ATTACHMENT D1

Uranium One ISR Wellfield Hydrologic Impact Analysis (Response to RAI 56)

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RAI 56

Description of Deficiency

The information provided in TR Section 3.1.6 does not meet the applicable requirements of 10 CFR Part 40 using review procedures in Section 3.1.2 and acceptance criteria outlined in Section 3.1.3 of the SRP.

Basis for Request

TR Section 3.1.6.1 provides the ROI for the 90 sand, 80 sand, and 70 sand as 550 ft, 500 ft, and 750 ft, respectively, based on the aquifer pumping tests. The TR also states there would be no impact to groundwater levels outside the project boundaries based on these estimates for the proposed bleed rate (15-45 gpm). These ROI were derived based on observations during the aquifer testing of these sands but the TR provided no calculations to support these numbers. Staff does not agree with Uranium One's definition of ROI. In practice, the ROI is defined by a function of transmissivity (T), time (t) and storage coefficient (S) in consistent units (Bear, 1979).

ROI=1.5*sqrt (Tt/S)

Staff requires the ROI and drawdown which will be realized at each satellite to assess the impacts of consumptive use on surrounding private wells and to provide reasonable assurance of the safe operation of the satellites.

Formulation of RAI

Uranium One should provide: (a) the ROI using the estimated T, S and the time of production and restoration for each satellite wellfield; and (b) a prediction of the drawdown for each satellite wellfield within 2 km for each phase of operation using the appropriate consumptive use (e.g. 15-45 gpm).

RAI-56 Response

A Theis-based analytical drawdown model for the 70, 80 and 90 Sand units at the proposed project was completed using site-specific aquifer parameters. The production sands of the Ludeman Project satisfy the assumptions required by the Theis model to the extent generally accepted for this type of hydrogeologic evaluation. Project-specific assumptions and limitations have been noted and discussed in this Memorandum. Model inputs were entered into AQTESOLV software, and graphs were produced showing the predicted time-drawdown behavior of the proposed project wellfields. Drawdown contour maps showing the estimated location of the five and 25 foot drawdown contours (at maximum drawdown) were produced using ArcGIS software. The maximum radii of typical 25 foot drawdown contours ranged from approximately seven to 16 miles, and the maximum radii of five foot drawdown contours ranged from about 14 to 29 miles. Non-ideal aquifer conditions in the vicinity of the site could potentially alter the magnitude and extent of actual versus modeled drawdowns.

Methods and Limitations

Project background information and data for model input were provided to HydroSolutions by TREC. Specifically, TREC provided a project operational schedule, a project summary, versions of *Appendix D6 Hydrology* (Uranium One, 2010) and *Appendix A-1 Pump Test Report* (Uranium One, 2010), a digital ArcGIS shapefile showing wellfield locations, and other documents and figures associated with the Ludeman Project. Project-specific model input data were determined from these documents and through communication with TREC. Additionally, data available on the hydrogeologic properties of Eocene and Paleocene confining units in the Powder River Basin, as summarized in the Powder River Basin Oil and Gas EIS Technical Report on Groundwater Modeling (Applied Hydrology Associates, Inc. and Greystone Environmental Consultants, Inc., 2002), were reviewed.

Analytical Model and Assumptions

The Hantush-Jacob (1955) analytical model for non-equilibrium radial flow to a well in a leaky confined aquifer was selected for estimation of cumulative groundwater drawdown associated with the Ludeman Project. The Hantush-Jacob equation provides a solution for determining groundwater flow and drawdown in time and space around a pumping well completed in a leaky confined aquifer.

In most natural settings, aquifer "confinement" tends to be imperfect, and typical confined aquifers receive some recharge by vertical leakage through confining units. The Hantush-Jacob leaky confined aquifer model allows for a more realistic prediction of groundwater drawdown in these leaky-confined hydrogeologic settings than the Theis model by accounting for this vertical leakage phenomenon. Furthermore, implementation of the Hantush-Jacob model with computer software lends itself to superposition of results through time and space, which allows the model to more accurately represent the interaction between different wellfields throughout the project area over the full duration of the project.

The 70, 80 and 90 Sand aquifers satisfy the requisite assumptions for application of the Hantush-Jacob model to the extent generally accepted in this type of hydrogeologic evaluation. General assumptions associated with application of the Hantush-Jacob model include those associated with the Theis (1935) model for confined aquifers, as well as several additional assumptions. The following list presents a summary of these assumptions:

- The aquifer is leaky-confined;
- The aquifer and leaky confining unit have an apparent infinite extent;
- The aquifer and leaky confining unit are homogeneous, isotropic, and of uniform thickness over the area influenced by pumping;
- The aquifer is compressible, and water is instantaneously released from storage as head is lowered;
- Groundwater storage is negligible in the leaky confining unit;
- The potentiometric surface of the aquifer is horizontal prior to pumping;
- The well is pumped at a constant rate;
- Flow to the pumping well is horizontal, and flow through the leaky confining unit is vertical;
- The well diameter is small, such that well storage is negligible, and the well is 100 percent efficient; and
- The leaky confining unit is overlain or underlain by an aquifer that maintains constant head at all times.

Further assumptions related specifically to this Ludeman Project model include:

- The modeled aquifers are not in hydraulic communication with the North Platte River; and
- The groundwater drawdown pattern associated with each wellfield can be approximated by utilizing a single hypothetical pumping well located at the center of each wellfield.

Analytical Model Limitations

Boundary conditions present a common challenge to the prediction of groundwater behavior using analytical models. Geologic data indicated that each of the production sands at the Ludeman project is bounded on top and bottom by low permeability confining units. The use of the Hantush-Jacob leaky confined aquifer model accounts for vertical recharge through confining units, and is therefore expected to improve the accuracy of drawdown predictions over the Theis model in this situation. The most limiting of the remaining model assumptions relate to the horizontal continuity of the aquifers and the potential for lateral boundary conditions. The production sands are not everywhere laterally continuous; however the analytical model assumes continuity, which could have the effect of altering observed drawdown patterns compared to modeled drawdown patterns. The possible effects of these lateral boundary conditions are discussed further below.

The project area is located near the southern edge or the Powder River Basin, and the targeted aquifer units crop out between the project area and uplifted basement rocks of the Laramie Mountains to the south (Love & Christiansen, 1985). Hydrologic studies of the Ludeman site found that the 70 Sand is continuous beneath the area, but that the 80 and 90 Sand aquifers are not everywhere continuous, and crop out in the southeastern portion of the site (Uranium One, 2010). Discontinuous aquifers will not respond ideally to drawdown, and may show locally greater drawdown near pumping wells and less drawdown at greater distances.

Specifically, the outcropping of the 80 Sand and 90 Sand aquifers suggest the possibility of a recharge boundary. Potential lateral recharge from an outcrop is not accounted for in this implementation of the Hantush-Jacob model. However, the existence of such a boundary could serve to restrict the extent and magnitude of drawdown. The site studies, however, found that all three production sand units were well confined on top and bottom by shale units within the proposed area of injection and recovery.

This model assumes that groundwater withdrawals are made from a single hypothetical point at the center of each wellfield. This point has been represented by a single well in the analytical model. This single well approximation results in near-well drawdowns that may at times exceed the available drawdown of the aquifer, and are thus unrealistic. However, based on a limited sensitivity analysis conducted prior to full-scale modeling, these effects are most pronounced in the near field and decrease dramatically with distance from the pumping center. At the scale of interest for this model, the single pumping center approach produces a close approximation of the geometry and magnitude of groundwater drawdown from an actual wellfield. Therefore, use of a single pumping center per wellfield is acceptable for the purpose of estimating cumulative drawdown for the Ludeman Project.

Analytical Modeling Methods

The Hantush-Jacob (1955) model was implemented using AQTESOLV software (Duffield, 2007) to calculate the predicted magnitude and extent of drawdown in each aquifer. ESRI ArcGIS software was utilized to aid with the input of spatial data and to contour and present the estimated groundwater drawdown produced by the model. This sub-section discusses the methods used to determine model input parameters, and the modeling methods. Specific model input parameters are presented in detail in the next section, *Model Inputs*.

Wellfield locations and groundwater consumption rates and schedules were based on information provided by TREC. Groundwater withdrawal rates were estimated by using wastewater production as a proxy for net consumptive use rates of the wellfields. Wastewater production rates are expected to approximate the difference between the rate of groundwater withdrawal and the rate of injection during operations. Separate model runs were conducted for the 70, 80 and 90 Sands.

The Hantush-Jacob analytical model equates the tendency of a confining layer to leak with a parameter called the *leakage factor* (B), which is related to the thickness and hydraulic conductivity of both the pumped aquifer and the confining layer (Neuman & Witherspoon, 1969) (Fetter, 2001). Small leakage factors correspond to highly leaky confining layers, whereas large leakage factors correspond to minimal leakage through confining units. The reciprocal of the leakage factor (1/B) is commonly utilized in practice. When the reciprocal is used, the above relationship is inverted such that large 1/B values correspond to highly leaky confining layers, and small 1/B values correspond to minimal leakage through confining units.

In order to calculate leakage factors, average confining unit thickness was determined by subtracting the thickness of sand units from the total thickness of the stratigraphic section in three locations along Cross-Section C-C' and three locations along Cross-Section K-K' (Uranium One, 2010). Vertical hydraulic conductivity for the confining units (K_V) was estimated based on values of K_V reported for Eocene and Paleocene confining units in the Powder River Basin in the Powder River Basin Oil and Gas EIS Technical Report on Groundwater Modeling (Applied Hydrology Associates, Inc. and Greystone

Environmental Consultants, Inc., 2002). AQTESOLV software utilizes the leakage factor in its reciprocal form (1/B), which was calculated for each aquifer using the above sources of information in addition to site specific data.

The pumping wells representing the withdrawal points in the model were located at the geographic center of each wellfield, using the ArcGIS Spatial Statistics tool package Mean Center tool. Positions of the pumping wells used to represent each wellfield were input into AQTESOLV, along with other aquifer properties (see *Model Inputs* section). The Hantush-Jacob model was then applied to each aquifer to predict the magnitude and distribution of groundwater drawdown around the project area over the duration of the project. The principle of superposition was utilized to account for the effects of multiple active wellfields, pumping rates and pumping periods across the project area (Duffield, 2007) (Reilly, Franke, & Bennett, 1987).

Using the results of the model runs, the time(s) of maximum drawdown during the project duration were identified for each aquifer using time-drawdown plots. Subsequently, the model-predicted drawdown in and around the project area was output to ArcGIS for the production of drawdown contour maps at the time(s) of maximum drawdown in each aquifer.

