to White Mesa, UT (785 miles 1-way) @ $3.55/loaded mile + $1.85/unloaded mile for 30 CY load	$/CY	140
	11e.(2) disposal fee, soil-like material	$/CY	150
	11e.(2) disposal fee, equipment	$/CY	150
5	**Pipeline removal cost**		
	Excavation & pipe removal - from Table 14		
	Pipelines ≥ 8"	$/(ft-pipe)	0.533
	Pipelines ≥ 3"-6" @ 50% rate of large pipe	$/(ft-pipe)	0.267
	well field pipelines 1"-2" @ 25% rate of large pipe	$/(ft-pipe)	0.133
	Pond disposal		
	Liner removal and shredding	$/(ft^2-liner)	0.05
	Pipe chipping	$/CF	0.15

Operation and Maintenance during Aquifer Restoration
Dewey-Burdock Project

O&M During aquifer restoration phase				
Dewey-Burdock Project			Subtotals	
O&M	DDW	LA	DDW	LA
1 Well field operations, prorated for length of restoration (years = 0.30)				
General well maintenance	54,000	54,000		
Well MIT- none in first 5 years	0	0		
Replacement of submersible pumps	12,000	12,000		
Header house maintenance	9,000	9,000		
Pipelines & road maintenance	9,000	9,000		
Subtotal well field operation			84,000	84,000
2 Capital equipment				
RO units, RO sump pumps, roll-offs (direct & indirect)	593,000	70,000		
Subtotal capital equipment			593,000	70,000
3 Pumping costs				
RO pumps	19,900			
Madison aquifer booster	1,700	5,700		
Plant to radium settling ponds	7,100	32,200		
From outlet pond to disposal (LA or DDW)	7,100	71,500		
Subtotal pumping costs			35,800	109,400
4 Facility operation				
Resin replacement	0	0		
Resin transport	300	300		
Electricity	17,000	17,000		
Propane	59000	59000		
Maintenance	12,000	12,000		
Subtotal facility operation			88,300	88,300
5 Chemicals				
For resin elution	2,300	2,300		
For Radium precipitation	2,610	8700		
Subtotal chemicals			4,910	11,000
6 Groundwater, Surface water monitoring				
	62,000	62,000		
Subtotal groundwater and surface water monitoring			62,000	62,000

Operation and Maintenance during Aquifer Restoration
Dewey-Burdock Project

O&M During aquifer restoration phase Dewey-Burdock Project				Subtotals	
		DDW	LA	DDW	LA
7 Disposal well					
Electricity		20,000			
Maintenance		9,863			
	Subtotal disposal well			29,863	-
8 Land application system					
Electricity			96,000		
Maintenance			35,000		
	Subtotal land application system			-	131,000
Total O&M for aquifer restoration	Totals	897,873	555,700	897,873	555,700
		DDW	LA	DDW	LA

Operation and Maintenance Costs
Dewey-Burdock Project

Table 3: Operating and maintenance costs					
Dewey-Burdock Project					
Powertech (USA), Inc.					
	Number	**Quantity**	**Units**	**Rate**	**Cost ($/yr)**
Annual well field costs during aquifer restoration assuming continuous 365-day/y operation					
Wells (per well)					
General well maintenance	1	1	lump sum	300	300
Well Mechanical Integrity Testing (every 5 yr)	1	0			0
Electric utilities:					
Well head heaters (0.5 kW, 8 hr/day, 180 days/yr)	1	720	kWh	0.070	50
Header houses (per HH)					
Flow meter maintenance (2 @ $50 ea.) per HH	2	1	ea	50	100
Replacement pressure gauges/switches	20	1	ea	50	1,000
Equip. maintenance (@ 2% of new equipment capital)	1	80,000	%	0.02	1,600
Subtotal maintenance					**2,700**
Electric utilities:					
Bldg. heating (5 kw, 180 days/yr)	1	22,000	kWh	0.070	1,500
Instrumentation (1 kw)	1	9,000	kWh	0.070	600
Subtotal power					**2,100**
Wellfield maintenance					
# Production (extraction) wells		195	prod wells		
# Injection wells		411	inj wells		
General well maintenance ($300/well * (PW+IW)/y)					182,000
Well MIT - none in first 5 years		-			
Replacement of submersible pumps (10%/yr @ $2,000 each)		39,000	$		
# Header houses (per MM # produced)		11.0	HH		
Header house maintenance (# HH x $2700/HH)			per HH	2,700	29,700
General well field maintenance					
Pipelines		1	lump sum	20,000	20,000
Road maintenance materials (gravel/culverts)		1	lump sum	10,000	10,000
Wireless telemetry and security systems maintenance		1	lump sum	2,000	2,000
Subtotal maintenance					**32,000**

POWERTECH (USA) INC.

Operation and Maintenance Costs
Dewey-Burdock Project

	Number	Quantity	Units	Rate	Cost ($/yr)
Annual Facility/Plant costs					
Ion exchange resin replacement - DOWEX 21K XLT		0	CF	221	0
Utilities:					
Electricity					
PC booster pump 250 gpm @ 90' TDH	2	83,000	kWh	0.070	5,800
IC booster pump 250 gpm @ 90' TDH	2	83,000	kWh	0.070	5,800
Resin transfer pump 100 gpm @ 50' TDH	1	9,180	kWh	0.070	643
Utility water pump (300 gpm @ 40' TDH)	1	22,020	kWh	0.070	1,500
RO unit - included in deep well disposal option below					
CPP HVAC	1	175	MWh	0.070	12,300
CPP lighting (0.8 W/ft^2 for 10^4 ft$^{2)}$	10,000	70,000	kWh	0.070	4,900
CPP instrumentation (2 kw)	1	18,000	kWh	0.070	1,300
Maintenance bldg. HVAC	1	87.6	MWh	0.070	6,100
Office bldg. HVAC	1	87.6	MWh	0.070	6,100
Satellite faiclity HVAC	1	88	MWh	0.070	6,100
Satellite facility instrumentation	1	18,000	kWh	0.070	1,300
Exterior lighting	1	88	MWh	0.070	6,100
Subtotal annual electric power					**57,943**
Propane @ 21,600 Btu/gal (gallons from ER)					
CPP/SF space heating	1	77,220	gal/y	2.150	166,000
CPP thermal fluid heater, prorated for restoration production of U3O8	2.59E-03	14,145	gal/y	2.150	100
Maintenance bldg	1	11,598	gal/y	2.150	24,900
Office bldg	1	4,883	gal/y	2.150	10,500
Subtotal annual propane					**201,500**
Resin transport to CPP		6	R/T per yr	50	**300**
Land Application Option Operating Cost	**Mgal**	**kWh/kgal**	**kWh**	**$/kWh**	**Lump Sum $**
Land app. pumps from pond to pivots (200' TDH) (water vol. from Table 1)	196	5.220	1,021,000	0.07	71,470
Days of irrigation	Days				
March 29-May 10	42				
May 11-Sept 24	136				
Sept 25-Oct 31	37				
Total available irrigation days per year	215				

Operation and Maintenance Costs
Dewey-Burdock Project

	Number	Quantity	Units	Rate	Cost ($/yr)
Pivot Irrigation system capacity	# installed	# used	@ gpm	subtotal gpm	
50 acre Pivot - 15 hp drive	5	5	104	520	
25 acre Pivot - 10 hp drive	0	0	52	0	
15 are Pivot - 7.5 hp	0	0	31	0	
Total land application rate (gpm)				520	
Total days of irrigation required (wastewater volume/total LA rate)				261	
Irrigation Years @ 215 days/y				1.2	
Cost of pivot irrigation operation				**$/kWh**	**Cost $**
Center pivot hydraulic pump; 15 hp for 50 ac areas (use 13 RHP)	5	350,471	kWh	0.07	24,500
Center pivot hydraulic pump; 10 hp for 25 ac areas (use 8 RHP)	0	0	kWh	0.07	0
Center pivot hydraulic pump; 7.5 hp for 15 ac areas	0	0	kWh		0
Sump pump at 25 ac land app site (return irrigation tailwater/runoff)	0	3,000	kWh	0.07	0
Sump pump at 50 ac land app site (return irrigation tailwater/runoff)	5	10,000	kWh	0.07	3,500
Subtotal land application power					**99,000**
Equipment maintenance				$	**Annual Cost**
Center pivot machines	5	1	year	500	2,500
Equip. maintenance (@ 3% of new equipment capital) - pumps only		78,000	%	3	2,300
Equipment replacement (@ 3% of new equipment capital)		1,464,000	%	3	43,900
Subtotal annual maintenance					**49,000**
Prorated pivot maintenance (129/365)					**35,038**
Total cost land application					**205,508**
Deep disposal well operating cost					
Injection pump maintenance and repair (assume 6%/y of cap cost)	2	150,000	Cap cost	0.06	**18,000**
Wastewater volume (Mgal)	43				
Days of DDW operaton (ww volume/(150 gpm total flow rate))	200				
Prorated DDW maintenance					**9,863**
Electric utilities:					
Deep disposal well PD pump (4, but only one operating)					
150 gpm @ 1000' TDH)	1	275,300	kwh	0.070	19,300
Bldg. heating (1 kw, 180 days/yr)	1	4,000	kwh	0.070	300
RO unit power	1	284	MWh	0.070	19,900
Subtotal annual DDW power					**20,000**
Prorated DDW power (216/365)					**10,959**
Total deep well cost (power + maint.)					**20,822**

Operation and Maintenance Costs
Dewey-Burdock Project

	Number	Quantity	Units	Rate	Cost ($/yr)
Restoration					
Treatment chemicals					
IX cost (from Operating Chemicals)			LS	1.000	11,000
Subtotal					**11,000**
Treatment maintenance					
Process hardware maintenance + replacement @ 4% of Capital		994,000	cap cost	0.040	39,760
Subtotal					**40,000**
Madison water supply power					
Maintenance @ 10%/y of replacement cost of ($75K/pump)	2	75,000		0.100	15,000
Madison booster pump (150 gpm; 500 TDH; 24 hr/day)	1	184,000	kwh	0.070	13,000
Subtotal					**28,000**
Power costs that vary with disposal option					
Madison water supply booster pump (free flowing) @ 40' TDH	Mgal	**kWh/kgal**	**$/kWh**	**Cost $**	
DDW option	23	1.040	0.07	1,700	
LA option	78	1.040	0.07	5,700	
Pump power from ponds to disposal	Mgal	**kWh/kgal**		**Cost $**	
DDW option Booster Pumps (90 TDH)	43	2.350	0.070	7,100	
LA option Booster Pumps (200 TDH)	196	5.220	0.070	71,500	
Booster pumps from plant to radium settling ponds	Mgal	**kWh/kgal**		**Cost $**	
DDW option booster pumps (90 TDH)	43	2.350	0.070	7,100	
LA option booster pumps (90 TDH)	196	2.350	0.070	32,200	

Capital Equipment
Dewey-Burdock Project

Description	Equipment List Number	No./Size	Quantity	Units	Unit Cost	Purchase Cost	Shipping Cost	Estimated Capital Cost
Table 4: Capital Equipment								
Disposal well option								
Capital equipment to be purchased								
					0	0	0	0
					0	0	0	0
Shredder (HDPE/poly/PVC/FRP)		1	1	each	50,000	50,000	2,500	53,000
BFI 30 CY roll-off containers		2	1	each	7,800	16,000	800	17,000
RO sump pump	300-P-011, spare	0	1	each	1,915	0	0	0
RO skid (Incl pretreatment, filtration and feed pump) 100 gpm	100-RO-001	2	1	each	248,841	498,000	24,900	523,000
	Estimated Restoration Equipment - Subtotal:							**593,000**

Description	Equipment List Number	No./Size	Quantity	Units	Unit Cost	Purchase Cost	Shipping Cost	Estimated Capital Cost
Land application option								
Restoration system								
					0	0	0	0
					0	0	0	0
Shredder (HDPE/poly/PVC/FRP)		1	1	each	50,000	50,000	2,500	53,000
BFI 30 CY roll-off containers		2	1	each	7,800	16,000	800	17,000
RO sump pump	300-P-011, spare	0	1	each	1,915	0	0	0
RO skid (Incl pretreatment, filtration and feed pump) 100 gpm	100-RO-001	0	1	each	248,841	0	0	0
	Estimated Restoration Equipment - Subtotal:							**70,000**

Chemicals
Dewey-Burdock Project

Table 5: Chemicals						
Dewey-Burdock Project						
Chemical usage		**usage rate**				
Hydrogen peroxide - 50% solution		0.36	lb/(lb U3O8)			
Sulfuric acid - 93%		1.00	lb/(lb U3O8)			
Sodium hydroxide - 50% solution		0.92	lb/(lb U3O8)			
Sodium chloride		4.60	lb/(lb U3O8)			
Sodium carbonate		0.92	lb/(lb U3O8)			
Barium chloride dihydrate		20	mg/(L-RC)			
Flow rate		500	gpm			
Uranium concentration		5	ppm			
Uranium concentration in IX tails		1	ppm			
Volume of restoration composite extracted		77,550,000	gal			
U3O8 production during restoration activities		2588	lb U3O8			
Chemical Costs ($/y)						
Project year	1	2	3	4	5	6
U3O8 production from restoration activities (lb U3O8)			2588	0	0	0
Cost of Chemicals						
Hydrogen peroxide - 50% solution			300			
Sulfuric acid - 93%			300			
Sodium hydroxide - 50% solution			300			
Sodium chloride			1100			
Sodium carbonate			300			
Barium chloride dihydrate			8,700			
Subtotal			**11,000**	-	-	-

11e.(2) Byproduct Material Disposal
Dewey-Burdock Project

Table 6: 11e(2) Byproduct Material Disposal								
Dewey-Burdock Project								
		Quantity	Units	Disposal Rate	Transportation Cost	Annual Disposal Cost	Years of Rest. + Stability	Total Cost
RO and IX waste	Costs included in CPP	0		$/CF	$/CF			
Well field waste	Assume 1 drum/4 weeks = 2 CF/wk	104	CF/yr	5.56	5.19	1,117	1.30	1,452
PPE	Assume 1 drum/4 weeks = 2 CF/wk	104	CF/yr	5.56	5.19	1,117	1.30	1,452
Decontamination waste	Assume 1 drum/4 weeks = 2 CF/wk	104	CF/yr	5.56	5.19	1,117	1.30	1,452
		Subtotal Byproduct Disposal during Restoration Ops.						**4,356**
11e.(2) byproduct material waste during decommissioning		Quantity	Units	Disposal Rate ($/unit)	Transportation Cost			Lump Sum transport +disposal $
					unit	no. units	$/unit	
Well field waste - from Table 6		8,230.00	CF	5.56	CF		5.19	88,396
Pond liners								
DDW option facility waste - from Table 9		19,930	CF	5.56	CF		5.19	214,063
LA option Facility waste - from Table 9		25,630	CF	5.56	CF		5.19	275,285
Equipment and resin - from Table 9		21,951	CF	5.56	Semi load	9	4,200.00	159,750
		Summary of Byproduct Disposal costs during Decommissioning						
							DDW	LA
				11e.(2) Byproduct Material Disposal			462,209	523,431

