ADDENDUM 4.2-A

CLASS I DEEP DISPOSAL WELL FIELD

APPLICATION

Petrotek

UIC Permit Application
Class I Injection Wells
Ross Disposal Wells
Crook County, Wyoming
Strata Energy, Inc.

Professional Engineer (Petroleum) KENNETH J. COOPER 8428 Date 6/18/2010 WYOMING

June 2010

PROFESSIONAL GEOLOGIST AARON A. PAYNE PG-3708 6/18/2010 WYOMING

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DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER QUALITY DIVISION
WATER QUALITY RULES AND REGULATIONS, CHAPTER XIII (1993)

DEQ/WQD Application No: Date received: ______________ (Agency Use Only)

1. Type of Application

This application is being made for a Class I injection well permit:

New Permit _**XX**___ Modified Permit _____

2. Name of Facility: Ross Injection Wellfield

The Ross disposal wellfield (area permit) will include five (5) Class I disposal wells.

Ross DW No. 1: NW ¼, NE ¼, NW ¼, Section 18, Township 53 North, Range 67 West, 6th Principal Meridian, Crook County, Wyoming.

57 feet from the North line; 1,869 feet from the West line of Section 18.

Ross DW No. 2: NW ¼, NE¼, SE ¼, Section 18, Township 53 North, Range 67 West, 6th Principal Meridian, Crook County, Wyoming.

2,610 feet from the South line; 1,320 feet from the East line of Section 18

Ross DW No. 3: SE ¼, SE ¼, NW ¼, Section 19, Township 53 North, Range 67 West, 6th Principal Meridian, Crook County, Wyoming.

2,304 feet from the North line; 2,021 feet from the West line of Section 19.

Ross DW No. 4: SE ¼, SE ¼, SE ¼, Section 13, Township 53 North, Range 68 West, 6th Principal Meridian, Crook County, Wyoming.

431 feet from the South line; 616 feet from the East line of Section 13.

Ross DW No. 5: SE ¼, NW ¼, NE ¼, Section 13, Township 53 North, Range 68 West, 6th Principal Meridian, Crook County, Wyoming.

778 feet from the North line; 1,385 feet from the East line of Section 13

Mailing Address of the Operator

Strata Energy, Inc.
406 W. 4th Street
Gillette, WY 82716

Street Address where the records will be kept

Strata Energy, Inc.
406 W. 4th Street
Gillette, WY 82716

Name and title of responsible individual

Tony Simpson, COO
Strata Energy, Inc.
406 W. 4th Street
Gillette, WY 82716

3. Name, address, and telephone number of the operator on site

Strata Energy, Inc.
406 W. 4th Street
Gillette, WY 82716
(307) 689-6080

4. Description of the discharge

This permit application is for the injection of industrial wastes, which are non-hazardous under the Resource Conservation and Recovery Act (RCRA).

The wastes consist of operational and restoration bleed streams from in-situ recovery (ISR) uranium mining operations, including but not limited to: normal overproduction (wellfield bleed) streams, yellowcake wash water, laboratory waste, reverse osmosis brine, groundwater sweep solutions, plant washdown water, process water from other ISR operations in Wyoming, well workover wastes from the Ross Project operations, pump test fluids, well development water and drilling fluids from the proposed Ross Project Class III operations (and from similar ISR operations in Wyoming), and other related waste waters from the Ross Project operations.

Applications to conduct ISR mining operations will be submitted to the U.S. Nuclear Regulatory Commission (NRC) and Wyoming Department of Environmental Quality Land Quality Division (LQD). These will include a Source Material License Application (NRC) and a Permit to Mine Application (LQD). These waste streams are benefication wastes, exempt from RCRA regulation under the Bevill Amendment found in 40 CFR 261.4(b)(7).

The Standard Industrial Classification (SIC) code for this waste is 1094. This is being replaced by the North American Industrial Classification System (NAICS) code, which for this operation is 212291.

5. Area Permit

This permit application is for five (5) Class I non-hazardous injection wells.

This permit request includes disposal of the wastes listed in Section 4.0 of this application to the Deadwood/Flathead interval through five new wells to be drilled expressly for the purpose of wastewater management for the Ross Project ISR uranium mining and processing operations. The location of the Ross Project is shown on Figure 1. The wells are referred to as the Ross DW No. 1, DW No. 2, DW No. 3, DW No. 4, and DW No. 5, or collectively as the Ross Disposal Wells. The new wells will be located within the Ross Project Permit to Mine Area as shown on Figure 2.

Information from Section 2.0 and Attachments A through Q are included for the proposed wells. The Area of Review (AOR) for each of the Class I Disposal Wells is shown on Figure 3. The calculation of the AOR is provided in Attachment D.

6. Summary of the ownership

a. Land ownership within the Area of Review

Land ownership in the Ross Project area is shown on Figure 4. Data were compiled by WWC Engineering from information obtained from the Crook County, Wyoming Assessor's Office.

b. Ownership of oil and gas lease(s) within the Area of Review

Oil and gas wells within the Areas of Review are shown on Figure 3 and listed in Table 1. Data were compiled from the Wyoming Oil and Gas Conservation Commission (WOGCC) website (http://wogcc.state.wy.us). Mineral Lease owners (including oil and gas) are shown on Plate 1. Data were provided by Strata Energy, Inc. and compiled by Fitzimmons, LLC.

c. Owners of mineral rights within the Area of Review

Mineral ownership in the Ross Project area is shown on Plate 2. Data were provided by Strata Energy, Inc. and compiled by Fitzimmons, LLC.

d. Water rights within the Area of Review

Water rights within the Areas of Review are shown on Figure 5 and listed in Table 2. Data were compiled from water well records from the Wyoming State Engineers Office (SEO) website (http://seo.state.wy.us).

7. Status as Federal, State, private, public or other entity

Strata Energy, Inc. (Strata) is the owner of record of the Ross Project mining claims and leases. Strata is a wholly owned subsidiary of Peninsula Minerals, Limited. Strata is a registered corporation in the State of Wyoming. Peninsula Minerals, Limited is an Australian-based uranium production company with a listing (PEN) on the Australian Stock Exchange.

8. Facility on Indian land? No

9. CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Tony Simpson ______________ COO, Strata Energy, Inc. ________

____________________________ ______________

Signature of Applicant Date Signed

LIST OF ATTACHMENTS

This UIC Permit application is for five (5) Class I non-hazardous injection wells to dispose into the Deadwood/Flathead interval. This UIC Permit application is organized and presented as attachments, tables, figures, and appendices summarized below:

A. Discharge Zone(s) and Confining Layer(s)
B. Wells Penetrating Receiver
C. Geologic Cross-Sections
D. Area of Review (AOR)
E. Water Quality Information – Proposed Injection Zone
F. Regional Water Quality
G. Further Description of Discharge
H. Description of the Wells
I. Operating Data
J. Monitoring Plan
K. Well Abandonment
L. Financial Surety
M. Mechanical Integrity
N. Signatory Requirements
O. Reports
P. Location Maps
Q. References

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INTRODUCTION

This Class I permit application requests approval for injection of remediation, restoration, and mining wastewater from the planned Ross Project into the Deadwood and Flathead Formations. Based on the projected water balance for the life of the project, the vast majority of the wastewater will originate from the mined aquifer (Lower Lance/Fox Hills Formation) and remediation/restoration operations in those formations; wastewater may also be derived from operation of the Ross Project Central Plant, toll milling operations, well workover fluids, and satellite operations.

The Deadwood/Flathead interval was selected as the target injection zone. In this permit application the target injection zone is further defined as the formations that occur beneath the base of the Icebox Shale member of the Winnipeg Group and above the top of the Precambrian basement. Due to the depth in the stratigraphic column at which these formations occur and apparent lack of hydrocarbons, there has been little exploration and few data are available in the Ross Project area. These units were selected as the target injection zone based on available data and analysis showing that (1) there are no porous and permeable zones below the Deadwood and Flathead that would make suitable injection zones, and (2) the proposed injection water and the native formation waters likely qualify for designation as Class VI waters under WDEQ Chapter 8 Water Quality Regulations. Unless otherwise noted, all depths in this permit application refer to ‘below ground surface’ (bgs).

It is noted that the Ross Project is located on the eastern margin of the Powder River Basin near two other distinct structural regions, the Williston Basin and the Black Hills Uplift (Figure 10); geologic nomenclature varies in the area as a result. This permit application adheres to the nomenclature used by the United States Geological Survey (USGS) when drilling the Madison Test Well No. 1 used as the east type log and further described below. A stratigraphic correlation depicting geologic units in the area is shown in Table 3.

To facilitate analysis, two type logs were selected that penetrate the target injection zones closest to the proposed Ross Project. The west type log, API No. 4900525366, is the Fieldgrove No. A-1 located approximately 22 miles WSW in T52N R71W, Section 22, (see Figure 23 for location; type log Figure 6). The well was drilled to the Precambrian basement to a total depth (TD) of 11,000 feet rig kelly bushing (RKB) and a resistivity log and neutron/density porosity log were run to TD. These logs were analyzed for water quality, porosity, and other formation parameters used in the area of review (AOR) calculations for the target injection zone.

The east type log (see Figure 23 for location; type as log Figure 7) is from the USGS Madison Test Well No. 1 (API 4901109528), located approximately 29 miles northeast of the Ross Project in T57N R65W, Section 15. This well was drilled into the Precambrian basement to a total depth of 4,355 feet RKB. The induction log from this well was used as the “type” response for the target injection zone. Cores were taken

and analyzed from the Flathead Formation as well as from the upper and lower confining zones for this well (Table 4).

Based on the west type log, the majority of the total porosity in the geologic section from the Deadwood to basement is likely to be in the Flathead interval. Water quality (evaluated as total dissolved solids [TDS]) is anticipated to be greater than 10,000 mg/L for the proposed injection zone below the Ross Project. Table 5 is a summary of calculated sodium chloride (NaCl) concentrations (in ppm, as an indicator of TDS) within the major formations from the Minnelusa to basement. These include the Minnelusa, Madison, Englewood, Red River, Winnipeg Group, Deadwood, and Flathead.

Based on electric logs, intervals with greater than 8% porosity were picked from the Deadwood and Flathead. This approach was used to implement a consistent selection methodology and allowed the analysis to focus on those zones in the specified intervals with the greatest potential for injection. Zone thickness and average porosity within the Deadwood/Flathead interval was determined based on the neutron/density log from the Fieldgrove No. A-1 well (west type log). This is the closest well to the Ross Project that fully penetrates the target injection zone. The estimated NaCl concentration was calculated for selected porous intervals from the Minnelusa to basement based on these selected values and deep resistivity curve information (Table 5 and Figure 6).

The Wyoming Department of Environmental Quality (WDEQ) Chapter VIII regulations state that *Class VI groundwater may be unusable or unsuitable for use:*

> *A. Due to excessive concentrations of total dissolved solids or specific constituents; or*
> *B. Is so contaminated that it would be economically impractical to make the water usable; or*
> *C. Is located in such a way, including depth below the surface, so as to make use economically and technologically impractical.*

Water quality calculations in this report show that the Deadwood/Flathead interval contains waters with average TDS concentrations greater than 10,000 mg/L to the west and north of the Ross Project (Table 5). Calculations for the Madison Test Well No. 1 show that the Deadwood/Flathead waters may have significantly lower TDS concentrations approximately 29 miles to the northeast, but primarily due to location relative to recharge and structural differences, it is unlikely that this is representative of water quality in the injection zone below the Ross Project. Water quality is discussed in greater detail in Attachments E and F.

All three criteria for a Class VI groundwater designation will likely be satisfied for the Deadwood/Flathead units on the eastern margin of the Powder River Basin. Concentrations of TDS make it unsuitable for use (Criterion A). It is so contaminated with dissolved solids that it would be economically impractical to make the water useable (Criterion B). The Deadwood/Flathead is also located at such a depth compared to more easily accessible and higher quality waters of the Madison (i.e., lowermost USDW) so as to make its use economically impractical (Criterion C). These Class VI criteria will be confirmed via well testing and sampling during installation.

The potential impacts from Class I injection at the Ross Project are limited. Assuming piston-like displacement (WDEQ Chapter XIII Regulations and Guidance Document #1), the radius of volumetric fill up for each well for a 20-year period (projected life of mine) is approximately 1,037 feet. Potential impacts from injection of wastewater containing concentrations of radionuclides will be limited as well. Because the Ross Project will be producing and selling uranium, concentrations of uranium in the wastewater are expected to be low. Transport of uranium and radium-226 is significantly retarded in a groundwater system. For example, a concentration reduction ratio of 7 was calculated for uranium in approximately 400 feet of travel at the Irigaray Mine (COGEMA/Petrotek, 2004). Radium-226 transport was retarded even more than uranium. Based on available data, the waters of the Deadwood/Flathead are not used as a source of drinking water in the vicinity of the Ross Project, nor at any regional location in the northeastern portion of the Powder River Basin.

Due to the class of water and the dominant porosity thickness (below the Madison) of the Deadwood/Flathead Sandstone, these units are the optimum potential targets for Class I wastewater disposal at the Ross Project.

ATTACHMENTS

A. Discharge Zone(s) and Confining Layer(s)

The injection zone proposed for the five injection wells requested in this Class I UIC permit application is the Cambrian-age Deadwood and Flathead Formations.

The proposed injection wells will be located in Crook County, Wyoming, within the Ross Project boundary where the Central Processing Plant will be located (Figures 1 and 2). The discussion of the geology, lithology, hydrology, and formation characteristics for the Deadwood and Flathead, and overlying and underlying confining zones is based on (1) regional and local geology from published sources and oil and gas logs (2) logs from the Fieldgrove No. A-1 (Section 22, T52N, R71W) and the Madison Test Well No. 1 (Section 15, T57N, R65W), and (3) cores from the Madison Test Well No. 1.

An analysis of the geology at Ross was performed and the results of this analysis for the proposed Deadwood/Flathead injection interval are presented in this attachment. Based on this analysis, the Deadwood/Flathead is the optimal injection zone available at this location due to its position in the stratigraphic column, permeability and porosity thickness, confinement, and estimated water quality. Further, the Deadwood/Flathead was suggested as an optimum zone for wastewater disposal in USGS Trace Elements Investigations Report 823 (Beikman, 1962) which states "*The Flathead Sandstone and sandstone within the Deadwood Formation overlie Precambrian basement rocks, which would be a barrier to downward seepage of liquid waste and are overlain by shale which may be sufficiently impermeable to prevent upward seepage*."

Deadwood Formation

The Cambrian-age Deadwood was deposited as the result of a fluctuating shoreline associated with offshore bars, lagoons, beaches, and tidal flats on an embayed coastline developed during marine transgression (Macke, 1993). The Deadwood is described as a very-fine to fine-grained, white sandstone with low to fair porosity (Blankennagel, et al., 1977). It consists of sandstone, shale, and glauconitic limestone (Darton and Paige, 1925). It ranges in thickness from less than 50 feet in south-central Montana to 500 feet in northeastern Wyoming and is predominantly sandstone (Peterson, 1984). Beneath the Ross Project the Deadwood is estimated to be approximately 400 feet thick (Figures 6 and 7, Table 6). A regional isopach map of the Deadwood is presented as Figure 8.

Flathead Formation

The Flathead Formation (also referred to in literature and records as the Flathead Sandstone) occurs below the Deadwood and is a basal transgressive sandstone that unconformably overlies the Precambrian basement (Peterson, 1984). The Cambrian-age Flathead Sandstone has been described as a light brown to reddish brown, medium to coarse-grained sandstone with good porosity (Blankennagel, et al., 1977). Regionally, the Flathead may be up to 500 feet thick (Beikman, 1962). The gross

thickness of the Flathead Sandstone is projected to be approximately 190 feet beneath the Ross Project (Figures 6 and 7, Table 6). A regional isopach map of the Flathead is presented as Figure 9.

Geologic Structure, Faulting, and Seismic Activity

During later stages of the Laramide orogeny, the actively rising Front Range and Casper Arch separated the Wind River and Powder River basins. In the Powder River Basin this upwelling disrupted the east-trending deposition and imposed a predominant drainage direction to the north, mimicking the actively subsiding basin axis. The Black Hills uplift, also part of the Laramide orogeny, formed east of the basin margin (Figure 10). On the eastern flank of the basin the structural dip is 3 to 5 degrees toward the axis of the basin (Beikman, 1962).

The Powder River Basin and Black Hills uplift are separated by the Black Hills monocline which occurs immediately to the east of the Ross Project (Figure 11). The rocks of the monocline dip from 20 degrees to near vertical. East of the monocline the strata are folded into northwest trending synclines and anticlines which are cut by normal faults that generally resulted in less than 100 feet of displacement. West of the monocline (i.e., toward the Ross Project) the strata are uninterrupted by folds or faults (Beikman 1962). It is noted that there is an unnamed reverse/thrust fault located approximately six miles north of the Ross Project that shows approximately 1,500 feet of displacement (Figure 17). The closest known fault zone aside from this, the Little Missouri fault zone, is located approximately 12 miles northeast of the Ross Project and shows less than 100 feet of displacement (Lisenbee, 1978). This fault zone is depicted relative to the Ross Project on Figure 12.

Figure 13 is a cross-section in the Minnelusa Formation across the Deadman Creek oil and gas field and shows no faulting in the Minnelusa. Figures 14 and 15 are structure contour maps of the Dakota and Minnekahta Formations, respectively, and show no evidence of displacement from faulting beneath the Ross Project. Additional structural maps available for the area are for the Madison and Precambrian basement and are presented as Figures 16 and 17, respectively. Figure 17 depicts a reverse/thrust fault located approximately six miles northeast of the Ross Project. The fault may reach from basement to the base of Cretaceous strata (Lisenbee and DeWitt, 1993) and shows approximately 1,500 feet of throw with the upthrown block on the east side of the fault. As such, the fault places the Precambrian basement in contact with the Paleozoic section approximately six miles northeast of the Ross Project.

It is noted that the radius of emplaced waste is calculated in Attachment D as 1,037 feet. In an infinite acting reservoir the calculated pressure rise at the distance of the fault due to injection into the Deadwood/Flathead approximately six miles away would be approximately 12.7 psi after 20 years. It should be noted that the critical pressure necessary to cause fluid to rise in an open pathway is approximately 95.4 psi. Therefore, the pressure rise of 12.7 psi at this distance after 20 years of injection is insufficient to cause vertical fluid migration from the Deadwood/Flathead to overlying

formations. The Black Hills monocline is the result of basement uplift, which does not appear to have caused faulting or folding that affects the confining zone or proposed injection interval east of the monocline. As such, the proximity of the Ross Project to the Black Hills monocline is not considered to be a limiting factor regarding the proposed Ross Disposal Wells.

The Ross Project area of northeastern Wyoming has been designated as a minor seismic risk area by the USGS. The peak ground acceleration that has a 2% probability of exeedance in 50 years is approximately 6 - 8% g near the Ross Project area (Figure 19) and no active faults have been mapped in the vicinity. No data are available to suggest that seismic activity presents a risk for injection at the Ross Project. Figures 18 and 19 present seismic and peak ground acceleration maps of Wyoming.

Injection Interval – Proposed Wells

The proposed injection interval is the permeable sands of the Deadwood/Flathead. Because the proposed wells have not yet been drilled, the depths of the injection intervals are estimated (Table 6). In an attempt to be as accurate as possible given the limited data available, formation tops are estimated based on correlation of logs from various wells. The location of these wells is shown on Figure 23. The top of the Goose Egg through Minnelusa are based on the Reynolds 22-19 (API No. 4901120332, completed in the Minnelusa) located within the Ross Project boundary. The Madison through Ice Box tops are based on the average formation thickness in the Fieldgrove No. A-1 (API No. 4900525366) and the Little Missouri Federal No. 1 (API No. 4901106100). The Deadwood through Precambrian tops are based on the average formation thickness in the Fieldgrove No. A-1 (API No. 4900525366) and the Madison Test Well No. 1 (API No. 4901109528). The surface elevation at the Ross Project ranges from approximately 4,140 to 4,300 feet AMSL for an average of 4,220 feet AMSL. The variable surface elevation, combined with regional structure, will result in only a slight variance of the injection interval depths for each well. Due to the lack of local and regional data, the surface elevation of the on-site log for the No. 22-19 Reynolds well (4,218 feet AMSL) has been used for estimating depth of formation tops and subsequent calculation of reservoir parameters.

Based on the regional geology, and specifically, geologic correlations from oil and gas wells as shown on cross-section A-A’ (Table 6, Figure 24), the Deadwood and Flathead Formations will likely be encountered at depths of approximately 8,163 and 8,565 feet bgs, respectively. The Deadwood/Flathead injection interval will be identified, as well as the upper and lower confining zones, from logs run during the drilling and completion of the wells. In this permit application, the injection interval is defined as those formations occurring between the Icebox Shale and Precambrian basement. The log picks will be presented to WDEQ for concurrence prior to perforating the casing in any of the Ross Disposal Wells.

For purposes of estimating the top and base of the injection interval for this application, it is assumed that the ground surface elevation for all five wells is 4,218 feet AMSL. As

previously noted, regional data for the injection interval are sparse. As such, the geologic cross-sections (Attachment C) cover a large area and indicate major structural change rising out of the basin in the Deadwood/Flathead interval between the west and east type logs. Cross-section A-A' extends between these two wells, passing through the Ross Project. For purposes of calculating injection interval depth and thickness, it is assumed that the top of the Deadwood/Flathead will be encountered at 8,163 feet bgs and the base of the injection interval (base of the Flathead Sandstone) will be encountered at 8,755 feet bgs.

The nearest well with a porosity log through the Deadwood/Flathead interval is the west type log (API No. 4900525366) located approximately 22 miles WSW of the Ross Project. Based on analysis of that log, most of the porosity-thickness occurs in the Flathead. The Deadwood/Flathead contains approximately 160 feet of sand with greater than 8 percent porosity and an average of 13 percent porosity in porous zones. A core from the Flathead taken in the Madison Test Well No. 1 indicates good permeability and porosity (Table 4). An average permeability of 95 millidarcies (md) has been estimated from this data relative to porosity (Figure 20). Final perforation intervals will be determined based on geophysical logs and formation testing data obtained from each well during the drilling and completion process.

Summary of Deadwood/Flathead Data	
Data Sources	Log data from the Fieldgrove No. A-1 (22, T52N, R71W), No. 22-19 Reynolds (19, T53N, R67W), Little Missouri Federal No. 1 (9, T55N, R67W), Madison Test Well No. 1 (15, T57N, R65W); reservoir data estimated from cores and Deadwood DST (Donald N. Griffis No. 1; 7,T53N, R63W).
Age	Cambrian
Lithology	Deadwood – Fine-grained sandstone with interbedded siltstone and shale, deposited in marine/nearshore conditions (i.e., tidal flats, beaches) Flathead – Fine to coarse-grained sandstone with thin interbeds of siltstone and shale, deposited under a partly-marine environment
Upper Confining Zone and Thickness	Red River Formation from approximately 7,711 – 8,075 ft bgs and Icebox Shale from approximately 8,111 – 8,163 ft bgs (approximately 416 feet total)
Lower Confining Zone and Thickness	Precambrian basement (undetermined thickness)
Est. Top and Base of **Deadwood** at Wells	-3,945 ft AMSL (8,163 ft bgs) / -4,347 ft AMSL (8,565 ft bgs)
Est. Top and Base of **Flathead** at Wells	-4,347 ft AMSL (8,565 ft bgs) / -4,537 ft AMSL (8,755 ft bgs)
Gross Injection Interval Thickness	Approx. 592 feet
Net Sand Thickness, Porosity > 8%	Approx. 160 feet (based on neutron/density porosity)
Permeability	95 md (based on Flathead cores from Madison Test Well #1)
Water Saturation	100%
Initial Pressure	3,558 psi @ midpoint depth of 8,459 feet bgs (0.42 psi/ft gradient)

Confining Zones

As shown on the structural geologic cross-sections (Figures 24 and 25) and type-logs (Figures 6 and 7), the Deadwood/Flathead is confined immediately above by the Icebox Shale Member of the Winnipeg Group. It ranges from 40 to 54 feet thick on the type logs and up to 64 feet thick north of the Ross Project at the Little Missouri Federal No. 1 well (Table 6). Based on correlation of logs that form Cross-section A-A’, the Icebox Shale is estimated to be approximately 52 feet thick below the Ross Project. As shown on the isopach map (Figure 21), the Icebox Shale is regionally continuous and thickens to the northeast. It should be noted that the thickness represented on the isopach map is less

than that which has been estimated below the Ross Project based on correlation of area logs.