Model Inputs

With the exception of confining unit hydraulic conductivity, all model input data were based on the hydrologic studies of the site conducted by Uranium One or its predecessors in interest (Uranium One, 2010). Details of the pertinent physical aquifer and confining unit parameters, as well as the consumptive use schedule and rates utilized in the drawdown models, are presented in Tables 1-4. In the model, the beginning of 2013 was selected as time = 0, because this is the point at which the first consumptive use of groundwater is scheduled to begin.

Physical aquifer parameters were determined from the *Pump Test Report* (Uranium One, 2010), and were confirmed with TREC. The parameters utilized for the 70, 80 and 90 sands are summarized on Table 1. Average confining unit thickness was estimated to be 66 feet using geologic data provided by TREC and the method described previously. Confining unit vertical hydraulic conductivity was estimated at 6×10^{-5} ft/day using published data (Applied Hydrology Associates, Inc. and Greystone Environmental Consultants, Inc., 2002). Using these representative confining unit properties, along with

70, 80 and 90 sand hydraulic conductivity and thickness values, reciprocal leakage factors (1/B) were calculated for each sand unit and are also presented on Table 1.

Average wastewater production rates of the satellite facilities were provided to HydroSolutions as a means to estimate consumptive groundwater use. During production, the wastewater production is estimated to range from 15–45 gallons per minute (gpm), and average 30 gpm. During restoration (reverse osmosis treatment), wastewater production is estimated to range from 60–150 gpm. These rates are not necessarily unique to any single wellfield, because satellite facilities each serve multiple wellfields, at times in different production phases. Therefore, precise consumptive use at each wellfield could not be determined at this time. Rather, rates of 30 gpm during production and 105 gpm during restoration were used as estimates of consumptive groundwater use by each wellfield. These rates are expected to produce reasonable estimates of drawdown.

The rates (in gpm), and timing of consumptive use for each aquifer, are presented on Tables 2 through 4. These values, along with pumping center locations, were entered into the analytical model.

Results and Discussions

Drawdown contours produced by the model were typically circular to somewhat elliptical in shape, depending on the distribution of active pumping centers in a given aquifer. At the time(s) of maximum drawdown, 25 foot drawdown contours for the 70, 80 and 90 Sand units had maximum radii that ranged between about 1.2 to 2.4 miles from their approximate pumping centers (wellfields) at the Ludeman site. Five foot drawdown contours for the 70, 80 and 90 sands typically had radii of approximately 3.4 to 4.8 miles from the pumping centers. A summary of approximate radial distances to the five and 25 foot drawdown contours for each aquifer is presented on Table 5.

Graphs showing the modeled time-drawdown characteristics of the pumping centers in each aquifer over the duration of the project are presented on Figures 1–3. Results of the analytical drawdown modeling are also presented as drawdown contour maps on Figures 4–8. Due to the operational schedules of the 80 and 90 Sand units, two distinct drawdown peaks were noted in the model output, which correspond to unique areal drawdown patterns. Thus, individual contour maps were prepared for both the first and second peaks in these cases.

Due to the low vertical hydraulic conductivity of the confining units, leakage across the confining units is expected to occur slowly in response to pumping. Therefore, the effects of this leakage on the observed drawdowns may not be evident in data collected during short-duration pumping tests at the site. However, on the scale of many years, over which the Ludeman Project will take place, it is reasonable to expect that the relatively slow leakage through the confining layers will make a substantial recharge contribution to the pumped aquifers. This vertical recharge contribution is expected to limit the geographic extent of drawdown to a degree, as predicted by these modeling results.

The physical properties of the confining units used in this model are expected to represent reasonable estimates for an average confining unit in the general project area. Note, however, that the results are sensitive to changes in these parameters. Specifically, as a confining unit thins, and/or its K_V increases, the modeled zone of influence (drawdown) contracts to smaller and smaller radii. Conversely, as a confining unit thickens or its K_V decreases, the modeled zone of influence will expand until it eventually converges with the Theis solution at large thicknesses or very small values of K_V.

By accounting for recharge from slow vertical leakage across confining units, the Hantush-Jacob model presents a more realistic estimate of drawdown for the Ludeman project setting compared to a Theis-based model that ignores recharge. Still, as indicated in the Methods and Limitations section, other non-ideal aquifer conditions would, to some extent, alter actual drawdown patterns compared to those predicted by this model. Small-scale boundary conditions, such as those that may exist between discontinuous segments of the 80 Sand and 90 Sand, would likely cause localized areas of increased drawdown immediately surrounding active wellfields. However such conditions would also limit the more distant extent and magnitude of drawdown.
Lateral boundary conditions due to outcropping of the 80 and 90 Sand units could result in offsetting effects. For instance, such boundaries could cause an increase in observed drawdown between the site and the outcrop and expansion of the drawdown elsewhere. However, periodic recharge at these outcrops would also be likely to have a limiting effect on the zones of influence.

Summary

A Hantush-Jacob based analytical drawdown model for the 70, 80 and 90 Sand units at Uranium One's Ludeman Project was completed using site-specific aquifer parameters, and estimates of confining unit characteristics. This model is expected to produce more accurate long term drawdown predictions than a Theis model, because it accounts for aquifer recharge from small amounts of leakage through confining units. The production sands of the Ludeman Project satisfy the assumptions required by the Hantush-Jacob model to the extent generally accepted for this type of hydrogeologic evaluation. Project-specific assumptions and limitations have been noted and discussed in this Memorandum.

Model inputs were entered into AQTESOLV software, and graphs were produced showing the predicted time-drawdown behavior of the Ludeman Project wellfields. Drawdown contour maps showing the estimated location of the five and 25 foot drawdown contours (at maximum drawdown) were produced using ArcGIS software. The maximum radii of typical 25 foot drawdown contours ranged from approximately 1.2 to 2.4 miles, and the maximum radii of five foot drawdown contours ranged from about 3.4 to 4.8 miles. Non-ideal aquifer conditions in the vicinity of the site could potentially alter the magnitude and extent of actual versus modeled drawdown, and the model is also sensitive to changes in the thickness and vertical hydraulic conductivity of the confining units.

References

Applied Hydrology Associates, Inc. and Greystone Environmental Consultants, Inc. (2002). Technical Report - Groundwater Modeling. *Powder River Basin Oil & Gas EIS.*

Duffield, G. M. (2007). AQTESOLV for Windows Version 4.5. Reston, VA: HydroSOLVE, Inc.

Fetter, C. W. (2001). *Applied Hydrogeology* (4th ed.). Upper Saddle River: Prentice Hall.

Hantush, M. S., & Jacob, C. E. (1955). Non-steady radial flow in an infinite leaky aquifer. *Am. Geophys. Union Trans, 36*, 95–100.

Love, J. D., & Christiansen, A. C. (1985). Geologic Map of Wyoming.

Neuman, S. P., & Witherspoon, P. A. (1969). Applicability of Current Theories of Flow in Leaky Aquifers. *Water Resources Research*, 817-829.

Reilly, T. E., Franke, O. L., & Bennett, G. D. (1987). Chapter B6: The Principle of Superposition and its Application in Ground-Water Hydraulics. *Techniques of Water-Resources Investigations of the United States Geological Survey, Book 3: Applications of Hydraulics*. Washington: U.S. Government Printing Office.

Theis, C. V. (1935). The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage. *Transactions of the American Geophysical Union, 2*, 519-524.

Uranium One. (2010, January). Ludeman Project Appendix D6: Hydrology for Wyoming Department of Environmental Quality Class III Underground Injection Control Permit Application.

Uranium One. (2010). *Ludeman Project, Addendum D5: Geology for Wyoming Department of Environmental Quality Class III Underground Injection Control Permit Application.*

Uranium One. (2010). Ludeman Project, Addendum D6-G Appendix A-1: Pump Test Report, for Wyoming Department of Environmental Quality Class III Underground Injection Control Permit Application.

Table 1: Aquifer Parameters Used in Analytical Drawdown Model.

Parameter	Aquifer		
	70 Sand	80 Sand	90 Sand
Transmissivity (ft^2/day)	96.4	70.0	94.6
Storativity (unitless)	5.08×10^{-5}	7.75×10^{-5}	5.57×10^{-5}
Average Saturated Thickness (ft)	42.75	66.25	48.75
Hydraulic Conductivity (ft/day)	2.25	1.06	1.94
1/B (ft^{-1})	9.7×10^{-5}	1.1×10^{-4}	9.8×10^{-5}

Table 2: 70 Sand consumptive use schedule showing estimated gallons per minute of consumptive use by year and wellfield.

70 Sand Wellfield	Elapsed Time in Years (Calendar Year)										
	1	2	3	4	5	6	7	8	9	10	11
2	0	30	30	105	105	105 (1/2 yr)	0	0	0	0	0
3	0	0	0	30	30	105	105	105	0	0	0
4	0	0	0	0	30	30	105	105	105	0	0
5a	0	0	0	0	0	30	30	30	105	105	105

Production periods are shown in blue, restoration periods are shown in green, and periods of no groundwater withdrawals are white.

Table 3: 80 Sand consumptive use schedule showing estimated gallons per minute of consumptive use by year and wellfield.

80 Sand Wellfield	Elapsed Time in Years (Calendar Year)										
	1	2	3	4	5	6	7	8	9	10	11
1b	30	30	105	105	105	105 (1/2 yr)	0	0	0	0	0
5b	0	0	0	0	0	30	30	30	105	105	105

Production periods are shown in blue, restoration periods are shown in green, and periods of no groundwater withdrawals are white.

Table 4: 90 Sand consumptive use schedule showing estimated gallons per minute of consumptive use by year and wellfield.

90 Sand Wellfield	Elapsed Time in Years (Calendar Year)										
	1	2	3	4	5	6	7	8	9	10	11
1a	30	30	105	105	105	105 (1/2 yr)	0	0	0	0	0
6	0	0	0	0	0	0	30	30	105	105	105

Production periods are shown in blue, restoration periods are shown in green, and periods of no groundwater withdrawals are white.

Table 5: Approximate maximum radii (in miles) of five and 25 foot drawdown contours from center of maximum drawdown at time(s) of maximum predicted drawdown (n/a indicates not a time of maximum drawdown).

	Time = 5.5 years		Time = 9 years		Time = 11 years	
Drawdown contour →	**5 ft**	**25 ft**	**5 ft**	**25 ft**	**5 ft**	**25 ft**
70 Sand	n/a	n/a	4.8	2.4	n/a	n/a
80 Sand	3.4	1.4	n/a	n/a	3.4	1.4
90 Sand	3.5	1.2	n/a	n/a	3.5	1.2

Figure 1: 70 Sand aquifer time-drawdown graph showing model estimated drawdowns in active 70 Sand wellfields during project lifespan. Based on current schedule; time = 0 corresponds to beginning of year 1. Displacement is shown in meters.