Monitoring
Dewey-Burdock Project

Table 7: Monitoring								
Dewey-Burdock Project								
Enninronmental Monitoring		**Number**	**Quantity**	**Units**	**Rate ($)**	**Cost ($/yr)**		
Met Station	Met station for site	1	12	visits/yr	200	2400		
Water Qual.								
	20 metals, mercury, alk, Cl, SO4, NO3, Fl, EC, pH, and TDS (Test America) @ $350 (w/ shipping)							
	spec, Th, U, and gross A/B (Test America) @ $550 (w/ shipping)							
	End-of-ISR sampling Sampling from set of 6 baseline wells in production zone for all analytes of TR Table 6.1-1. Assume analytical cost of $1,000/sample. Sample prior to beginning of restoration activity.	1	6	wells/ sampling event	1000	6,000	$/sampling event	
	Restoration: Monitoring during restoration for optimization, efficiency and to identify spatial discrepancies. Sample composite restoration stream at completion of of each pore volume extracted at each site, analyze for Table 6.1-1 analytes.	2	6	wells/ sampling event	1000	12,000	$ total	
	Excursion monitoring: Sampling every 60 days of all monitor wells for excursion indicator parameters + water level. Analytes tested in CPP lab @ ~ $10/sample.	1	77	wells/ sampling event	10	770	$/sampling event	
	Stability: Same as End-of-ISR sampling at beginning of stability period and after each quarter for 12-month stability period	5	6	wells/ sampling event	1000	30,000	$/stability period	
Radon	CPP (10 dose buttons quarterly)	4	10	buttons/qtr	50	2,000	$/year	
	Satell/Well Field (5 dose buttons/quarter)	4	5	buttons/qtr	50	1,000	$/year	
	Restor/Decom (5 buttons quarterly)	4	5	buttons/qtr	50	1,000	$/year	
	Project Year		1	2	3	4	5	6
	Restoration/Stability		Construction	production	restoration + stability mon.		Decomm.	Decomm.
	End-of-ISR				6,000			
	Met station				2,400	720		
	Restoration				12,000			
	Stability				20,000	10,000		
	Excursion monitoring				4,620	1,500		
	Radon				2,600.0	2,000		
	Annual Subtotals				48,000	14,000	-	-
	Total Monitoring	62,000						

Well Field Reclamation
Dewey-Burdock Project

Table 8: Well Field Reclamation
Dewey-Burdock Project

			Value	Units
Well Decommissioning				
Unit cost per well (assume avg. depth of 650 feet)				
5" diameter casing =			0.131	CF/LF
Average well depth =			525	LF
Volume per well =			69.0	CF
Cement grout cost =			9.00	$/CF
Cement plug cost/well			621.29	$/well
Equipment + labor: pull tube, pump; cut & remove casing below grade.				
Contract labor/equipment (incl. mob/demob) = 4 crew-hr/well @ $125/hr			500	$/well
Total abandonment cost/well (rounded) =			1,100	$/well
Cost of plugging wells	# wells (from Table 1) =	683	751,300	$LS
	Total well plugging & abandonment costs		**751,000**	**$LS**

Surface Structures		No./Size	Quantity	Units	Cost	Demo Cost	Waste vol (Cu. Ft) SubtitleD	11e.(2)
Overhead Power								
Power poles: one every 200' (40' H, 5' in ground); pull + cut in half, place pole and cross arms in roll-off	47+54K' OHE	505	505	each	297	150,000	27,888	
Power cables	Assumed zero net cost (removal cost = salvage value)					0		
Wells	**CF per well**	**# wells**	**Quantity**					
Casing/wellhead appurtenances/cover from prod/inj/mon. wells @ 64 CF/well	64	683	683				43,712	
Well pumps from PW+MW	1	272	272					272
Down-hole tubing wells (2" X 625' x 0.36" wall)	14	683	683					9,579
Total WF Surface structures							71,600	9,851

Well Field Reclamation
Dewey-Burdock Project

Table 8: Well Field Reclamation (cont.)

Header Houses Included with building demolition/disposal in Table 9

Pipelines to be chipped and disposed as 11e.(2) byproduct material
Trunklines from CPP or SF to well fields;

	No.	pipes	ft.	lb/ft	Chipped vol (CF)
Burdock (CPP to WF)					
1 16" HDPE per site	1	2	4000	24.2	3,600
2 10" HDPE per site	1	2	4000	10.93	1,600
Dewey (SF to WF)					
1 16" HDPE per site	1	2	1000	24.2	900
2 10" HDPE per site	1	2	1000	10.93	400
Per HH (valve vaults to HH)					
1 6" HDPE per HH	11	2	120	4.15	200
2 2" HDPE per HH	11	2	120	0.534	30
Per Well (HH to well)					
1 2" HDPE per PW, IMW	202	1	210	0.534	400
2 2" HDPE per PMW	70	1	720	0.534	500
3 1.5" HDPE per Inj. Well	411	1	210	0.342	600
Total to 11e.(2) byproduct material disposal - Table 6					8,230

	# pipes	ft of trench	$/(ft-pipe)	Cost $
Pipeline chipping @ $0.15/CF				1,235
Pipeline removal				
CPP-SF Trunklines	4	5,000	0.533	10,660
CPP-SF trunklines	4	19,800	0.533	42,214
Valve vaults to HH	3	1320	0.267	1,057
Well field pipelines	4	35,498	0.133	18,885
Cost of pipeline removal				72,816
Total Well Field Decommissioning Costs				975,050

Site Demolition
Dewey-Burdock Project

Table 9: Site Demolition								
Dewey-Burdock Project								
Description	**Units**	**No./Size**	**Quantity**	**Units**	**Unit Cost**	**Estimated Demo Cost**	**Vol. (CF) to Load on Trucks**	
Byproduct Materials								
Pond Demo and Send to 11e(2) Disposal Site								
Accumulated solids - radium settling pond (@ 20 mg/L)							**10,430**	CF
Load 30 CY roll-offs at site w/ front-end loader			386	cy	2	770		
Deep Well Disposal Option								
CPP pond (liner and leak detection system)								
80 mil HDPE primary liner @ 26 ft^2/CF		1	123,281	sq ft	0.05	6,200	**4,742**	
Radium settling & spare ponds (liner and leak detection system)								
80 mil HDPE primary liner @ 26 ft^2/CF		2	123,281	sq ft	0.05	12,300	**4,742**	
Subtotal Materials to Demo and Send to Rad Waste Disposal Site:						18,500	**9,500**	CF
Load 30 CY roll-offs at site w/ front-end loader			352	cy	2	700		
Subtotal pond disposal - DDW option						**19,970**	19930	CF
Land Application Disposal option								
CPP pond (liner and leak detection system)								
80 mil HDPE primary liner @ 26 ft^2/cu.ft		1	189,231	sq ft	0.05	9,500	**7,278**	
Radium settling ponds (liner and leak detection system)								
80 mil HDPE primary liner @ 26 ft^2/cu. ft.		2	205,959	sq ft	0.05	20,600	**7,922**	
Subtotal Materials to Demo and Send to Rad Waste Disposal Site:						30,100	**15,200**	CF
Load 30 CY rolloffs at site w/ front-end loader			563	cy	2	1,100		
Subtotal pond disposal - land application option						**31,970**	25630	CF
Equipment to be transported to 11e.(2) byproduct material disposal							**CF**	**Semi-loads**
Ion exchange columns, incl. resin: assume 12' dia. x 15'H	1,700	12	12	LS	1,000	12,000	**20,400**	6
Vacuum dryers and appurtenances								
Dryers	1071	1	2	LS	10,000	20,000	**1,071**	2
Vacuum pump/condensor skids, hot oil boiler skids, cooling tower system	480	1	2	LS	2,000	4,000	**480**	1
Subtotal removal/loading of (byproduct) equipment						36,000	21951	**9**
Equipment/Materials for transport to re-use or recycling facility							**CF**	**Semi-loads**
Pad or pole-mounted transformers (one per Header Hse) - 10 per truckload		11	1	LS	500	600		
Haul transformers to Rapid City (100 mi one-way)		1	200	mile	3.50	800		
Wire in OHE lines - 47,000' of OHE at Dewey; 54,000' at Burdock - 4 wires			404,000	lf	0	0		

Site Demolition
Dewey-Burdock Project

Description	Units	No./Size	Quantity	Units	Unit Cost	Estimated Demo Cost	Vol. (CF) to Load on Trucks	
Valve vaults: cut off lid and dispose of lid	200	11	0.5	hrs	50	275		
Valve vaults: truck haul to recycler			200	mile	3.50	700		
Resin transfer truck and trailers (1 truck; 2 trailers)			1	LS	0	0		2
Chain-link fencing								
Around CPP site			2,240	lf	3.43	7,700		
Around Satellite site			1,440	lf	3.43	4,900		
Around CPP pond (380' sq)		440 ft. per side	1,760	lf	3.43	6,000		
Around radium settling ponds; CPP			9,700	lf	3.43	33,300		
Around radium settling ponds; Satellite			8,200	lf	3.43	28,100		
Barbed wire fencing in wellfields - 3 strand			87,000	lf	1.75	152,300		
Support steel in Drying area	4,500	1	1	LS	5,000	5,000	**4,500**	2
Standby generator	512	1	1	each	500	500	**512**	0.5
Diesel fuel tank - above ground, assume 15,000 gal	2,005	1	1	each	500	500	**2,005**	1
Gasoline fuel tank - above ground, assume 15,000 gal	2,005	1	1	each	500	500	**2,005**	1
Fire suppression pump system	512	1	1	LS	500	500	**512**	0.5
Subtotal Demolition and Transportation/Disposal Equip/Mat'ls to be Sold or Recycled						**242,000**	**9,500**	**7**
Equipment re-used/recycled						**242,000**		
Equipment disposal specific to Wastewater Disposal method.								
DDW option								**Semi-loads**
Equipment at DDW		1	4	LS	1,000	4,000		1
Pond outlet structures, pumps (DDW option)		1	4	LS	**500**	2,000		1
CPP pond (liner and leak detection system)								
60 mil HDPE secondary liner		1	123,281	sq ft	0.05	6,200	**3,522**	
Geonet		1	123,281	sq ft	0.05	6,200	**3,522**	
Single lined ponds (liner and leak detection system)								
40 mil single liner (outlet, surge)			280,946	sq. ft	0.05	14,000	**8,027**	
Uncontaminated 80 mil liner from unused spare ponds								
80 mil liner		2	123,281	sq ft	0.05	12,300	**3,522**	
Radium settling ponds (liner and leak detection system)								
60 mil HDPE secondary liner		2	123,281	sq ft	0.05	12,300	**3,522**	
Geonet (radium settling + spare ponds)		4	123,281	sq ft	0.05	24,700	**3,522**	
							25,639	2
Load 30 CY roll-offs at site w/ front-end loader			950	cy	2	1,900		
Subtotal DDW option						83,600		
LA option								**Semi-loads**
Land application center pivot machines	4,000	21	21	LS	1,000	21,000		5
Pond outlet structures, pumps (LA option)		1	5	LS	500	2,500		2

Site Demolition
Dewey-Burdock Project

Description	Units	No./Size	Quantity	Units	Unit Cost	Estimated Demo Cost	Vol. (CF) to Load on Trucks	
Single lined ponds (liner and leak detection system)								
40 mil single liner (outlet, storage, spare storage)			2,457,374	sq. ft	0.05	122,900	**70,211**	
CPP pond (liner and leak detection system)								
60 mil HDPE secondary liner		1	189,231	sq ft	0.05	9,500	**5,407**	
Geonet		1	189,231	sq ft	0.05	9,500	**5,407**	
Uncontaminated 80 mil liner from unused spare ponds								
80 mil liner		2	205,959	sq ft	0.05	20,600	**5,885**	
Radium Settling Ponds (liner and leak detection system)								
60 mil HDPE secondary liner		2	205,959	sq ft	0.05	20,600	**5,885**	
Geonet (radium settling + spare ponds)		4	205,959	sq ft	0.05	41,200	**5,885**	
							98,678	7
Load 30 CY roll-offs at site w/ front-end loader			3,655	cy	2	7,300		
Subtotal LA option						255,100		
Equipment/Materials to Demo and Dispose at Construction and Demolition Landfill								
Process pumps in buildings	16	60	60	LS	200	12,000	**960**	1
Shaker screens: 10'x7'x5'H	400	2	2	LS	2,000	4,000	**800**	1
Elution columns: 7' dia x 15'H	600	4	4	LS	1,000	4,000	**2,400**	2
13' dia. tanks x 16'H	2,100	22	22	LS	500	11,000	**46,200**	11
11' dia. tanks x 16'H	1,500	2	2	LS	1,000	2,000	**3,000**	1
10' dia. tanks x 16'H	1,300	1	1	LS	1,000	1,000	**1,300**	1
RO units	400	4	4	LS	1,000	4,000	**1,600**	1
Thickeners	10,600	2	2	LS	10,000	20,000	**21,200**	5
Screw conveyors	100	2	2	LS	1,000	2,000	**200**	6
Filter presses	2000	2	2	LS	5,000	10,000	**4,000**	1
Chemical storage tanks outside CPP - assume 20,000 gal	2674	3	3	LS	500	1,500	**8,021**	3
Drum conveying system	2,900	1	1	LS	1,000	1,000	**2,900**	0.5
Drum washer and drying system	1,200	1	1	LS	1,000	1,000	**1,200**	0.5
Paint booth	400	1	1	LS	500	500	**400**	0
Building Structures								
Office building	60x90x20+roof		148,500	CF	0.15	22,300	**18,600**	
Maintenance/Warehouse	140x120x20		462,000	CF	0.15	69,300	**33,800**	
Fire suppression tank	240,000 gal		30,968	CF	0.15	4,600		
Building Structure								
CPP, includes loading dock area	392'x130'x20'+roof		1,486,840	CF	0.15	223,000	**77,560**	
Lab/control rm/break rm/showers/restrooms w/in CPP	30x90x20'		54,000	CF	0.15	8,100	**10,200**	
Rad container bldg	30x24x15		10,800	CF	0.15	1,600	**2,340**	
Header houses - assume equip/piping inside demo'd w/ bldg	10x40x8	11	3,200	CF	0.15	5,280	**8,800**	
Satellite bldg, incl interior wall	124x156x20		396,552	CF	0.15	59,500	**39,448**	
Lab/control rm/break rm/showers/restrooms w/in Satellite	45x45x20		40,500	CF	0.15	6,100	**4,950**	
					Subtotal Bldgs Demo:	**399,780**	**342,600**	34