The Red River Formation which overlies the Winnipeg Group is also part of the confining zone and ranges from 318 to 460 feet thick in wells used for cross-section A-A'. It is estimated to be approximately 364 feet thick (based on log correlation) below the Ross Project. A core taken from the basal portion of the Red River in the Madison Test Well No. 1 shows porosity ranging from 1.9 to 3.2 percent, horizontal permeability at <0.01 md; vertical permeability could not be measured (Table 4). An isopach map of the Red River Formation is presented as Figure 22 and shows it to be regionally continuous, thickening to the northeast. It is noted that the thickness represented on the isopach map is less than that which has been estimated below the Ross Project based on correlation of area logs.

Confinement below the Deadwood/Flathead injection zone is provided by the granitic and metamorphic rocks of the Precambrian basement (Beikman 1962). Core analysis from the Precambrian is presented in Table 4. Figure 17 presents a structure map of the Precambrian basement.

B. Wells Penetrating Receiver

A total of four oil and gas wells are located within the AORs and are listed on Table 1. To compensate for potential inaccuracy regarding location, wells within 150 feet of the AORs were also included in the table. Plugging and abandonment records and well completion details for these wells are provided in Appendix A. The Deadman Creek oil and gas field is located within the Ross Project boundary.

It is noted that all oil and gas wells within the AORs are completed in the top of the Minnelusa, the base of which is estimated to be approximately 1,114 feet above the top of the proposed injection zone. As such, historic oil and gas wells do not present any potential for vertical fluid migration into any USDW due to artificial penetration. The nearest well that penetrates the top of the proposed injection zone is the Coltharp No. 1 (API 4901105736) located approximately 14 miles southeast of the Ross Project (T51N, R66W, Section 18).

Water rights located within the AORs of the proposed Ross Disposal Wells were gathered from the Wyoming State Engineers Office (SEO) website and are listed in Table 2 and shown on Figure 5. There is one water well located within the AORs of the proposed Ross Disposal Wells. Permit No. P50917.0W is for an industrial well drilled to 750 feet that is used for waterflood operations in conjunction with a nearby injection well (API No. 4901120332). While the completion formation is not noted in available SEO files, records indicate that the well is perforated from 458 to 679 feet. Based on formation tops from completion records (Appendix A) from the onsite injection well (API No. 4901120332) used in cross-sections in this application, the top of the Fox Hills Formation occurs at 684 feet BGS (695 feet RKB). It is then reasonable to conclude that the water well listed on Table 2 was drilled to total depth in the Fox Hills Formation and

is completed in overlying formations. As such, it does not present any potential for fluid migration into any USDW due to artificial penetration.

It is noted that there are no coal bed methane (CBM) wells within the AORs. The closest CBM well is located approximately 18.7 miles from the Ross Project boundary. It should be noted that latitude and longitude coordinates from the WOGCC website for the locations of some CBM wells in the area do not agree with the corresponding Section, Township, and Range locations listed on the website and on well records in the state files. In these cases, the Section, Township, and Range locations listed on the WOGCC website and on well records are assumed to be correct and erroneous coordinate-based locations are not plotted.

C. Geologic Cross Sections

A cross-section index map is provided as Figure 23. Geologic cross-sections representing major formations are included as Figures 24 and 25. Cross-section A-A' depicts the regional structure west to east rising out of the Powder River Basin toward the Black Hills monocline. It is composed of four wells, three of which penetrate the target injection zone. The No. 22-19 Reynolds well is located within the Ross Project boundary and was completed as an injection well in the Minnelusa Formation. Cross-section A-A' serves to demonstrate the lateral continuity of the confining layers and target injection zone across the region. Cross-section B-B' depicts the structure along the margin of the basin north to south. As noted previously, there are few available data for the Deadwood/Flathead in the region. As such, the cross-sections were created based on available logs and span a large area.

D. Area of Review (AOR)

The Area of Review (AOR) for each of the proposed wells has been evaluated in accordance with WDEQ-WQD Chapter XIII, Section 5. Determination of the Deadwood/Flathead AOR requires calculation of the cone of influence (COI), which has been performed for each individual well as specified by Chapter XIII, Section 5(b)(iv)(A), and calculation of the volumetric fillup (also referred to as the ultimate limit of emplaced waste [ULEW]) as stated in Chapter XVI and Chapter XIII, Section 5(b)(iv)(B).

The equations required by state regulations for these calculations, including the input data and necessary assumptions are presented below. The calculated values for the COI and volumetric fillup for each well are summarized in the following section, and are shown in detail on Table 7. This information is followed by the identification of the final AOR.

Little variation in topography exists between potential well locations. As such, all depths in this section are based on an estimated surface elevation of 4,218 feet AMSL, as this is the approximate average elevation for ground surface within the Ross Project area. AOR calculations are based on the assumption of a single well in an infinite-acting reservoir.

a. Cone of Influence (COI)

As mentioned previously, the depth and completion intervals for the proposed wells (DW No. 1, DW No.2, DW No. 3, DW No. 4, and DW No. 5) are expected to be similar. Hence the same depths were used for each of the wells. Reservoir data used in the calculation were estimated based on regional information and correlation of available logs. Estimated reservoir data for the target injection interval are provided in Table 7.

Section 5(b)(iv)(A) of Chapter XIII states that the cone of influence for a single well is calculated as follows:

$$r = ((2.25\ KHt)/(S10^{x}))^{1/2}$$

$$\text{Where: } x = (W/G - B)(4\pi KH/2.3Q)$$

r = Radius of the cone of influence of an injection well (feet)
K = Hydraulic conductivity of the injection zone (feet/day)
H = Thickness of the injection zone (feet)
t = Time of injection (days)
S = Storage coefficient (dimensionless)
W = Hydrostatic head of underground source of drinking water (feet), measured from the base of the injection zone
G = Specific gravity of fluid in the injection zone (dimensionless)
B = Original hydrostatic head of injection zone (feet) measured from the base of the injection zone
Q = Injection rate (cubic feet/day)
π = 3.142

To convert intrinsic permeability (in millidarcies) to permeability (or hydraulic conductivity) in ft/day, the following formula is used:

$$K = K_i\ (\rho g/m\mu)$$

Where:

K = Permeability (cm/sec)
K_i = Intrinsic permeability (95 millidarcies)
ρ = 1.006 gm/cm3 - the density of fluid in injection zone
g = 980 cm/sec^2 - the acceleration of gravity
m = 0.01 gm/(sec cm)
μ = 0.50 centipoise

And: 1 Darcy = 9.87×10^{-9} cm^2 and 1 cm/sec is equivalent to 2,835 ft/day

Based on extrapolation of core data for the Flathead Formation from the USGS Madison Test Well no. 1 (Figure 20), the average intrinsic permeability of the Flathead/Deadwood is

estimated to be 95 millidarcies (md). The calculated permeability value was converted to hydraulic conductivity as follows:

K_i = 95 millidarcies = 0.095 Darcies

K_i = (0.095 Darcies)(9.87 X 10^{-9} cm^2/Darcy)

K_i = 9.38 X 10^{-10} cm^2

K = (9.38 X 10^{-10} cm^2)(1.006gm/cm^3)(980 cm/sec^2) / (0.005 gm/sec/cm)

K = 1.85 X 10^{-4} cm/sec

K = (1.85 X 10^{-4} cm/sec)(2835 ft/day / cm/sec)

K = 0.5243 ft/day

Other assumptions and input parameters used for calculations in this section are summarized below:

- Per the WDEQ Guidance Document #1, Permitting of Class I Injection Wells (page 4), the Coefficient of Storage (S) is the thickness of the injection zone multiplied by 10^{-6}/ft.
- The value for B as specified by WDEQ regulations is the original hydrostatic head of the injection zone in feet measured from the base of the injection zone. The nearest pressure data available for the Deadwood/Flathead is the DST from the Donald N. Griffis No. 1 (API 4901120253; T53N, R63W, Sec 7) located approximately 24 miles east of the Ross Project, which indicated an original reservoir pressure gradient in the interval of 0.28 psi/ft. Using a more conservative estimated reservoir pressure gradient of 0.42 psi/ft, the head in the Deadwood/Flathead (B) is 8,492 feet (3,677 psi at a depth of 8,755 ft).

- Based on an estimated water level at ground surface for the Madison, which is known to be artesian in the region, it is calculated that the head (W) in the overlying lowermost USDW (Madison) is approximately 8,755 feet per Chapter XIII, Section 5, of the WDEQ Water Quality Regulations. The head was calculated from the base of the Flathead Sandstone (estimated at 8,755 ft bgs from log correlations).

- Based on log analysis from the Fieldgrove No. A-1 well and correlation of available logs, the net sand thickness of the Deadwood/Flathead injection zone is estimated at approximately 160 feet (cut-off 8%). The average formation porosity (based on the neutron/density log porosity from the Fieldgrove No. A-1 and extrapolation of core data from the Madison Test Well No. 1) is 13 percent.

- Required injection period by regulation is 10 years. However, at the request of WDEQ staff, the injection period is assigned as 20 years (projected life of project).

- For the purpose of these calculations an average injection rate of 1,714 bbl/day (50 gpm), or 9,626 cubic feet per day, is used over the life of the mine. For each well, the requested maximum injection rate is 2,571 bbl/day (75 gpm), or 14,438 cubic feet per day.

- Based on regional water quality calculations, the total dissolved solids (TDS) concentration of the injection zone fluid is estimated at 20,000 mg/L; the specific gravity is 1.006 based on fluid property calculations accounting for pressure, temperature, and TDS concentration (CREWES, 2010). Water quality in the proposed injection zone will be assessed during the drilling and completion process.

- The injection zone fluid viscosity (0.50 cp at 146 degrees F, which represents the temperature at the midpoint depth of the injection interval, at approximately 8,459 ft bgs) was corrected for temperature, density, and TDS and calculated utilizing the CREWES Fluid Properties Calculator (CREWES, 2010).

- The COI and ULEW have been calculated for each well with an assumption of a single well in an isotropic, homogeneous, and infinite-acting reservoir as specified by WDEQ UIC Guidance Document #1.

AOR and ULEW calculations for each well are based on the condition of a single well in an infinite-acting reservoir. Based on the COI equations and the input variables shown above, the COI for each of the proposed Ross Disposal Wells is approximately 1 foot. The detailed calculations are shown on Table 7.

b. Area of the ultimate limit of emplaced waste (ULEW)

The following formula was used for this calculation:

$$R = (Qt/\pi Hp)^{1/2}$$

Where:
R = Radius of volumetric fillup (feet)
Q = Injection rate (9,626 $feet^3$/day)
t = Time of injection (7,300 days)
π = 3.142
H = Thickness of the injection zone (160 feet)
p = porosity expressed as a pure decimal (0.13)

Using the assumptions listed in the previous section, the ULEW for DW No. 1, No. 2, No. 3, No. 4, and No. 5 is 1,037 feet for each well (Figure 23). These calculations are shown on Table 7.

c. Minimum Area of Review

In accordance with Chapter XIII, the minimum AOR for a Class I well is the area of emplaced waste. According to Chapter XIII, Section 5(b)(iv)(C) and (D), the minimum area

of review for a Class I non-hazardous well shall never be less than one-quarter (¼) mile, the cone of influence, or the area of emplaced waste, whichever is greatest. As such, to comply with Class I standards, the minimum AOR for each of the wells is equal to ¼ mile, or 1,320 feet.

d. Final Area of Review

As previously stated, the AOR for each of the Ross Disposal Wells is ¼-mile. In accordance with Chapter XVI and XIII, Section 5(b)(iv)(E), the final areas of review shall conform to the public land survey and be legally described by Township, Range and Section to the nearest quarter-quarter section. The final AORs for the proposed Ross Disposal Wells are summarized below and shown on Figures 3 and 5. Upon completion of testing within the Deadwood/Flathead, and assuming this proposed injection zone has sufficient injection capacity, AOR calculations will be updated with site-specific data.

Proposed Well	AOR Section Portions	Section	Township	Range
Ross DW No. 1	S 1/2, SW 1/4	7	53N	67W
	SW 1/4, SE 1/4	7	53N	67W
	N 1/2, NW 1/4	18	53N	67W
	NW 1/4, NE 1/4	18	53N	67W
	SE 1/4, NW 1/4	18	53N	67W
Ross DW No. 2	S 1/2, NE 1/4	18	53N	67W
	SW 1/4	18	53N	67W
Ross DW No. 3	NW 1/4	19	53N	67W
	N 1/2, SW 1/4	19	53N	67W
	W 1/2, NE 1/4	19	53N	67W
	NW 1/4, SE 1/4	19	53N	67W
Ross DW No. 4	SE 1/4	13	53N	68W
	N 1/2, NE 1/4	24	53N	68W
	NW 1/4, NW 1/4	19	53N	67W
	W 1/2, SW 1/4	18	53N	67W
Ross DW No. 5	S 1/2, SE 1/4	12	53N	68W
	NE 1/4	13	53N	68W

e. Potential Groundwater Impacts in the Area of Review

The potential groundwater impacts from Class I injection at the Ross Project are limited. As shown in this section, assuming radial flow and piston-like displacement, the radius of volumetric fillup (ULEW) for each well for a 20-year period is 1,037 feet. It is acknowledged that dispersion will occur and the front of the dispersed injection plume will exceed the calculated plume front derived based on piston-like displacement. However,

the magnitude of dispersion is expected to be small, and the 1/4–mile AOR requested in this application exceeds the calculated radius of fluid displacement.

Potential groundwater impacts from injection of wastewater containing concentrations of radionuclides will be limited as well. Concentrations of uranium in the wastewater are expected to be low due to capture of uranium in the processing plant. Transport of uranium and radium-226 is also significantly retarded in a groundwater system. For example, a concentration reduction ratio of 7 was calculated for uranium in approximately 400 feet of travel at the Irigaray Mine (Cogema/Petrotek, 2004). Radium-226 transport was retarded even more than uranium.

E. Water Quality Information - Proposed Injection Zone

Groundwater Classification

According to Section 4(d)(ix) of Chapter VIII of the WDEQ Water Quality Rules and Regulations, groundwater is classified as *Class VI water and unusable or unsuitable for use* according to the following guidelines:

(A) Due to excessive concentrations of total dissolved solids or specific constituents; or
(B) Is so contaminated that it would be economically impractical to make the water usable; or
(C) Is located in such a way, including depth below the surface, so as to make use economically and technologically impractical.

Water quality data in this section show that the Deadwood/Flathead interval are projected to contain waters with TDS concentrations in excess of 10,000 mg/L near the Ross Project. Formation fluid samples will be collected and analyzed during the drilling and completion process. The results will subsequently be submitted to the WDEQ.

It is projected that Deadwood/Flathead water would require extensive treatment to meet applicable water quality standards. This would likely require the installation of a disposal well locally to manage the resulting brine byproducts. Due to the high cost of installation and operation of wells in the Deadwood/Flathead relative to the shallower and higher quality Fox Hills and Madison Formations, the Deadwood/Flathead waters meet the criteria of economical and technological impracticality at the Ross Project for Class VI designation. It is also noted that typical well construction costs for a Deadwood/Flathead Class I injection well is on the order of $2.0 MM to $2.5 MM, and a water supply well would equal or exceed this cost.

All three criteria for a Class VI groundwater designation will likely be satisfied for the Deadwood/Flathead units on the eastern margin of the Powder River Basin. Concentrations of TDS make it unsuitable for use (Criterion A). It is so contaminated with dissolved solids that it would be economically impractical to make the water useable (Criterion B). The Deadwood/Flathead is also located at such a depth compared to more easily accessible and higher quality waters of the Madison (i.e., lowermost USDW) so as to make its use economically impractical (Criterion C).

a. Water quality data

The following is a summary of available water quality data for the Deadwood/Flathead injection interval. A thorough evaluation was performed to identify all water wells within a two-mile radius of the proposed injection well locations. Data obtained from the Wyoming State Engineer's Office show no permitted wells that utilize the Deadwood/Flathead within a 2-mile radius of the proposed Ross Disposal Wells, nor is the Deadwood/Flathead thought to supply any water wells in the region. Completion depths are not provided by the SEO for most of the identified wells. However, due to lithology, it is likely that all identified private water supply wells are completed to the overlying Lance and Fox Hills Formations (e.g., completion depths less than 800 feet). The City of Gillette water wells, located approximately 10 miles southeast of the proposed wells (T51N, R66W) on the east side of the monocline, are completed in the Madison Formation. The Madison is separated from the proposed injection zone by approximately 500 feet below the Ross Project. No use of the Deadwood/Flathead interval for public drinking water supply has been identified in the area.

There are no oil and gas wells that penetrate the Deadwood/Flathead in the AORs. To assess water quality, the state-wide water quality database was searched for the Deadwood/Flathead interval on the Wyoming Oil and Gas Conservation Commission website (http://wogcc.state.wy.us). Table 8 presents a summary of all available data obtained from this source for water quality in the Flathead Formation, which range from 10,970 to 19,700 mg/L TDS. No data were available for the Deadwood Formation. The Flathead data are from wells located more than 180 miles away in Park and Sweetwater Counties and may not be representative of the formation in the Ross Project area. As noted previously, data for the proposed injection zone are sparse. Formation fluid quality will be assessed during the drilling and completion process.

Water quality data for the Deadwood/Flathead were also obtained from the USGS Produced Water Database (http://energy.cr.usgs.gov/prov/prodwat/intro.htm). The Flathead/Deadwood water quality data for the State of Wyoming from this source are presented in Table 9, including the water source and date of analysis (if available). The data indicate the TDS concentration in the Deadwood/Flathead range from 2,509 to 17,657 mg/L. The wells sampled are located in the Wind River, Big Horn, and Green River Basins and may not be representative of the proposed injection zone in the Ross Project area. Formation fluid quality will be assessed during the drilling and completion process.

Water quality calculations based on porosity and resistivity for the proposed injection zone as well as major formations from the Minnelusa to basement are presented on Table 5. The porosity used for these calculations is based on the neutron/density log from the Fieldgrove No. A-1 located approximately 22 miles west-southwest of the proposed well locations. This is the well closest to the Ross Project that fully penetrates the target injection zone. Further, it is the only well in the area with an available porosity log in the Deadwood/Flathead. As such, the average porosity in selected zones from the Fieldgrove No. A-1 was applied to the water quality calculations for the other wells. The

porosity from several porous zones from each formation was used, along with deep resistivity at coinciding depths, to calculate NaCl concentrations as an indicator of TDS for each of the three wells on cross-section A-A’ that penetrate the proposed injection zone.

The calculations for the two wells closest to the Ross Project from cross-section A-A’ (Fieldgrove No. A-1 [22 miles WSW]; Little Missouri Federal No.1 [14 miles N]) indicate average TDS concentrations significantly greater than 10,000 mg/l in the proposed injection zone. Due to the structural and hydrogeologic location of these wells relative to the Ross Project and recharge, it is reasonable to assume that, of the data available, these data are most indicative of the target injection interval below the Ross Project. As further described below, the resistivity calculations for the Deadwood/Flathead interval in the Madison Test Well No. 1 (located approximately 29 miles northeast) indicate TDS concentrations less than 10,000 mg/l but are not likely to be representative of Deadwood/Flathead water quality below the Ross Project.

The primary sources for recharge in the region are the upland areas of the Black Hills uplift (Figure 26). Generalized TDS concentration maps in the upper and lower Paleozoic section are presented as Figures 27 and 28, respectively. These maps indicate that the location of the Madison Test Well No. 1 (northern Crook County, Wyoming) is more directly influenced by recharge from the Black Hills than intervals below the Ross Project and a marked variance in water quality should be expected moving westward toward the Powder River Basin. Further, there is major structural change due to the Black Hills monocline and a reverse/thrust fault between the two locations. Figure 17 presents a map of the structure on top of the Precambrian basement. It indicates a structural change of nearly 4,000 feet at the base of the proposed injection zone between the Ross Project and the Madison Test Well No. 1 (T57N, R67W). This structural change is in agreement with the projected formation top of the Precambrian for the Ross Disposal Wells (Table 6) which is approximately 3,860 feet deeper than in the Madison Test Well No. 1. As such, it is unlikely that the water quality at the Madison Test Well No. 1 is representative of the Deadwood/Flathead below the Ross Project. Proposed injection interval water quality on site will be assessed during the drilling and completion process of the Ross Disposal Wells.

<u>b. Analysis of water from any usable aquifer within the AOR</u>

Information from the Wyoming State Engineer’s Office indicates that there is 1 industrial well (permit No. P50917.0W) completed within the AORs of the proposed Ross Disposal Wells (Table 2; Figure 5). This well was drilled to 750 feet and is likely completed in the Lance and Fox Hills Formations. No water quality data from the well within the AORs are available.

<u>c. Quality assurance data</u>

Quality assurance information for the WOGCC and USGS water quality data is available on the previously referenced WOGCC and USGS Websites.

F. Regional Water Quality and Water Supply

Based on occurrence of shallow porous formations, local wells are likely completed in the Lance and Fox Hills Formations. It is noted that depth of completion is not specified by the SEO for many local water wells, and water quality data from local wells are not available. Total dissolved solids levels within the Fox Hills Sandstone are generally higher in the western side of the Powder River Basin than the eastern side, ranging between 1,000 and 2,000 mg/L. No water type appears to be prevalent (Hodson, 1973).

Water quality data from the USGS Produced Waters database and the Wyoming Oil and Gas Conservation Commission have been plotted with respect to the Powder River Basin for several formations. Example plots are included as Figure 29 (Lance Formation), Figure 30 (Frontier Formation), Figures 31 and 32 (Minnelusa Formation), and Figure 33 (Madison Formation).

Osborne (1981) states that there were few data (as of 1981) regarding the water quality of the Mesaverde, and states that basin-wide TDS concentrations can range from less than 600 mg/L to about 3,900 mg/L. The Shannon water quality is available through oil field samples, which indicate that TDS concentrations in the western portion of the Basin can vary from about 2,000 to over 5,000 mg/L; waters east of Casper exhibit TDS of about 9,000 mg/L (Osborne, 1981). The Frontier aquifer waters contain little sulfate and exhibit TDS concentrations ranging from 1,417 to over 24,000 mg/L.

Dakota sandstones exhibit gross spatial variability in water quality (Osborne, 1981). In the east half of the basin, Dakota waters at outcrop exhibit a TDS of 350-3,300 mg/L, with water quality becoming more saline away from recharge areas. Across the Black Hills monocline, TDS increases from less than 3,000 mg/L to over 10,000 mg/L. In the southwest part of the Powder River Basin, Dakota units generally contain 1,500-3,000 mg/L TDS, but Osborne states that data are limited in this area. Data from the Muddy Sandstone in western parts of the Basin indicate that TDS vary from about 9,000 to more than 17,000 mg/L.

The Sundance Formation exhibits variable water quality, with TDS in the northern part of the Basin at 894-1,870 mg/L (Osborne, 1981). Away from outcrops, the Sundance Formation waters from oil fields along the southern margin of the basin ranges from about 4,000-15,500 mg/L TDS, exceeding 10,000 mg/L in northeastern Natrona and southeastern Johnson counties.

The Minnelusa water quality is more variable than that of the underlying Madison, with water quality varying from 200 mg/L TDS near outcrop along the eastern margin of the Powder River Basin, to over 100,000 mg/L in the center of the basin. Osborne (1981) states that west of the Black Hills monocline, TDS can be over 100,000 mg/L in the Minnelusa. In the western half of the Powder River Basin, the Minnelusa/Tensleep outcrop waters exhibit a water quality of under 500 mg/L TDS, with increasing salinity basinward, but Osborne states that the “high TDS waters, present in the deep parts of the aquifer in the east half of the basin are not found in the western part.” It is noted

that approximately five miles west of the Ross Project, EPA and WDEQ have exempted a large area (46 townships) of the Minnelusa for oil and gas activities. Maps depicting the dissolved solids within the Minnelusa are presented as Figures 34 through 36.

The Madison Formation supplies the City of Gillette water wells (located approximately 10 miles to the southeast) and is considered to be the lowermost USDW below the Ross Project. It is noted that Osborne indicated TDS concentrations in the Madison vary from less than 300 mg/L to over 3,000 mg/L within the basin. TDS increases basinward, with waters progressively enriched in dissolved sulfate, sodium and chloride. Regional water quality data from the USGS Produced Waters Database is presented on Table 9. Figures 37 and 38 present dissolved solids in the Madison Formation. An isopach map of the Madison is presented as Figure 39.