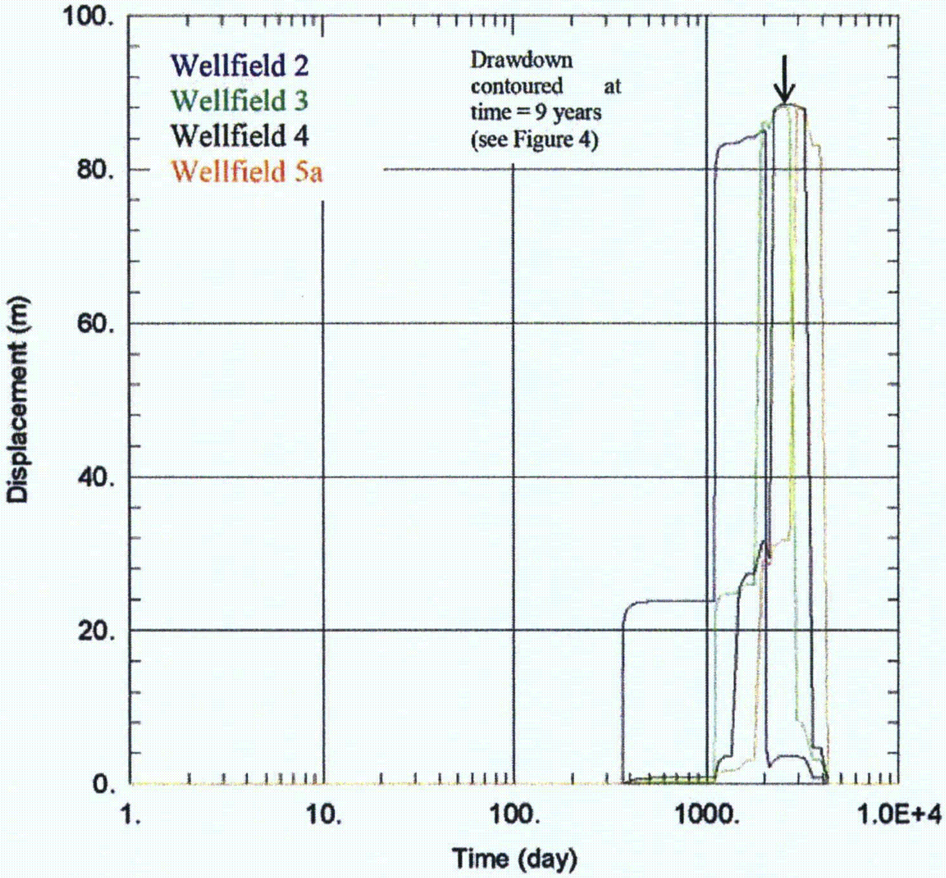


Figure 2: 80 Sand aquifer time-drawdown graph showing model estimated drawdowns in active 80 Sand wellfields during project lifespan. Based on current schedule; time = 0 corresponds to beginning of year 1. Displacement is shown in meters.

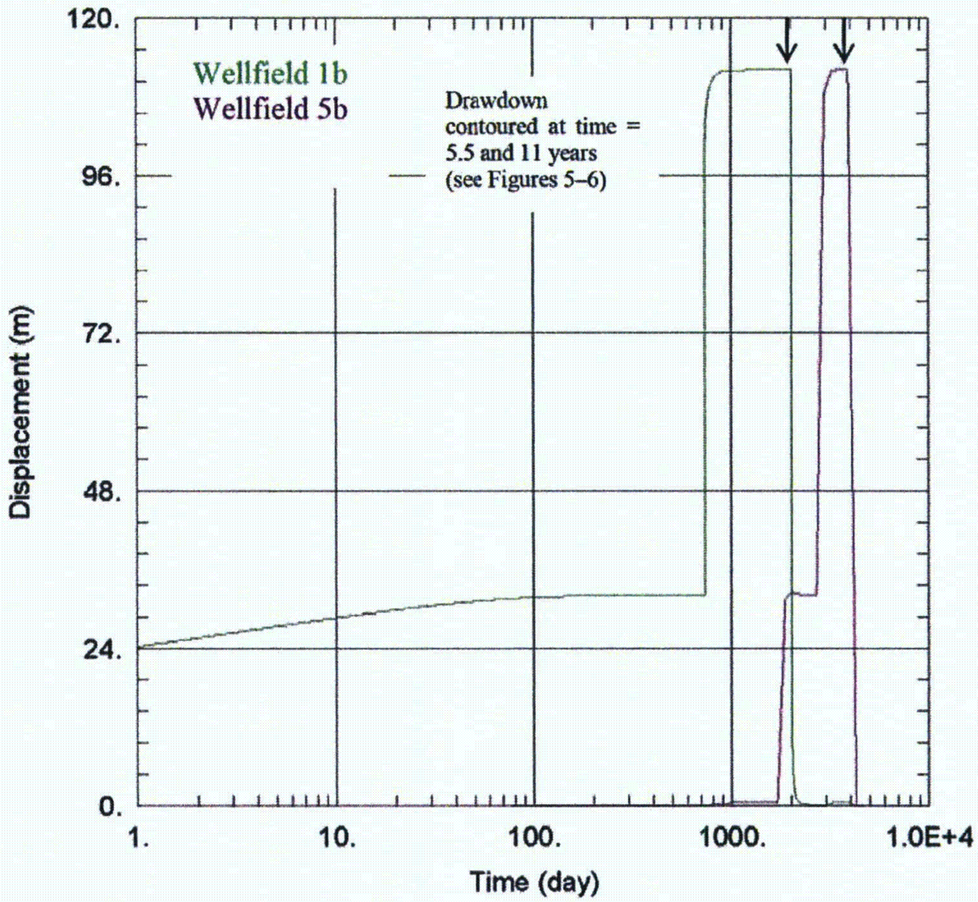
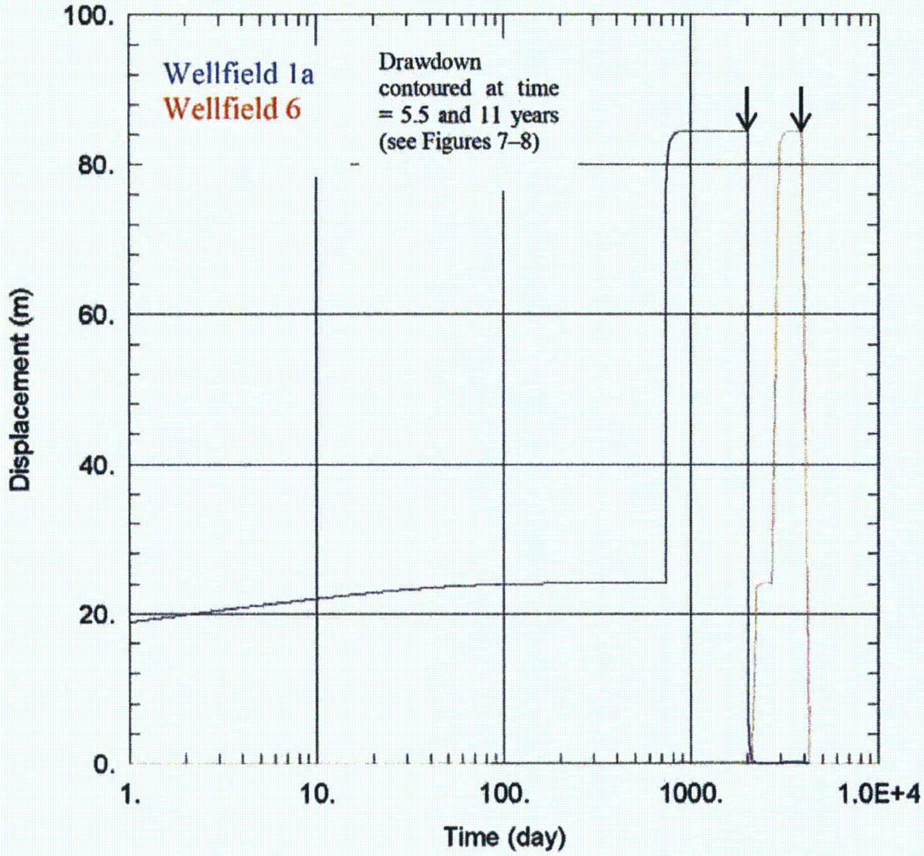
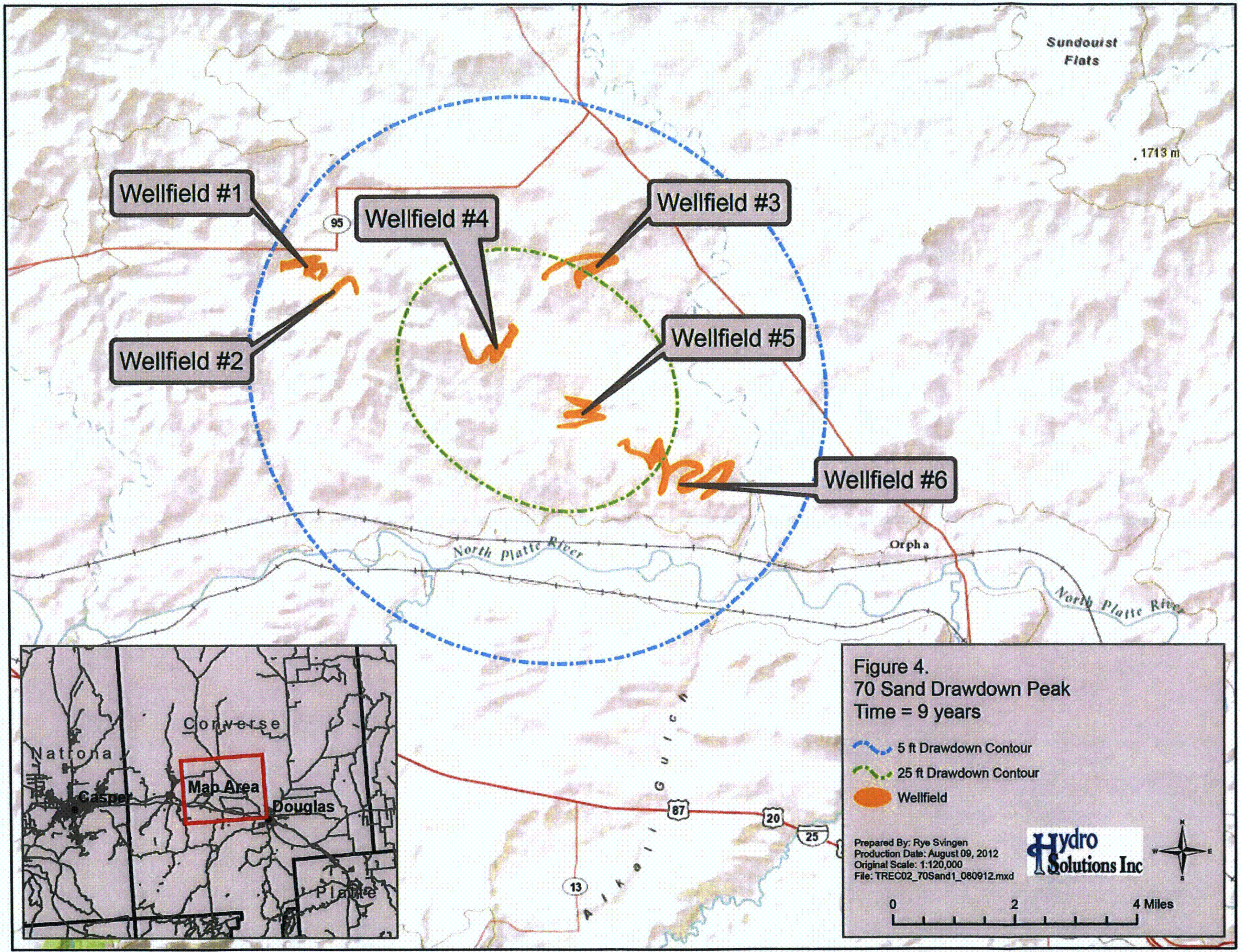


Figure 3: 90 Sand aquifer time-drawdown graph showing model estimated drawdowns in 90 Sand wellfields during project lifespan. Based on current schedule; time = 0 corresponds to beginning of year 1. Displacement is shown in meters.