Site Demolition
Dewey-Burdock Project

Description	Units	No./Size	Quantity	Units	Unit Cost	Estimated Demo Cost	Vol. (CF) to Load on Trucks
Transportation/Disposal							
Loading 30 CY rolloffs at site w/ front-end loader			12,689	CY	2	25,400	
Loading process equipment			34	semi load	1,000	34,000	
Transportation to Regional landfill at Edgemont, SD @ 16 miles	$3.50/mi x 16 mi + $1.98/mi x 1		423	semi-load	88	37,100	
Transportation to RE-use/Recycling sit @ Rapid City, SD @ 87 miles	$3.50/mi x 87 mi + $1.98/mi x 8		7	semi load	477	3,300	
Disposal fee at Custer -Fall River landfill, Edgemont, SD			12,689	CY	10	126,900	
					Subtotal Transportation/Disposal - Subtitle D Material:	**226,700**	
					Transportation/Disposal in Landfill	**626,000**	
Other Misc Demo Activities							
Rinse piping and treat rinsewater - assume 3 piping volumes	2,263,486 gal/pipe vol		6,790	1,000 gal	3	20,400	
Valve vaults at well fields - leave in place fill with soil		11	11	CY	20	2,500	
Septic tank - CPP: 15,000 gal (fill with soil, leave in place)	15,000 gal	1	2,005	CY	10	20,100	
Septic tank - Satellite: 10,000 gal (fill with soil, leave in place)	10,000 gal	1	1,337	CY	10	13,400	
Backfill excavation and compact surge pond (Dewey)			59,259	CY	1	59,300	
Backfill excavation and compact radium settling ponds volume (Dewey)			185,185	CY	1	185,200	
Abandon DDWs			0	wells	100,000	0	
Reseed well field areas (fertilize, seeding, mulching)			67	acre	1,500	100,700	
Reseed CPP site			11	acre	1,500	16,600	
Reseed CPP radium settling ponds			48	acre	1,500	71,300	
Reseed Satellite plant area			35	acre	1,500	52,300	
Reseed access road to CPP			11	acre	1,500	16,500	
Reseed access road to Satellite			8	acre	1,500	12,000	
					Subtotal Other Misc Demo Activities:	**570,300**	
LA Option only							
Backfill excavation and compact storage ponds	8 x 63.8 ac ft		823,000	CY	1	823,000	
Reseed storage pond area			24	acre	1,500	35,800	
					Subtotal addl other Misc for LA option	**858,800**	
Summary of Facility Decommissioning Costs			DDW		LA		
A Reclyclable/salvageable equipment			242,000		242,000		
B Non-salvageable buildings & equipment disposal			710,080		1,123,580		
C 11e.(2) byproduct material processing/loading			55,970		67,970		
D Restore contaminated areas			570,300		1,429,100		

Table 10: Survey Dewey-Burdock Project		
	Disposal Option	
Gamma Survey Area (acre)	DDW	LA
Disturbed area after first year of production		
Well fields		
Burdock WF1	17.6	17.6
Dewey WF1	39.3	39.3
Site areas: CPP, SF, pipelines between CPP-SF, site access roads	23.8	23.8
Major pipelines (est. 30% of 24.79 ac total)	7.4	7.4
WF access roads (est. 30% of 140 acres total)	6.2	6.2
DDWs (assume 0.1 acre per DDW)	0.2	0
Irrigation area		1,052
Impoundments, topsoils	33	136
Total survey area (acre)	**128**	**1,282**
Gamma Survey Costs		
Mob/Demob	4,000	4,000
100-m transects ($/acre)	10	12
Survey cost	1,280	15,384
Survey report	5,000	5,000
Survey Total $	10,300	24,400
Total Survey Cost	10,300	24,400

Labor
Dewey-Burdock Project

Table 11: Labor		Project Year					
		1	2	3	4	5	6
	Activity	Constrctn	Prodctn	Restoration+ stability		Recl. + Decomm.	
Administration							
Radiation Safety Officer				1	1	1	1
Restoration							
Superintendent				1	1	1	
Restoration Engineer				1	1	0	0
Restoration Operator				2	0	0	0
Lab Technicians				1	1	0	0
Unit Labor Costs including 35% overhead							
Administration							
Radiation Safety Officer	135,000			135,000	135,000	135,000	135,000
Restoration							
Superintendent	135,000			135,000	135,000	135,000	0
Restoration Engineer	81,000			81,000	81,000	0	0
Restoration Operator	68,000			136,000	0	0	0
Lab Technicians	47,000			47,000	47,000	0	0
Project Year		1	2	3	4	5	6
Restoration and Reclamation Labor Cost				534,000	398,000	270,000	135,000

Management
Dewey-Burdock Project

Table 12: Management and Miscellaneous Costs
Dewey-Burdock Project

		Project year				
		3	4	5	6	Total
Mob/Demob		12,500			12,500	25,000
Total Management						
Facility Manager @ $150,000 + 35%		202,500	202,500	202,500	202,500	810,000
Contractor Profit						
Percent of labor	10%	53,400	39,800	27,000	13,500	133,700
Subtotals Mgmt & Misc. - $		268,400	242,300	229,500	228,500	968,700

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Impoundments
Dewey-Burdock Project

Table 13: Impoundments											
Dewey-Burdock Project											
			# ponds	DDW				LA			
		PONDS		capacity	liner/pond	Primary	Secondary	capacity	Liner	Primary	Secondary
				ac-ft	ft^2 *	mil	mil	ac-ft	ft^2 *	mil	mil
		CPP	1	15.9	123,281	80	60	36.2	189,231	80	60
		Radium Settling	2	15.9	123,281	80	60	39.4	205,959	80	60
		Spare	2	15.9	123,281	80	60	39.4	205,959	80	60
		Outlet	2	5.1	53,068	40		4.9	18,588	40	
		Surge	2	8.4	87,405	40					
		Storage	8					63.8	242,020	40	
		Spare Storage	2					63.8	242,020	40	
Totals		Liner ft^2 (KP)-Dewey			264,718	80			433,190	80	
		Liner ft^2 (KP)-Dewey			264,718	60			433,190	60	
		Liner ft^2 (KP)-Dewey			140,473	40			1,228,687	40	
		Liner ft^2 (KP)-Burdock			351,689	80			579,875	80	
		Liner ft^2 (KP)-Burdock			351,689	60			579,875	60	
		Liner ft^2 (KP)-Burdock			140,473	40			1,228,687	40	
		Total 80 mil (KP)			616,407	80			1,013,065	80	
		Total 60 mil (KP)			616,407	60			1,013,065	60	
		Total 40 mil (KP)			280,946	40			2,457,374	40	

KP= Total liner areas, as reported by Knight Piesold (KP) in Pond Design Report
* Liner area of individual ponds estimated as proportional to pond capacity

Well Field Pipe Removal
Dewey-Burdock Project

Table 14: Well Field Pipe Removal
Dewey-Burdock Project

Assumptions

1. Backhoe trench to uncover pipe @ 1,500 ft/day
2. Extract pipeline and backfill @ 1,500 ft/day
3. Backhoe rental $2688/mo., plus fuel, maint., mob. @ $1,200/wk) = $1,840/wk
4. Backhoe operator @ $20/hr
5. Pipeline extraction with 2 workers @ $17/hr in addition to backhoe operator
6. Operating schedule: 8 hr/day, 5 days/week

Main pipeline removal

Equipment

$$\frac{\$\ 1840}{\text{week}} \times \frac{1\ \text{week}}{5\ \text{days}} \times \frac{1\ \text{day}}{1{,}500\ \text{ft}} = \$\ 0.245333\ /\text{ft}$$

Labor

Backhoe operator

$$\frac{\$\ 20}{\text{man-hr}} \times \frac{8\ \text{man-hr}}{1\ \text{day}} \times \frac{1\ \text{d}}{1{,}500\ \text{ft}} = \$\ 0.11\ /\text{ft}$$

Pipeline extraction

$$\frac{\$\ 17}{\text{man-hr}} \times \frac{16\ \text{man-hr}}{1\ \text{day}} \times \frac{1\ \text{day}}{1{,}500\ \text{ft}} = \$\ 0.18\ /\text{ft}$$

Pipelines extraction cost per foot =$ 0.533

APPENDIX 6.6-B

Numerical Modeling of Groundwater Conditions Related to In Situ Recovery

NUMERICAL MODELING OF GROUNDWATER CONDITIONS RELATED TO INSITU RECOVERY AT THE DEWEY-BURDOCK URANIUM PROJECT, SOUTH DAKOTA

Introduction

Powertech (USA) Inc., has submitted an application to the U.S. Nuclear Regulatory Commission (NRC) for a Source Materials License (SML) to conduct in-situ recovery (ISR) of uranium from the Dewey-Burdock Project in South Dakota (Powertech, 2009). Wellfield-scale modeling simulations were conducted in response to the Request for Additional Information (RAI) from NRC presented to Powertech in a correspondences dated May 19, 2010 and May 28, 2010. The target ore zone at the Dewey site is the lower Fall River Formation, and this is the aquifer represented in these hydrological modeling simulations. Ore is also present in the Lakota Formation to the south at the Burdock site area, but flow in this aquifer is not simulated.

The following lists the specific RAIs presented by NRC that are addressed in this report (references to pore volume are not addressed in this report):

Correspondence dated May 19, 2010, entitled "Summary of April 8, 2010, Teleconference Addressing Technical Issues, Powertech (USA), Inc., Proposed Dewey-Burdock In-Situ Recovery Facility (TAC No. J00606)".

- Section III (Miscellaneous Issues), #4(d): *The applicant includes a flare factor of 1.5 in its calculation of restoration costs. In addition ground water restoration costs are based on treatment of 10 pore volumes. Provide justification for the flare factor and for using 10 pore volumes total.*

Correspondence dated May 28, 2010, entitled "Request for Additional Information, Powertech (USA), Inc., Proposed Dewey-Burdock In Situ Recovery Facility (TAC No. J00606)".

- Section 5.7.8, #10: *On page 3-14 of the Technical Report, the applicant proposes for the perimeter monitoring ring to be 400 feet from the production well field, with a minimum spacing between wells of a spacing that ensures a 70 degree angle. The applicant references three NUREG guidance documents on the proposed spacing but does not justify the spacing based on site-specific hydrogeological and geochemical conditions. Please provide the appropriate justification.*
- Section 6.1, #7: *The application did not include estimates on the pore volume for a wellfield, porosity, or flare factors. The staff needs this information to evaluate the financial assurance calculations and the proposed schedule and water balance for the restoration process. Please provide this information for staff to review.*

A numerical groundwater flow model was developed to evaluate wellfield-scale issues related to ISR production at the site. This report describes the development of the numerical model and summarizes the results of numerical simulations used to address NRC concerns regarding ISR operations at the site.

Models and simulations presented in this report are not intended to fully characterize the regional groundwater flow system and are based on data currently available. It is noted that there are hydrologic complexities to the site and surrounding area, such as aquifer heterogeneities and recharge and fault boundaries that may require further characterization. This modeling exercise is provided for the analysis of wellfield flare and demonstrating hydraulic control at the monitor well ring. The modeling presented in this report is site specific and is not intended to represent the regional groundwater flow system.

Purpose and Objectives

The numerical groundwater flow model was developed to support Powertech in planning and operation of the ISR project. The numerical model was used to assess impacts of ISR mining on lower Fall River Formation in the Dewey area of the proposed Dewey-Burdock Uranium Project. Model simulations were developed to:

- Evaluate the wellfield balance and net bleed at the proposed F-13 wellfield.
- Estimate wellfield flare during mining operations.
- Demonstrate that proposed monitor well spacing is adequate to detect any potential excursions, specifically by simulating an excursion out of the wellfield.
- Demonstrate that hydraulic control of the simulated excursion can be established by changing injection/extraction rates and altering groundwater flow direction at the perimeter monitor well ring.

The model was developed to allow adequate discretization within the wellfields such that the impacts of individual wells can be discerned.

Conceptual Model

Description of the geology and hydrogeology of the Permit Area can be found in the SML application (Powertech, 2009). Based on that document and hydrologic testing conducted in 2008 (Knight Piesold, 2008), a conceptual hydrologic model for the Dewey area at the Dewey-Burdock Project is summarized below.

The aquifer being simulated is the lower Fall River Formation, which is the proposed uranium production zone at the Dewey area. The total thickness of the Fall River Formation is approximately 165 feet in the area. There are three distinct ore zones of about 10 to 15 feet thick within the lower Fall River sandstone interval. This sandstone at the base of the Fall River is approximately 75 feet thick, and dips to the south-southwest at approximately 0.01 ft/ft. This interval of the lower Fall River Formation is the aquifer that was modeled in the following simulations.

The Fall River Formation is a confined aquifer system at the Dewey area, with a hydraulic gradient generally following the dipping beds to the south-southwest. Measured gradients in the Dewey area are locally as high as 0.01 ft/ft, but generally are closer to an average of 0.006 ft/ft (Knight Piesold, 2008). A hydraulic gradient of 0.006 ft/ft is utilized for all baseline (non-pumping) conditions around the simulated wellfield. There is also a vertical-upward hydraulic gradient of approximately 0.2 ft/ft measured between well screens in the lower sandstone versus the upper sandstone in the Fall River Formation. For the purposes of these simulations that focus on hydraulic behavior within the monitoring well ring, this vertical gradient was not considered, nor was potential leakage from or into overlying and underlying layers.

Results of hydrologic testing conducted in 2008 (Knight Piesold, 2008) provided the basis for aquifer parameters values used in the modeling. Results of testing in the Dewey area in the lower Fall River indicate an average transmissivity of 255 ft^2/day and average storativity of 4.6 x 10^{-5}. Based on an assumed 75-foot thickness of the lower Fall River, the hydraulic conductivity is calculated as 3.4 ft/day. Total porosity of the lower Fall River was estimated at 29 percent, based on analysis of core samples. These values were the initial values used in the model calibration simulations. The initial values were modified during model calibration.

Average groundwater velocity under the stated aquifer conditions of hydraulic conductivity of 3.4 ft/d, hydraulic gradient of 0.006 ft/ft and porosity of 29 percent is 0.07 ft/d, or 26 ft/yr.

Anticipated production rates were assumed to be approximately 20 gallons per minute (gpm) per well pattern, with a net bleed (overproduction) of approximately 1%. Figure 1 shows the wellfield layout that was modeled in the Dewey area.

Model Code

Three-dimensional analysis of groundwater flow in the lower Fall River aquifer system was performed with the finite difference groundwater flow model (MODFLOW), developed by the U.S. Geological Survey (USGS) (McDonald 1988, 1996). MODFLOW was selected for simulating groundwater flow at the Dewey site because it is capable of a wide array of boundary conditions, in addition to being a public domain code that is well accepted in the scientific community. MODFLOW can be used to simulate transient or steady-state saturated groundwater flow in one, two, or three dimensions. The code simulates groundwater flow using a block-centered, finite-difference approach. Modeled aquifers can be simulated as unconfined, confined, or a combination of thereof.

Advective transport was evaluated using MODPATH, Version 3, developed by the USGS (Pollock, 1994). MODPATH's particle-tracking code was utilized because it is compatible with model outputs from the MODFLOW groundwater flow model and is suitable for flowpath analysis of steady-state or transient simulations, and is a widely accepted public domain code. MODPATH utilizes the output head files from MODFLOW to calculate particle velocity changes over time in three dimensions.

MODPATH was used to provide computations of groundwater seepage velocities and groundwater flow directions at the site.

The pre/post-processor Groundwater Vistas (Environmental Simulations, Version 5, 2007) was used to assist with input of model parameters and output of model results. Groundwater Vistas serves as a direct interface with MODFLOW and MODPATH. Groundwater Vistas provides an extensive set of tools for developing, modifying and calibrating numerical models and allows for ease of transition between the groundwater flow and particle tracking codes. Full description of the Groundwater Vistas program is provided in the Users Guide to Groundwater Vistas 5 (Environmental Simulations, Inc., 2007).

Model Domain and Grid

The model encompasses an area of approximately 1,530 square miles and is shown on Figure 2. The model domain is aligned to the prevailing potentiometric gradient to the southwest (model is oriented 26 degrees east of north) and the model grid is centered over the F-13 wellfield. Northeast-southwest dimensions are 206,840 feet (39.2 miles), and northwest-southeast dimensions are 206,562.5 feet (39.1 miles).