Regional water quality for the Deadwood/Flathead was discussed in Attachment E. As previously noted, there are few water quality data available for the proposed injection zone. Water quality will be assessed during the drilling and completion process.

Water Supply Information

The Deadwood/Flathead is not used as a source of drinking water at any location in the Ross Project area. Local supplies in the area are provided by surface water, shallow wells, and the Madison Formation (e.g., City of Gillette, Wyoming).

G. Further description of the discharge

This permit application is for the injection of wastewater that is non-hazardous under the Resource Conservation and Recovery Act (RCRA). It is noted that the Ross ISR project is not yet operational. As such, water quality has been estimated. Typical water chemistry of the injected waste stream for ISR operations is presented in Table 10. Additional examples of the waste stream produced at operational ISR facilities (Crow Butte and COGEMA) are included from publically available data as Tables 10a and 10b. Minor concentrations of corrosion inhibitors, scale inhibitors, and/or biocides may be used as needed to maintain the well in optimum condition.

The wastewater consists of operational and remediation/restoration bleed streams from ISR uranium mining and processing operations, including but not limited to: normal overproduction (wellfield bleed) streams, yellowcake wash water, laboratory waste, reverse osmosis brine, groundwater sweep solutions, plant washdown water, process water from other ISR operations in Wyoming, well workover wastes from the Ross Project operations, pump test fluids, well development water and drilling fluids from the proposed Ross Project Class III operations (and from similar ISR operations in Wyoming), and other related waste waters from the Ross operations. These waste streams are benefication wastes, exempt from RCRA regulation under the Bevill Amendment found in 40 CFR 261.4(b)(7). The Standard Industrial Classification (SIC) code for this waste is 1094. This is being replaced by the North American Industrial Classification System (NAICS) code, which for this operation is 212291.

H. Description of the Wells

A preliminary well schematic is shown on Figure 40; a preliminary wellhead schematic is shown on Figure 41.

Drilling Procedures

A general, preliminary drilling prognosis follows. Final design will be performed prior to mobilizing a drilling rig and may be modified based on site-specific conditions encountered (see section e. of this Attachment).

1. Drill and set 16" conductor casing at approximately 100 feet (if needed). Cement to surface.
2. Drill 12 ¼" surface hole to 900'; run 8 ⅝" casing to bottom; cement to surface (Class A or 50/50 Poz)
3. Drill 7 ⅞" hole to approximately 8,755'
4. Run cement bond log (CBL) on surface casing
5. Run openhole geophysical logs from surface casing to bottom
6. Conduct formation testing/fluid sampling and collect sidewall cores (if warranted)
7. Run 5 ½" casing to bottom; cement to surface (Class A or 50/50 Poz + Lite) in two stages placing DV tool at approximately 5,000 feet bgs; wait on cement minimum 12 hrs between stages; release drilling rig
8. Rig up completion rig, drill out DV tool and run CBL on production casing
9. Perforate Deadwood/Flathead and develop as needed (swabbing and/or jetting)
10. Run 2 ⅞" tubing and packer (both coated with TK-99)
11. Run radioactive tracer (RAT) log and perform pressure falloff test
12. Perform standard annular pressure test (SAPT) and release rig.

a. Packer, Annulus Fluid, Wellhead and Tree

The tubing in each well will be isolated from the annulus with a packer. It is anticipated that the packer likely will be a Baker Lok-Set mechanical packer, or suitable equivalent. If warranted, an on/off tool may be installed above the packer. The tubing and packer will be internally coated with TK-99 or equivalent.

The annulus fluid will consist of fresh water with corrosion inhibitor.

For each well, the tubing will hang in a 5 ½" x 2 ⅞" tubing head and a tree will be installed above the tubing hanger. It is anticipated that a 3' tree (rated for 3,000 psi by API) will include a bottom master valve, a flow tee with one side outlet and valve, a swab valve, and a pressure gauge above the swab valve (Figure 41). Annulus pressure will be maintained with nitrogen and an annulus tank (Figure 42).

b. Cementing

Each of the proposed wells will be cemented in accordance with Chapter XIII, Section 11. The 8 ⅝" surface casing strings will be cemented from total depth to surface using Class A or 50/50 Pozmix, or suitable equivalent cement.

The 5 ½" production casing will be cemented as follows: (1) Class G or 50/50 Pozmix in the interval from total depth (8,755 feet) to 5,000 feet; and (2) Class G and lite cement from 5,000 feet to surface. It is anticipated that the 5 ½" casing will be cemented in two stages, with the DV tool placed at approximately 5,000 feet.

c. Logs and Cores

Open-hole and cased-hole logs will be run as summarized on Table 11. Whole cores or sidewall cores will likely be collected from the injection interval and upper confining zones in the first disposal well drilled and standard oil field core testing will be conducted (e.g. porosity and permeability).

d. Formation Testing

Openhole testing and logging will be conducted in the Deadwood/Flathead to determine optimum zones for injection in the interval. Fluid sampling using wireline equipment or other methods as dictated by equipment availability and hole conditions will also be conducted to assess formation fluid quality. A tracer will be added to the drilling mud to enable evaluation of the fluid sample quality.

e. Alternate Well Design

It is possible that a traditional two-stage cementing program may prove to be problematic due to the nature of the Madison Formation in some areas. If it is determined that the preliminary design described previously is inadequate, then an alternate casing design and cementing program will be used. This would likely entail an additional string of casing set at the base of the Minnelusa and cemented to surface.

I. Operating Data

a. Discharge Rates

Strata is requesting that the permit limit be equal to a total injection rate for the five Deadwood/Flathead wells combined (375 gpm based on an assumed maximum injection rate of 75 gpm for each of the five wells).

b. Injection Pressure

Per WDEQ guidance, the following equation was used to estimate fracture pressure for the proposed wells.

$$P = F \times D$$

Where: P = Fracture pressure of the receiver (psi)
F = Fracture gradient (psi/ft of depth)
D = Depth to the bottom of the receiver (feet)

Based on available information from the Enhanced Oil Recovery Institute (EOR Database), a fracture gradient of 0.68 psi/ft was assigned to the proposed injection zone (Table 12). It is noted that site specific fracture pressure data for the Deadwood/Flathead are not available in the Ross Project area and will be collected as part of the well testing process.

Using the equation above specified by WDEQ Guidance Document #1, Section 3.0), the fracture pressure at the base of the receiver for the proposed wells is calculated to be 5,953 psi (see Table 13 for detailed calculations).

Calculation of the Limiting Surface Injection Pressure requires input of the fracture pressure, hydrostatic head, and friction losses as follows:

Limiting surface injection pressure (L in psi) = $(P - h + T + Lp)(0.90)$

Hydrostatic head (h) = $G \times D \times 0.433$

Where: h = Hydrostatic head at the bottom of the receiver (psi)
G = Specific Gravity of the injection fluid
D = Depth to the bottom of the receiver (feet)

- Specific gravity of the injection fluid (G) = 1.025 (based on 40,000 mg/L TDS; corrected for estimated temperature at surface [65° F] and formation pressure [3,677 psi])
- Tubing pressure loss (T) was obtained from Western Company charts. The pressure loss at an injection rate of 75 gpm in 2 ⅞" tubing is 162 psi for each of the proposed new wells. Tubing pressure loss was considered for new, bare pipe. For lower injection rates, a smaller friction loss would need to be applied (i.e., 81 psi for the estimated average injection rate of 50 gpm). In the unlikely event that a higher rate could be attained within permit limits, a higher friction loss would be assigned.
- Perforation pressure loss (Lp) was neglected

Based on the above equation, and the noted assumptions, the Limiting Surface Injection Pressure (LSIP) to the base of the receiver for each of the proposed wells is 1,969 psi (Table 13).
Based on WDEQ instruction, the previous calculation was also evaluated at the top of the injection interval, where the depth to the top of the receiver (D) equals 8,163 feet, and is presented in Table 12. Based on this calculation, the fracture pressure is calculated to be 5,551 psi. Relative to the top of the injection zone, the calculated LSIP is 1,846 psi (Table 14). Strata will perform testing during the well completions to clearly determine the LSIP

for each well consistent with Chapter XIII of the WDEQ Water Quality Rules and Regulations and the applicable permit.

c. Proposed stimulation program

The need for formation stimulation will be assessed during the completion of each well. At this time, it is anticipated that each of the wells may be stimulated with 10 to 15 percent HCl. It is possible that mud acid treatments (HCl: HF) may also be performed. The need for subsequent (periodic) treatments will be assessed during operation of the well.

While hydraulic fracture treatments (using sand as a proppant) are not considered necessary at this time, they may be considered in the future if the combined injection capacity of the well is not sufficient to meet Strata's requirements. Any potential hydraulic (propped) frac job would be (1) designed to contain the fracture within the zone of interest in the Deadwood/Flathead, and within the cemented interval of the production casing, and (2) performed after approval by WDEQ.

In addition, small-scale fracture treatments using either acid or water may be performed to overcome near-wellbore damage caused during drilling. Such treatments, which utilize no proppant, typically create fractures with a length and height of one to five feet.

d. Injection procedure

The specific injection procedure for the well will depend on (1) the capacity of the well as determined from testing performed during the well completion operations, and (2) Strata's disposal requirements at that time. In general, it is anticipated that injection operations will commence at 25 to 50 percent of the anticipated injection capacity for a period of 1 to 5 days, with subsequent increases to the maximum rate over the next week. During the startup period, the flow monitoring and injection equipment, annulus monitoring system and the pressure shutdown systems will be checked to assure proper operation.

To protect the well tubulars, low concentrations of corrosion inhibitor and antiscalant may be added to the injection stream at the surface. In addition, periodic batch treatments with an oxygen scavenger may be performed. This type of treatment/prevention program is similar to that which has been used on other Class I wells used for ISR operations.

e. Surface Equipment

A schematic drawing of surface equipment including storage tanks, pumps, filters, meters, valves, recording devices, wellhead monitoring devices and control valves for the Ross Disposal Wells are included in Figure 42. It is anticipated that a similar configuration of surface equipment will be installed for each of the wells. A wellhead schematic is presented as Figure 41.

f. Description of flow monitoring devices

As noted above, the surface injection facilities for Ross DW No. 1, No. 2, No. 3, No. 4, and No. 5 will include continuous recording devices to monitor injection pressure, flow rate, and annulus pressure between the long string and the tubing.

g. Methods and procedures used for inspection and failure detection

The wells will be equipped with a high-level shutoff switch on the injection tubing to prevent operation of the pumps at pressures greater than the Limiting Surface Injection Pressure assigned by permit. In addition, the wells will be equipped with a low-pressure shut-down switch on the surface injection line that will deactivate the injection pump in the event of a surface leak. Finally, the wells will include a high/low pressure shutdown switch with a pressure sensor on the tubing/casing annulus. This switch will stop the injection pump in the event of either (1) a tubing leak or (2) a casing, packer, or wellhead leak.

h. Staffing and training information

The Ross Disposal Wells will be staffed and operated consistent with Class I injection well standards. Strata will prepare written standard operating procedures (SOPs) for well startup, operation, and shutdown and will train staff to operate in accordance with the SOPs.

Operation and maintenance will be the responsibility of the Ross Project Supervisor and operating personnel. The Ross Project operating personnel will operate and monitor the injection well pumps, valves, and scale/corrosion inhibitor systems. They will be instructed in the purpose of the continuous recording devices and procedures to implement if a fault is indicated.

J. Monitoring Plan

a. Monitoring Injected Water

A composite sample of the waste stream will be collected quarterly, or when process change occurs that could significantly alter the chemical composition of the waste stream. Samples will be collected upstream of the high-pressure injection pump. Analyses will be performed using approved methods and in accordance with WDEQ Rules and Regulations, Chapter VIII, Section 7. The proposed parameter list follows:

Ra-226 (pCi/L)
Uranium (mg/L)
TDS (mg/L)
pH (units)

Monitoring records will be submitted to WDEQ quarterly (within 30 days after the end of the quarter) and will include:

1) Date, location and time of sampling
2) Name(s) of sampling personnel
3) Date(s) of analysis
4) Analytical laboratory and laboratory chains of custody
5) Analytical procedures or methods used
6) Analytical results

Reporting will include injection and annulus pressures and injection volumes. Further, the average reservoir pressure will be determined once per year by conducting a pressure falloff test on one of the Ross Disposal Wells.

Quality control/quality assurance related to sampling and pressure monitoring operations will remain consistent with those already in place for the selected analytical laboratory and other Class I injection wells.

b. Monitoring wells

Due to the extreme depth of the Deadwood/Flathead interval and the confining zones above and below the injection horizon, the installation of monitoring wells within the final AORs to assess fluid migration in the proposed injection zone is not necessary.

Shallow water quality monitoring for the Ross Project ISR operations within the vicinity of the injection wells will be performed as required under the WDEQ Permit to Mine.

c. Quality assurance plan

A quality assurance program will be developed for the Ross DW No. 1, DW No. 2, DW No. 3, DW No. 4, and DW No. 5.

K. Well Abandonment

a. Abandonment Procedures: Ross Disposal Wells

Well abandonment will be performed in accordance with WDEQ and the WOGCC regulations. The general proposed procedures for Ross DW Nos. 1-5 would include the following:

1. Rig up pulling unit. Rig down tree and rig up 3,000 psi BOPs. Test same.

2. Latch tubing, release on/off tool; pull out of hole and lay down tubing.

3. Pick up 2 ⅞” workstring. Run in hole, latch on/off tool and pull packer. Pull out of hole and lay down same.

4. Run in hole and cement well from TD to approximately 4,000’ in 3 runs with 465 sx 50/50 Pozmix cement (1.26 ft^3/sx). Tag top of plug. Cement from 3,000’ to 20’ in 3 runs with 281 sx 50/50 Pozmix cement.

Note: This approach is proposed due to the likely extensive perforated interval in the Deadwood/Flathead, and may be changed, on approval from WDEQ, to include multiple conventional squeeze jobs rather than filling the casing.

5. Tie into 8 5/8" x 5 ½" annulus and attempt to bullhead 40 sacks 50/50 Pozmix A cement.

6. Rig down BOPs and pulling unit.

7. Cut and remove wellhead at 5-10 feet below ground surface. Place a dry hole monument in a 10-sack cement plug at the surface.

L. Financial Surety

Strata will provide a surety instrument equal to the estimated cost for plugging and abandonment of the proposed injection wells prior to the commencement of construction.
A detailed plugging and abandonment estimate can be found in Table 15.

The annual updates of Strata's financial surety estimate for the Class I well abandonments will be reviewed and approved by the Wyoming Department of Environmental Quality. Costs associated with the Class I wells surface facilities will be covered in the WDEQ LQD financial surety estimate associated with an approved LQD Permit to Mine application.

M. Mechanical Integrity

After completion of the Ross Disposal Wells, Part I mechanical integrity will be demonstrated for each well before injection commences, in accordance with the procedures specified by WDEQ regulations.

For each well Part II mechanical integrity will be demonstrated prior to injection by either (1) a Radioactive Tracer Log and Temperature Survey coupled with a casing pressure test, or (2) an oxygen activation log with a casing pressure test. Part II MIT will also be demonstrated (1) if significant abnormal annulus pressures are observed, (2) every five years at a minimum, and (3) any time the tubing and packer are removed from the well.

N. Signatory Requirements

In accordance with Chapter XIII, Section 5(b) (xiv), this permit application has been signed by Tony Simpson, Chief Operating Officer, Strata Energy, Inc.

O. Reports

The required quarterly and annual reports for Class I injection wells will be filed no later than 30 days after the end of the calendar quarter. Annual reports will be submitted

along with the 4th Quarterly Report. Those reports will be signed in accordance with Section 5(b)(xiv) and 5(b)(xv).

P. Location Maps

All tables, figures and plates have been previously referenced in this application.
A list of information sources follows.

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Table 1
Oil and Gas Wells
within the Areas of Review

API No.	Company	Well Name	Section	Township	Range	Elevation (ft)	Formation	TD (ft)	Status
4901120325	BURLINGTON RESOURCES	FEDERAL 44-13	13	53N	68W	Unknown	Minnelusa	6,487	Plugged/Abandoned
4901120328	MERIT ENERGY COMPANY	FEDERAL W-34679 33-18	18	53N	67W	4,172	Minnelusa	6,360	Producing Oil Well
4901120332	MERIT ENERGY COMPANY	REYNOLDS 22-19	19	53N	67W	4,218	Minnelusa	6,450	Active Injector
*4901120856	PRENALTA CORPORATION	WESLEY 14-7-5	7	53N	67W	Unknown	Minnelusa	6,401	Plugged/Abandoned
*4901122539	MAXIM DRILLING & EXPL INC	WESLEY 34-7	7	53N	67W	4,204	Minnelusa	6,344	Plugged/Abandoned
4901121701	MILESTONE PETROLEUM	BERGER FEE 42-18	18	53N	67W	4,115	Minnelusa	6,398	Plugged/Abandoned

*Not shown within AOR, but included due to close proximity
Source: Wyoming Oil and Gas Conservation Commision, May 2010

Table 2
Water Rights with Areas of Review

Permit #	Date	Water Right	Well Name	Well Use	TotalFlow	Well Depth (ft)	Static Depth (ft)
P27819.0D	11/01/1982	Cancelled	#1-15 Sun Federal Water Haul	DRI; IND_SW; OIL; TEM	1	0	0
P15509.0S	08/22/2003	Cancelled	Butte #1 Stock Reservoir	STO	0	0	0
P7913.0R	05/16/1978	Cancelled	Evaporation Reservoir	IND_SW; MIS_SW; COMBBU	17	0	0
P30061.0D	10/17/1988	Cancelled	#31-14-53-68 Water Haul	DRI; IND_SW; OIL; TEM	0	0	0
P21242.0D	07/15/1953	Fully Adjudicated	Oshoto Sprinkler Irrigation System	IRR_SW	1	0	0
P41439.0W	03/16/1977	Cancelled	MH #3	MON	0	0	0
P6046.0R	07/15/1953	Fully Adjudicated	Oshoto Reservoir	IRR_SW	173	0	0
CR CR03/149	07/15/1953	Unknown	Oshoto Reservoir	IND_SW	0	0	0
CR CR02/178	07/15/1953	Unknown	Oshoto Reservoir	IRR_SW	173	0	0
P17592.0S	02/01/2006	Unadjudicated	Butte #1 Stock Reservoir	STO	0	0	0
P50917.0W	01/17/1980	Unknown	22X-19	IND_GW	20	750	150

Source: Wyoming State Engineer's Office, April 2010
Notes: Shading indicates drilled water well.
Permit # P41439.0W was cancelled at the request of the applicant in 1979; the well was never drilled.
Permit # suffixes are denoted as follows:
D = Ditch or pipeline permit
R = Reservoir permit
S = Stock reservoir permit
W permits are for wells with a priority date for the date of filing with the sate engineer
CR refers to Reservoir Certificate record book (surface water right)

Table 3
Stratigraphic Correlation Chart

Stratigraphic Correlation – Powder River Basin, Williston Basin, and Black Hills Area

ERA	System, Series, Subdivision			Powder River Basin		Williston Basin		Black Hills Area	
Cenozoic	Quaternary			Alluvium		Alluvium & Glacial Deposits		Undifferentiated Alluvium, Terraces, and Colluvium	
	Tertiary	Pliocene	Upper						
		Miocene							
		Oligocene	Lower	White River Formation		White River Fm. or Group		White River Group	
		Eocene		Wasatch Formation		Golden Valley		Intrusive Igneous Rocks	
		Paleocene		Fort Union Formation		Fort Union Fm.	Tongue River		
							Cannonball		
							Ludlow		
Mesozoic	Cretaceous		Upper	Lance Formation		Hell Creek Fm.			
				Fox Hills Sandstone		Fox Hill Sandstone			
				Lewis Shale		Pierre Shale		Pierre Shale	
				Mesa Verde Fm.					
				Steele Shale		Niobrara Fm.		Niobrara Fm.	
				Cody Shale		Carlile Shale		Carlile Shale	
				Frontier Formation		Greenhorn Fm.		Greenhorn Fm.	
				Mowry Shale		Bell Fourche Shale		Bell Fourche Shale	
						Mowry Shale		Mowry Shale	
			Lower	Muddy Sandstone		Newcastle or Dakota Sandstone		Muddy Sandstone	Newcastle Sandstone
				Thermopolis Shale		Skull Creek Shale		Skull Creek Shale	
				Inyan Kara Group	Fall River Fm.	Fall River Sandstone		Fall River Fm.	
						Fusion Fm.			
					Lakota Fm.	Lakota Fm		Lakota Fm.	
	Jurassic			Morrison Fm.		Morrison Fm.		Morrison Fm.	
				Sundance Fm		Swift Fm.		Unkpapa Sandstone	
						Riordon Fm.		Sundance Formation	
				Gypsum Springs Fm.		Piper Fm		Gypsum Spring Formation	
	Triassic			Chugwater Fm					
Paleozoic	Permian			Goose Egg Fm.		Spearfish Fm.		Spearfish Formation	
						Minnekahta Limestone		Minnekahta Limestone	
						Opeche Fm.		Opeche Formation	
	Pennsylvanian			Tensleep Sandstone	Minnelusa Fm.	Amsden Fm.	Minnelusa Formation	Minnelusa Formation	
				Amsden Fm.		Tyler Fm.			
	Mississippian					Big Snowy Group	Heath		
							Otter		
							Kibbey		
				Madison Limestone		Madison Group	Charles Fm.	Madison (Pahasapa) Limestone	
							Mission Canyon Limestone		
							Lodgepole Limestone		
	Devonian			Darby Fm & Equivalents		Bakken Formation		Englewood Fm.	
	Silurian								
						Interlake Fm.			
	Ordovician			Bighorn Dolomite	Whitewood Dolomite	Stonewall Formation			
						Red River Formation		Whitewood (Red River) Fm.	
				Harding Sandstone	Winnipeg Formation	Winnipeg Formation or Group	Roughlock	Winnipeg Formation	
							Icebox		
							Black Island		
	Cambrian			Gallatin Limestone		Deadwood Formation		Deadwood Formation	
				Gross Ventre Formation					
				Flathead Sandstone					
	Precambrian							Undifferentiated Igneous and Metamorphic Rocks	

Modified from:
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Table 4
Core Analysis from USGS Madison Test Well No. 1

USGS Madison Test Well #1 Core Analysis				
Depth (ft)	**Vertical Permeability (md)**	**Horizontal Permeability (md)**	**Porosity (%)**	**Formation**
3491.9	*	<0.01	1.9	Red River (Hecla Member)
3495	*	*	1.2	Red River (Hecla Member)
3497.9	*	<0.01	1.6	Red River (Hecla Member)
3502.6	*	<0.01	2.4	Red River (Hecla Member)
3505.9	*	<0.01	1.6	Red River (Hecla Member)
3512.4	*	<0.01	3.2	Red River (Hecla Member)
3514.3	*	<0.01	3.2	Red River (Hecla Member)
3515.8	*	*	*	Red River (Hecla Member)
3516.7	*	*	*	Winnepeg
3610.5 - 3611	*	*	*	Winnepeg
4145.4 - 4146.4	5.5	268	20.2	Winnepeg
4152	297	271	18	Flathead
4155.6	269	521	18.6	Flathead
4157.7 - 4158.4	3.9	158	16	Flathead
4160	1.4	93	13.3	Flathead
4161.7	17	274	19.9	Flathead
4163.5	*	*	1.4	Flathead
4166	907	523	17.2	Flathead
4170	2.4	103	12.9	Flathead
4172.3	*	341	19.6	Flathead
4174.3	321	351	14.5	Flathead
4292.5	223	928	12.9	Flathead
4293.7	<0.01	0.01	3.4	Flathead
4295.7	2.4	16	6.7	Precambrian
4296.5	217	204	12.8	Precambrian
4308.6	*	*	11.5	Precambrian
4311.7	*	*	4.3	Precambrian
4313.1	*	*	4	Precambrian
4315	*	*	1.5	Precambrian
4316.5	*	*	2.3	Precambrian
4320.9	*	*	1.2	Precambrian
4346.2	*	*	*	Precambrian
4349.5	*	*	*	Precambrian
4352.4	*	*	1.4	Precambrian

* No data available
Source: Blankennagel et al., 1977, Report on Preliminary Data for Madison Test Well No. 1

Table 5
Calculated NaCl Concentrations in Select Zones of the Minnelusa to Flathead Formation