Sundouist Flats
1713 m
Wellfield #1
Wellfield #2
Wellfield #3
Wellfield #4
Wellfield #5
Wellfield #6
95
North Platte River
Orpha
North Platte River
Alkali Gulch
87
20
25
13
Natrona
Converse
Casper
Map Area
Douglas
Platte
Figure 4.
70 Sand Drawdown Peak
Time = 9 years
5 ft Drawdown Contour
25 ft Drawdown Contour
Wellfield
Prepared By: Rye Svingen
Production Date: August 09, 2012
Original Scale: 1:120,000
File: TREC02_70Sand1_080912.mxd
Hydro Solutions Inc
0
2
4 Miles

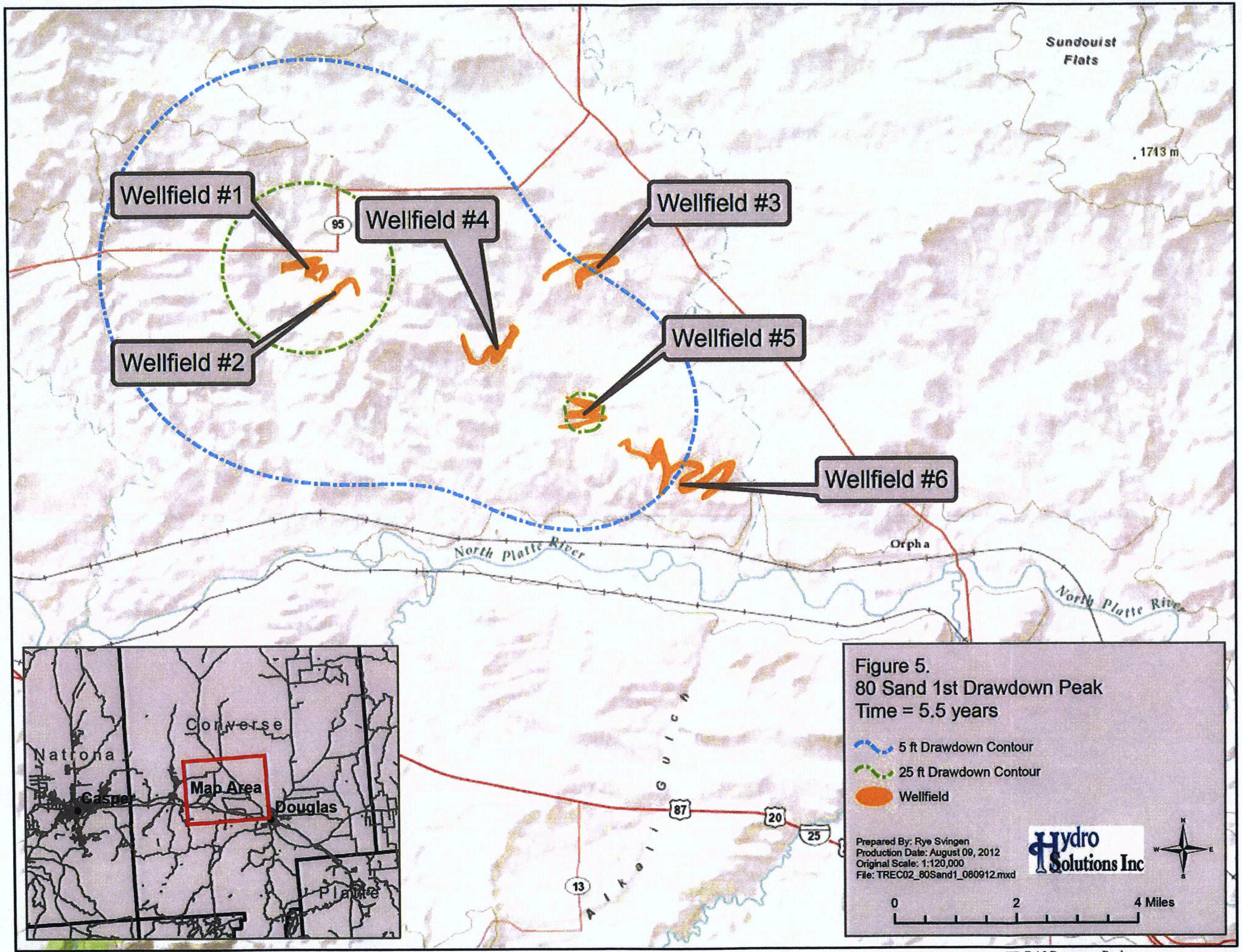


Figure 5.
80 Sand 1st Drawdown Peak
Time = 5.5 years

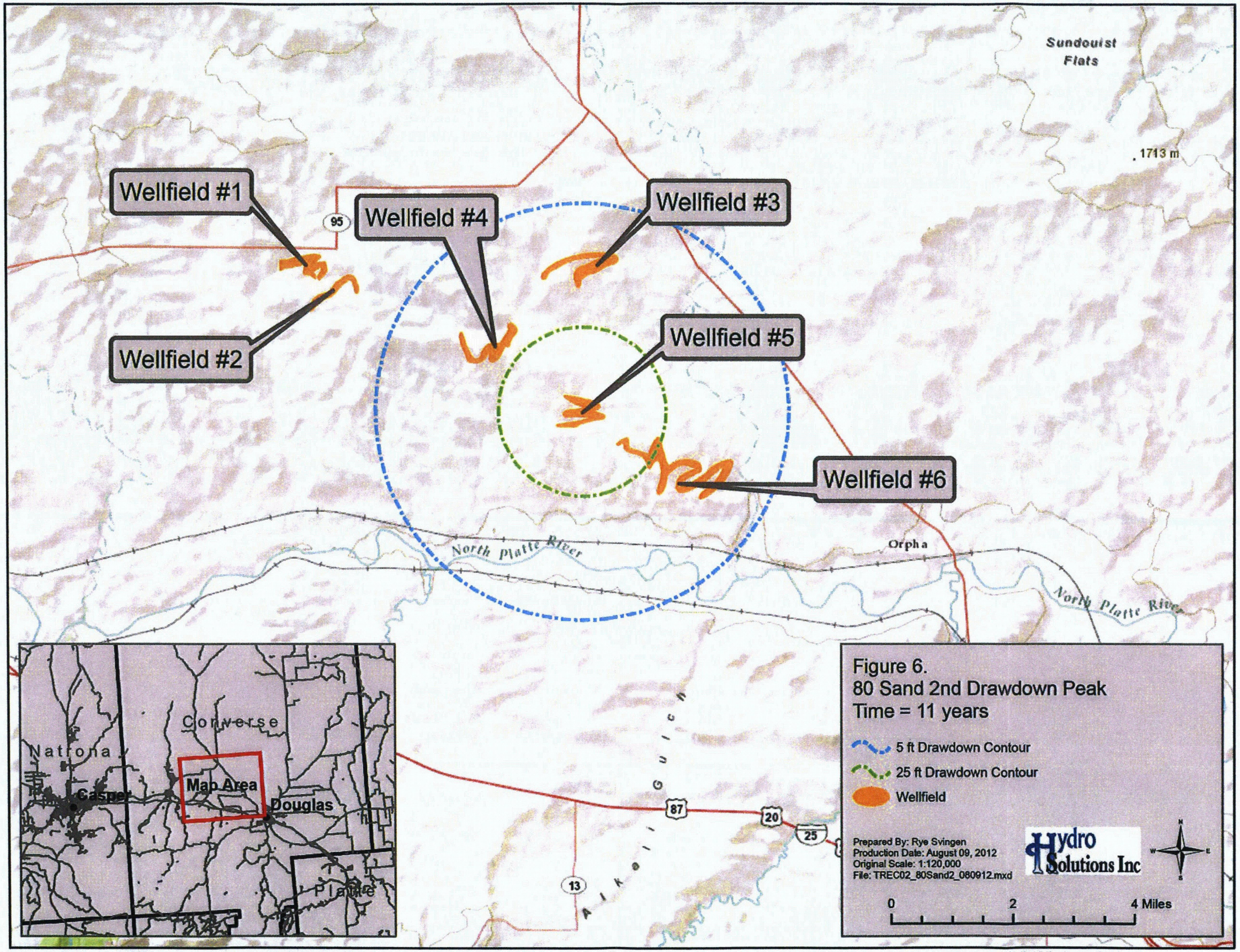
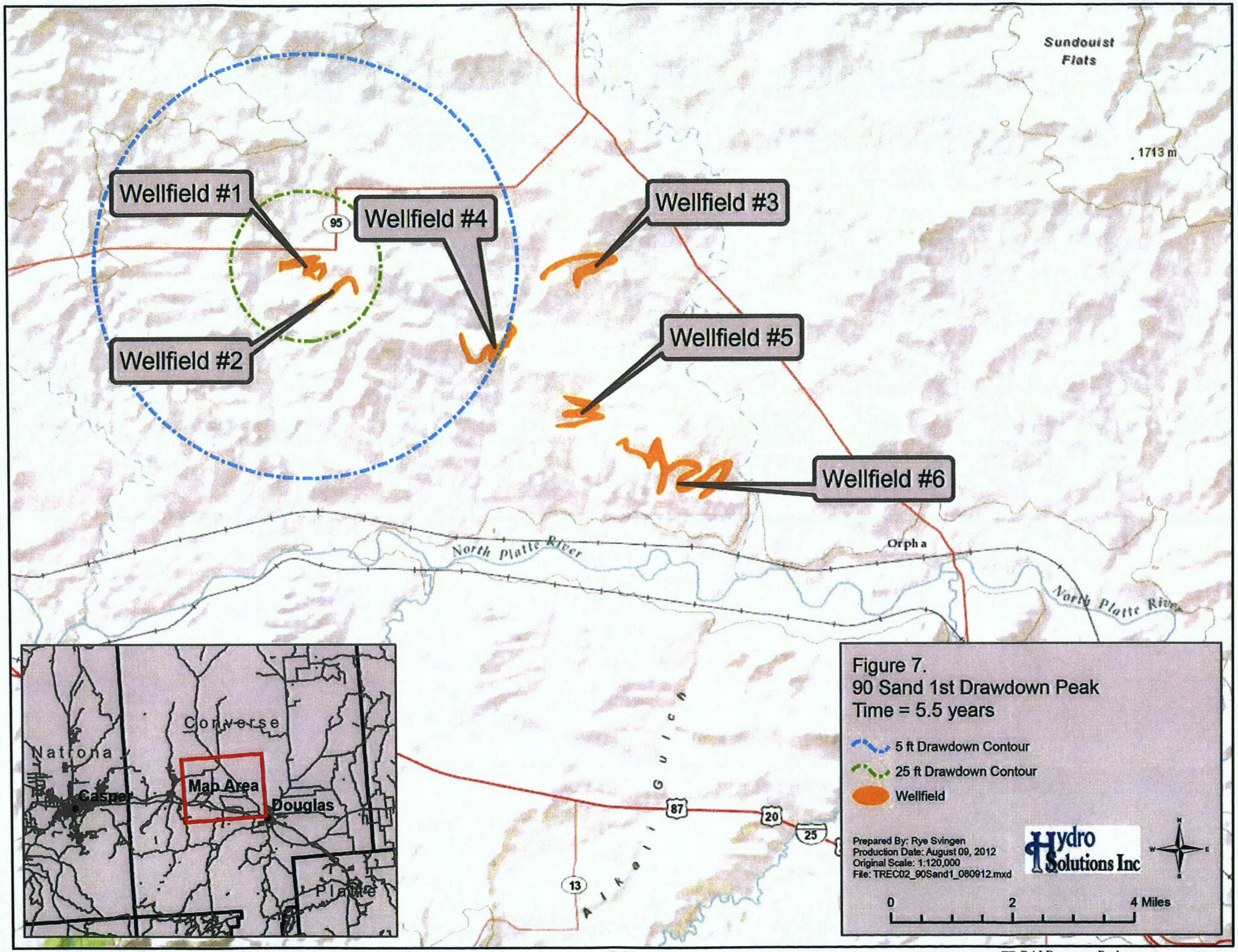
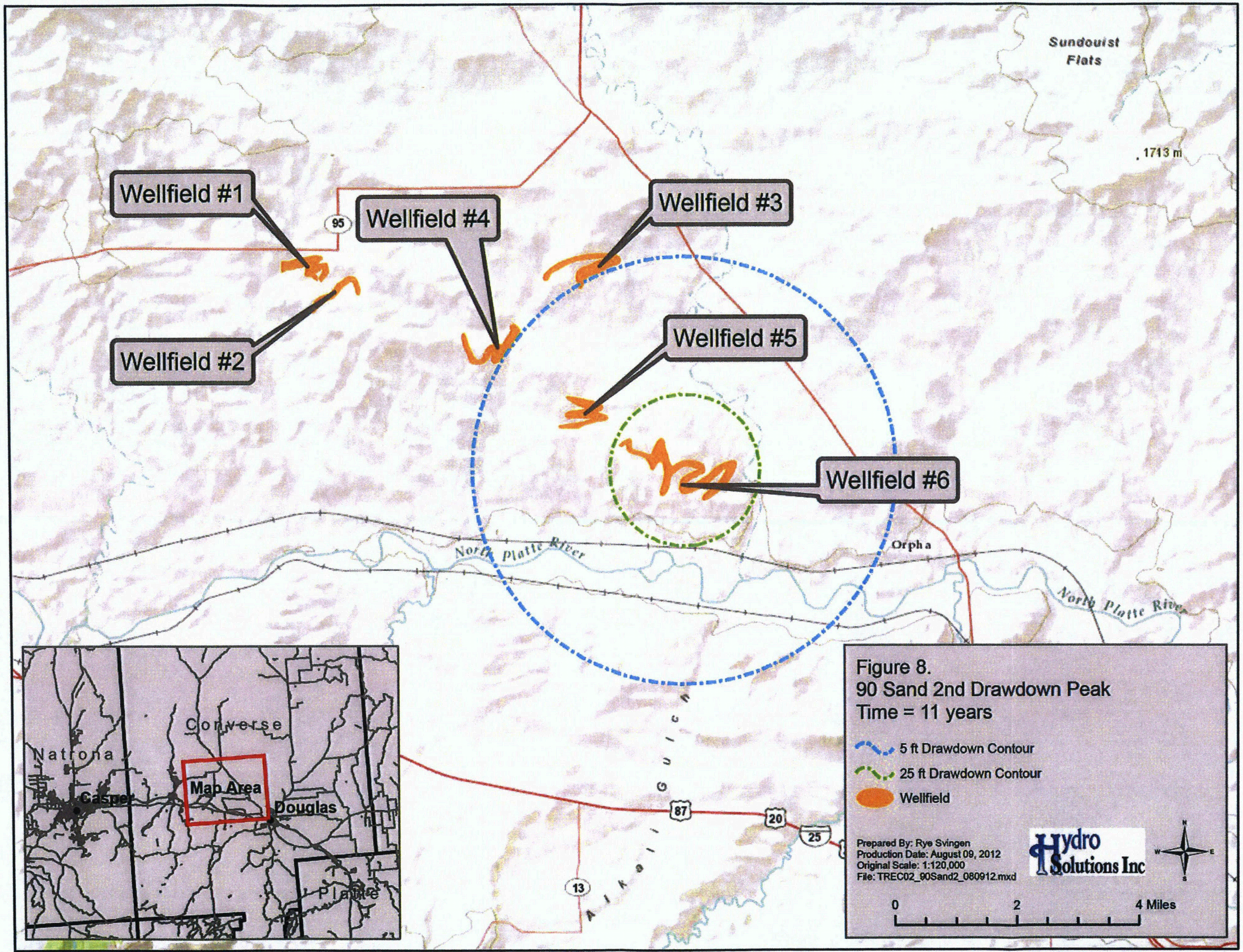


Figure 6.
80 Sand 2nd Drawdown Peak
Time = 11 years



Sundquist Flats
1713 m
Wellfield #1
Wellfield #2
Wellfield #3
Wellfield #4
Wellfield #5
Wellfield #6
95
North Platte River
Orpha
North Platte River
Alkali Gulch
87
20
25
13
Converse
Natrona
Casper
Map Area
Douglas
Platte
Figure 7.
90 Sand 1st Drawdown Peak
Time = 5.5 years
5 ft Drawdown Contour
25 ft Drawdown Contour
Wellfield
Prepared By: Rye Svingen
Production Date: August 09, 2012
Original Scale: 1:120,000
File: TREC02_90Sand1_080912.mxd
Hydro Solutions Inc
0
2
4 Miles



Sundquist Flats
1713 m
Wellfield #1
Wellfield #2
Wellfield #3
Wellfield #4
Wellfield #5
Wellfield #6
95
North Platte River
Orpha
North Platte River
Alkali Gulch
87
20
25
13
Converse
Natrona
Map Area
Casper
Douglas
Platte
Figure 8.
90 Sand 2nd Drawdown Peak
Time = 11 years
5 ft Drawdown Contour
25 ft Drawdown Contour
Wellfield
Prepared By: Rye Svingen
Production Date: August 09, 2012
Original Scale: 1:120,000
File: TREC02_90Sand2_080912.mxd
Hydro Solutions Inc
0
2
4 Miles