The model grid was designed to provide adequate spatial resolution within the wellfield area in order to simulate response of the aquifer to typical extraction and injection rates anticipated at the Dewey area in the lower Fall River Formation. The model grid was extended a considerable distance from the wellfield boundaries to minimize potential impacts of exterior boundary conditions on the model solution in the area of interest.

Cell dimensions within the area of the proposed wellfield are 17.5 feet by 17.5 feet. Cell dimensions are gradually increased to a size of 1,500 feet by 1,500 feet near the edges of the model. The model consists of 476 rows and 291 columns, and contains 138,516 active cells.

Model Boundary Conditions

Boundary conditions imposed on a numerical model define the external geometry of the groundwater flow system being studied. Boundary conditions assigned in the model were determined from available reported potentiometric conditions (Knight Piesold, 2008). Descriptions of the types of boundary conditions that can be implemented with the MODFLOW code are found in McDonald and Harbaugh (1988).

This numerical model was designed for a conceptual evaluation of wellfield flare and near-wellfield groundwater movement, and is not a rigorous conceptualization of the potential heterogeneities and hydrogeologic boundaries present in the larger regional groundwater flow system.

Boundary conditions used to represent hydrologic conditions at the Dewey site include general-head boundaries (GHB) and wells (extraction and injection). The locations of the GHB conditions within the model are illustrated in Figure 2. Discussion of the placement and values for these boundary conditions is provided below. The placement and values for the well boundary conditions are described under the simulation discussion.

The GHB was used in the Dewey Area model to account for inflow and outflow from the model domain on all sides. GHBs were assigned along the edges of the model domain by extrapolating available potentiometric data (Knight Piesold, 2008), including observed water level elevations and observed hydraulic gradients. GHBs were used because the groundwater elevation at those boundaries can change in response to simulated stresses. In the Dewey wellfield model, GHBs were assigned to all four sides of the model. The values of head assigned to the GHBs ranged from 4,269 feet above mean sea level (ft amsl) along the north edge of the model and 3,036 ft amsl, along the south edge. The values of head assigned to the GHBs on the west and east sides of the model vary linearly between assigned heads at the north and south boundaries of the model. This configuration represents a hydraulic gradient of 0.006 ft/ft to the southwest, consistent with water levels and hydraulic gradients observed in the lower Fall River monitor wells.

The wellfield configuration includes a series of 5-spot well patterns with an extraction well located in the center, surrounded by four injection wells. Each well pattern is approximately 70 feet on a side. Figure 1 presents the wellfield layout of injection and extraction wells, and the perimeter monitor well ring. Extraction and injection rates applied to the wells are described under the simulation discussions of this report.

The model domain was extended a suitable distance from the location of the proposed production wellfield to minimize perimeter boundary effects on the interior of the model where the hydraulic stresses were applied.

Aquifer Properties

Input parameters used in the model to simulate aquifer properties are consistent with site-derived data, including the following:

- Top and bottom elevations of the lower Fall River sandstone, of approximately 3,066 feet above mean sea level (ft amsl) and 2,991 ft amsl at the southwest corner of the modeled wellfield
- Saturated thickness of 75 feet
- Hydraulic gradient of 0.006 ft/ft
- Hydraulic conductivity of 3.4 ft/day and storativity of 4.6 x 10^{-5}, based on hydrologic testing (to be modified by model calibration)
- Porosity of 29%, based on core analysis

For the purposes of a wellfield-scale model simulating ISR production, the additional geologic and hydrogeologic complexities that are present in the Dewey area were not included, owing to the lack of data. The wellfield is located on a homoclinal limb of the Fall River Formation, but the aquifer is represented as an extension of the stratigraphic dip observed near the wellfield. Thus, the observed top of the lower Fall River sandstone is extended to the model boundaries at a dip of 0.01 ft/ft, though limited local data and regional mapping indicates that the degree of dip in both the up-dip and down-dip directions decreases.

Static water level conditions within the model domain are similarly presented. Utilizing a potentiometric elevation of 3,654 ft amsl at the southwest corner of the wellfield, an average measured gradient of 0.006 ft/ft is extended to the edges of the model boundaries.

A hydrologic test conducted in 2008 (Knight Piesold, 2008) in the Dewey area included a pump test at well DB-07-32-03C for 3.08 days, at a constant rate of 30.2 gpm. The median reported aquifer transmissivity (T) for the lower Fall River (estimated thickness of 75 feet) was approximately 255 ft^2/day, which corresponds to a hydraulic conductivity of 3.4 ft/day. Median storativity (S) was determined to be 4.6×10^{-5}. These two values (T = 3.4 ft/day; S = 4.6×10^{-5}) represent starting aquifer input values for the wellfield model calibration to the results of testing.

No attempt was made to calibrate the model to natural background potentiometric conditions because of limited data.

Modeled Aquifer Response versus 2008 Hydrologic Testing

The groundwater model was calibrated to the 2008 pump test conducted in the Dewey area (Knight Piesold, 2008). The pumping well (DB-07-32-03C) is completed in a portion of the lower Fall River (ore zone), and three observation wells completed to the ore zone were monitored. The pumping well and two closest observation wells are located within or near the wellfield. Overlying and underlying wells were also monitored, but because the model is a single layer, the overlying and underlying data was not utilized in the calibration.

The pumping well was simulated at a constant rate of 30.2 gpm for 3.08 days. The initial condition was the previously described potentiometric surface with a hydraulic gradient of 0.006 ft/ft. Simulated drawdown at the three observation wells was compared to the pump test results and hydraulic conductivity and storativity values were varied in the model input to attempt a best fit to the limited hydrologic data. No attempt was made to compare the results of the pumping well drawdown at the end of the test, due to the lack of data regarding well efficiency at this well.

The following table briefly summarizes the results of the 2008 testing:

Well	Type	Radial Distance to Pumping Well (ft)	Observed Drawdown at End of Pumping (ft)
DB 07-32-3C	Pumping	0	44.8
DB 07-32-05	Observation	265	13.0
DB 07-32-4C	Observation	467	9.8
DB 07-29-7	Observation	2,400	1.5

During calibration, model input parameters for K and S were varied from the average reported aquifer parameters (K = 3.4 ft/day, S = 4.6 x 10^{-5}, Knight Piesold [2008]). Table 1 summarizes the calculated residual values (difference between observed versus model results of drawdown), and shows that a K value of 3.1 ft/day and S value of 4 x 10^{-5} provides the best match to observed drawdowns. The model output at the distal observation well (DB 07-29-7, 2,400 ft distant) overpredicts drawdown in all simulated cases. The purpose of the modeling simulations are to simulate flow at a wellfield scale and within the monitoring well ring (spaced 400 feet from the ore body wellfield patterns, therefore the drawdown fit at the two closest wells was weighed more heavily in the choice of aquifer parameters for the wellfield model (see Table 1). Based on this approach, a conductivity of 3.1 ft/day and storativity of 4 x 10^{-5} were determined to best fit the limited hydrologic data available. Figure 3 presents the simulated drawdown versus observed drawdown.

Dewey Wellfield Balance and Determination of Flare

The wellfield balance and flare determination simulation was conducted to (1) attempt to balance injection and production volumes within the wellfield while minimizing excursion potential and (2) track groundwater particle pathways that illustrate the horizontal flare around the wellfield. The following wellfield simulation was run for a period of two years, and flare was evaluated at the end of this time frame.

Input parameters for the modeled aquifer are a K value equal to 3.1 ft/day and S equal to 4 x 10^{-5}. Total wellfield overproduction (bleed) in this simulation is 1.0%. Balancing was conducted by starting with an idealized wellfield balance, with each extraction well producing at 20 gpm. Each injection well rate is defined by the number of neighboring extraction wells. An interior injection well surrounded by four extraction wells and injects at a rate of 19.8 gpm (1.0% bleed). For an exterior injection well adjacent to three extraction wells, the injection rate is 75% of an interior well, and 50% and 25% for an injection well adjacent to two and one extraction wells, respectively.

Total production at the 104 extraction wells is 2080 gpm, equivalent to 20 gpm per well. Total injection at the 160 injection wells is 2059.2 gpm, ranging in rate from 3.2 gpm to 20.8 gpm. Figure 4 presents the modeled wellfield, with posted extraction and injection volumes at each of the 264 wells.

Particle tracking by MODPATH was implemented utilizing multiple particles originating in the model cell of each of the exterior injection wells. Figure 5 presents the particle flowpaths of the balanced wellfield at 1.0% bleed, and the perimeter of the particle traces were traced. Horizontal flare is calculated by taking the ratio of the flare perimeter and boundary of the injection wells. Horizontal flare was minimized by adjusting injection rates at specific wells while maintaining the overall balance at a 1% bleed. Horizontal flare is calculated at 1.19 by dividing the area of particle traces by the exterior boundary of the wellfield. Vertical flare cannot be evaluated in the single-layer model that was utilized in this simulation, but it is expected that the magnitude of vertical flare is similar, or less, in scale to horizontal flare. Due to the vertical anisotropy likely present in the sand layers (i.e., horizontal conductivity is greater than vertical conductivity) and the presence of overlying and underlying confining layers, it is likely that flare in the vertical dimension is less than in the horizontal. Therefore, a total flare value of 1.4 is reasonable and appropriate for the Dewey wellfield.

Simulated Regional Drawdown and Wellfield Potentiometric Levels

Regional drawdown was evaluated based on the results of the two-year operational simulation conducted in the wellfield flare evaluation. Based on the model results, regional drawdown impacts of 5 feet and 1 foot are approximately 14,000 ft (2.7 mi) and 68,000 ft (12.9 mi), respectively (see Figure 6). Figures 7 and 8 present the modeled potentiometric surface of the ore zone near the wellfield and modeled drawdown near the wellfield, respectively.

For model verification, an analytical Theis equation is used to compare the radius of drawdown from the wellfield. Using the Theis solution in a spreadsheet produced by the USGS (Halford and Kuniansky, 2002), a pumping rate of 20.8 gpm (i.e., 2080 gpm – 2059.2 gpm) over a two-year period is used. Results of this calculation indicate that the radius of 5-foot and 1-foot of drawdown is approximately 16,000 feet and 80,000 feet, respectively, which compares well to the results of the modeling simulations.

The wellfield model simulates a homogeneous and isotropic aquifer, without any potential hydrogeologic boundaries (e.g., recharge and/or fault boundaries). The presence of potential boundaries at some distance from the wellfield, or heterogeneity within the wellfield could increase or decrease the overall drawdown within the wellfield area, and may require changes in the overall wellfield balance, but is not expected to significantly alter flow within the wellfield.

Dewey Wellfield Simulated Excursion

In order to assess the proposed 400 foot monitoring well spacing (i.e., wells spaced approximately 400 feet distant from the wellfield, and laterally spaced 400 feet apart in the monitor well ring), an excursion was simulated to illustrate that the spacing is adequate to detect a potential excursion that might occur.

To simulate the excursion, the extraction well at the extreme southwest corner of the wellfield was turned off, with all remaining injection and extraction wells operating at the same rates evaluated in the 1% bleed wellfield flare simulation. This location in the wellfield was utilized because the downgradient and southern portion of the wellfield would be most susceptible to particles exiting the hydraulic sink of the wellfield and traveling southwest with the regional groundwater gradient. Particles to track the flow of injectate from the wellfield during the simulated excursion were placed at the three downgradient injection wells.

Figure 9 presents the particle paths originating from the "out of balance" corner of the wellfield. Figure 10 presents the simulated potentiometric surface at this time near the wellfield. Groundwater flow vectors at the end of the excursion simulation are presented in Figure 11 and illustrate that groundwater flow in the southern area near the monitoring wells is dominantly to the south, in the direction of regional hydraulic gradient. As can be observed from Figure 9, the modeled excursion would eventually intersect the perimeter monitor wells. Therefore, the proposed 400 foot monitoring well spacing is adequate to detect any potential excursion.

Dewey Wellfield Simulated Excursion Recovery

To demonstrate that any potential excursion to the monitoring well ring can be hydraulically controlled, the previously simulated excursion was recovered by adjusting wellfield production/injection. Injection rates at the three downgradient injection wells were set to zero, and the two downgradient extraction wells were adjusted to pump at a rate of 24 gpm each.

Figure 12 presents the potentiometric surface near the simulated excursion at approximately one hour after the recovery was initiated. As can be seen in this figure and contrasted with the potentiometric levels during the excursion (see Figure 10), a local gradient from the southernmost monitor well back to the wellfield is induced. Figure 13 illustrates the velocity vectors of groundwater flow at the same time, which has been reversed and modeled groundwater flow at the area of the simulated excursion is moving back towards the wellfield.

The previously simulated excursion, where a single extraction well was turned off, was run for an additional 30 days, and particles just inside the perimeter monitor well boundary at the downgradient side of the wellfield were tracked. At the end of the 30 days, the excursion recovery was initiated and particles representing the downgradient extent of the simulated excursion were tracked for a period of 60 days. Figure 14 illustrates the simulated groundwater flowpaths immediately adjacent to the monitor well for this scenario, as well as illustrating that the excursion recovery scenario is adequate to reverse the hydraulic gradient and reverse the direction of groundwater flow at a distance of 400 ft, and pull the simulated excursion back inside the perimeter boundary. This figure also provides an indication of the scale of simulated groundwater travel times, as groundwater migrates only approximately 3 ft in the 30 day simulated excursion scenario, and a similar distance for the 60 day recovery. Differences in velocity at this location during the excursion and subsequent recovery are because the induced hydraulic gradient during recovery is lower than the regional gradient that was simulated during the out-of-balance wellfield excursion.

In order to assess the validity of this simulation, an analytical Theis solution for a confined aquifer was utilized. The excursion recovery represents an additional 28 gpm of production (24 gpm at one well previously not operating, and the other well increased from 20 gpm to 24 gpm) and a deduction of approximately 16 gpm (see Figure 4 for posted injection rates), a net pumping rate of 44 gpm. At a distance of 400 ft from the pumping well, the drawdown at one hour is estimated to be approximately 4 feet. Therefore, the Theis solution verifies the results of the modeling simulation that indicate the local gradient can be influenced at a distance of 400 ft. This relatively rapid response at this distance is due to that fact that the lower Fall River is a relatively low-storage system (based on hydrologic testing).

Summary

Numerical modeling was conducted to evaluate wellfield-scale issues related to ISR production at the Dewey-Burdock Project. Wellfield flare was determined and the proposed 400 foot well spacing was demonstrated through modeling to be adequate to detect a potential excursion at this distance. Model simulations also demonstrated that hydraulic control of the simulated excursion can be established by changing wellfield operational rates at this distance away from the wellfield.

Horizontal flare from a balanced wellfield operating at a 1% net bleed was determined to be 1.19. Vertical flare was not evaluated, but considering a similar scale of flare in this direction, total wellfield flare is estimated at approximately 1.4.

An excursion was simulated by varying the wellfield balance, and particle pathways representing the flow of injectate indicate that the 400 foot monitoring well spacing is adequate to detect the excursion away from the wellfield. The recovery of a potential excursion was also demonstrated by varying the wellfield balance to reverse the hydraulic gradient at this distance and change the direction of travel of groundwater back towards the wellfield.