Temp ground surface (deg F)	38		
Temp at bottom hole (deg F)	166	API	4900525366
Calculated gradient (deg/ft)	0.01164	T, R, S	52N, 71W, 22
Log TD (ft)	11,000	Dist. to Ross	~22 miles

Fieldgrove No. A-1	**Top Depth (ft; RKB)**	**Bottom Depth (ft; RKB)**	**Rt deep (Ohm-M)**	**R shallow (Ri) (Ohm-M)**	**Neutron Porosity %**	**Density Porosity %**	**Assumed (Avg) Porosity**	**Calculated Rw Resistivity (Ohm-M)**	**Gen-9 NaCl (ppm)**	**Temp (deg F)**
Formation										
Minnelusa (8,627' KB)	8,660	8,660	8	2.3	26	18	18.0	0.26	12,500	138.8
	8,694	8,694	4	1.6	19	14	14.0	0.08	45,000	139.2
	8,800	8,800	3.3	1	24	22	22.0	0.16	21,000	140.4
Madison (9,488' KB)	9,718	9,718	80	8.5	35	22	22.0	3.87	650	151.1
	9,868	9,868	60	15	29	18	18.0	1.94	1,300	152.8
	9,967	9,967	80	18	29	15.5	15.5	1.92	1,350	154.0
Englewood (10,012' KB)	10,012	10,033	105	60	30	19	19.0	3.79	650	154.6
Red River (10,033' KB)	10,074	10,074	90	28	22	9	9.0	0.73	5,000	155.2
	10,112	10,112	15	2.3	28	16	16.0	0.38	7,500	155.7
	10,220	10,220	75	15	21.5	11	11.0	0.91	2,800	156.9
Winnipeg Group (10,351' KB)	10,361	10,361	35	35	4	9.5	9.5	0.32	9,000	158.6
	10,370	10,370	10	10	10	19.5	19.5	0.38	7,500	158.7
Deadwood (10,420' KB)	10,480	10,480	45	55	4.5	5	5.0	0.11	30,000	159.9
	10,613	10,613	5.5	6.5	27	16	16.0	0.14	21,000	161.5
	10,735	10,735	3	3.5	30	28.5	28.5	0.24	11,500	162.9
	10,420	10,820	20	20	30	13	13.0	0.34	11,500	161.6
Flathead (10,820' KB)	10,858	10,858	5	5.5	22	25	25.0	0.31	8,500	164.3
	10,931	10,931	2.5	2.5	16.5	22.5	22.5	0.13	22,000	165.2
	10,978	10,978	2.7	2.7	10	17	17.0	0.08	37,000	165.7
	10,832	11,000	5	5	13	13	13.0	0.08	37,000	165.0

Temp ground surface (deg F)	38		
Temp at bottom hole (deg F)	119	API	4901120332
Calculated gradient (deg/ft)	0.01256	T, R, S	53N, 67W, 19
Log TD (ft)	6,449	Dist. to Ross	On site

No. 22-19 Reynolds	**Top Depth (ft; RKB)**	**Bottom Depth (ft; RKB)**	**Rt deep (Ohm-M)**	**R shallow (Ri) (Ohm-M)**	**Neutron Porosity %**	**Density Porosity %**	**Assumed (Avg) Porosity**	**Calculated Rw Resistivity (Ohm-M)**	**Gen-9 NaCl (ppm)**	**Temp (deg F)**
Formation										
Minnelusa (6,290' KB)	6,346	6,346	35	15	17	8	17.0	1.01	3,500	117.7
	6,389	6,389	25	20	20	9	20.0	1.00	3,500	118.2
	6,432	6,432	25	20	24	14	24.0	1.44	2,500	118.8

Temp ground surface (deg F)	38		
Temp at bottom hole (deg F)	130	API	4901106100
Calculated gradient (deg/ft)	0.01488	T, R, S	55N, 67W, 9
Log TD (ft)	4,111	Dist. to Ross	~14 Miles

Little Missouri Federal #1	**Top Depth (ft; RKB)**	**Bottom Depth (ft; RKB)**	**Rt deep (Ohm-M)**	**R shallow (Ri) (Ohm-M)**	**Neutron Porosity %**	**Density Porosity %**	**Assumed (Avg) Porosity**	**Calculated Rw Resistivity (Ohm-M)**	**Gen-9 NaCl (ppm)**	**Temp (deg F)**
Formation										
Minnelusa (2,072' KB)	2,100	2,100	7	7	26	18	18.0	0.23	25,000	85.0
	2,282	2,282	6	6	19	18	18.0	0.19	28,000	89.1
Madison (2,750' KB)	2,800	2,800	25	25	35	18.5	18.5	0.86	5,000	100.7
	3,118	3,118	18	18	29	18.5	18.5	0.62	6,500	107.8
	3,448	3,448	15	15	29	18.5	18.5	0.51	7,300	115.2
Englewood (3,503' KB)	3,520	3,520	15	15	30	19	19.0	0.54	7,000	116.8
Red River (3,530' KB)	3,590	3,590	14	14	22	12	12.0	0.20	20,000	118.3
	3,875	3,875	17	17	28	12	12.0	0.24	15,500	124.7
	3,912	3,912	16	16	21.5	12	12.0	0.23	16,000	125.5
Winnipeg Group (3,940' KB)	3,952	3,952	10	10	4	14.5	14.5	0.21	17,500	126.4
	3,968	3,968	12	12	10	14.5	14.5	0.25	15,000	126.8
Deadwood (4,047' KB)	4,053	4,053	20	20	4.5	5	5.0	0.05	85,000	128.7
	4,082	4,082	18	18	27	5	5.0	0.05	85,000	129.4

Table 5
Calculated NaCl Concentrations in Select Zones of the Minnelusa to Flathead Formation

Temp ground surface (deg F)	38		
Temp at bottom hole (deg F)	130	API	4901109528
Calculated gradient (deg/ft)	0.021125	T, R, S	57N, 65W, 15
Log TD (ft)	4,355	Dist. to Ross	~29 Miles

Madison Test Well #1	**Top Depth (ft; RKB)**	**Bottom Depth (ft; RKB)**	**Rt deep (Ohm-M)**	**R shallow (Ri) (Ohm-M)**	**Neutron Porosity %**	**Density Porosity %**	**Assumed (Avg) Porosity**	**Calculated Rw Resistivity (Ohm-M)**	**Gen-9 NaCl (ppm)**	**Temp (deg F)**
Formation										
Minnelusa (1,570' KB)	1,610	1,610	5	5	26	18	18.0	0.16	42,000	72.0
	1,800	1,800	9	9	19	18	18.0	0.29	21,000	76.0
	2,010	2,010	28	28	24	18	18.0	0.91	5,200	80.5
Madison (2,292' KB)	2,480	2,480	40	40	35	18.5	18.5	1.37	3,400	90.4
	2,670	2,670	28	28	29	18.5	18.5	0.96	4,500	94.4
	3,000	3,000	18	18	29	18.5	18.5	0.62	7,200	101.4
Englewood (3,030' KB)	3,050	3,050	25	25	30	19	19.0	0.90	4,600	102.4
	5,605	5,622	25	35	21	14	14.0	0.49	4,700	156.6
	5,642	5,666	45	75	21	12	12.0	0.65	3,100	157.4
	5,692	5,748	35	65	18	11	11.0	0.42	5,000	158.8
	5,772	5,810	45	75	19	13	13.0	0.76	3,100	160.3
Red River (3,070' KB)	3,100	3,100	65	65	22	12	12.0	0.94	4,300	103.5
	3,200	3,200	60	60	28	12	12.0	0.86	4,800	105.6
	3,400	3,400	50	50	21.5	12	11.0	0.61	6,300	109.8
	6,466	6,501	50	57	19	13	13.0	0.85	2,850	175.0
	6,617	6,642	14	33	18	13	13.0	0.24	10,800	178.0
	6,714	6,722	20	30	18	9	9.0	0.16	8,500	179.9
	6,792	6,804	14	24	18	8	8.0	0.09	15,000	181.6
	6,840	6,862	15	32	20	11	11.0	0.18	10,000	182.7
	6,972	6,997	18	30	20	11	11.0	0.22	7,500	185.5
	7,058	7,077	15	29	19	9	9.0	0.12	11,000	187.3
	7,138	7,157	22	42	19	10	10.0	0.22	7,400	189.0
	7,240	7,252	15	33	18	11	11.0	0.18	10,200	191.1
Winnipeg Group (3,530' KB)	3,620	3,620	17	17	4	14.5	14.5	0.36	10,500	114.5
	10,370	10,370	10	10	10	19.5	19.5	0.38	7,500	257.1
	7,477	7,490	22	28	17	6	6.0	0.08	10,500	196.1
	7,498	7,539	18	31	17	11	11.0	0.22	8,700	196.8
	7,567	7,615	19	32	18	12	12.0	0.27	7,200	198.4
	7,710	7,715	19	27	19	10	10.0	0.19	8,000	200.9
	7,838	7,868	20	25	16	9	9.0	0.16	9,300	203.9
	8,042	8,094	15	15	18	8	8.0	0.10	11,000	208.4
	8,748	8,758	28	30	12	3	3.0	0.03	15,000	222.9
	8,964	8,980	40	42	14	7	7.0	0.20	5,300	227.5
	9,045	9,054	33	37	15	10	10.0	0.33	5,000	229.2
	9,245	9,257	32	33	11	6	6.0	0.12	9,700	233.4
	9,274	9,285	34	35	12	8	8.0	0.22	7,000	234.0
	9,290	9,301	31	33	14	8	8.0	0.20	6,400	234.4
	9,323	9,332	47	48	13	9	9.0	0.38	4,100	235.0
Deadwood (3,692' KB)	3,780	3,780	19	19	4.5	16.5	16.5	0.52	7,000	117.9
	3,950	3,950	10	10	27	16.5	16.5	0.27	14,000	121.4
	4,050	4,050	6.5	6.5	30	16.5	16.5	0.18	21,000	123.6
Flathead (4,096' KB)	4,150	4,150	40	40	22	21.5	21.5	1.85	1,800	125.7
	4,215	4,215	47	47	16.5	21.5	21.5	2.17	1,450	127.0
	4,280	4,280	28	28	10	21.5	21.5	1.29	2,700	128.4

Notes: Equations adapted from Archie (SW^2 = FRw/RT; F = 1/porosity^2 ; Rw = Rt*porosity^2)

Table 6
Formation Depths for Cross-Section A-A' and Projected Formation Depths for Ross Disposal Wells

Formation Depths for Cross-section A-A'

Well	**Fieldgrove No. 1-A (4900525366)**				**No. 22-19 Reynolds (4901120332)**				**Little Missouri Federal #1 (4901106100)**				**Madison Test Well #1 (4901109528)**			
Location	**T52N, R71W, Section 22**				**T53N, R67W, Section19**				**T55N, R 67W, Section 9**				**T57N, 65W, Section 15**			
Distance from Ross	**Approximately 22 Miles**				**On site**				**Approximately 14 Miles**				**Approximately 29 Miles**			
Surface Elevation	**4,175 ft.**				**4,218 ft.**				**3,886 ft.**				**3,604 ft.**			
Formation	**Top (KB)**	**BGS**	**AMSL**	**Thickness**	**Top (KB)**	**BGS**	**AMSL**	**Thickness**	**Top (KB)**	**BGS**	**AMSL**	**Thickness**	**Top (KB)**	**BGS**	**AMSL**	**Thickness**
Goose Egg	8,250	8,238	-4,063	340	5,954	5,943	-1725	210	1,772	1,762	2,124	220	1,294	1,280	2,324	212
Minnekahta	8,590	8,578	-4,403	20	6,164	6,153	-1935	33	1,992	1,982	1,904	41	1,506	1,492	2,112	28
Opeche	8,610	8,598	-4,423	17	6,197	6,186	-1968	93	2,033	2,023	1,863	39	1,534	1,520	2,084	36
Minnelusa	8,627	8,615	-4,440	861	6,290	6,279	-2061	N/A	2,072	2,062	1,824	678	1,570	1,556	2,048	722
Madison	9,488	9,476	-5,301	524	N/A	N/A	N/A	N/A	2,750	2,740	1,146	753	2,292	2,278	1,326	738
Englewood	10,012	10,000	-5,825	21	N/A	N/A	N/A	N/A	3,503	3,493	393	27	3,030	3,016	588	40
Red River	10,033	10,021	-5,846	318	N/A	N/A	N/A	N/A	3,530	3,520	366	410	3,070	3,056	548	460
Winnipeg Group	10,351	10,339	-6,164	69	N/A	N/A	N/A	N/A	3,940	3,930	-44	107	3,530	3,516	88	162
Icebox Shale	10,380	10,368	-6,193	40	N/A	N/A	N/A	N/A	3,983	3,973	-87	64	3,542	3,528	76	54
Deadwood	10,420	10,408	-6,233	400	N/A	N/A	N/A	N/A	4,047	4,037	-151	N/A	3,692	3,678	-74	404
Flathead	10,820	10,808	-6,633	180	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4,096	4,082	-478	199
Precambrian	11,000	10,988	-6,813	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4,295	4,281	-677	N/A

Note: Top of Precambrian is estimated for Fieldgrove No. 1-A
N/A indicates that formation was not penetrated at well location

Projected Tops for Ross DW Nos. 1- 5			
Based on surface elevation of 4,218 ft AMSL			
Formation	**BGS (ft)**	**AMSL**	**Thickness (ft)**
Goose Egg	5,943	-1,725	210
Minnekahta	6,153	-1,935	33
Opeche	6,186	-1,968	93
Minnelusa	6,279	-2,061	770
Madison	7,049	-2,831	639
Englewood	7,687	-3,469	24
Red River	7,711	-3,493	364
Winnipeg Group	8,075	-3,857	88
Icebox Shale	8,111	-3,893	52
Deadwood	8,163	-3,945	402
Flathead	8,565	-4,347	190
Precambrian	8,755	-4,537	n/a

Notes:
Goose Egg - Minnelusa tops from No. 22-19 Reynolds
Madison - Icebox Shale tops estimated from average formation thickness in Fieldgrove No. A-1 and Little Missouri Federal #1
Deadwood - Precabrian tops estimated from average formation thickness in Fieldgrove No. A-1 and Madison Test Well No. 1
Projected thickness of Winnipeg Group includes that of the Icebox Shale

Table 7
Calculation of COI, ULEW, and AOR
Ross Disposal Wells

Permeability/Hydraulic Conductivity Conversion			
K =	K = Ki (ρ g/mu)		
u =	0.50	cp @ 154 deg. F. BHT	
mu =	0.50 cp * 0.01 gm-sec/cm =	0.005	
Ki (md)	K (ft/day)	Assume kh =	15200 md-ft
95.00	0.524	Source: Page 19, Figure 20	
			Source
Base of Flathead (lowermost injection zone)	8755	feet; bgs	Table 6
Depth to Water in USDW	0	feet; bgs	Estimated
Head in USDW from base of Flathead (W) =	8755	feet; bgs	Calculated
Pressure Grad. of Deadwood/Flathead =	0.42	psi/ft	Estimated
Pressure in Deadwood/Flathead =	3677	psi	Calculated
Head in Deadwood/Flathead (B) =	8492	feet	Calculated
W - B =	263	feet	Calculated
Thickness of Deadwood/Flathead (H) =	160	feet	Table 6
Storage of Deadwood/Flathead (S)=	1.60E-04		Calculated
Average Deadwood/Flathead Porosity (f) =	0.13		Figure 20
Injection Rate =	50	gpm	Estimated
Injection Rate (Q) =	9626	ft^3/day	Calculated
Injection Period (t) =	20	years	Estimated
Injection Period (t) =	7300	days	Calculated
Fluid in Inj. Zone =	20,000	TDS	Table 5
SP Gravity(G) =	1.006		Calculated based on TDS, temp, P
CONE OF INFLUENCE CALCULATION			
Cone of Influence (r) =	$(2.25KHt/S10^{x})^{1/2}$		
Where x =	$(W/G-B) * (4*\pi*KH/2.3Q)$		
x =	10.017		
r =	1 foot		
ULTIMATE LIMIT OF EMPLACED WASTE			
R = radius of volumetric fillup (feet)			
R =	$(Qt/\phi H\pi)^{1/2}$		
R =	1037 feet		
MINIMUM AREA OF REVIEW			
Cone of Influence =	1 foot		
Radius of Volumetric Fillup (ULEW) =	1037 feet		
Minimum Radius (1/4 mile) =	**1320 feet**		

Table 8
WOGCC Water Quality Data-Flathead Formation

Field	Basin	Section	Township	Range	Distance from Ross (mi)	API	Well Name	Sampled Formation	Sample Date	TDS (Mg/L)
Lost Soldier	Great Divide	3	26N	90W	~200	4903720170	19 Unit Patented	Flathead	7/30/1971	10,970
Oregon Basin	Big Horn	32	51N	100W	~186	4902920318	27 Samuel	Flathead	9/17/1992	19,700
Oregon Basin	Big Horn	5	51N	100W	~186	4902920658	13 Govt Tract 3B	Flathead	1/8/1996	11,100

Source: WOGCC Water Analysis Database, May 2010

Table 9
USGS Water Quality Data-Madison, Deadwood, and Flathead Formations

Madison Formation (Regional)*												
County	**Geologic Basin**	**Section**	**Township**	**Range**	**API**	**Well Name**	**Sampled Formation**	**Upper Depth (ft)**	**Lower Depth (ft)**	**Sample Method**	**Sample Date**	**TDS (Mg/L)**
CROOK	POWDER RIVER BASIN	5	N 49	W 68	4901105352	GOVERNMENT BURROWS B-19	MADISON			UNKNOWN		4,300
CROOK	POWDER RIVER BASIN	6	N 50	W 67	4901105639	2 DAVIS-SCHURICHT	MADISON	7,192	7,267	DST		2,972
CROOK	POWDER RIVER BASIN	14	N 56	W 61	4901106127	GOVERNMENT-MILLER NO. 1	MADISON	2,602	2,651	DST		1,223
CAMPBELL	POWDER RIVER BASIN	2	N 52	W 72	4900505888	UNIT 1	MADISON	9,865	9,945	DST		3,070
CAMPBELL	POWDER RIVER BASIN	14	N 53	W 72	4900505919	UNIT 4	MADISON	9,664	9,714	DST		1,703
Flathead Formation (State-wide)												
County	**Geologic Basin**	**Section**	**Township**	**Range**	**API**	**Well Name**	**Sampled Formation**	**Upper Depth (ft)**	**Lower Depth (ft)**	**Sample Method**	**Sample Date**	**TDS (Mg/L)**
FREMONT	WIND RIVER BASIN	10	N 33	W 96	4901305664	68 UNIT	FLATHEAD	13,070	13,193	DST	3/1/65	2,593
HOT SPRINGS	BIG HORN BASIN	28	N 43	W 93		GOVERNMENT - PARKER W-1	FLATHEAD	2,388	2,661	DST	10/30/64	2,800
HOT SPRINGS	BIG HORN BASIN	28	N 43	W 93		GOVERNMENT PARKER W-1	FLATHEAD	2,408	2,544	DST	11/2/64	2,729
HOT SPRINGS	BIG HORN BASIN	12	N 43	W 96	4901705366	CARTER - GOVERNMENT 1	FLATHEAD	2,370	2,520	BAILER		3,294
HOT SPRINGS	BIG HORN BASIN	23	N 44	W 95	4901720159	UNIT 65	FLATHEAD	7,229	7,279	DST	10/3/74	3,624
HOT SPRINGS	BIG HORN BASIN	14	N 44	W 98	4901705808	GOVERNMENT 51	FLATHEAD	4,735		DST		3,576
HOT SPRINGS	BIG HORN BASIN	19	N 46	W 98	4901706311	PRE-TENSLEEP UNIT NO. 2	FLATHEAD	6,366	6,552	SWAB	9/27/58	4,165
HOT SPRINGS	BIG HORN BASIN	19	N 46	W 98	4901706311	PRE-TP UNIT 2	FLATHEAD	6,366	6,552	SWAB		4,149
PARK	BIG HORN BASIN	32	N 51	W 100	4902905471	SAMUEL NO. 22	FLATHEAD	6,194	6,259	DST	4/9/57	3,951
PARK	BIG HORN BASIN	32	N 51	W 100	4902905471	SAMUEL NO. 22	FLATHEAD	6,174	6,190	DST	3/20/57	3,432
PARK	BIG HORN BASIN	32	N 51	W 100	4902905471	SAMUEL NO. 22	FLATHEAD	6,159	6,174	DST	3/20/57	4,019
PARK	BIG HORN BASIN	32	N 51	W 100	4902905471	SAMUEL 22	FLATHEAD	6,159	6,174	DST		4,003
PARK	BIG HORN BASIN	29	N 51	W 100	4902905502	5	FLATHEAD	6,341	6,346	WELLHEAD	12/10/45	4,159
PARK	BIG HORN BASIN	29	N 51	W 100		CONNAGHON 5	FLATHEAD	6,341	6,346	PRODUCTION		4,137
PARK	BIG HORN BASIN	32	N 52	W 100	4902905750	CUSTER NO. 17	FLATHEAD	6,035	6,100	DST	7/31/67	13,253
PARK	BIG HORN BASIN	32	N 52	W 100	4902905750	CUSTER NO. 17	FLATHEAD	6,035	6,100	DST	7/31/67	12,889
PARK	BIG HORN BASIN	5	N 52	W 100		SIDNEY NO 10	FLATHEAD	5,858	5,953	PRODUCTION	3/15/73	4,421
SWEETWATER	GREEN RIVER BASIN	11	N 26	W 90	4903720213	TR-13-T-127	FLATHEAD	5,831	5,998	PRODUCTION	8/9/71	15,140
SWEETWATER	GREEN RIVER BASIN	3	N 26	W 90		CAMBRIAN FREE WATER KNOCK OUT	FLATHEAD			PRODUCTION	8/9/71	12,461
SWEETWATER	GREEN RIVER BASIN	3	N 26	W 90		TR-13-C-111	FLATHEAD	5,215	6,099	PRODUCTION	8/9/71	17,657
SWEETWATER	GREEN RIVER BASIN	3	N 26	W 90		TR-9-C-9	FLATHEAD	6,052	6,752	PRODUCTION	8/9/71	13,232
SWEETWATER	GREEN RIVER BASIN	3	N 26	W 90		TR-9-C-6	FLATHEAD	6,409	6,482	PRODUCTION	8/9/71	11,730
Deadwood Formation (State-wide)												
County	**Geologic Basin**	**Section**	**Township**	**Range**	**API**	**Well Name**	**Sampled Formation**	**Upper Depth (ft)**	**Lower Depth (ft)**	**Sample Method**	**Sample Date**	**TDS (Mg/L)**
NATRONA	WIND RIVER BASIN	35	N 40	W 79		29	DEADWOOD	5,165	5,170	OPEN HOLE	8/11/30	2,509
NATRONA	WIND RIVER BASIN	35	N 40	W 79		29	DEADWOOD-GRANITE	5,165	5,420	WELLHEAD	8/25/30	2,705

*Madison data provided from Crook, Campbell, and Weston Counties only
Source: USGS Produced Waters Database, April 2010

Table 10
Example of Injectate from Typical ISR Project

Table 2.7-3. Estimated Flow Rates and Constituents in Liquid Waste Streams for the Highland *In-Situ* Leach Facility*

	Water Softener Brine	**Resin Rinse**	**Elution Bleed**	**Yellowcake Wash Water**	**Restoration Wastes**
Flow Rate, gal/min	1	<3	3	7	450
As, ppm					0.1–0.3
Ca, ppm	3,000–5,000				
Cl, ppm	15,000–20,000	10,000–15,000	12,000–15,000	4,000–6,000	
CO_3, ppm		500–800			300–600
HCO_3, ppm		600–900			400–700
Mg, ppm	1,000–2,000				
Na, ppm	10,000–15,000	6,000–11,000	6,000–8,000	3,000–4,000	380–720
NH_4, ppm			640–180		
Se, ppm					0.05–0.15
Ra-226, pCi/L	<5	100–200	100–300	20–50	50–100
SO_4, ppm					100–200
Th-230, pCi/L	<5	50–100	10–30	10–20	50–150
U, ppm	<1	1–3	5–10	3–5	<1
Gross Alpha, pCi/L					2,000–3,000
Gross Beta, pCi/L					2,500–3,500

*NRC. NUREG–0489, "Final Environmental Statement Related to Operation of Highland Uranium Solution Mining Project, Exxon Minerals Company, USA." Washington, DC: NRC. November 1978.