ATTACHMENT D2

Cameco Deep Disposal Well Final Radius of Review (FROR) Calculations

Table 1

Cameco Resources - Combined Permit for Deep Disposal Wells

Final Radius of Review Calculation - 20 Year Facility Life

Including Calculations for Cone of Influence and Radius of Emplaced Fluid

Parameter	Symbol (units)	Morton 1-20 (1)	Vollman 33-27	SRHUP NO. 6	SRHUP NO. 7 (3)	Proposed SRHUP NO. 8 (4)	SRHUP NO. 9	SRHUP NO. 10 (2)	SR DDW#1 (5)	SR DDW#2	Reynolds Ranch	Data Source / Formula / Comment
		TTP	TTP	TP	TTP	TP	TP	TP	TTP	TTP	TTP	
Top Perforation (GL)		8013	8482	8942	8444	8942	8858	8931	8410	8562	8293	
Base Perforation (GL)		9127	9454	9543	9830	9543	9295	9612	9824	9827	9763	
Surface Elevation GL		5418.0000	5536.0000	5555	5666	5555	5455	5535	5571	5653	5555	
Final Radius of Review - FROR	**R (miles)**	**0.25**	**2.56**	**2.16**	**1.39**	**2.24**	**2.13**	**1.16**	**1.47**	**2.86**	**1.001**	**FROR is maximum of COI, emplaced fluid or 1/4 mile**
Radius - COI	Rcoi (miles)	0.0000	2.5578	2.159	1.391	2.242	2.1307	1.1575	1.469	2.856	1.0007	40 CFR 146.6 ZOEI - modified Theis
Radius - COI	rcoi (feet)	0	13505	11400	7344	11840	11250	6112	7755	15078	5284	40 CFR 146.6 ZOEI - modified Theis
Radius - emplaced fluid	Ref (miles)	0.1941	0.2406	0.1815	0.3221	0.2831	0.2025	0.1050	0.223	0.268	0.2701	=SQRT(Qt/pi/h/phi)
Radius - emplaced fluid	ref (feet)	1025	1270	959	1701	1495	1069	554	1178	1415	1426	=SQRT(Qt/pi/h/phi)
exponent	x	*12.1685*	*0.3119*	*0.1193*	*0.0628*	*0.0445*	*0.2147*	*0.7774*	*0.0323*	*0.5000*	*0.0262*	*40 CFR 146.6 Area of Review - modified Theis*
permeability	**k (md)**	**2.30**	**2.74**	**1.21**	**0.49**	**1.21**	**1.50**	**1.62**	**0.40**	**4.27**	**0.75**	**APFT average over previous 5-years**
permeability (Inner Composite perm)									12.5			APFT Analysis
M, D									34.4			Ratio of Inner k to Outer k
permeability	k (cm2)	2.26987E-11	2.70411E-11	1.19415E-11	4.83581E-12	1.19415E-11	1.47739E-11	1.59878E-11	3.92786E-12	4.21209E-11	7.40175E-12	conversion to cm2
hydraulic conductivity	K (ft/day)	0.0165	0.0211	0.0095	0.0038	0.0095	0.0115	0.0127	0.0031	0.0332	0.0018	K=kρg/μ
receiver thickness	h (ft)	243	114.5	214.5	232	214.5	118.5	291	228	228	275	Log Analysis
injection period	t (days)	10110	7881	8039	7300	7300	8009	7834	9362	9617	7300	t = 20 year life plus any ppsuedo time to correct for past injection
storage	S	0.000243	0.000115	0.000215	0.000232	0.000215	0.000119	0.000291	0.000228	0.000228	0.000275	EPA Guidance Document S=h*10E-6
injection rate	q(gpm)	43	65	56	**150**	**150**	39	26	70	101	**150**	Max recorded rate for each individual well
injection rate	q (bwpd)	1484	2237	1920	5143	5143	1325	894	2403	3455	5143	conversion to barrels
injection rate	Q (ft3/day)	8330	12560	10782	28878	28878	7441	5020	13490	19399	28878	conversion to cubic ft
pressure of receiver	p (psi) - at Base of Receiver	NA	3382	3578	3319	3578	3627	3808	3404	3413	3290	Initial Falloff or APFT
midperf or gauge depth (datum for Pressure)		NA	8447	8710	8482	8710	8817	9291	8348	8500	8275	Initial Falloff or APFT Datum
head of receiver	*B (ft) - at Base of Receiver*	4312	8824	9099	8997	9099	8853	9115	9321	9193	9069	*Conversion from PSI to Ft of Head*
depth of receiver	Depth - Base of Receiver (ft)	9138	9474	9562	9830	9562	9312	9631	9824	9827	9763	Base of Perforations, Wellbore Diagram
Pressure of USDW	psi	3122	3122	3122	3122	3122	3122	3122	3122	3122	3122	Fox Hills Pressure from SRHUP 6 DST
Pressure Datum for USDW	ft MSL	-2010	-2010	-2010	-2010	-2010	-2010	-2010	-2010	-2010	-2010	Fox Hills Pressure Datum is -2010 MSL
head of USDW	w (ft)	222	340	359	470	359	259	339	375	386	359	Fox Hills well Fluid Level - ft below Surface
head of USDW	W (ft)	8916	9134	9203	9360	9203	9053	9292	9449	9441	9404	converted to Base Receiver Datum
Receiving Zone												
TDS or Salinity	TDS (ppm)	4673	4120	4520	4942	4520	5225	5585	4942	4942	5295	Avg TTP Water Analysis from subject well or adjacent wells
specific gravity	SG (dimen)	1.002	1.001	1.002	1.002	1.002	1.002	1.0020	1.0018	1.0018	1.0019	Specific Gravity calculated from TDS
porosity	θ (phi)	0.105	0.171	0.14	0.10	0.14	0.14	0.14	0.127	0.13	0.12	Log Analysis
G	G (dimen)	0.999	0.999	0.999	0.999	0.999	0.998	0.998	1.0015	1.0015	1.006	G = density USDW / density Inj zone per correspondence w/ G.L.
temperature	T (Degrees F)	168	174	177	176	177	175	178	176	177	174	Standard PRB Gradient
viscosity	m(cp)	0.38	0.36	0.35	0.35	0.35	0.36	0.35	0.36	0.35	0.36	Calculated from P, T and TDS using Excel PVT Props (Haywood, Numbere, Keenan, Van Wylen)
viscosity	m(gm/cm sec)	0.0038	0.0036	0.0035	0.0035	0.0035	0.0036	0.0035	0.0036	0.0035	0.0114	100 cp = 1 gm/cm sec
density	r (gm/cm3)	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	=0.999099*SG
Pressure Gradient	(psi/ft)	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434	conversion to psi/ft
acceleration due to gravity	g (cm/sec^2)	980	980	980	980	980	980	980	980	980	980	constant value
USDW												
TDS or Salinity	TDS (ppm)	736	736	736	736	736	736	736	736	736	736	Water Analysis - SRHUP 6 - avg of 6 samples
specific gravity	SG (dimen)	1.0003	1.0003	1.0003	1.0003	1.0003	1.0003	1.0003	1.0003	1.0003	1.0003	Specific Gravity calculated from TDS
temperature	T (Degrees F)	155	155	155	155	155	155	155	155	155	155	PRB Grad at depth of 7664' (Ranges from 156 to 162 from Schlumberger PTA)
viscosity	m(cp)	0.408	0.412	0.408	0.408	0.408	0.408	0.408	0.408	0.408	0.408	Calculated from P, T and TDS using Excel PVT Props (Haywood, Numbere, Keenan, Van Wylen)
viscosity	m(gm/cm sec)	0.004	0.0041	0.0041	0.0041	0.0041	0.0041	0.0041	0.0041	0.0041	0.0041	100 cp = 1 gm/cm sec
density	r (gm/cm3)	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	=0.999099*SG
Pressure Gradient	*(psi/ft)*	0.433	0.433	0.433	0.433	0.433	0.433	0.433	0.433	0.429	0.433	*conversion to psi/ft*
acceleration due to gravity	g (cm/sec^2)	980	980	980	980	980	980	980	980	980	980	constant value
Cumulative Injection (Through March 2014):		4,168,129	1,299,401	1,419,127	0	1,920	939,638	477,643	4,954,057	8,005,667	0	BBLS
		23,402,378	7,295,617	7,967,829	0	10,781	5,275,690	2,681,772	27,815,046	44,948,618	0	CF
Future Injection Rate:		1,484	2,237	1,920	5,143	5,143	1,325	894	2,403	3,455	5,143	BPD
Pseudo Historical Injection Period = Cum/Rate		2,810	581	739	0	0	709	534	2,062	2,317	0	Days
Total Injection period = 20 years + pseudo injection period =		10,110	7,881	8,039	7,300	7,300	8,009	7,834	9,362	9,617	7,300	Days

(1) Morton 1-20 was an oil producer prior to conversion to injection, As such, the pressure at the beginning of injection was depleted. The potentiometric map (Plate 7) in the original application showed a head of 4312'

(2) Initial Pressure for SRHUP 10 is suspect; it is higher than other initial pressures for wells of the same vintage. Results of the 2012 APFT yield a lower reservoir pressure (3808 psi) which results in a B<W

(3) Preliminary values for SRHUP 7

(4) Reservoir parameters from SRHUP 6 were used for the proposed SRHUP 8

(5) SR DDW #1 APFT analysis indicates a boundary affect that is modeled as a composite permeability reservoir - see discussion in text