List of Tables

List of Figures

References

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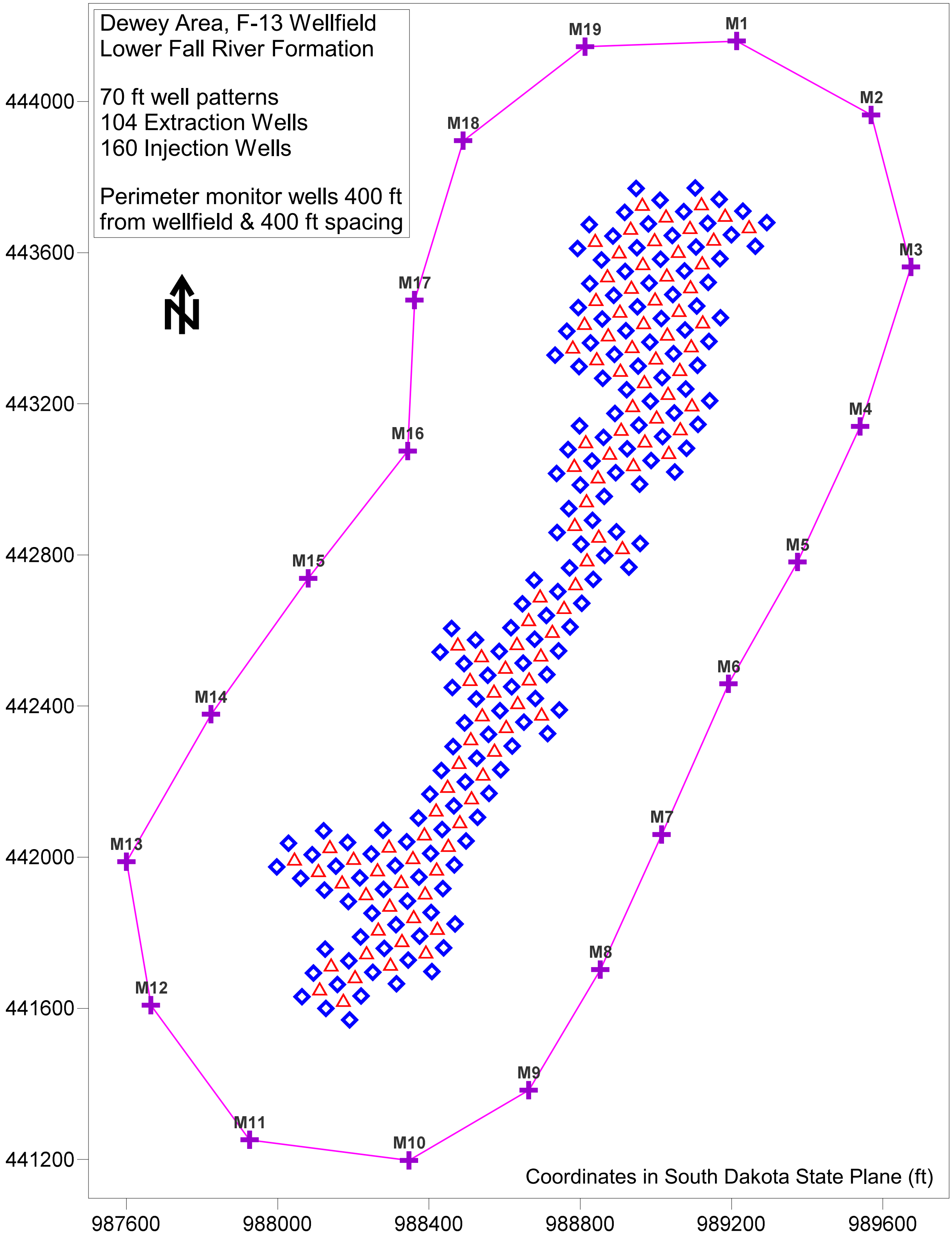
Table 1. Dewey Wellfield Model, Calibration of Model to 2008 Hydrologic Testing

	Drawdown Residual* (DB 07-32-05) (265 ft from PW)	Drawdown Residual* (DB 07-32-04C) (467 ft from PW)	Drawdown Residual* (DB 07-29-7) (2,400 ft from PW)	Residual Sum of Squares, 2 Closest Wells[1]
K = 3.1 ft/day				
S=3e-5	-0.34	-1.11	-3.03	1.35
S=4e-5	**0.23**	**-0.53**	**-2.5**	**0.33**
S=5e-5	0.68	-0.09	-2.09	0.47
S=6e-5	1.04	0.28	-1.77	1.16
K = 3.2 ft/day				
S=3e-5	0.01	-0.83	-2.94	0.69
S=4e-5	0.57	-0.37	-2.43	0.46
S=5e-5	1	0.16	-2.03	1.03
S=6e-5	1.35	0.51	-1.72	2.08
K = 3.4 ft/day				
S=3e-5	0.67	-0.31	-2.79	0.55
S=4e-5	1.19	0.21	-2.3	1.46
S=5e-5	1.6	0.62	-1.93	2.94
S=6e-5	1.93	0.95	-1.63	4.63
K = 3.6 ft/day				
S=4e-5	1.75	0.65	-2.18	3.49
S=5e-5	2.13	1.03	-1.83	5.60
S=6e-5	2.45	1.34	-1.54	7.80

Notes:
* - A positive sign indicates underprediction of drawdown; negative sign indicates model output drawdown more than observed drawdown.
1 - Calibration based on evaluation at two closest monitoring wells, as indicated in text.
Bold indicates best fit utilized for wellfield model simulations.



Extraction Well

Injection Well

Monitor Well

Monitor Well Ring

0 ft 200 ft 400 ft

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Figure 1. Dewey Model Wellfield

Dewey-Burdock Uranium Project, South Dakota

By: AP Checked: HD File ID:Fig1_Dewey Wellfield.srf Date: 10/22/10

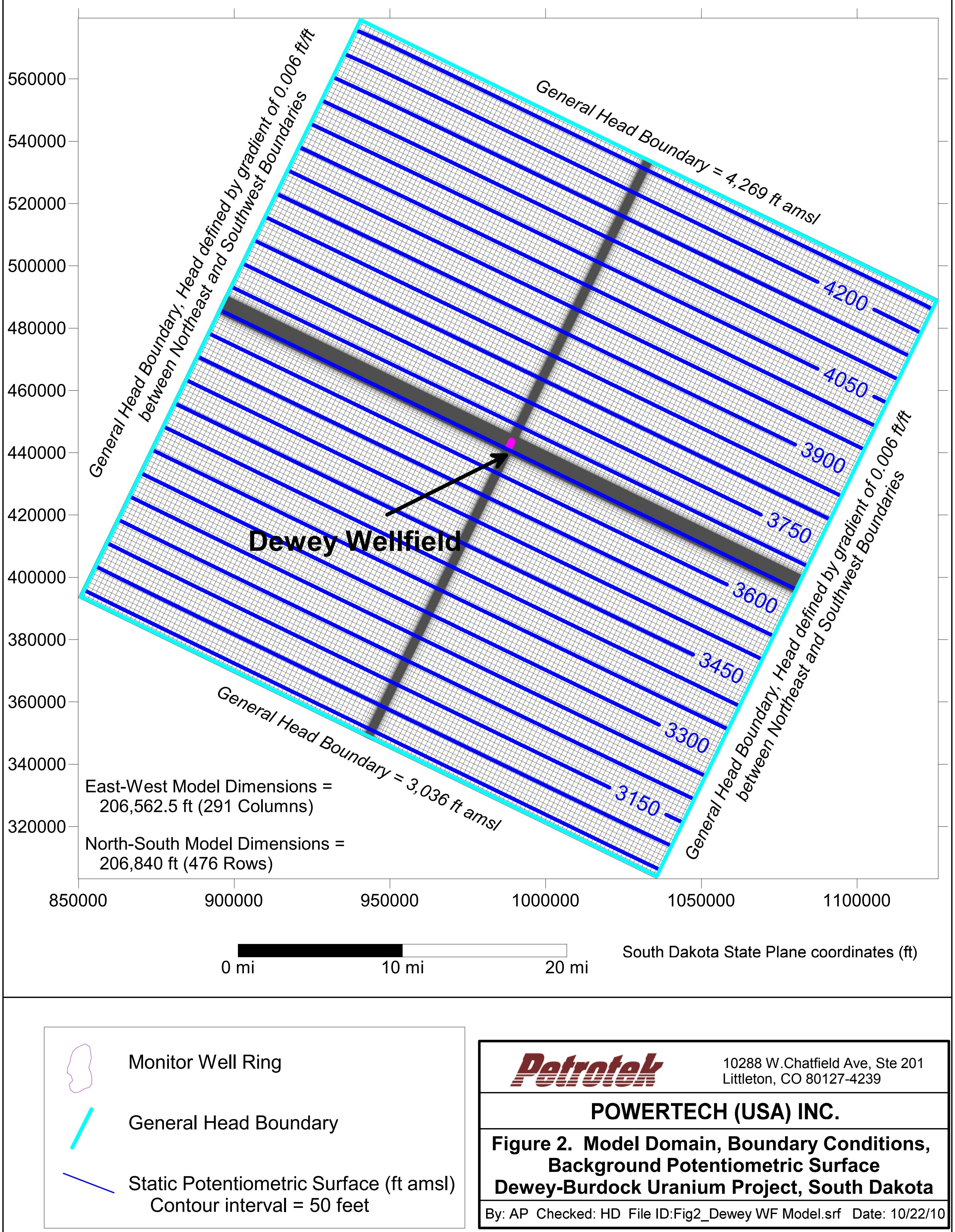

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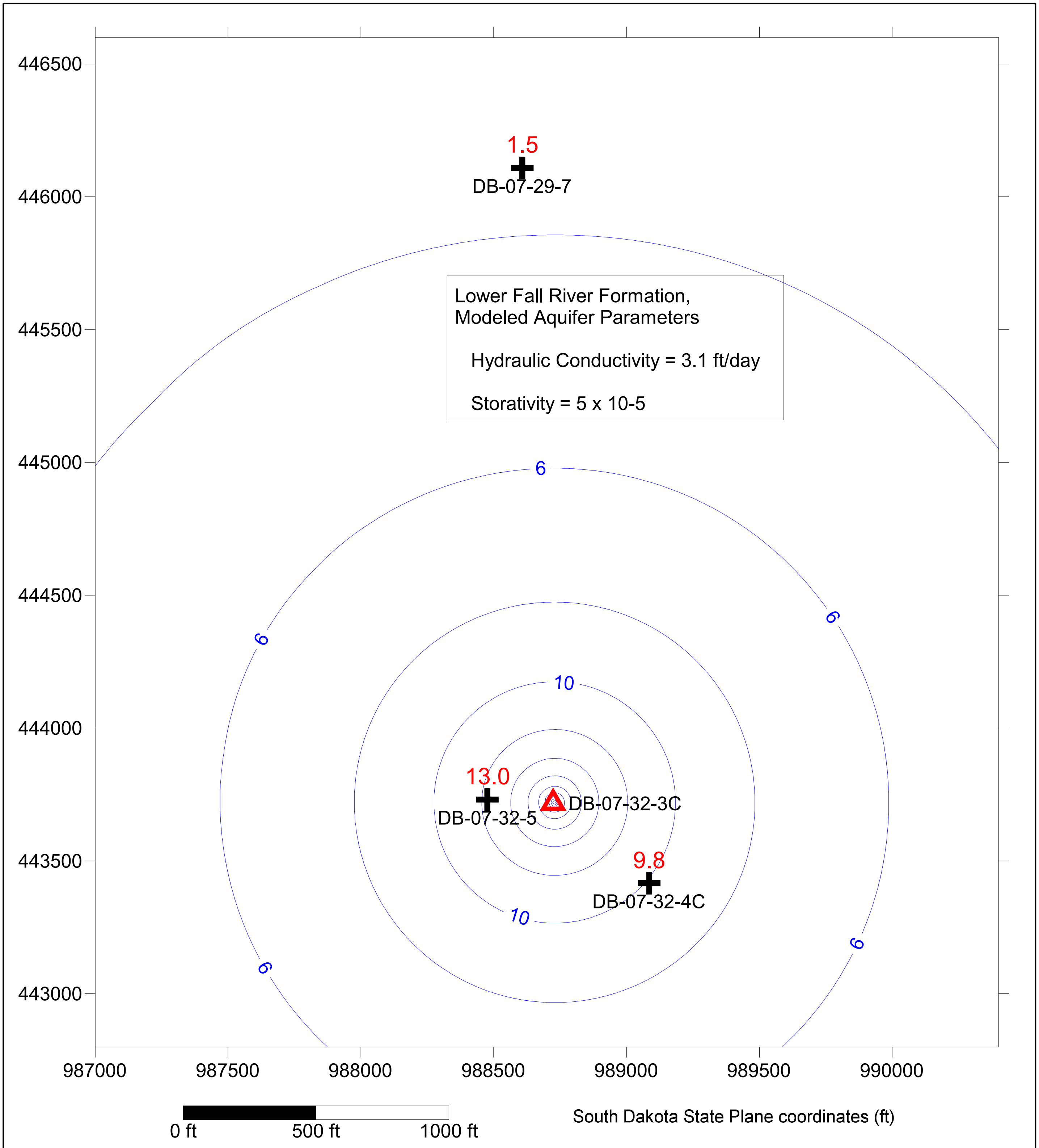
Figure 2. Model Domain, Boundary Conditions, Background Potentiometric Surface Dewey-Burdock Uranium Project, South Dakota