Source: Table reproduced from NUREG-0489

Table 10a
Example of Injectate from Crow Butte Resources

Historical Water Quality - Class I Injection Well
Crow Butte Resources DW # 1
PERMIT NE0206369 - Class I

		2002 to 2004 (2-year composite)		
ELEMENT	**UNITS**	**AVERAGE**	**MAXIMUM**	**MINIMUM**
Na	mg/l	4,766	10,236	1,568
Ca	mg/l	91	108	69
SO4	mg/l	1,388	2,200	1,052
Cl	mg/l	6,522	24,085	732
V	mg/l	33	69	3
Alkalinity	mg/l	1,242	1,650	850
pH	Std. Units	8.46	8.88	8.14
As	mg/l	0.1	0.14	< 0.10
Ba	mg/l	0.1	0.1	< 0.10
Cd	mg/l	< 0.10	< 0.10	< 0.10
Cr	mg/l	< 0.50	< 0.50	< 0.50
Pb	mg/l	< 0.50	< 0.50	< 0.50
Hg	mg/l	0.0001	0.0004	< 0.0001
Se	mg/l	0.1	0.13	< 0.10
Ag	mg/l	< 0.50	< 0.50	<0.01
U-nat	mg/l	13	25	5
Ra 226	pCi/l	951	1,370	419

Source: *Crow Butte Resources DW No. 1 Permit Rewal Application; Crow Butte Resources, 2004*

Table 10b
Example of Injectate from COGEMA Mining

Well	Month	Year	Total Volume for Month (bbls)	TDS (mg/l)	Alkalinity (mg/l)	Natural Uranium (mg/l)	Radium 226 (piC/l)	pH (units)
18-3	Mar	2000	22,602	4,060	2,140	9.51	243	8.1
18-3	May	2000	75,138	4,490	2,040	709.00	516	6.9
18-3	Aug	2000	83,738	6,700	2,180	1.55	700	7.5
18-3	Oct	2000	71,753	6,480	2,110	2.83	702	7.2
18-3	Jul	2001	62,450	10,300	3,160	4.60	1020	7.6
18-3	Oct	2001	68,594	7,670	2,000	2.20	585	7.2
18-3	Jan	2002	67,405	8,200	2,300	1.08	579	7.5
18-3	Apr	2002	65,957	7,540	1,520	3.82	534	7.3
18-3	July	2002	70,141	8,040	1,700	2.10	646	7.6
18-3	October	2002	75,230	5,830	1,730	1.57	831	7.4
18-3	January	2003	72,977	8,590	2,100	2.55	696	7.5
18-3	April	2003	67,394	7,280	1,540	1.68	826	6.8
18-3	July	2003	66,343	5,620	1,120	0.37	836	7.4
18-3	November	2003	70,246	5,620	1,120	0.37	836	7.4
18-3	February	2004	70,048	8,580	1,640	1.07	289	7.2
18-3	April	2004	70,507	10,100	2,590	0.48	323	7.3
18-3	July	2004	71,280	9,880	2,020	0.91	1180	7.6
18-3	November	2004	72,211	20,200	1,590	7.60	431	7.5
18-3	February	2005	52,939	17,100	1,400	13.50	495	7.5
18-3	April	2005	46,998	5,920	577	0.36	339	6.7
DW No. 1	January	2000	85,765	4,000	2,130	5.49	136	8.3
DW No. 1	May	2000	86,200	4,480	2,050	0.77	547	7.8
DW No. 1	August	2000	69,053	6,640	2,180	1.36	704	7.6
DW No. 1	October	2000	76,211	6,510	2,150	2.65	816	7.1
DW No. 1	May	2001	85,620	11,400	3,520	5.19	989	7.7
DW No. 1	July	2001	86,348	10,300	3,170	4.46	1670	7.5
DW No. 1	October	2001	80,968	7,720	1,980	2.60	560	7.2
DW No. 1	January	2002	90,852	8,220	2,290	3.70	567	7.4
DW No. 1	April	2002	79,443	9,170	1,870	3.80	541	8.0
DW No. 1	July	2002	78,642	8,070	1,730	2.26	504	7.7
DW No. 1	October	2002	78,597	7,640	1,680	1.72	788	7.7
DW No. 1	January	2003	80,595	8,610	2,070	2.51	695	7.6
DW No. 1	April	2003	73,873	7,310	1,540	1.62	818	6.8
DW No. 1	July	2003	74,920	5,550	1,050	0.33	872	9.1
DW No. 1	November	2003	66,293	5,550	1,050	0.33	872	9.1
DW No. 1	February	2004	73,392	8,580	1,640	1.08	433	7.2
DW No. 1	April	2004	71,580	10,100	2,530	0.47	780	7.4
DW No. 1	July	2004	73,513	9,800	1,990	0.86	905	7.6
DW No. 1	November	2004	34,751	19,300	1,590	7.28	468	7.4
DW No. 1	February	2005	30,112	17,000	1,390	14.30	416	7.3
DW No. 1	April	2005	46,998	5,920	577	0.36	339	6.7

Source: WDEQ GEMS website (https://gem.trihydro.com/Registration.aspx): COGEMA Quartely Data

Table 11
List of Proposed Logs for Ross Dispoal Wells

Description	Approx. Depth Run at Ross DW Nos. 1-5 (ft, BGS)
Dual Induction Laterolog, Gamma Ray, BHC Sonic, Formation Density, and Caliper Logs (openhole before production casing)	0 - 900
Cement Bond Log (Surface casing)	0 - 900
Dual Indution Laterolog, SP, Gamma Ray, BHC Sonic, Formation Density, Compensated Neutron, and Caliper Log (openhole before production casing)	900 - 8,755
Cement Bond Log and Casing Inspection Log (production casing)	0 - 8,755
Temperature Log	surf - TD
Radioactive Tracer Log* (RAT)	Production Casing
Pressure/Temperature Gradient and Pressure Transient Falloff test	Injection Intervals

Note: all depths are estimated based on area type logs
* RAT run in and approximately 500' above injection zone

Table 12
Fracture Gradient Data - Deadwood and Flathead Formations

Location	Basin/Region	Formation	Depth (ft)	Fracture Pressure (psi)	*Fracture Gradient (psi/ft)
T43N, R93W	Big Horn Basin	Flathead	2,525	1,717	0.68
T26N, R89-90W	Red Desert Basin	Flathead	7,743	5,265	0.68
T50-51-52N, R100W	W. FlankBighorn Basin	Flathead	5,906	4,016	0.68
T39-40N, R78-79W	E. Flank Casper Arch	Deadwood	5,293	3,599	0.68
T39-40N, R78-79W	E. Flank Casper Arch	Deadwood	5,168	3,514	0.68

*Calculated from available data
Source: University of Wyoming EOR Database

Table 13
Calculation of Limiting Surface Injection Pressure, Base of Injection Interval,
Ross Disposal Wells

Fracture Pressure

P = F x D

P = fracture pressure at the bottom of the receiver (psi)
F = Fracture gradient (psi/ft)
D = Depth to the bottom of the receiver (8,755 feet bgs)

Hydrostatic Head

h = G x D x 0.433 psi/ft

h = hydrostatic head at the bottom of the receiver (psi)
G = specific gravity of the injection fluid
D = Depth to the bottom of the receiver (feet; bgs)

Limiting Surface Injection Pressure

L = (P - h + T + Lp) x 0.90

L = limiting surface injection pressure (psi)
P = fracture pressure at the bottom of the receiver (psi)
h = hydrostatic head at the bottom of the receiver (feet)
T = tubing pressure loss (psi)
Lp = perforation pressure loss (psi)

Assume:
Lp = 0
Injection Rate = 75 gpm
Tubing length = 8,093 feet
From charts, friction loss is 20 psi/1000 feet (bare 2 7/8" tubing at 75 gpm)

	F	D	P	G	h	T	L
Well	(psi/ft)	(ft)	(psi)		(psi)	(psi)	(psi)
Ross DW Nos. 1-5	0.68	8,755	5,953	1.036	3,927	162	**1,969**

Table 14
Calculation of Limiting Surface Injection Pressure, Top of Injection Interval
Ross Disposal Wells

Fracture Pressure

P = F x D

P = fracture pressure at the top of the receiver (psi)
F = Fracture gradient (psi/ft)
D = Depth to the top of the receiver (8,163 feet bgs)

Hydrostatic Head

h = G x D x 0.433 psi/ft

h = hydrostatic head at the top of the receiver (psi)
G = specific gravity of the injection fluid
D = Depth to the top of the receiver (feet; bgs)

Limiting Surface Injection Pressure

L = (P - h + T + Lp) x 0.90

L = limiting surface injection pressure (psi)
P = fracture pressure at the top of the receiver (psi)
h = hydrostatic head at the top of the receiver (feet)
T = tubing pressure loss (psi)
Lp = perforation pressure loss (psi)

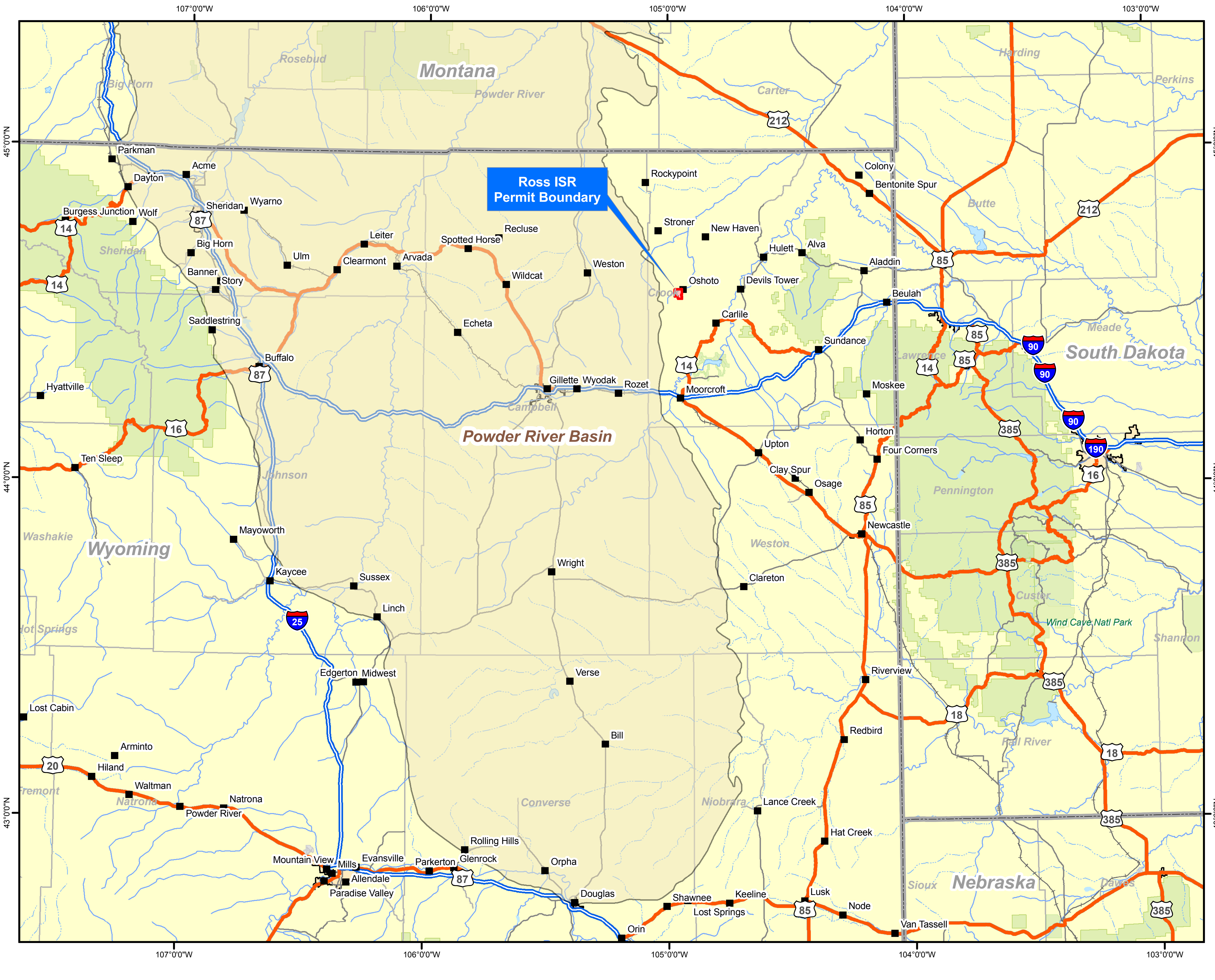
Assume: Lp = 0
Injection Rate = 75 gpm
Tubing length = 8,093 feet
From charts, friction loss is 20 psi/1000 feet (bare 2 7/8" tubing at 75 gpm)

	F	D	P	G	h	T	L
Well	(psi/ft)	(ft)	(psi)		(psi)	(psi)	(psi)
RossDW Nos. 1-5	0.68	8,163	5,551	1.036	3,662	162	**1,846**

Table 15
Estimated Plugging and Abandonment Cost-Deadwood/Flathead Class I Well

Approximate Well Depth = 8,755' bgs **FIELD OPERATIONS**	**Unit Cost**	**Units Req'd.**	**Total Cost**
Subcontractors - Direct bill to Strata			
Mob/demob & Location Preparation	$6,000	1	$6,000
Workover Rig and Associated Equipment (days)	$5,000	4	$20,000
Rental Tools (days)	$2,500	4	$10,000
Rental Tubing Inspection	$10,000	1	$10,000
Falloff Test	$6,500	1	$6,500
RAT Log	$4,500	1	$4,500
Trucking	$6,000	1	$6,000
Contract Labor	$2,000	2	$4,000
Cement (746 sx), pumping & equipment	$14,920	1	$14,920
Contingency	$8,000	1	$8,000
Total Estimated Subcontractor Charges			$89,920
Test Design and Project Management (hours)	$115	24	$2,760
Supervision (days)	$850	5	$4,250
Travel (hours)	$115	8	$920
Field Truck and Fuel (days)	$150	6	$900
Per Diem (days)	$100	6	$600
Data Analysis (lump sum)	$2,000	1	$2,000
Report Preparation (hours)	$115	24	$2,760
Total Estimated Petrotek Charges			$14,190
TOTAL ESTIMATED COST PER WELL			**$104,110**
TOTAL ESTIMATED COST FOR 5 WELLS			**$520,550**

Assumptions:
Subcontractors will bill Strata directly - otherwise a 12.5% markup will apply.
Field activities can be completed in 5 days for each well; otherwise T&M rates will apply.
Falloff test is required if > 6 months since last test; RAT log required if > 2 years since last log.
The well is cemented from bottom to top in 3-4 stages.
Strata will be responsible for disposal of all well equipment.



Legend

Ross ISR Permit Boundary

Miles

0 10 20 30 40

N

STRATA ENERGY

Figure 1
Ross ISR Site Location Map
2010 Ross ISR Class I Permit Application

Scale: 1:1,250,000	Date: May 2010	
2010_Ross_CIPA_Fig_01.mxd	By: JLM	Checked: HD

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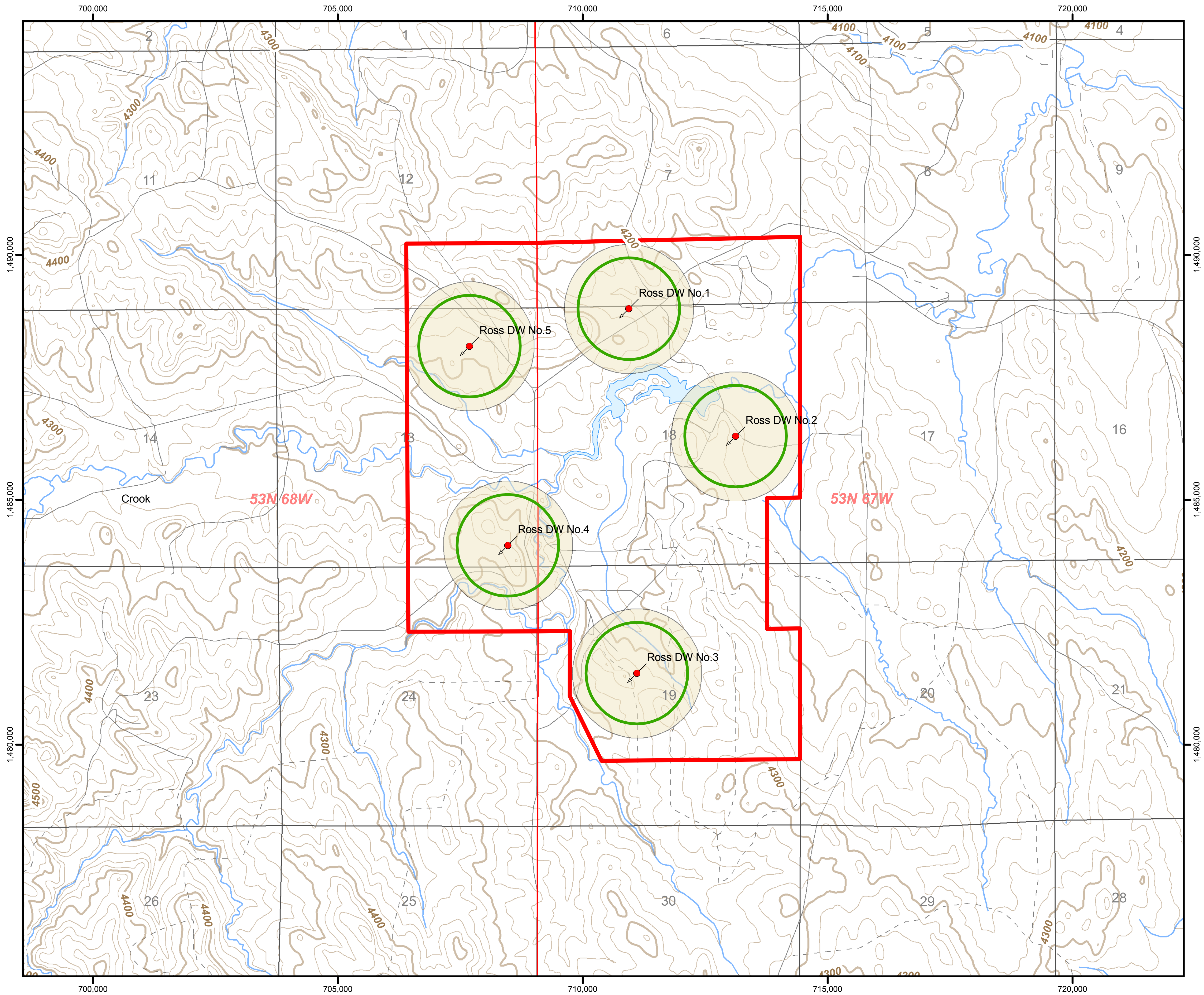

Legend

- Proposed Ross DWs
- Proposed Ross DWs 1037ft ULEW
- Ross ISR Permit Boundary
- Proposed Ross DWs 1320ft AOR

Projection: Wyoming State Plane East, NAD 83, (feet)

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Figure 2
Site Topographic Map