Table 2

Cameco Resources - Combined Permit for Deep Disposal Wells

Final Radius of Review Calculation - 10 Year Permit Life

Including Calculations for Cone of Influence and Radius of Emplaced Fluid

Parameter	Symbol (units)	Morton 1-20 (1)	Vollman 33-27	SRHUP NO. 6	SRHUP NO. 7 (3)	Proposed SRHUP NO. 8 (4)	SRHUP NO. 9	SRHUP NO. 10 (2)	SR DDW#1 (5)	SR DDW#2	Reynolds Ranch	Data Source / Formula / Comment
		TTP	TTP	TP	TTP	TP	TP	TP	TTP	TTP	TTP	
Top Perforation (GL)		8013	8482	8942	8444	8942	8858	8931	8410	8562	8293	
Base Perforation (GL)		9127	9454	'9543	9830	9543	9295	9612	9824	9827	9763	
Surface Elevation GL		5418.0000	5536.0000	5555	5666	5555	5455	5535	5571	5653	5555	
Final Radius of Review - FROR	**R (miles)**	**0.25**	**1.87**	**1.60**	**0.98**	**1.59**	**1.57**	**0.85**	**1.15**	**2.25**	**0.708**	**FROR is maximum of COI, emplaced fluid or 1/4 mile**
Radius - COI	Rcoi (miles)	0.0000	1.8741	1.595	0.984	1.586	1.5719	0.8459	1.147	2.249	0.7076	40 CFR 146.6 ZOEI - modified Theis
Radius - COI	rcoi (feet)	0	9895	8423	5193	8372	8300	4466	6057	11877	3736	40 CFR 146.6 ZOEI - modified Theis
Radius - emplaced fluid	Ref (miles)	0.1552	0.1763	0.1341	0.2278	0.2002	0.1494	0.0767	0.174	0.211	0.1910	=SQRT(Qt/pi/h/phi)
Radius - emplaced fluid	ref (feet)	819	931	708	1203	1057	789	405	920	1115	1008	=SQRT(Qt/pi/h/phi)
exponent	x	12.1685	0.3119	0.1193	0.0628	0.0445	0.2147	0.7774	0.0323	0.5000	0.0262	40 CFR 146.6 Area of Review - modified Theis
permeability	**k (md)**	**2.30**	**2.74**	**1.21**	**0.49**	**1.21**	**1.50**	**1.62**	**0.40**	**4.27**	**0.75**	**APFT average over previous 5-years**
permeability (Inner Composite perm)									12.5			APFT Analysis
M, D									34.4			Ratio of Inner k to Outer k
permeability	k (cm2)	2.26987E-11	2.70411E-11	1.19415E-11	4.83581E-12	1.19415E-11	1.47739E-11	1.59878E-11	3.92786E-12	4.21209E-11	7.40175E-12	conversion to cm2
hydraulic conductivity	K (ft/day)	0.0165	0.0211	0.0095	0.0038	0.0095	0.0115	0.0127	0.0031	0.0332	0.0018	K=kρg/μ
receiver thickness	h (ft)	243	114.5	214.5	232	214.5	118.5	291	228	228	275	Log Analysis
injection period	t (days)	6460	4231	4389	3650	3650	4359	4184	5712	5967	3650	t = 20 year life plus any ppsuedo time to correct for past injection
storage	S	0.000243	0.000115	0.000215	0.000232	0.000215	0.000119	0.000291	0.000228	0.000228	0.000275	EPA Guidance Document S=h*10E-6
injection rate	q(gpm)	43	65	56	**150**	**150**	39	26	70	101	**150**	Max recorded rate for each individual well
injection rate	q (bwpd)	1484	2237	1920	5143	5143	1325	894	2403	3455	5143	conversion to barrels
injection rate	Q (ft3/day)	8330	12560	10782	28878	28878	7441	5020	13490	19399	28878	conversion to cubic ft
pressure of receiver	p (psi) - at Base of Receiver	NA	3382	3578	3319	3578	3627	3808	3404	3413	3290	Initial Falloff or APFT
midperf or gauge depth (datum for Pressure)		NA	8447	8710	8482	8710	8817	9291	8348	8500	8275	Initial Falloff or APFT Datum
head of receiver	B (ft) - at Base of Receiver	4312	8824	9099	8997	9099	8853	9115	9321	9193	9069	Conversion from PSI to Ft of Head
depth of receiver	Depth - Base of Receiver (ft)	9138	9474	9562	9830	9562	9312	9631	9824	9827	9763	Base of Perforations, Wellbore Diagram
Pressure of USDW	psi	3122	3122	3122	3122	3122	3122	3122	3122	3122	3122	Fox Hills Pressure from SRHUP 6 DST
Pressure Datum for USDW	ft MSL	-2010	-2010	-2010	-2010	-2010	-2010	-2010	-2010	-2010	-2010	Fox Hills Pressure Datum is -2010 MSL
head of USDW	w (ft)	222	340	359	470	359	259	339	375	386	359	Fox Hills well Fluid Level - ft below Surface
head of USDW	W (ft)	8916	9134	9203	9360	9203	9053	9292	9449	9441	9404	converted to Base Receiver Datum
Receiving Zone												
TDS or Salinity	TDS (ppm)	4673	4120	4520	4942	4520	5225	5585	4942	4942	5295	Avg TTP Water Analysis from subject well or adjacent wells
specific gravity	SG (dimen)	1.002	1.001	1.002	1.002	1.002	1.002	1.0020	1.0018	1.0018	1.0019	Specific Gravity calculated from TDS
porosity	θ (phi)	0.105	0.171	0.14	0.10	0.14	0.14	0.14	0.127	0.13	0.12	Log Analysis
G	G (dimen)	0.999	0.999	0.999	0.999	0.999	0.998	0.998	1.0015	1.0015	1.006	G = density USDW / density Inj zone per correspondence w/ G.L.
temperature	T (Degrees F)	168	174	177	176	177	175	178	176	177	174	Standard PRB Gradient
viscosity	m(cp)	0.38	0.36	0.35	0.35	0.35	0.36	0.35	0.36	0.35	0.36	Calculated from P, T and TDS using Excel PVT Props (Haywood, Numbere, Keenan, Van Wylen)
viscosity	m(gm/cm sec)	0.0038	0.0036	0.0035	0.0035	0.0035	0.0036	0.0035	0.0036	0.0035	0.0114	100 cp = 1 gm/cm sec
density	r (gm/cm3)	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	=0.999099*SG
Pressure Gradient	(psi/ft)	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434	0.434	conversion to psi/ft
acceleration due to gravity	g (cm/sec^2)	980	980	980	980	980	980	980	980	980	980	*constant value*
USDW												
TDS or Salinity	TDS (ppm)	736	736	736	736	736	736	736	736	736	736	Water Analysis - SRHUP 6 - avg of 6 samples
specific gravity	SG (dimen)	1.0003	1.0003	1.0003	1.0003	1.0003	1.0003	1.0003	1.0003	1.0003	1.0003	Specific Gravity calculated from TDS
temperature	T (Degrees F)	155	155	155	155	155	155	155	155	155	155	PRB Grad at depth of 7664' (Ranges from 156 to 162 from Schlumberger PTA)
viscosity	m(cp)	0.408	0.412	0.408	0.408	0.408	0.408	0.408	0.408	0.408	0.408	Calculated from P, T and TDS using Excel PVT Props (Haywood, Numbere, Keenan, Van Wylen)
viscosity	m(gm/cm sec)	0.004	0.0041	0.0041	0.0041	0.0041	0.0041	0.0041	0.0041	0.0041	0.0041	100 cp = 1 gm/cm sec
density	r (gm/cm3)	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	=0.999099*SG
Pressure Gradient	(psi/ft)	0.433	0.433	0.433	0.433	0.433	0.433	0.433	0.433	0.429	0.433	conversion to psi/ft
acceleration due to gravity	g (cm/sec^2)	980	980	980	980	980	980	980	980	980	980	constant value
Cumulative Injection (Through March 2014):		4,168,129	1,299,401	1,419,127	0	1,920	939,638	477,643	4,954,057	8,005,667	0	BBLS
		23,402,378	7,295,617	7,967,829	0	10,781	5,275,690	2,681,772	27,815,046	44,948,618	0	CF
Future Injection Rate:		1,484	2,237	1,920	5,143	5,143	1,325	894	2,403	3,455	5,143	BPD
Pseudo Historical Injection Period = Cum/Rate		2,810	581	739	0	0	709	534	2,062	2,317	0	Days
Total Injection period = 20 years + pseudo injection period =		6,460	4,231	4,389	3,650	3,650	4,359	4,184	5,712	5,967	3,650	Days

(1) Morton 1-20 was an oil producer prior to conversion to injection, As such, the pressure at the beginning of injection was depleted. The potentiometric map (Plate 7) in the original application showed a head of 4312'

(2) Initial Pressure for SRHUP 10 is suspect; it is higher than other initial pressures for wells of the same vintage. Results of the 2012 APFT yield a lower reservoir pressure (3808 psi) which results in a B<W

(3) Preliminary values for SRHUP 7

(4) Reservoir parameters from SRHUP 6 were used for the proposed SRHUP 8

(5) SR DDW #1 APFT analysis indicates a boundary affect that is modeled as a composite permeability reservoir - see discussion in text

Combined Permit AOR Calculation - Appendix

Cameco Resources - Cumulative Injection Into Deep Disposal Wells - Through March 2014

DDW#1	January	February	March	April	May	June	July	August	September	October	November	December	Yrly Totals	Cumulative Gallons	Cumulative BBLs	Max Rate gal/mo	Max Rate BWPD
Pre-2006	From 2007 4th QTR Report												98,877,510				
2006	0	133,379	4,503	0	0	0	300,777	257,141	110,379	0	0	0	806,178				
2007	0	0	0	0	0	0	42,000	719,847	0	0	0	0	761,847				
2008	0	0	0	0	0	0	0	149,867	1,339,614	2,145,298	2,376,039	2,246,552	8,257,369				
2009	1,908,689	2,046,739	2,207,751	2,044,098	2,035,282	2,166,353	2,315,295	2,391,249	2,128,008	1,763,258	2,165,968	2,089,946	25,262,635				
2010	2,222,323	1,882,650	2,102,685	1,960,139	1,885,634	1,665,609	1,390,822	1,891,579	1,706,644	1,271,208	1,527,313	1,712,333	21,218,940				
2011	1,799,490	1,651,634	1,724,928	1,640,877	1,732,425	1,533,730	1,485,436	1,669,182	1,717,771	1,239,989	1,324,850	1,280,255	18,800,566				
2012	1,769,016	409,972	0	0	0	0	0	0	0	0	0	935,760	3,114,748				
2013	2,214,030	2,835,168	2,451,078	2,079,802	1,800,095	1,872,125	1,625,303	2,160,728	1,949,539	1,162,976	1,223,767	1,589,351	22,963,962				
2014	2,172,775	2,756,182	3,077,661										8,006,618	208,070,375	4,954,057	3,077,661	2403

DDW#2	January	February	March	April	May	June	July	August	September	October	November	December	Yrly Totals	Gallons	BBLs	gal/mo	BWPD
Pre-2006	From 2007 4th QTR Report												48,557,105				
2006	2,042,370	1,847,132	1,965,348	2,252,080	2,312,182	2,229,138	1,706,993	2,152,379	2,347,242	2,564,176	2,494,469	2,762,578	26,676,085				
2007	2,398,297	2,150,597	3,134,068	3,313,144	2,992,059	3,265,279	2,566,594	2,383,194	3,009,112	3,140,984	3,186,726	3,282,795	34,822,850				
2008	3,216,045	2,882,002	3,228,715	3,295,377	3,019,827	2,681,728	2,884,537	2,806,806	1,722,376	2,534,976	1,567,131	1,208,006	31,047,528				
2009	2,155,337	1,791,799	2,290,231	2,263,260	2,289,295	2,212,998	2,519,808	2,529,521	2,257,059	1,958,759	2,328,006	2,355,842	26,951,914				
2010	2,445,653	2,128,579	2,292,417	2,144,168	2,088,714	2,004,573	1,715,321	2,027,112	2,125,596	2,934,492	3,858,739	4,029,018	29,794,381				
2011	4,016,817	3,720,891	4,197,577	3,775,705	4,425,690	4,039,275	3,084,263	4,060,477	3,757,452	3,686,746	2,827,953	4,194,072	45,786,919				
2012	4,325,481	3,396,042	3,694,869	3,865,726	4,397,142	4,250,526	4,033,176	4,331,796	3,072,426	3,739,974	3,754,044	3,428,418	46,289,621				
2013	3,372,436	3,217,334	3,521,360	3,401,105	2,315,673	3,332,213	3,394,126	3,449,582	1,844,417	2,109,505	3,369,893	3,199,706	36,527,350				
2014	3,405,523	2,876,023	3,502,714										9,784,260	336,238,014	8,005,667	4,425,690	3455

Morton 1-20	January	February	March	April	May	June	July	August	September	October	November	December	Yrly Totals	Gallons	BBLs	gal/mo	BWPD
PRE-1998	From 2008 5-yr report												96,912,167				
1998	447,045	645,346	375,121	644,155	655,882	402,169	537,248	573,390	295,467	620,429	635,728	596,914	6,428,894				
1999	723,101	783,452	588,652	426,735	561,669	458,780	334,597	549,306	467,352	134,976	544,283	186,001	5,758,904				
2000	615,156	431,887	430,397	451,549	578,566	348,797	328,573	525,005	517,559	645,594	361,406	597,203	5,831,692				
2001	583,662	275,577	637,733	418,037	558,609	281,329	393,968	386,595	275,812	120,417	625,855	619,377	5,176,971				
2002	450,223	558,394	133,817	182,651	496,102	146,370	70,758	469,728	353,547	389,880	19,070	0	3,270,540				
2003	0	0	0	0	0	0	0	0	0	0	0	0	0				
2010	0	0	0	0	0	0	0	409,617	1,684,088	1,768,912	1,658,554	1,882,532	7,403,703				
2011	1,900,381	1,597,507	1,767,463	1,336,661	1,030,443	375,596	374,897	1,137,564	1,570,312	1,023,744	1,084,929	1,118,712	14,318,209				
2012	1,092,930	270,287	478,278	790,314	1,281,143	1,531,362	906,780	1,188,432	1,227,072	1,508,724	1,518,090	1,721,202	13,514,614				
2013	1,773,496	1,525,448	1,507,073	769,100	345,521	745,483	1,380,700	1,424,203	1,232,112	897,498	1,236,613	972,917	13,810,166				
2014	1,252,967	770,676	611,922										2,635,565	175,061,425	4,168,129	1,900,381	1484