By: AP Checked: HD File ID:Fig2_Dewey WF Model.srf Date: 10/22/10



Pumping Well

Observation Well

13.0 Observed Drawdown (ft)

Simulated Drawdown
Contour Interval = 2 foot

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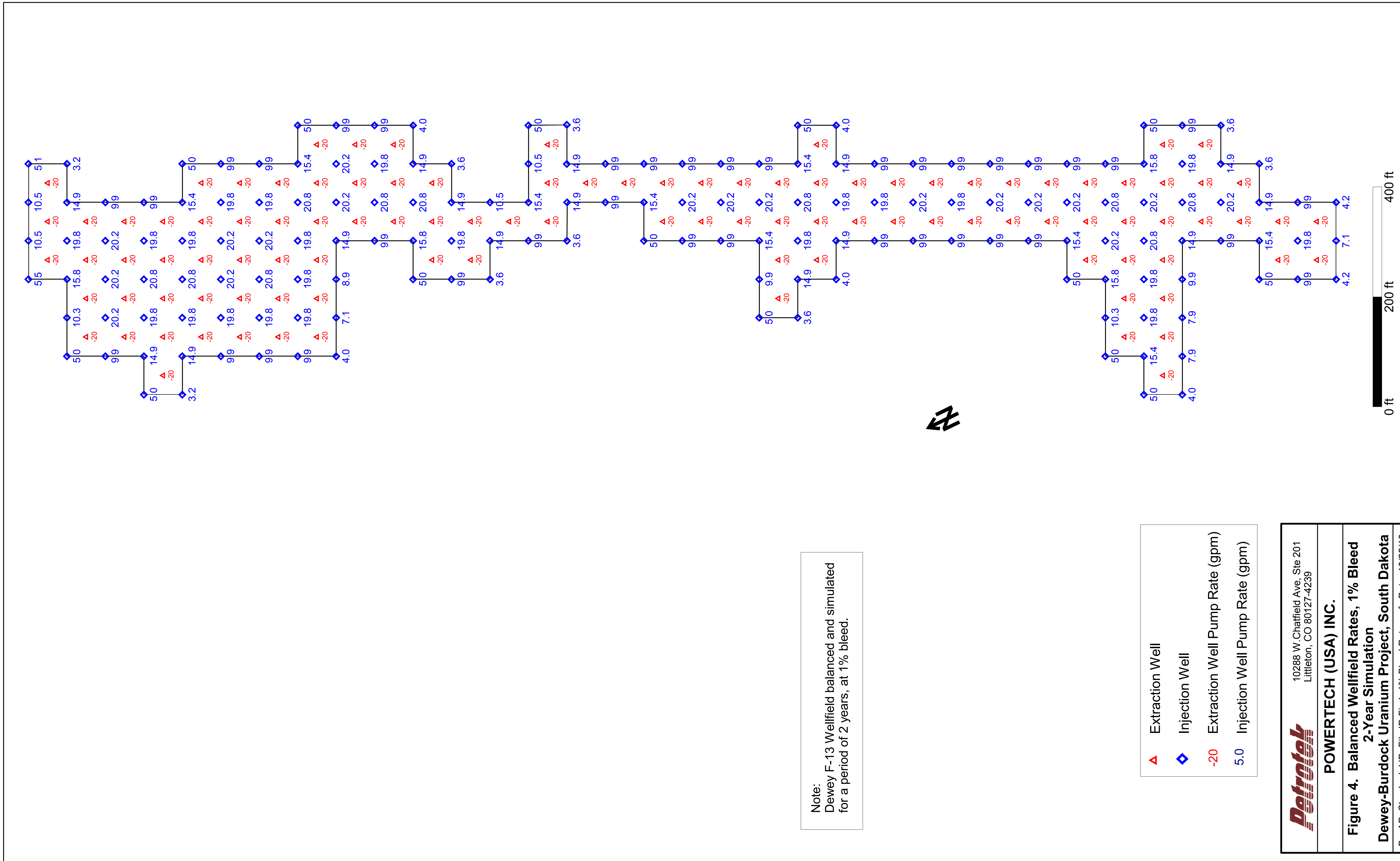
Figure 3. Dewey Area 2008 Pump Test Calibration Results
Dewey-Burdock Uranium Project, South Dakota

By: AP Checked: HD File ID:Fig3_PT Calibration.srf Date: 10/22/10



Note:
Dewey F-13 Wellfield balanced and simulated for a period of 2 years, at 1% bleed.
Extraction Well
Injection Well
-20 Extraction Well Pump Rate (gpm)
5.0 Injection Well Pump Rate (gpm)
0 ft
200 ft
400 ft
N
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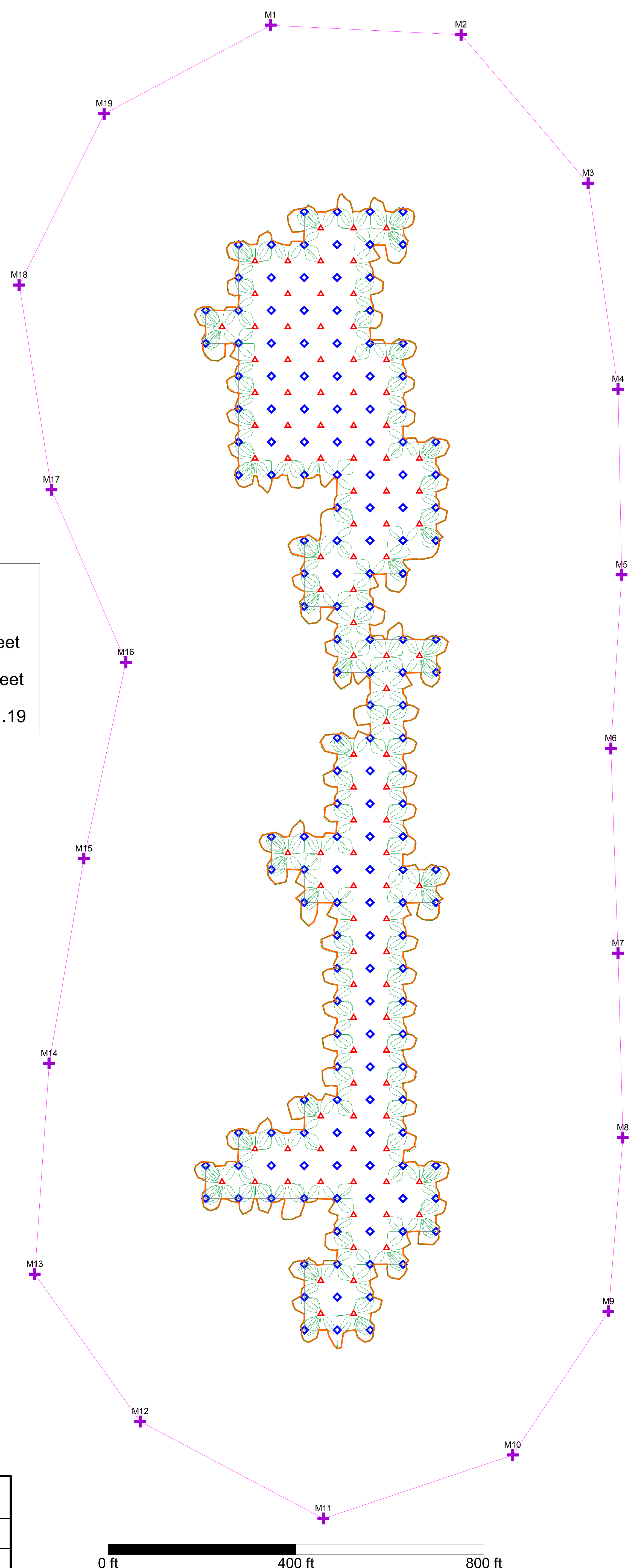
Figure 4. Balanced Wellfield Rates, 1% Bleed
2-Year Simulation
Dewey-Burdock Uranium Project, South Dakota
By: AP Checked: HD File ID:Fig4_1% Bleed Rates.srf Date: 10/22/10



Horizontal Wellfield Flare Calculation:

Injection Well Boundary, Area = 509,593 sq. feet

Particle Trace Boundary, Area = 607,185 sq. feet

Horizontal Well Flare = 607,185 / 509,593 = 1.19

Note:
Dewey F-13 Wellfield balanced and simulated for a period of 2 years. Groundwater flow particles were tracked along injection well boundary over simulated interval.

- Extraction Well
- Injection Well
- Monitor Well
- Monitor Well Ring
- Particle Flow Path
- Horizontal Flare Boundary

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Figure 5. Wellfield Flare, 1% Bleed
2-Year Simulation
Dewey-Burdock Uranium Project, South Dakota

By: AP Checked: HD File ID:Fig5_WF Flare_1%.srf Date: 10/22/10

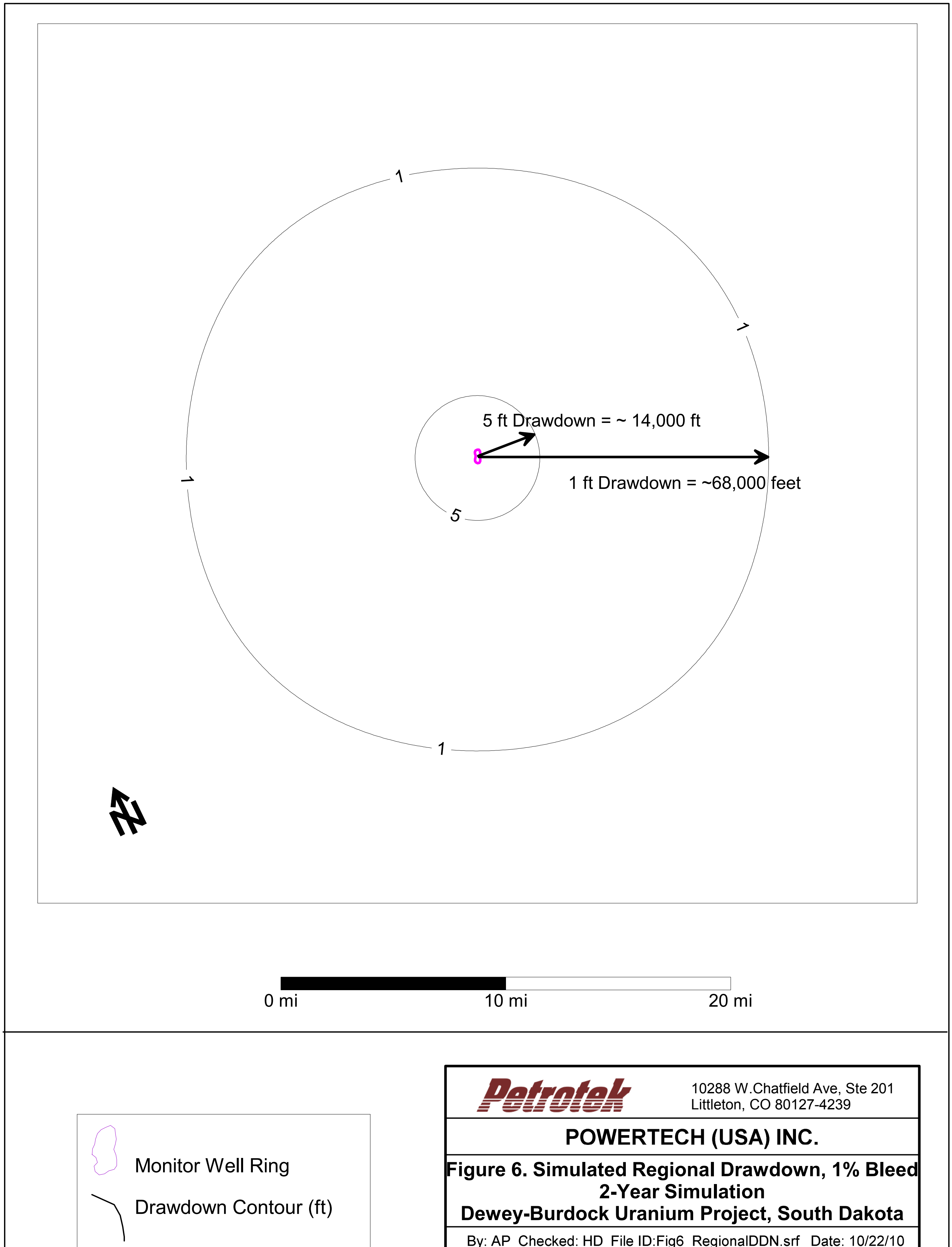

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Figure 6. Simulated Regional Drawdown, 1% Bleed
2-Year Simulation
Dewey-Burdock Uranium Project, South Dakota