2010 Ross ISR Class I Permit Application

Scale: 1:24,000	Date: May 2010	
2010_Ross_CIPA_Fig_02.mxd	By: JLM	Checked: HD

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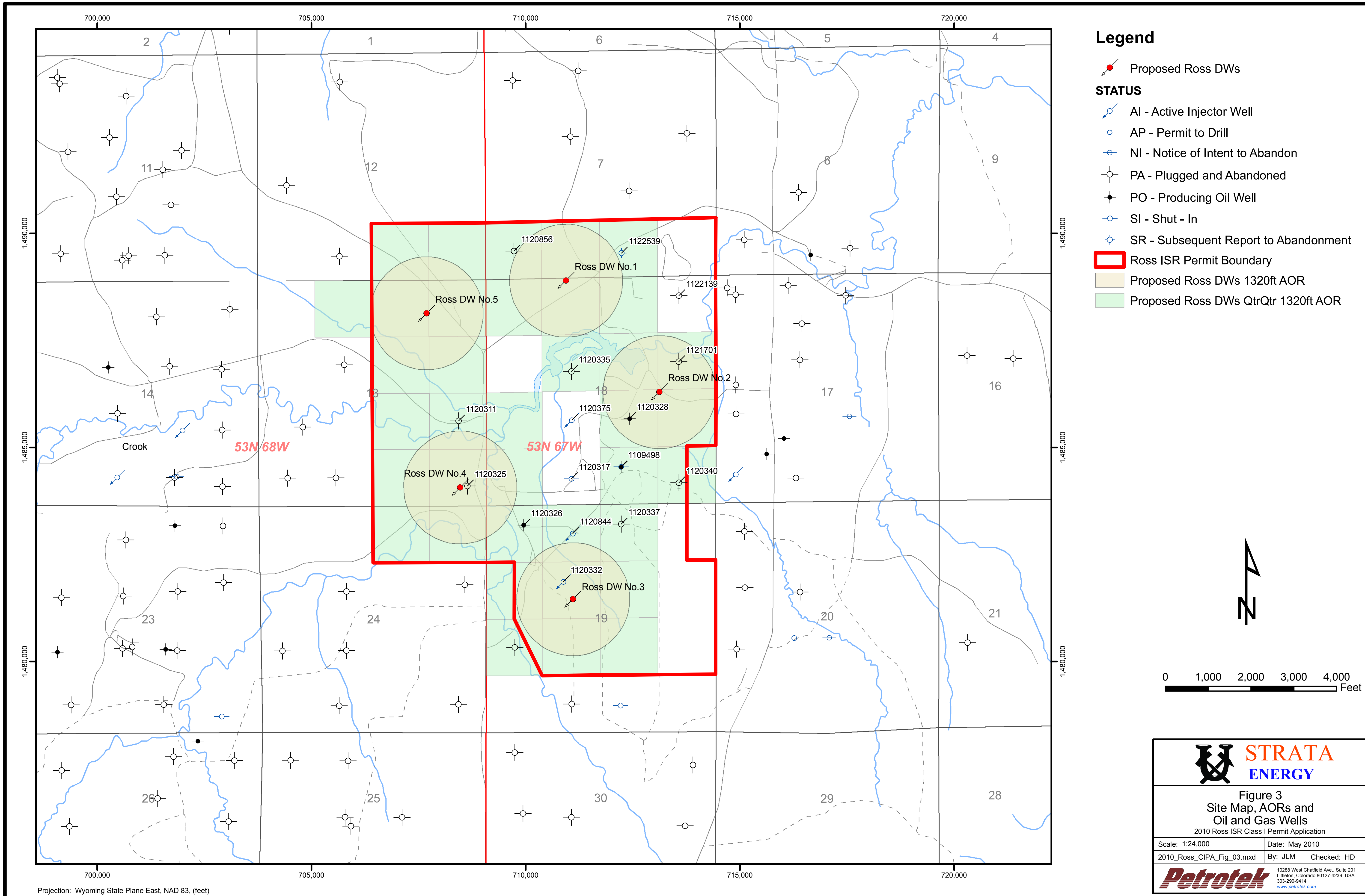
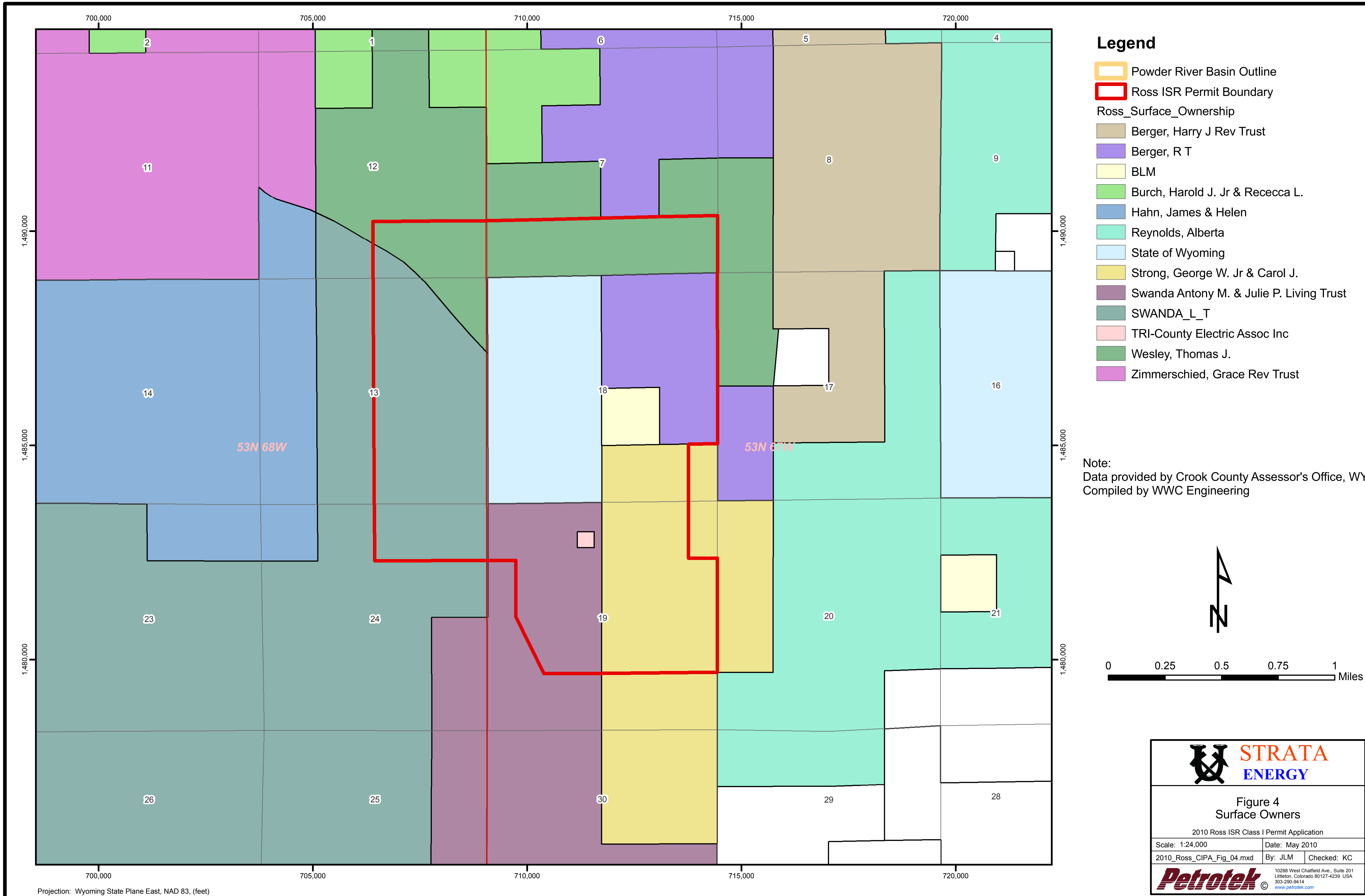
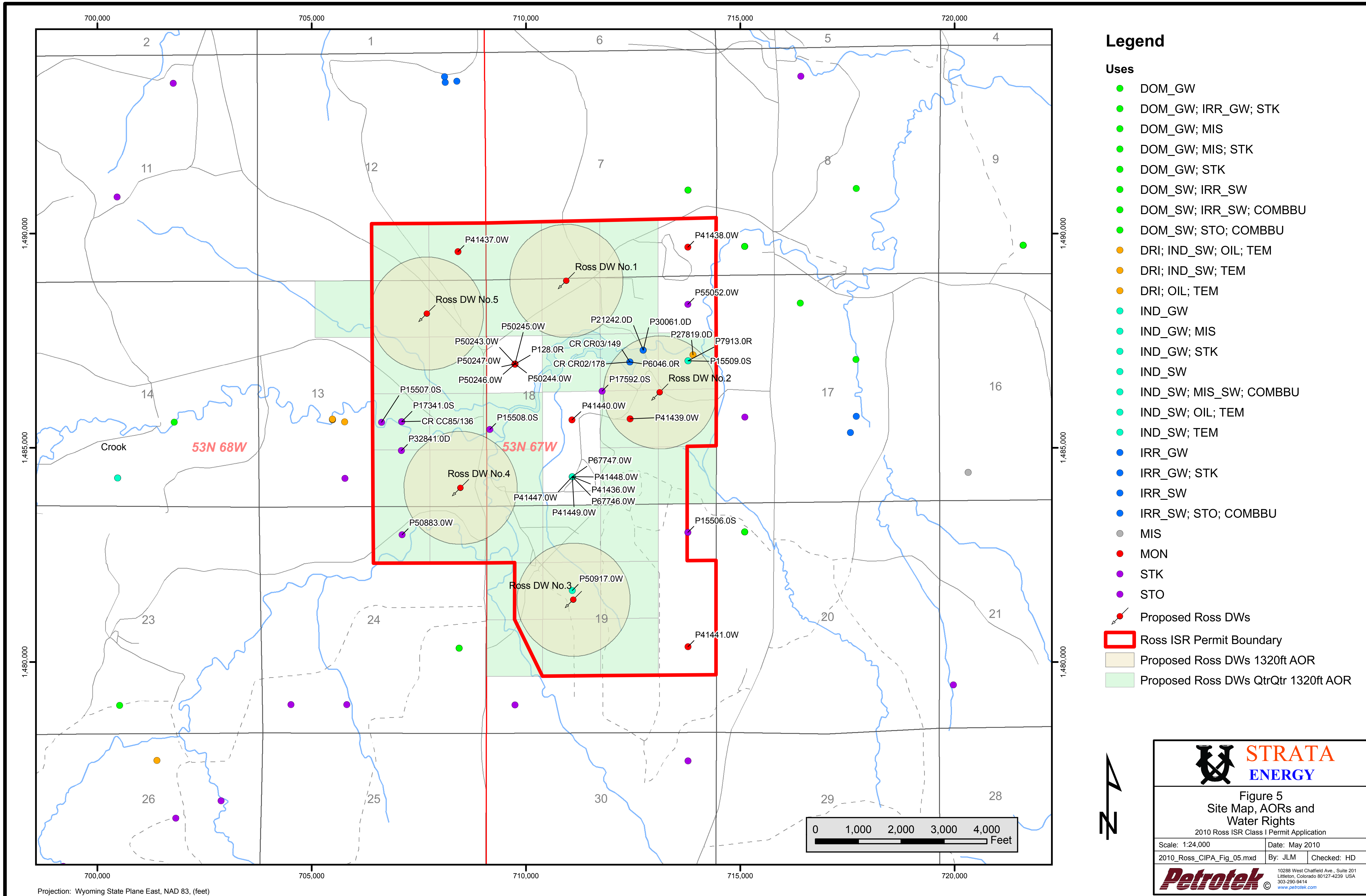


Figure 3
Site Map, AORs and Oil and Gas Wells
2010 Ross ISR Class I Permit Application


Legend
Powder River Basin Outline
Ross ISR Permit Boundary
Ross_Surface_Ownership
Berger, Harry J Rev Trust
Berger, R T
BLM
Burch, Harold J. Jr & Rececca L.
Hahn, James & Helen
Reynolds, Alberta
State of Wyoming
Strong, George W. Jr & Carol J.
Swanda Antony M. & Julie P. Living Trust
SWANDA_L_T
TRI-County Electric Assoc Inc
Wesley, Thomas J.
Zimmerschied, Grace Rev Trust
Note:
Data provided by Crook County Assessor's Office, WY
Compiled by WWC Engineering
53N 68W
53N 67W
0 0.25 0.5 0.75 1 Miles
N
STRATA ENERGY
Figure 4
Surface Owners
2010 Ross ISR Class I Permit Application
Scale: 1:24,000
Date: May 2010
2010_Ross_CIPA_Fig_04.mxd
By: JLM
Checked: KC
Petrotek
Projection: Wyoming State Plane East, NAD 83, (feet)


Legend
Uses
DOM_GW
DOM_GW; IRR_GW; STK
DOM_GW; MIS
DOM_GW; MIS; STK
DOM_GW; STK
DOM_SW; IRR_SW
DOM_SW; IRR_SW; COMBBU
DOM_SW; STO; COMBBU
DRI; IND_SW; OIL; TEM
DRI; IND_SW; TEM
DRI; OIL; TEM
IND_GW
IND_GW; MIS
IND_GW; STK
IND_SW
IND_SW; MIS_SW; COMBBU
IND_SW; OIL; TEM
IND_SW; TEM
IRR_GW
IRR_GW; STK
IRR_SW
IRR_SW; STO; COMBBU
MIS
MON
STK
STO
Proposed Ross DWs
Ross ISR Permit Boundary
Proposed Ross DWs 1320ft AOR
Proposed Ross DWs QtrQtr 1320ft AOR
STRATA ENERGY
Figure 5
Site Map, AORs and Water Rights
2010 Ross ISR Class I Permit Application
Scale: 1:24,000
Date: May 2010
2010_Ross_CIPA_Fig_05.mxd
By: JLM
Checked: HD
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0 1,000 2,000 3,000 4,000 Feet
N
Projection: Wyoming State Plane East, NAD 83, (feet)
700,000
705,000
710,000
715,000
720,000
1,490,000
1,485,000
1,480,000
53N 68W
53N 67W
Crook
Ross DW No.1
Ross DW No.2
Ross DW No.3
Ross DW No.4
Ross DW No.5
P41437.0W
P41438.0W
P55052.0W
P50245.0W
P50243.0W
P50247.0W
P50246.0W
P50244.0W
P128.0R
P21242.0D
P30061.0D
P27819.0D
P7913.0R
P15509.0S
CR CR03/149
CR CR02/178
P6046.0R
P17592.0S
P15507.0S
P17341.0S
CR CC85/136
P15508.0S
P41440.0W
P41439.0W
P32841.0D
P67747.0W
P41448.0W
P41436.0W
P67746.0W
P41447.0W
P41449.0W
P50883.0W
P15506.0S
P50917.0W
P41441.0W

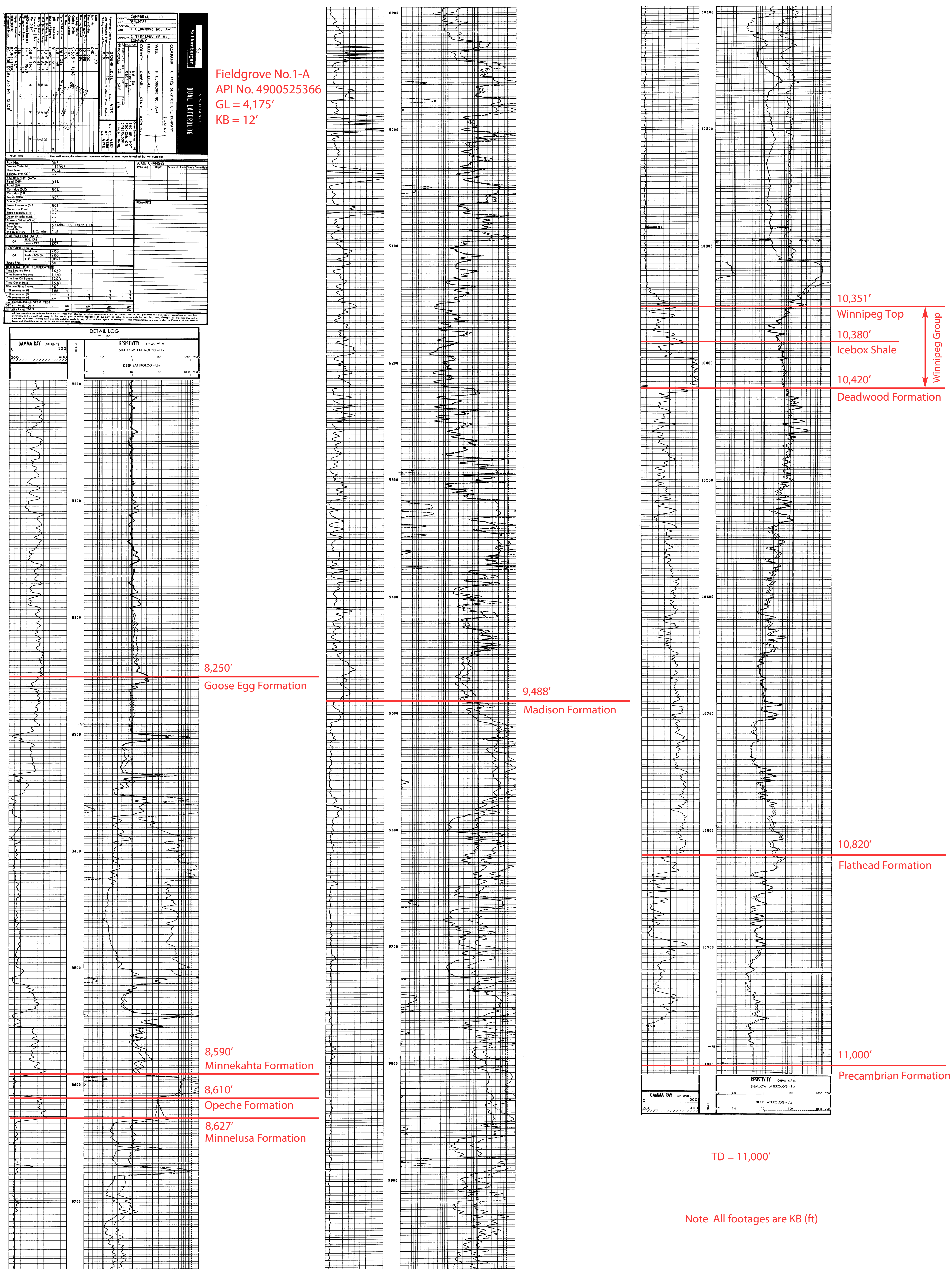

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Figure 6
West Type Log

2010 Ross ISR Class I Permit Application

Scale: NTS	Date: May 2010
2010_Ross_CIPA_Fig_06.ai	By: JLM / Checked: HD

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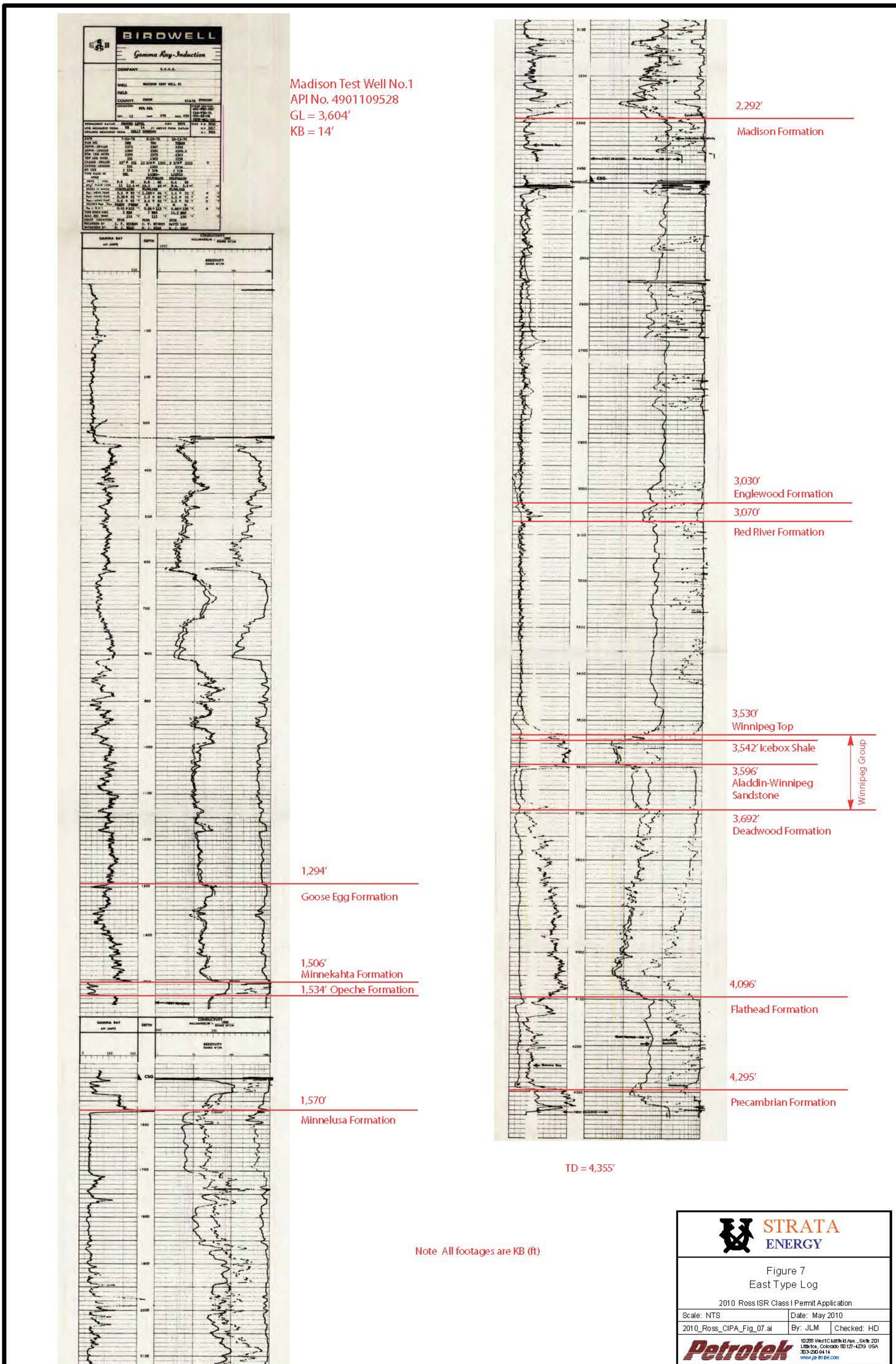
Madison Test Well No.1
API No. 4901109528
GL = 3,604'
KB = 14'
1,294'
Goose Egg Formation
1,506'
Minnekahta Formation
1,534' Opeche Formation
1,570'
Minnelusa Formation
2,292'
Madison Formation
3,030'
Englewood Formation
3,070'
Red River Formation
3,530'
Winnipeg Top
3,542' Icebox Shale
3,596'
Aladdin-Winnipeg
Sandstone
3,692'
Deadwood Formation
Winnipeg Group
4,096'
Flathead Formation
4,295'
Precambrian Formation
TD = 4,355'
Note All footages are KB (ft)
STRATA
ENERGY
Figure 7
East Type Log
2010 Ross ISR Class I Permit Application
Scale: NTS
Date: May 2010
2010_Ross_CIPA_Fig_07.ai
By: JLM
Checked: HD
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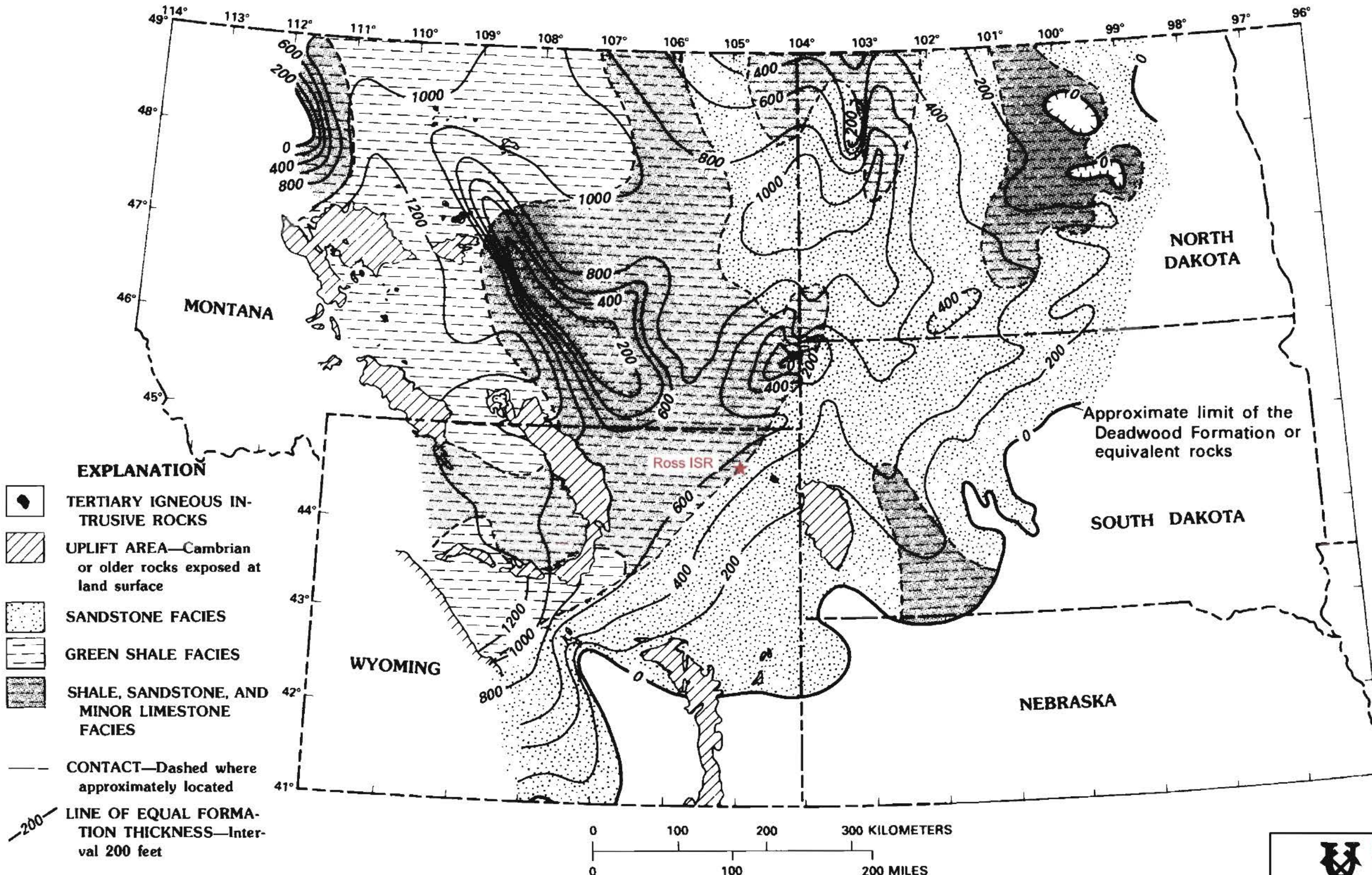

From:
Geological Survey Professional Paper 1273-A
Peterson, 1984

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Figure 8
Isopach Map of the Deadwood Formation

2010 Ross ISR Class I Permit Application

Scale: See Bar Scale	Date: May 2010
2010_Ross_CIPA_Fig_08.ai	By: JLM / Checked: HD

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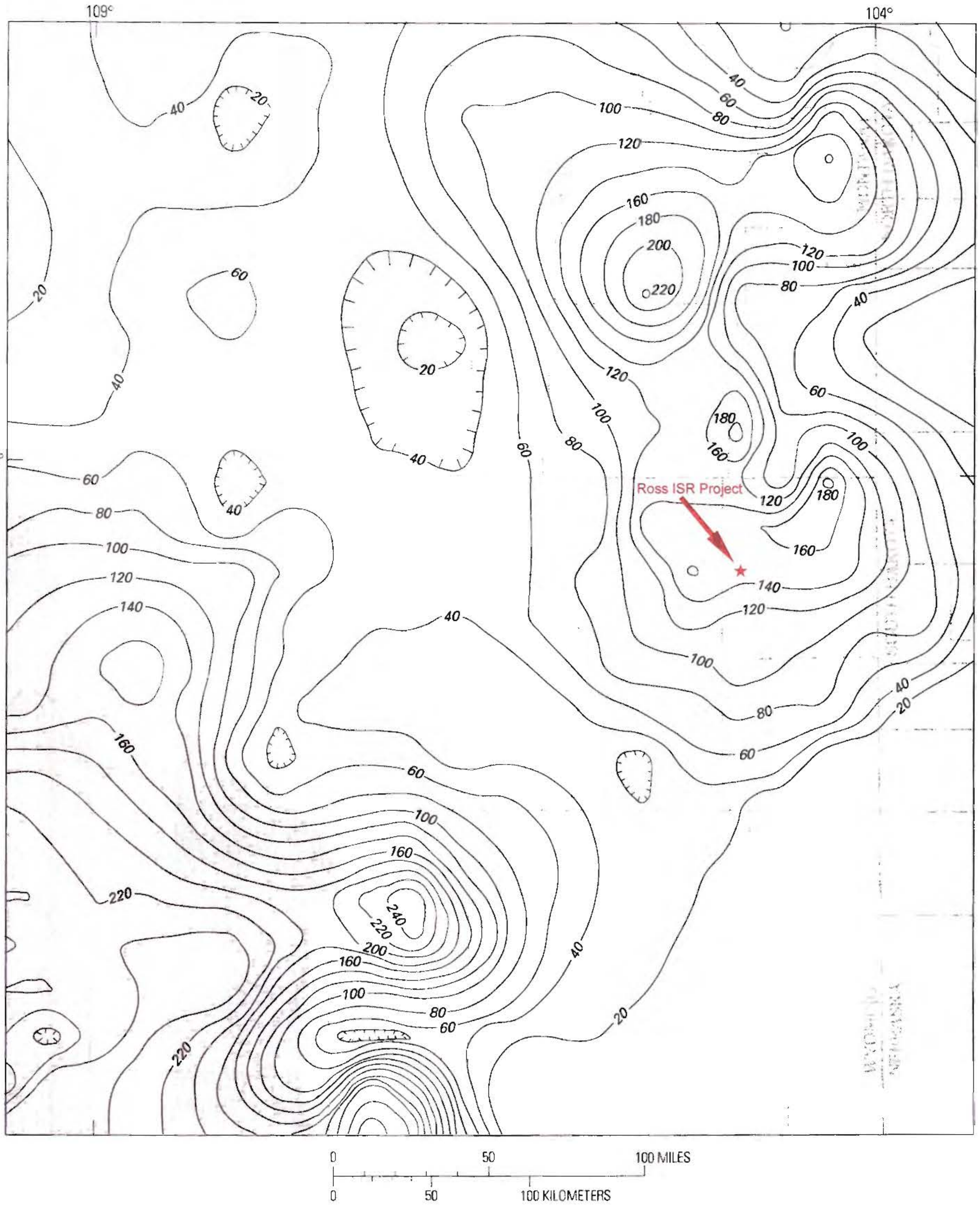