Vollman 33-27	January	February	March	April	May	June	July	August	September	October	November	December	Yrly Totals	Gallons	BBLs	gal/mo	BWPD
2011	0	0	0	920,346	1,227,413	1,330,860	708,613	1,674,214	1,136,515	987,250	1,266,494	420,901	9,672,606				
2012	1,729,134	2,226,979	1,513,717	1,380,527	1,979,074	2,338,308	1,923,138	1,870,092	2,273,292	2,409,540	2,496,858	2,773,344	24,914,003				
2013	2,865,383	2,380,904	2,284,283	1,630,776	512,366	856,607	1,435,742	1,042,608	579,411	161,175	1,465,724	1,140,787	16,355,767				
2014	1,360,737	901,318	1,370,415										3,632,470	54,574,846	1,299,401	2,865,383	2237

SRHUP #6	January	February	March	April	May	June	July	August	September	October	November	December	Yrly Totals	Gallons	BBLs	gal/mo	BWPD
2011	1,073,476	1,024,559	1,188,935	1,127,901	1,190,240	2,134,673	2,325,476	1,905,655	2,459,738	2,171,764	1,691,421	1,218,391	19,512,229				
2012	1,407,840	1,791,497	2,139,335	2,000,761	1,906,538	1,911,378	1,970,136	1,973,412	2,003,988	1,957,956	1,518,468	1,732,500	22,313,809				
2013	1,359,183	1,306,427	1,261,562	1,150,170	567,168	760,435	1,178,149	777,025	1,241,596	1,465,892	1,214,899	1,270,044	13,552,551				
2014	1,293,263	1,292,933	1,638,542										4,224,738	59,603,327	1,419,127	2,459,738	1920

SRHUP #9	January	February	March	April	May	June	July	August	September	October	November	December	Yrly Totals	Gallons	BBLs	gal/mo	BWPD
2011	0	0	953,065	1,551,692	1,316,089	1,046,277	466,713	1,235,848	1,545,203	1,353,316	1,222,027	1,640,334	12,330,564				
2012	745,832	190,198	1,348,749	859,099	1,470,992	1,409,940	993,804	1,146,390	1,350,468	1,483,776	1,471,932	1,559,250	14,030,430				
2013	1,697,543	1,444,901	1,540,253	1,049,454	1,117,763	1,229,705	1,223,421	1,070,051	979,810	1,093,936	341,936	224,974	13,013,747				
2014	28,699	59,842	1,500										90,041	39,464,782	939,638	1,697,543	1325

SRHUP #10	January	February	March	April	May	June	July	August	September	October	November	December	Yrly Totals	Gallons	BBLs	gal/mo	BWPD
2011	0	0	253,471	897,389	10,188	0	0	0	0	0	588,326	1,145,171	2,894,545				
2012	1,042,907	857,278	796,716	477,998	892,886	820,554	763,434	798,756	739,368	762,762	691,824	676,368	9,320,851				
2013	17,647	741,161	651,382	679,391	663,474	639,429	540,183	427,073	351,301	375,106	477,477	547,467	6,111,091				
2014	494,772	585,756	653,976										1,734,504	20,060,992	477,643	1,145,171	894

Reynold's Ranch 1	January	February	March	April	May	June	July	August	September	October	November	December	Yrly Totals	Gallons	BBLs	gal/mo	BWPD
2013													0				
2014													0	0	0	0	0

ATTACHMENT E

POTENTIAL IMPACTS FROM IRRIGATION WELL SMITH #1

INTRODUCTION

Power Resources, Inc. d/b/a Cameco Resources (Cameco) has conducted an assessment to evaluate potential hydrologic impacts of the Smith #1 Irrigation Well on ISR wellfield operations at the Smith Ranch-Highland-Reynolds Ranch (SRH-RR) facility. The Smith #1 well is located in Section 12, T35N, R74W. The well is located approximately 3,200 feet east of the closest injection and production wells in Mine Unit 15A (See **Figure 1**). This assessment was requested by the United States Nuclear Regulatory Commission (NRC) in their review of the Technical Report (TR) portion of the license renewal application for Source Materials License SUA-1584 as a Request for Additional Information (RAI) 8. Specifically, RAI 8 states:

> *"Cameco stated two irrigation wells were completed in Section 12 of T35N, R74 W on page D6-12 of the Wyoming Department of Environmental Quality (WDEQ) Smith Ranch permit. Staff was not able to find the Wyoming State Engineer's Office (WSEO) permit numbers for these wells to determine their completion interval or ground water rates to assess if they may affect the safety of operations.*
>
> *Please provide the WSEO permit names for the two irrigation wells installed in Section 12 of T35NR74 W. Please identify the aquifers in which these wells are completed. Please provide the current status of these wells. Please assess if the ground water use at these wells could affect hydraulic control of nearby mine units within the Smith Ranch license area".*

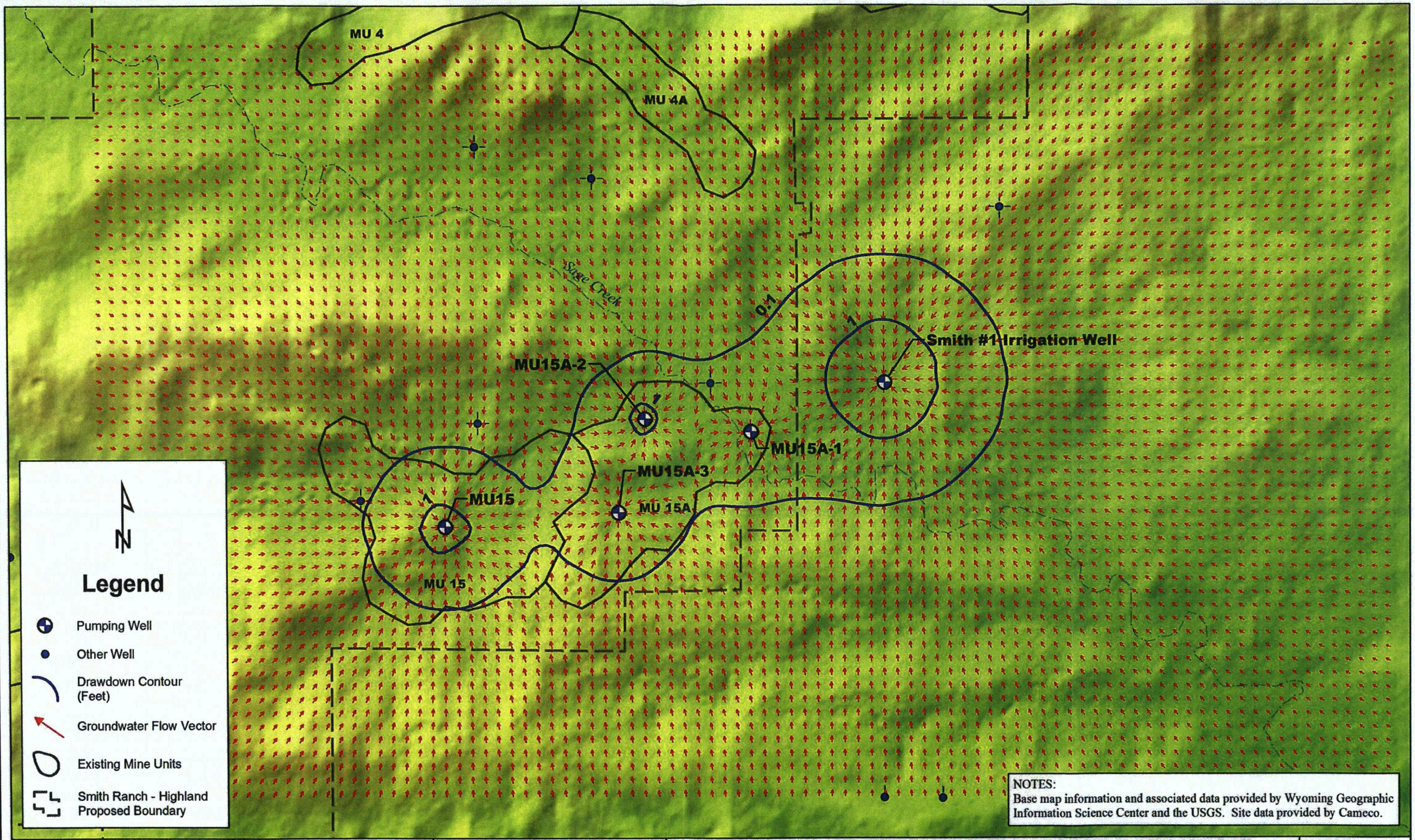
IMPACT ASSESSMENT

A single permitted irrigation well is located within Section 12 of T35N, R74W. The permit number is P2414W (Smith #1). WSEO records indicate that this well has a total depth of 600 feet, a static water level of 154 feet, and has a permitted maximum flow rate of 100 gpm. The well is perforated from 218-230, 350-400, 402-420, and 450-555 feet below ground surface. The lower perforated zones are located in the O-Sand within the Fort Union Aquifer System. This well is located approximately 3,200 feet east of the closest injection and production wells (P196924W) in Mine Unit 15A (T25N, R74E, Sec 11, SENE). The injection and production wells are also perforated in the O-Sand.

A groundwater model simulation was performed to address the influence of irrigation well Smith #1 on wellfield operations in the nearest mine unit completed within the O-Sand (MU-15A). The following operational parameters were assumed for the simulation:

- Irrigation well Smith #1 operates for approximately 5-months per year, corresponding to the approximate maximum length of the irrigation season.
- The well operates at a pumping rate of 100 gpm for a maximum of 12-hours per day.
- Based on the aforementioned well completion data, the well pumps water from the U-Sand, Q-Sand, and O-Sand (model layers 3 through 19). The model apportions pumping to each layer based on the relative transmissivity of these aquifers.
- Neighboring wellfields are assumed to be in operation at same time as Smith #1. A conservatively low total wellfield bleed rate of 9 gpm was utilized for MU-15A, distributed as three pumping centers across the mine unit, corresponding to the minimum average annual bleed rate for MU-15A at any point during mine unit lifecycle.

The resulting maximum drawdown and radius of influence produced by irrigation well Smith #1 after 5 months of irrigation is shown on **Figure 1**. These results demonstrate irrigation pumping from Smith #1 should not adversely affect hydraulic control of mining solutions in neighboring mine units, as the drawdown and resulting radius of influence produced by irrigation pumping is insufficient to overcome the inward hydraulic gradient produced by the production bleed in MU-15A.



AquiferTek

0 1,000 2,000 4,000
Feet
1 inch = 2,000 feet
STATE PLANE NAD 27

PROJECT # 40100545
DATE: Revised 6/5/2014
DRAWN BY: CLIN
REVIEWED BY: BLEWIS
DOCUMENT NAME AND PATH

MAXIMUM DRAWDOWN AND RADIUS OF INFLUENCE OF SMITH #1 IRRIGATION WELL, O-SAND AQUIFER

SMITH RANCH-HIGHLAND/REYNOLDS RANCH FACILITIES
CONVERSE COUNTY - WYOMING

FIGURE:
1