By: AP Checked: HD File ID:Fig6_RegionalDDN.srf Date: 10/22/10

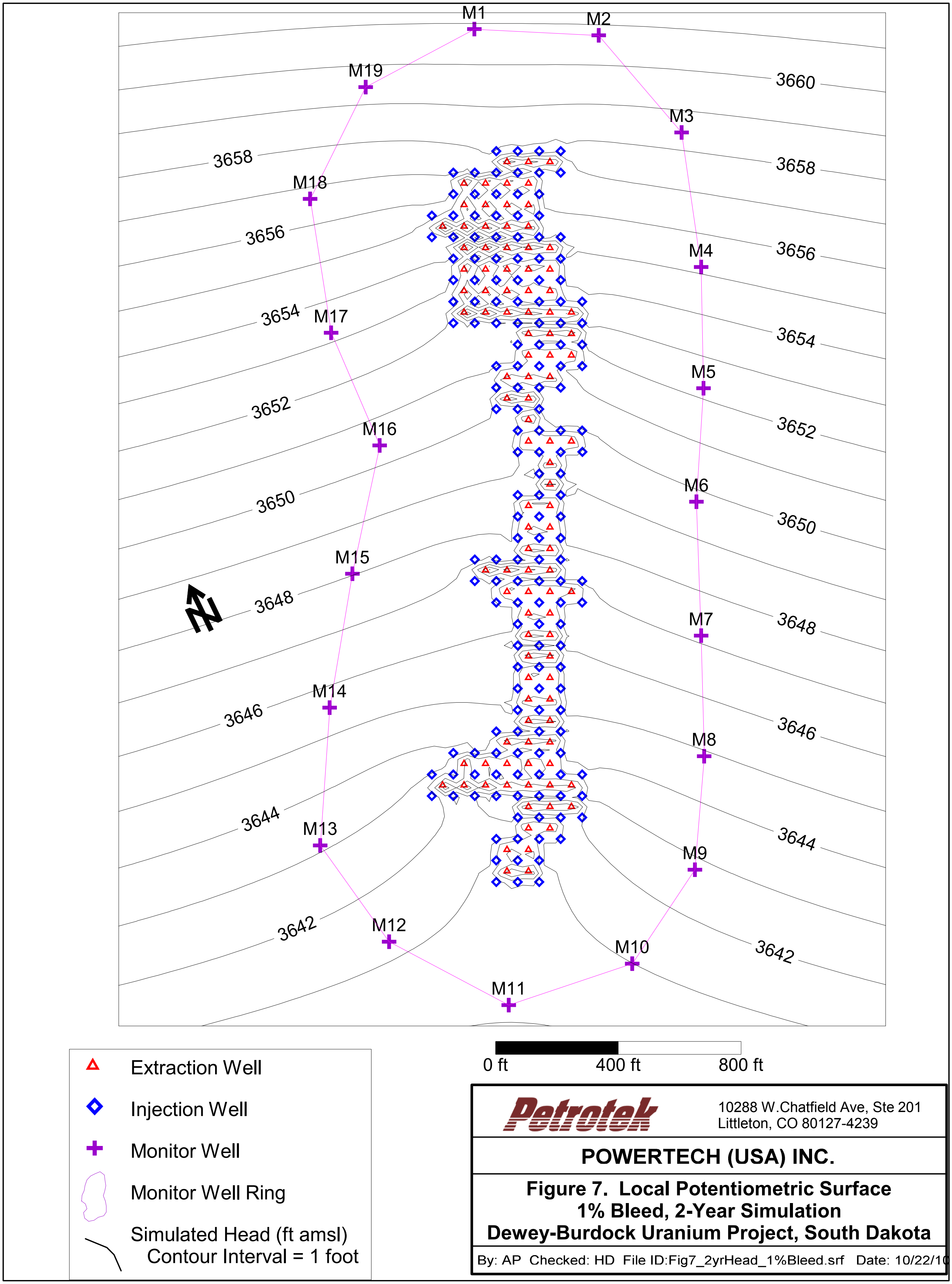

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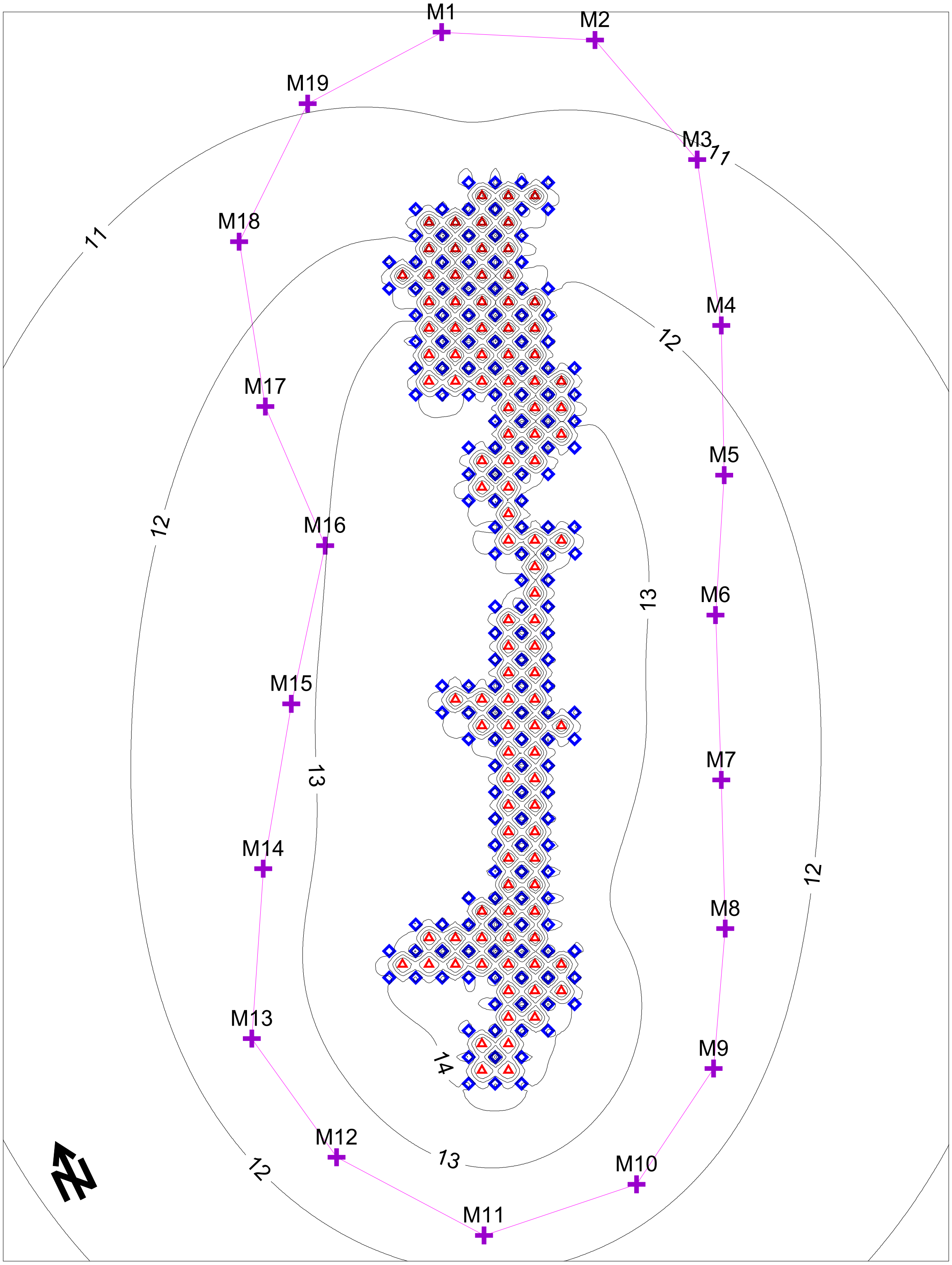
Figure 7. Local Potentiometric Surface
1% Bleed, 2-Year Simulation
Dewey-Burdock Uranium Project, South Dakota

By: AP Checked: HD File ID:Fig7_2yrHead_1%Bleed.srf Date: 10/22/10



Extraction Well
Injection Well
Monitor Well
Monitor Well Ring
Simulated Drawdown (ft)
Contour Interval = 1 foot

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Figure 8. Local Simulated Drawdown 1% Bleed, 2-Year Simulation Dewey-Burdock Uranium Project, South Dakota

By: AP Checked: HD File ID:Fig8_2yrDDN_1%Bleed.srf Date: 10/22/10

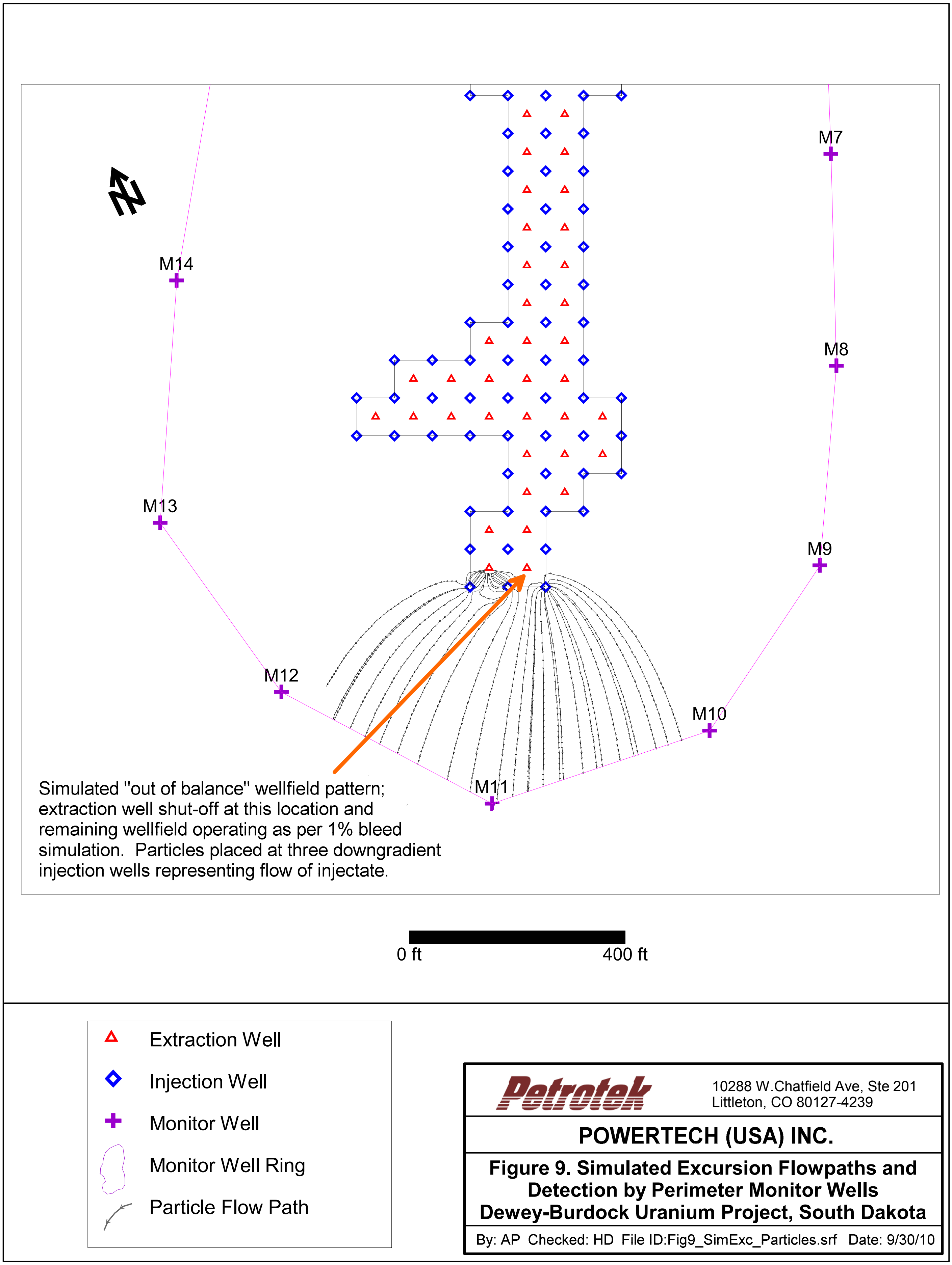
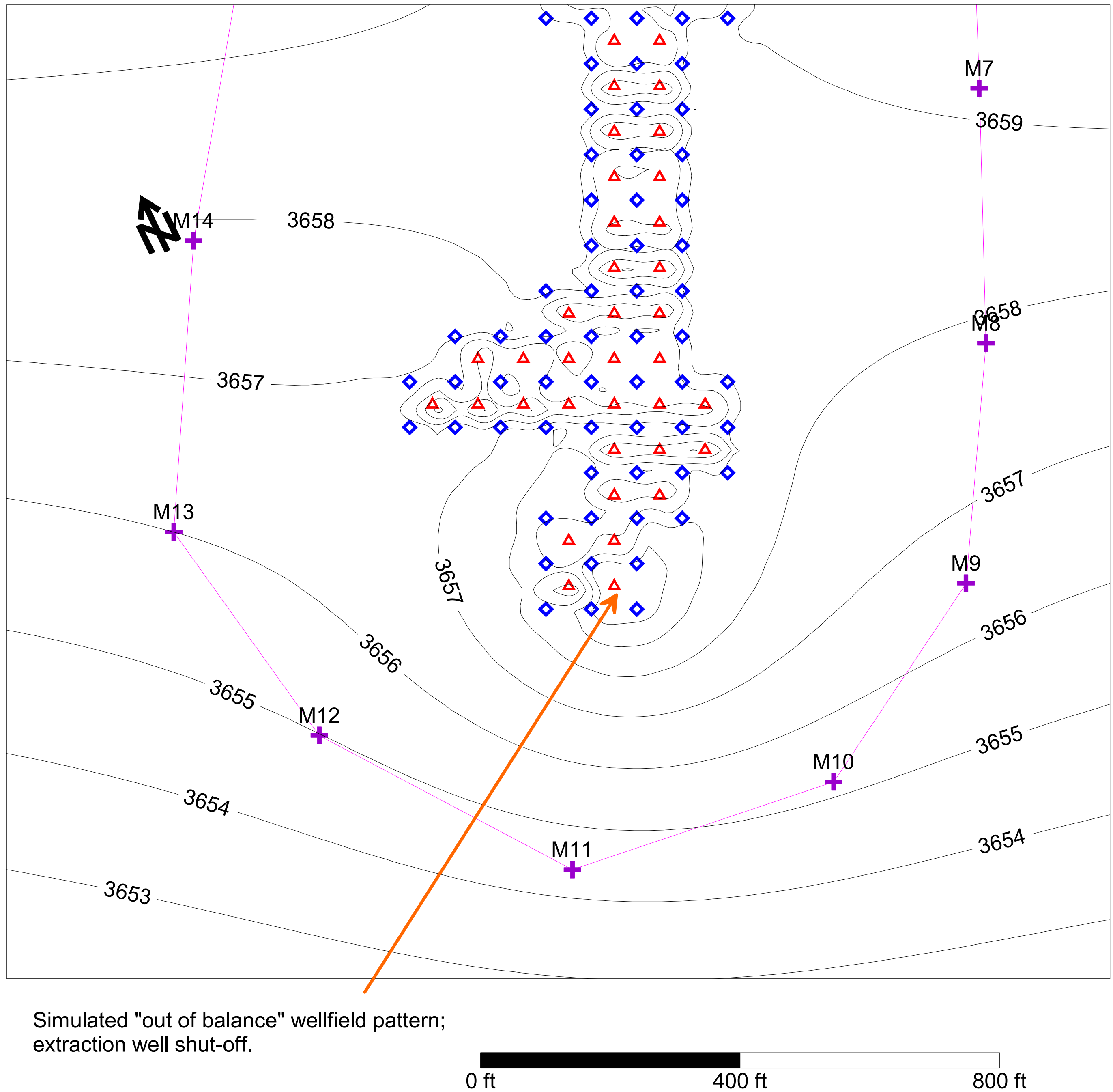


Figure 9. Simulated Excursion Flowpaths and Detection by Perimeter Monitor Wells
Dewey-Burdock Uranium Project, South Dakota



Extraction Well

Injection Well

Monitor Well

Monitor Well Ring

Potentiometric Surface (ft amsl)
Contour Interval = 1 foot

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Figure 10. Potentiometric Surface, Simulated Excursion Dewey-Burdock Uranium Project, South Dakota

By: AP Checked: HD File ID:Fig10_SimExc_Head.srf Date: 10/22/10

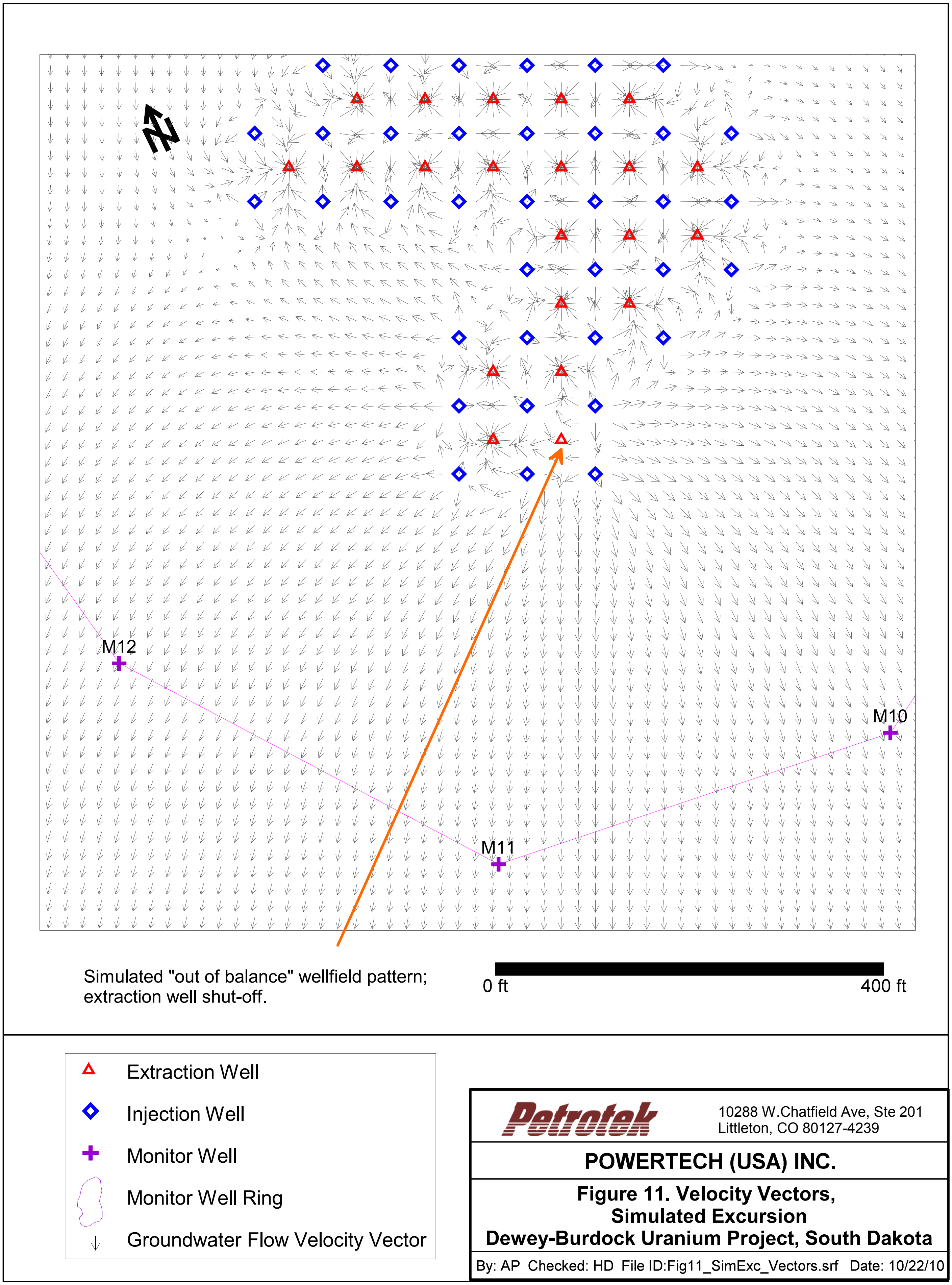

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Figure 11. Velocity Vectors, Simulated Excursion
Dewey-Burdock Uranium Project, South Dakota