From:
USGS Bulleten 1917
by:
D. Macke, 1993

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Figure 9
Isopach Map of the Flathead Formation

2010 Ross ISR Class I Permit Application

Scale: See Bar Scale	Date: May 2010
2010_Ross_CIPA_Fig_09.ai	By: JLM Checked: HD

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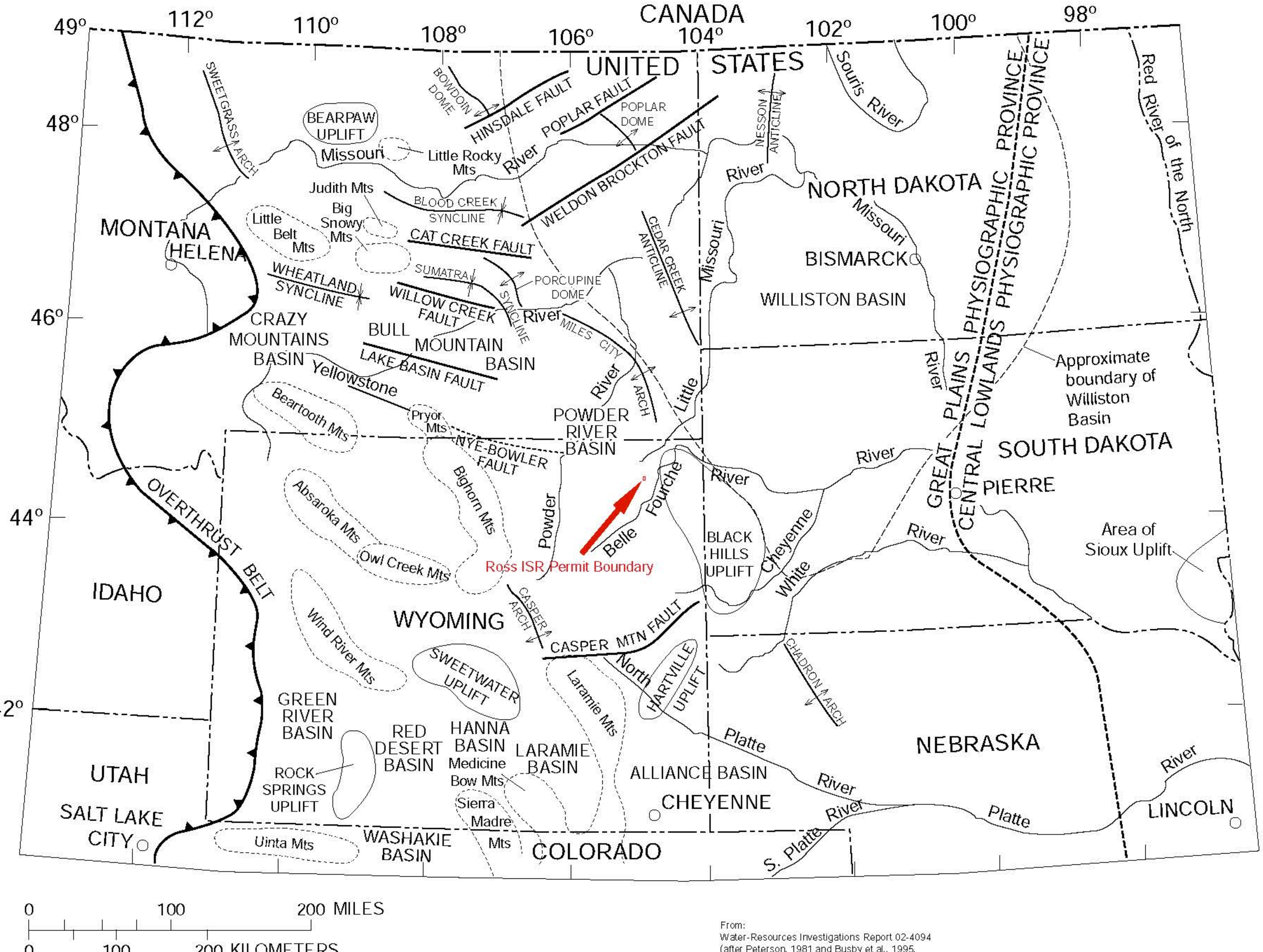

From:
Water-Resources Investigations Report 02-4094
(after Peterson, 1981 and Busby et al., 1995,
modified by Driscoll et al., 2002)

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Figure 10
Present-day Structure and Physiographic Features in the Northern Great Plains Area

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Scale: See Bar Scale	Date: May 2010	
2010_Ross_CIPA_Fig_10.ai	By: JLM	Checked: HD

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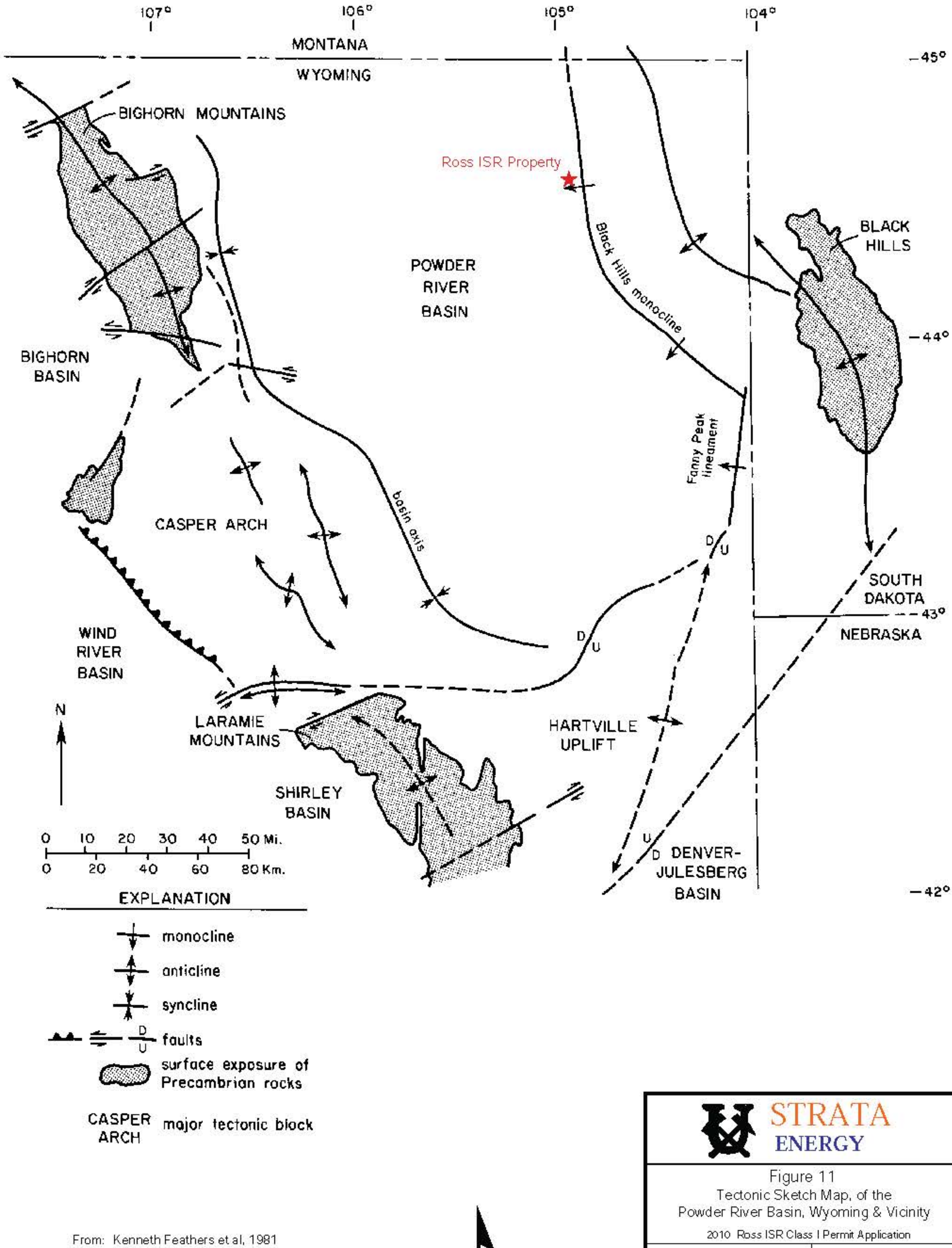

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Figure 11
Tectonic Sketch Map, of the
Powder River Basin, Wyoming & Vicinity

2010 Ross ISR Class I Permit Application

Scale: See Bar Scale	Date: May 2010
2010_Ross_CIPA_Fig_11.ai	By: JLM Checked: HD

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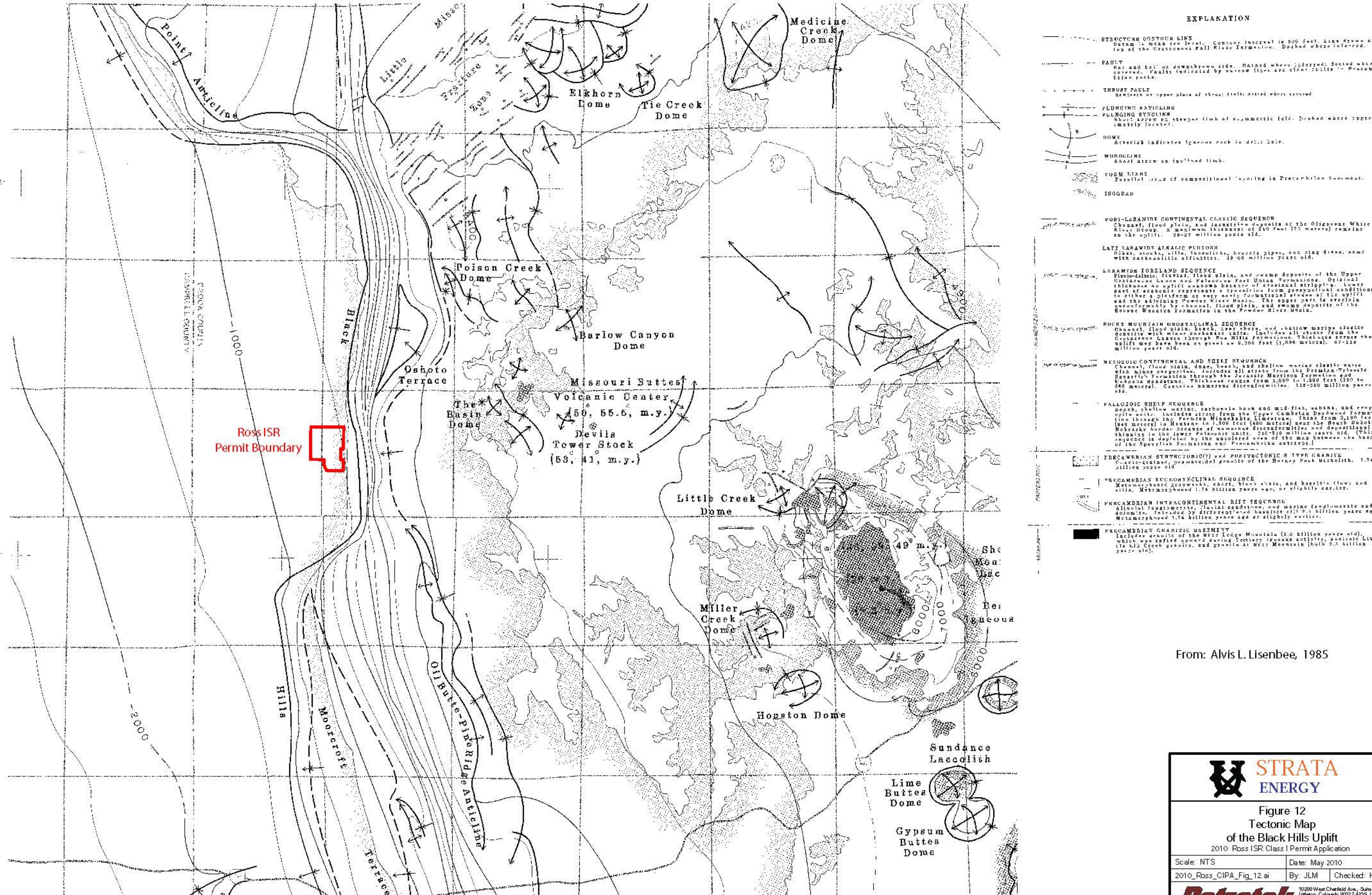

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Figure 12
Tectonic Map
of the Black Hills Uplift
2010 Ross ISR Class I Permit Application

Scale: NTS	Date: May 2010
2010_Ross_CIPA_Fig_12.ai	By: JLM / Checked: HD

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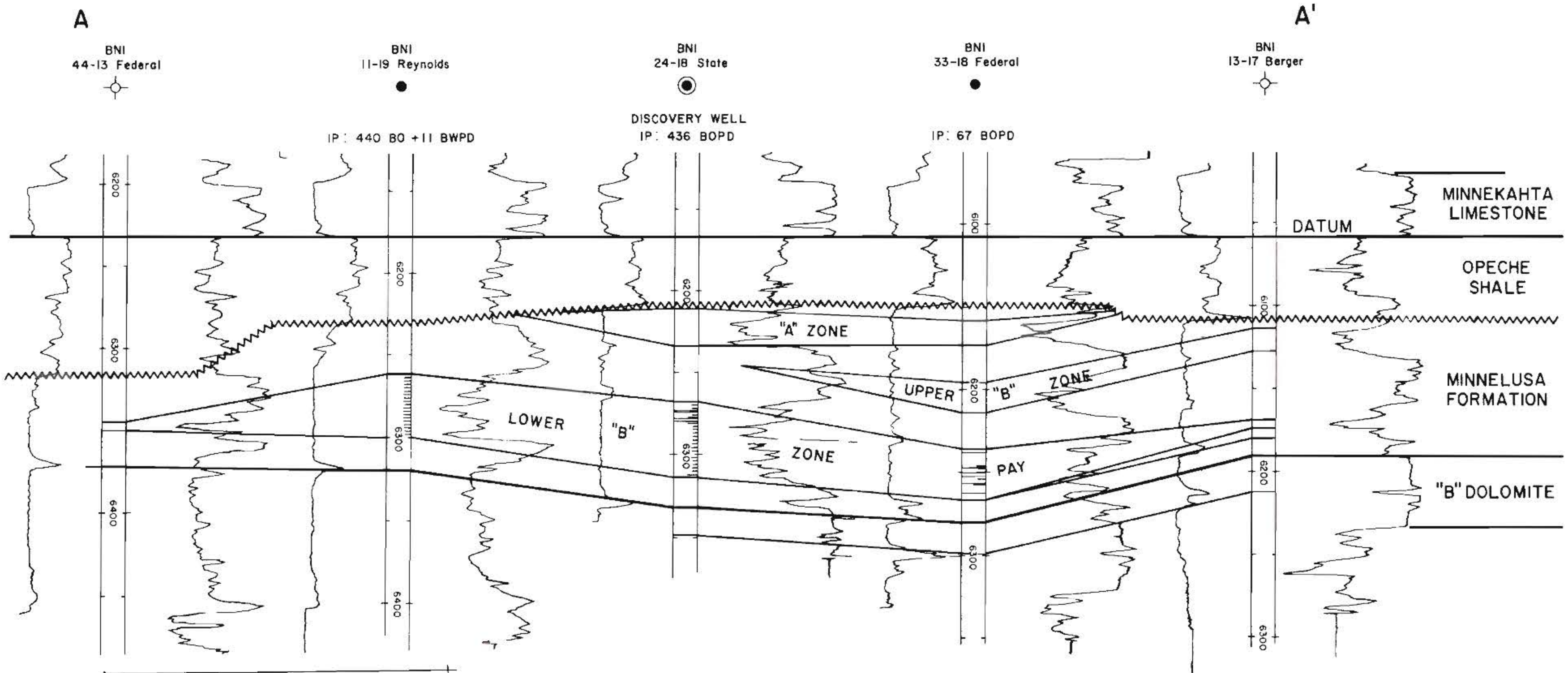

FIGURE 1

DEADMAN CREEK FIELD

CROOK COUNTY, WYOMING

CROSS SECTION A-A'

E. ARRO
APRIL, 1976

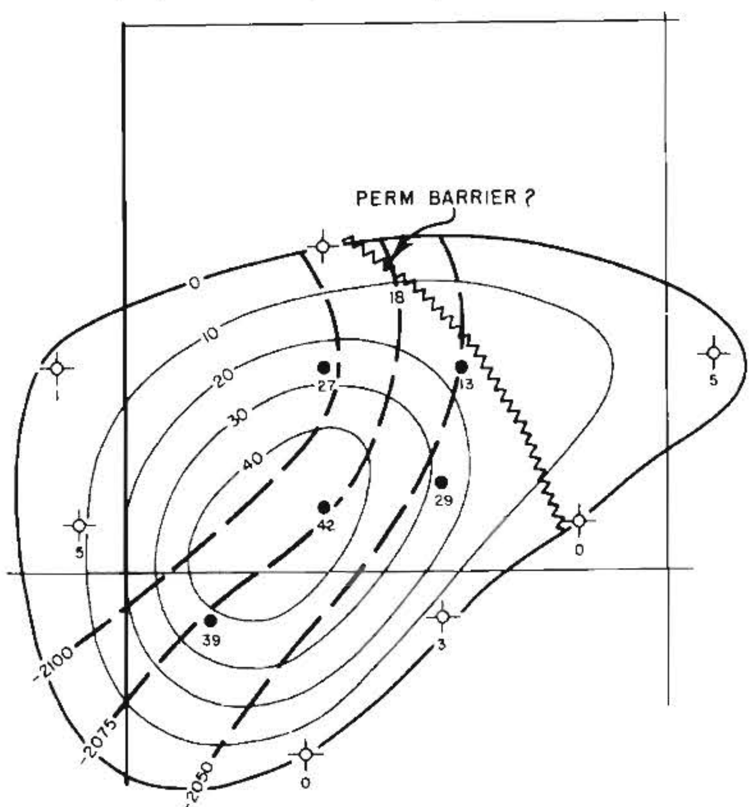

FIGURE 2

DEADMAN CREEK FIELD

CROOK COUNTY, WYOMING

ISOPACH-MINNELUSA LOWER "B" SAND

(POROSITY ≥ 12%)

WITH STRUCTURE MAP-TOP LOWER "B"

CONTOUR INTERVAL 10 FEET AND 25 FEET

E. ARRO
APRIL, 1976

Note
See Figure 15 for cross-section location relative to the Ross Property.

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Figure 13
Deadman Creek Field Cross Section A - A' and Isopach - Minnelusa Lower "B" Sand

2010 Ross ISR Class I Permit Application

Scale: NTS	Date: May 2010
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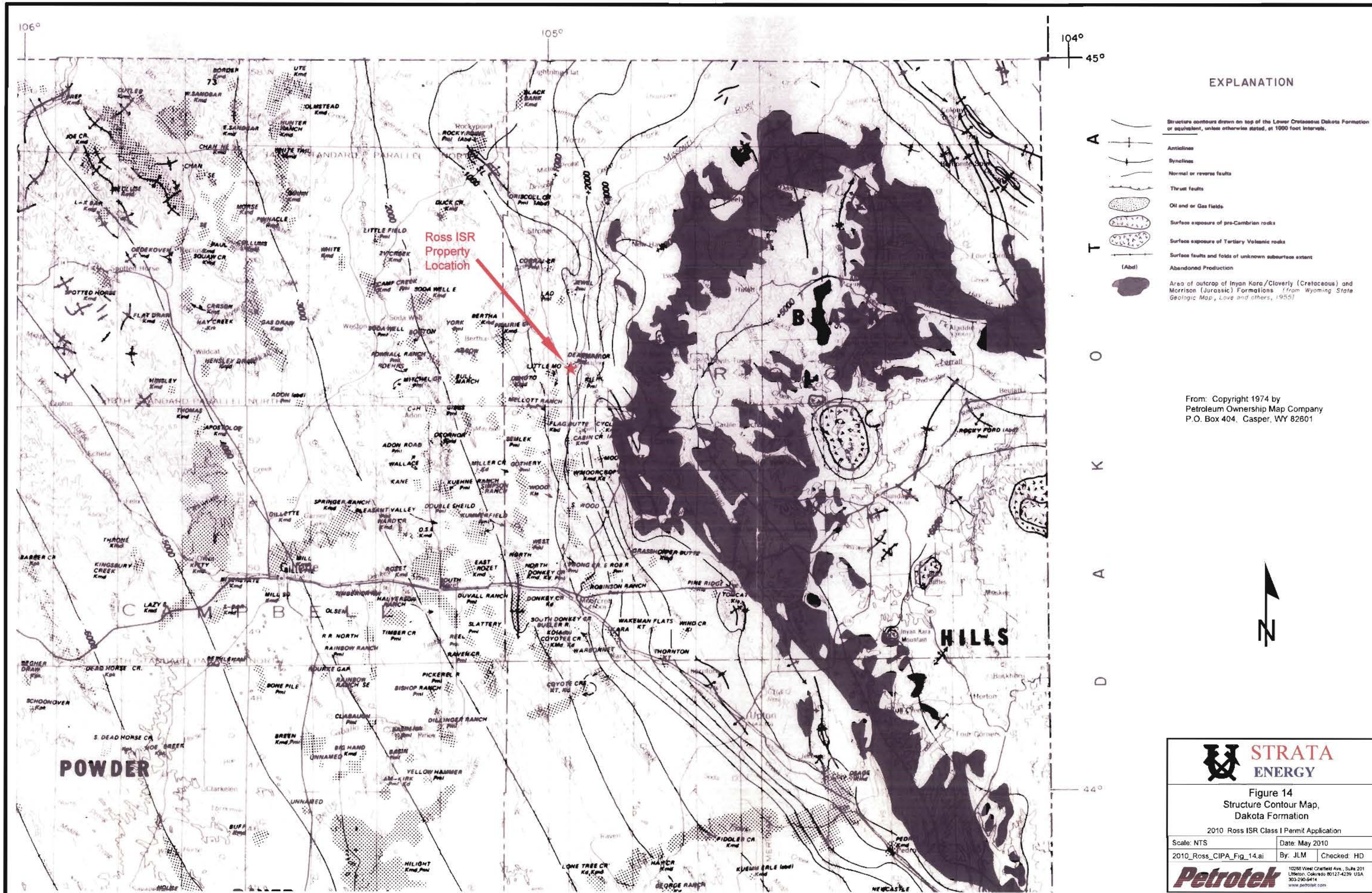
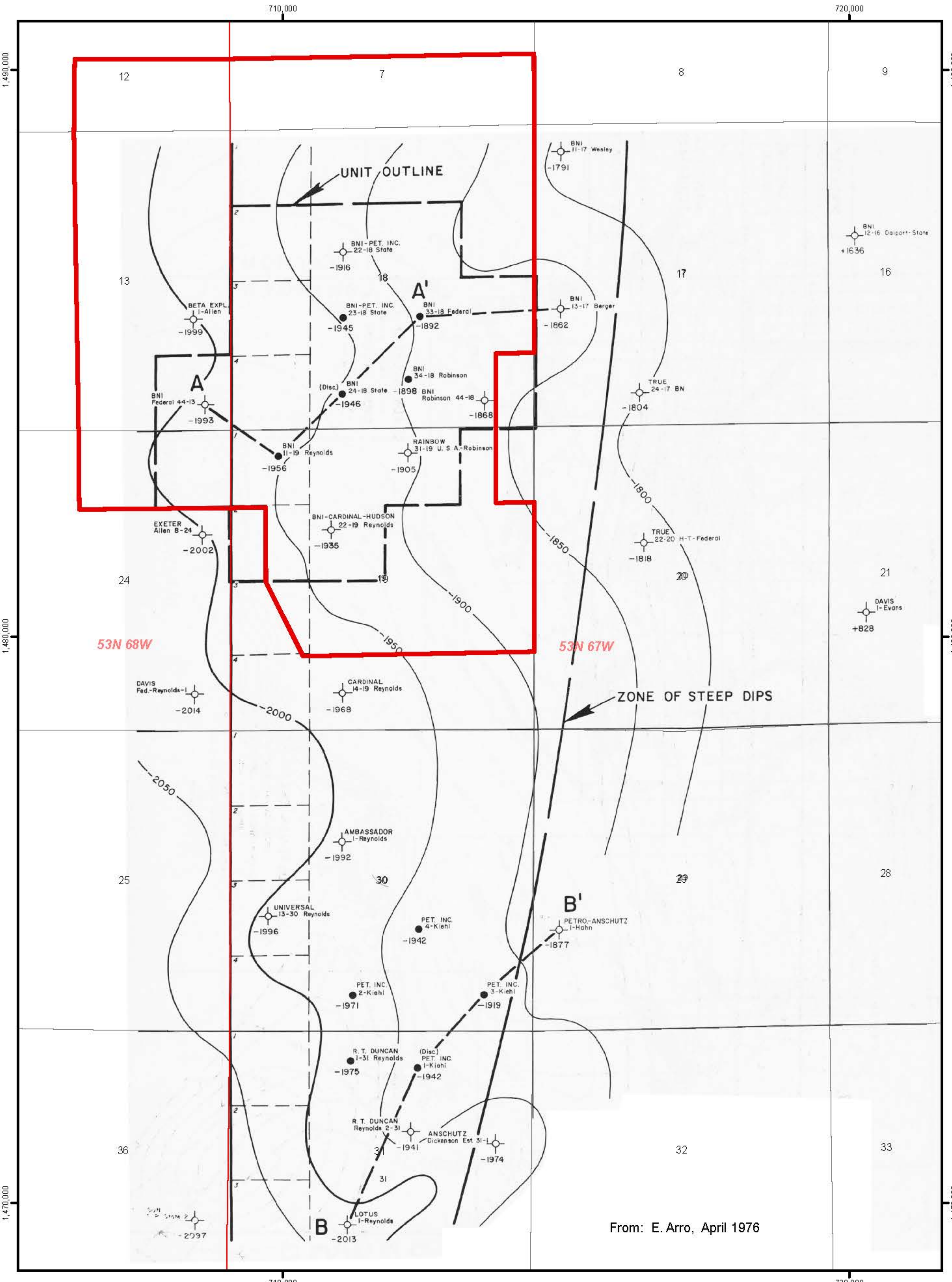


Figure 14
Structure Contour Map,
Dakota Formation
2010 Ross ISR Class I Permit Application



Legend

Ross ISR Permit Boundary

Contour Interval = 50ft.