By: AP Checked: HD File ID:Fig11_SimExc_Vectors.srf Date: 10/22/10

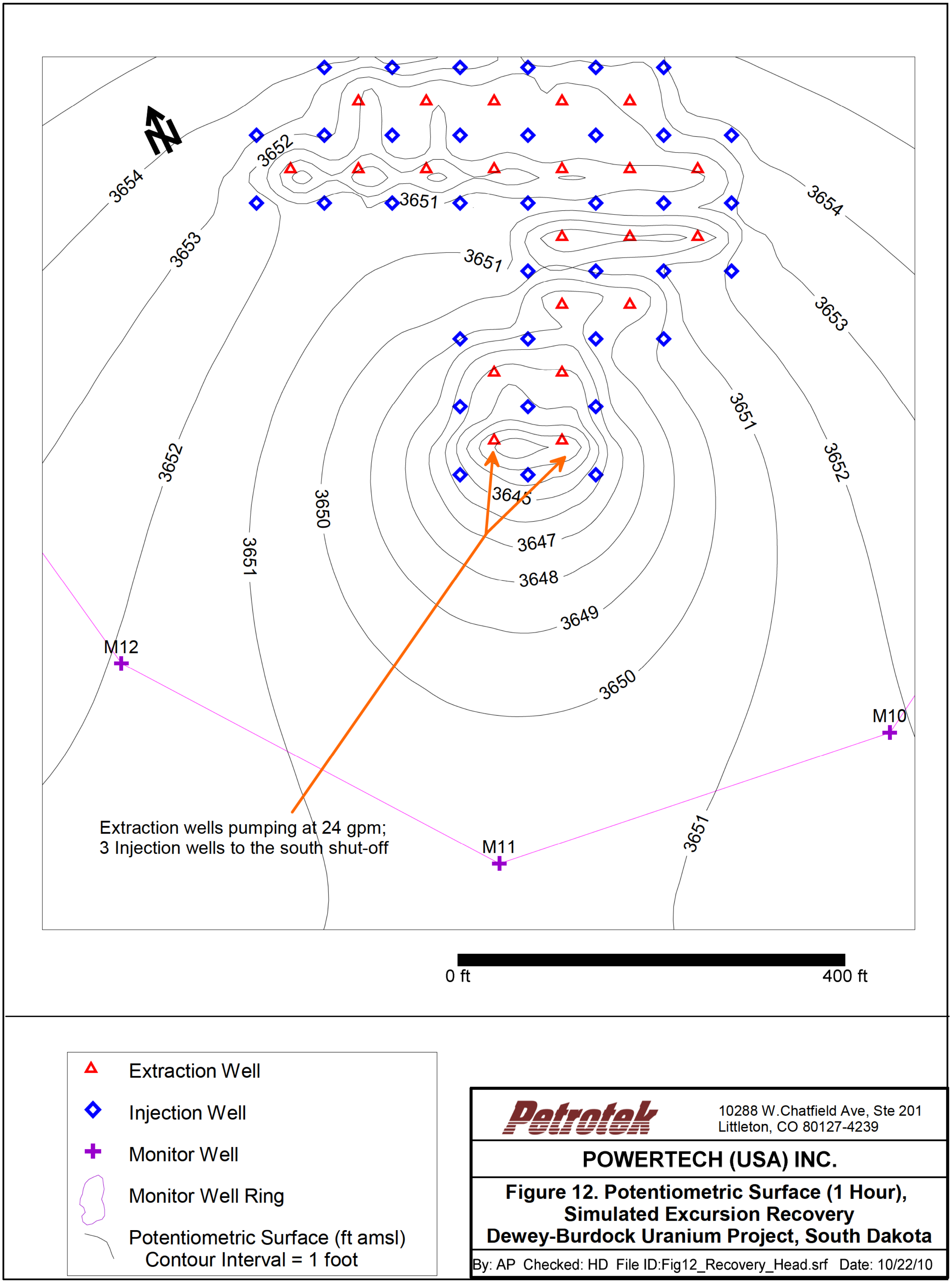

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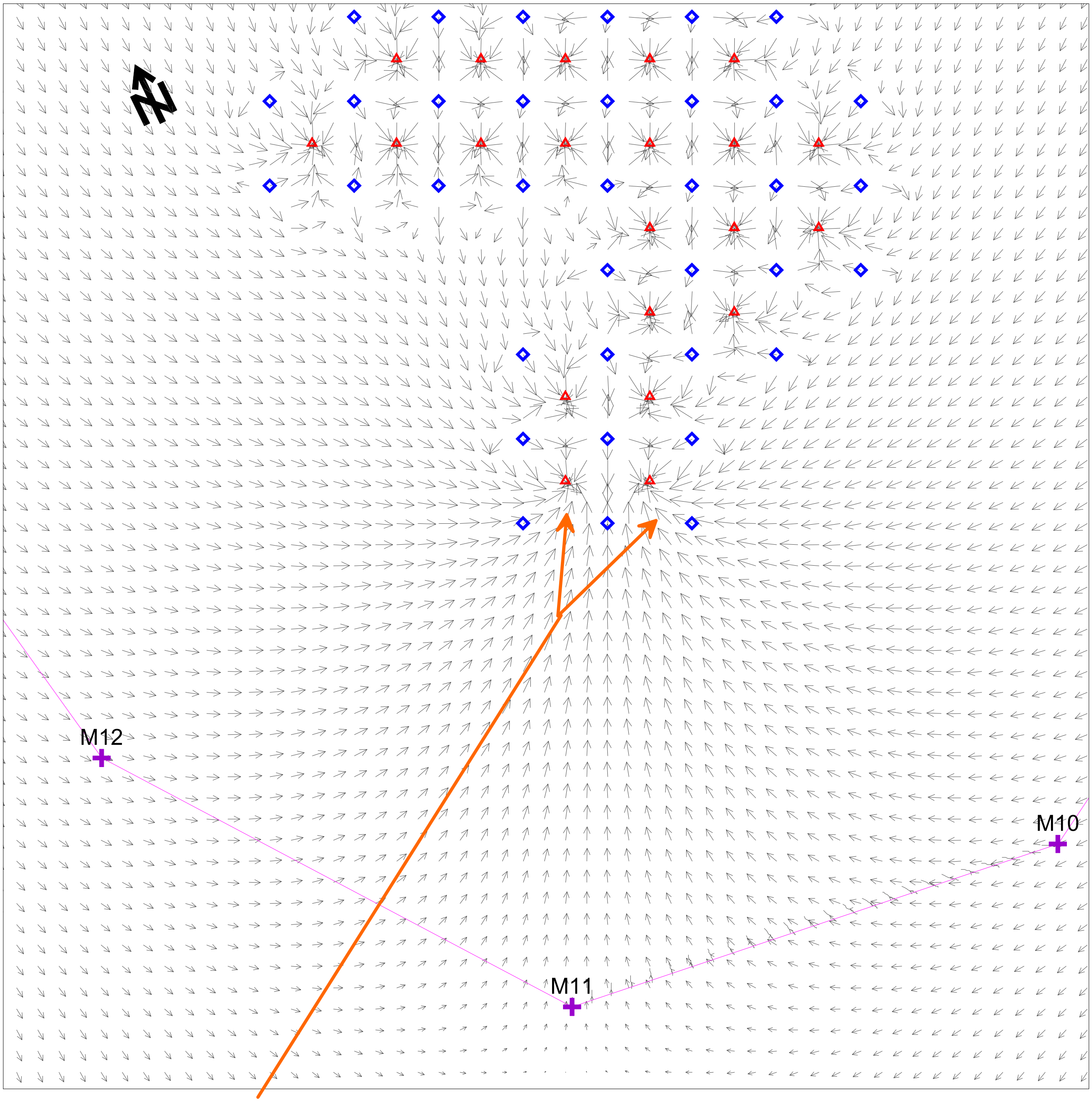
Figure 12. Potentiometric Surface (1 Hour), Simulated Excursion Recovery Dewey-Burdock Uranium Project, South Dakota

By: AP Checked: HD File ID:Fig12_Recovery_Head.srf Date: 10/22/10



Extraction Well	
Injection Well	
Monitor Well	
Monitor Well Ring	
Groundwater Flow Velocity Vector	

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Figure 13. Velocity Vectors (1 Hour), Simulated Excursion Recovery Dewey-Burdock Uranium Project, South Dakota

By: AP Checked: HD File ID:Fig13_Recovery_Vector.srf Date: 10/22/10

Flowpath representing simulated excursion

Flowpath representing simulated recovery

Monitor Well

Monitor Well Ring

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Figure 14. Particle Flow Paths at Monitor Well Simulated Excursion & Recovery Dewey-Burdock Uranium Project, South Dakota

By: AP Checked: HD File ID:Fig14_Exc&RecovPath.srf Date: 10/22/10

APPENDIX 7.3-C

MILDOS-AREA Input Parameters

Table 7.3.1: Parameters used to estimate radionuclide releases from the Dewey-Burdock site

Parameter	Value	Unit	Variable Name	Source
Rate of land application - 1	1.27E-03	$m\ d^{-1}$	AR_1	Application
Rate of land application - 2	2.79E-3	$m\ d^{-1}$	AR_2	Application
Area of land application - Dewey	1.27E+06	m^2	LA_{Dewey}	Application
Area of land application - Burdock	1.27E+06	m^2	$LA_{Burdock}$	Application
Time of land application in a year - 1	80	d	t_{d1}	Application
Time of land application in a year - 2	137	d	t_{d2}	Application
Years of land application	15	y	t_y	Application
Concentration of natural uranium in water	300	$pCi\ L^{-1}$	$[U\text{-}nat]_{water}$	Application (NRC effluent values)
Concentration of thorium-230 in water	100	$pCi\ L^{-1}$	$[Th\text{-}230]_{water}$	Application (NRC effluent values)
Concentration of radium-226 in water	60	$pCi\ L^{-1}$	$[Ra\text{-}226]_{water}$	Application (NRC effluent values)
Concentration of lead-210 in water	10	$pCi\ L^{-1}$	$[Pb\text{-}210]_{water}$	Application (NRC effluent values)
Density of soil - Dewey	1.28	$g\ cm^{-3}$	ρ_{Dewey}	Application
Density of soil - Burdock	1.24	$g\ cm^{-3}$	$\rho_{Burdock}$	Application
Depth of contamination	0.15	m	x	Assumption
Distribution coefficient of natural uranium in loam soil	15	$cm^3\ g^{-1}$	$K_{d,U\text{-}nat}$	"Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil" by Yu et al.
Distribution coefficient of thorium-230 in loam soil	3300	$cm^3\ g^{-1}$	$K_{d,Th\text{-}230}$	"Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil" by Yu et al.
Distribution coefficient of radium-226 in loam soil	36000	$cm^3\ g^{-1}$	$K_{d,Ra\text{-}226}$	"Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil" by Yu et al.
Distribution coefficient of lead-210 in loam soil	16000	$cm^3\ g^{-1}$	$K_{d,Pb\text{-}210}$	"Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil" by Yu et al.
Soil volume water content - Dewey	0.91	unitless	w_{Dewey}	Application
Soil volume water content - Burdock	0.80	unitless	$w_{Burdock}$	Application
Rate of resuspension of radionuclides in surface soil	4E-06	h^{-1}	ARR	DOE Handbook "Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities" by the US Department of Energy
Respirable fraction of resuspended radionuclides in surface soil	1.0	unitless	RF	DOE Handbook "Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities" by the US Department of Energy

Parameter	Value	Unit	Variable Name	Source
Soil porosity - Dewey	0.5429	unitless	n_{Dewey}	Application
	0.5340	unitless	$n_{Burdock}$	Application
Lixiviant flow rate - production	1.49E+04	L min^{-1}	$M_{production}$	Application
Lixiviant flow rate - restoration	3.73E+03	L min^{-1}	$M_{restoration}$	Application
Lixiviant residence time	108	d	t	Application
Production days per year	360	d	D	Application
Formation porosity	0.34	unitless	n_{form}	"Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil" by Yu et al. (coefficient for sandstone)
Content of radium in ore	592	pCi g^{-1}	$[Ra]_{ore}$	Application
Formation density	1.9	g cm^{-3}	ρ_{form}	Application
Storage time in mud pits	7	d	T	Application
Number of mud pits per year	725	y^{-1}	N	Application
Resin porosity	0.38	unitless	n_{resin}	Application
Resin transfers per day	0.5	d^{-1}	N_i	Application
Volume of resin per transfer	1.42E+04	L	V_i	Application
Average mass of ore material in mud pit	185	g	m	Application
Radon emanation coefficient	0.22	unitless	E	"Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil" by Yu et al.

Table 7.3-2: Estimated soil concentrations (pCi g^{-1}) and release rates (Ci y^{-1}) of natural uranium (U-Nat), thorium-230 (Th-230), radium-226 (Ra-226), and lead-210 (Pb-210) from the Dewey-Burdock Site.

Location	X (km)	Y (km)	U-Nat		Th-230		Ra-226		Pb-210	
			Soil Conc.	Rel. Rate	Soil Conc.	Rel. Rate	Soil Conc.	Rel. Rate	Soil Conc.	Rel. Rate
Land Application - Dewey	-6.02	3.80	10.8	0.0974	3.78	0.0325	2.27	0.0195	0.378	0.00325
Land Application - Burdock	-1.09	0.99	11.2	0.0974	3.91	0.0325	2.34	0.0195	0.391	0.00325

Table 7.3-3: Estimated releases (Ci y^{-1}) of radon-222 from the Dewey-Burdock site.

Location	X (km)	Y (km)	Production	Restoration	Drilling	Resin Transfer	Land Application	Total
Production Well Field(5)	-3.86	3.48	212	26.5	3.6E-05	0	0	238.5
Production Well Field (2)	1.83	-0.56	212	26.5	3.6E-05	0	0	238.5
SF	-5.00	3.54	134	16.7	0	0.523	0	151.2*
SF Deep Well	-5.00	3.54	57	7.1	0	0	0	64.1*
Total SF			191	23.8		0.523		215.3
CPP	0	0	134	16.7	0	0	0	150.7*
CPP Deep Well	0	0	57	7.1	0	0	0	64.1*
Total CPP			191	23.8	0	0	0	214.8
Land Application - Dewey	-6.02	3.80	0	0	0	0	6.08	6.08
Land Application - Burdock	-1.09	0.99	0	0	0	0	7.49	7.49
Total			806	100.6	7.2E-05	0.523	14.0	921

*These estimated releases are included in the total SF and CPP estimated releases and are not added again in the Total of 921 Ci/y.