Projection: Wyoming State Plane East, NAD 83, (feet)

N

0 0.25 0.5 0.75 1 Miles

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Figure 15
Stucture Contour,
Minnekahta Formation
2010 Ross ISR Class I Permit Application

Scale: 1:20,000	Date: May 2010	
2010_Ross_CIPA_Fig_15.mxd	By: JLM	Checked: KC

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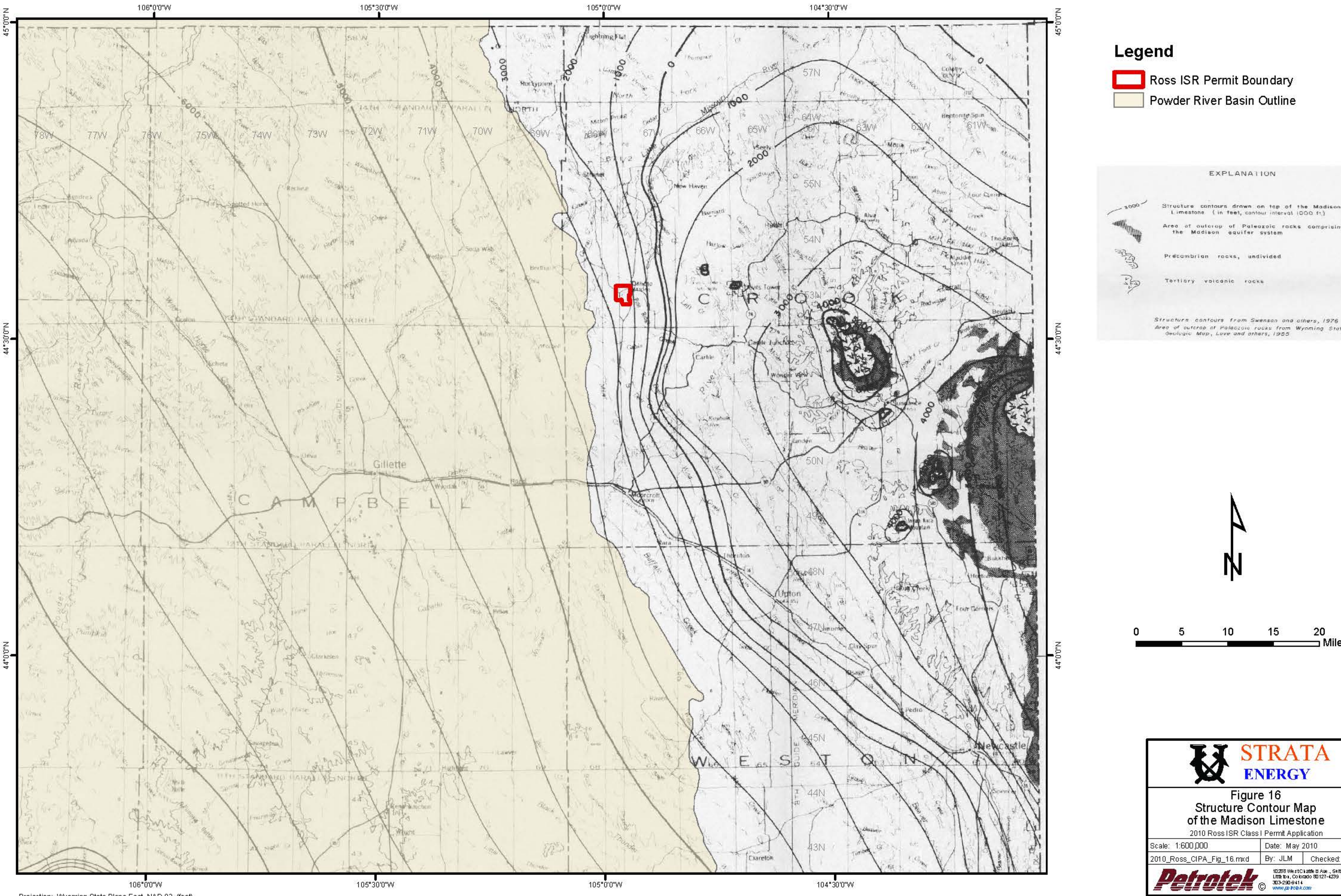

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Figure 16
Structure Contour Map
of the Madison Limestone
2010 Ross ISR Class I Permit Application

Scale: 1:600,000	Date: May 2010
2010_Ross_CIPA_Fig_16.mxd	By: JLM / Checked: HD

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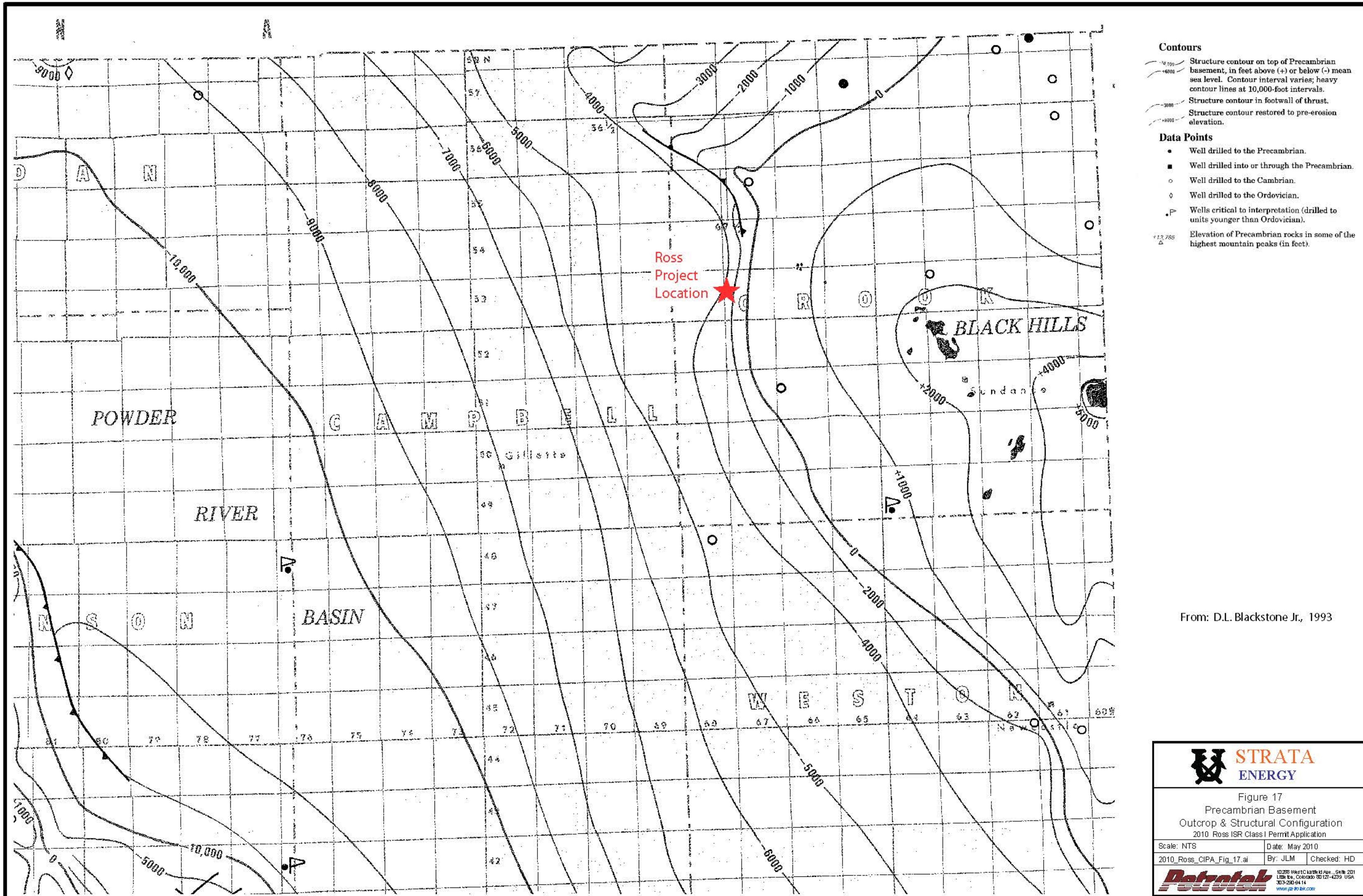

Contours
Structure contour on top of Precambrian basement, in feet above (+) or below (-) mean sea level. Contour interval varies; heavy contour lines at 10,000-foot intervals.
Structure contour in footwall of thrust.
Structure contour restored to pre-erosion elevation.
Data Points
Well drilled to the Precambrian.
Well drilled into or through the Precambrian.
Well drilled to the Cambrian.
Well drilled to the Ordovician.
Wells critical to interpretation (drilled to units younger than Ordovician).
Elevation of Precambrian rocks in some of the highest mountain peaks (in feet).
Ross
Project
Location
POWDER
RIVER
BASIN
BLACK HILLS
Gillette
Sundance
Newcastle
From: D.L. Blackstone Jr., 1993
STRATA
ENERGY
Figure 17
Precambrian Basement
Outcrop & Structural Configuration
2010 Ross ISR Class I Permit Application
Scale: NTS
Date: May 2010
2010_Ross_CIPA_Fig_17.ai
By: JLM
Checked: HD
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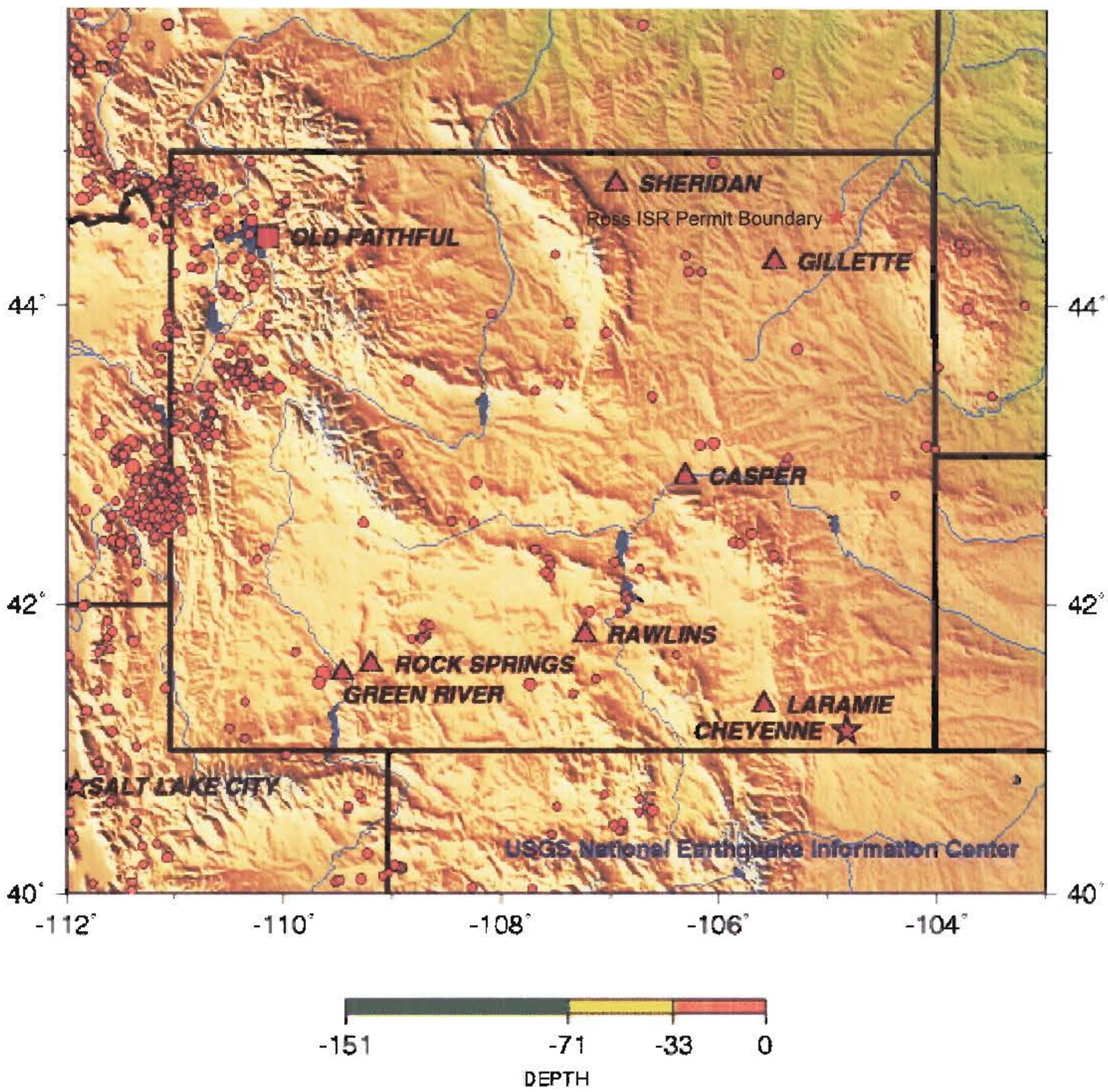
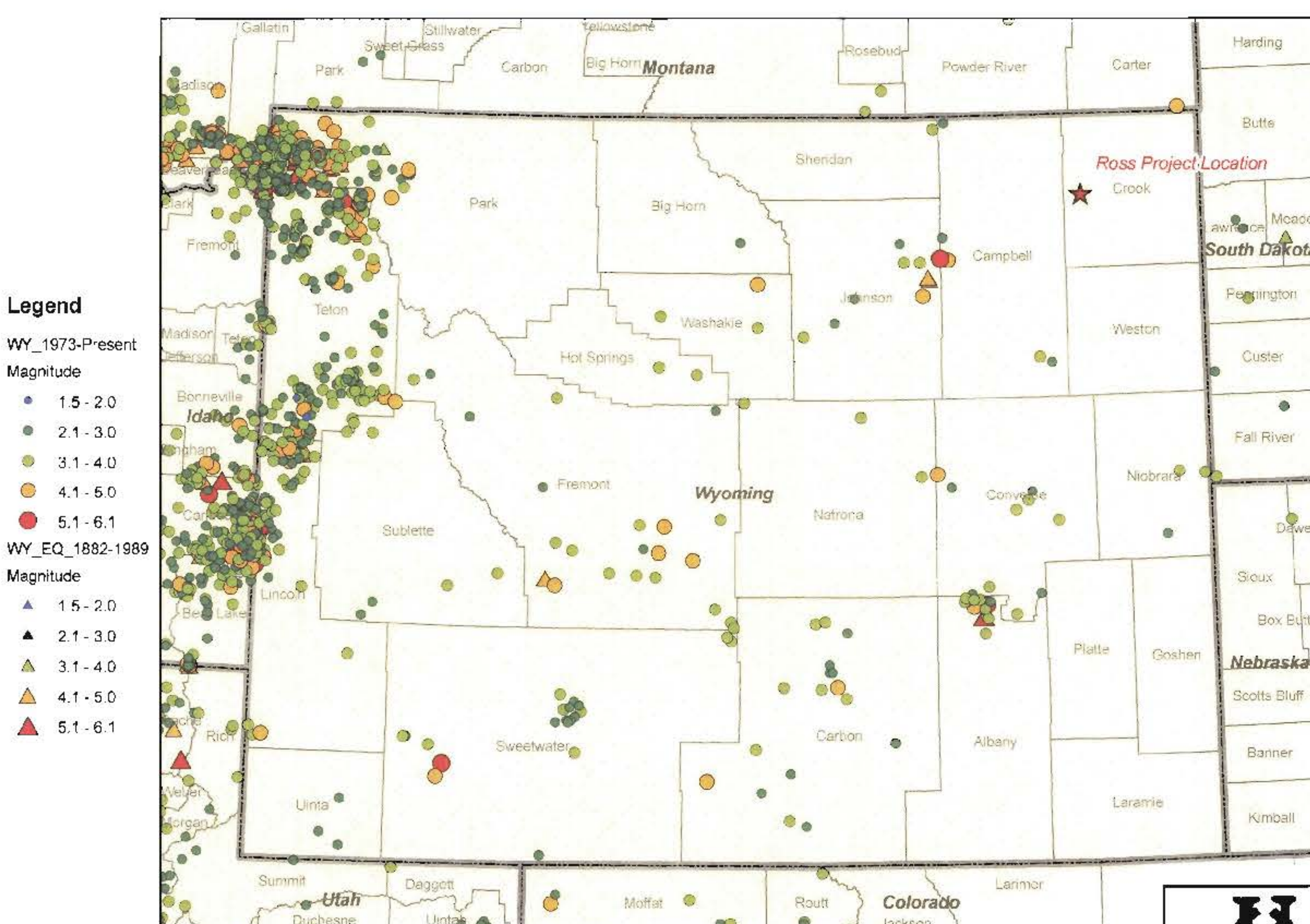
Seismicity of Wyoming
1990 - 2006



Depth is in kilometers.
Purple Triangles: Cities
Purple Star: Capital City
Circles: Earthquakes
(color represents depth range)



Earthquakes of Wyoming
1882 - Present

Map Source: USGS website
Earthquake locations are from the USGS/NEIC PDE catalog.

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Figure 18
Seismicity of Wyoming, 1990-2006; and Earthquakes in Wyoming, 1882-Present
2010 Ross ISR Class I Permit Application

Scale: NTS	Date: May 2010	
2010_Ross_CIPA_Fig_F-18.ai	By: JLM	Checked: HD

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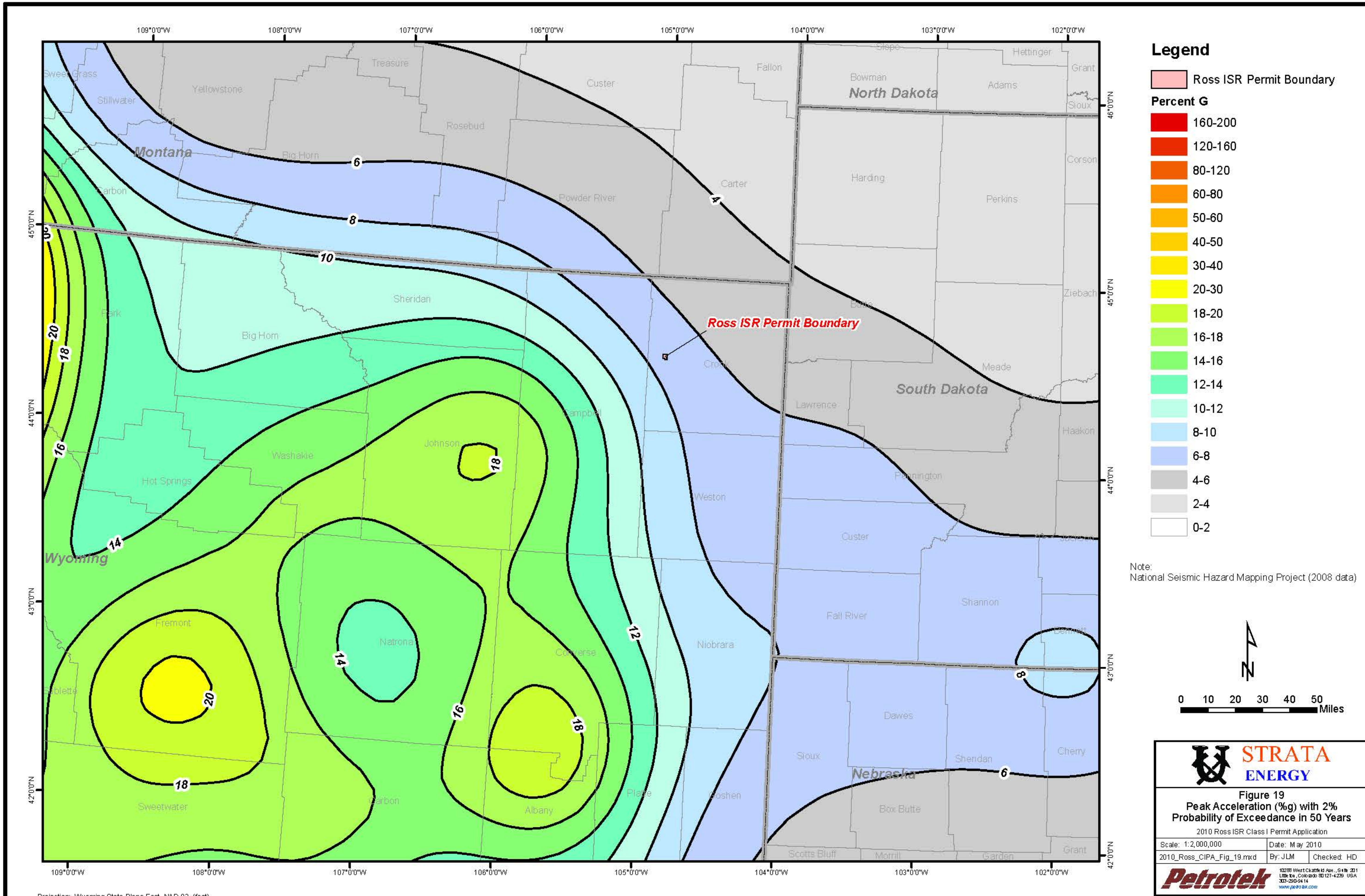
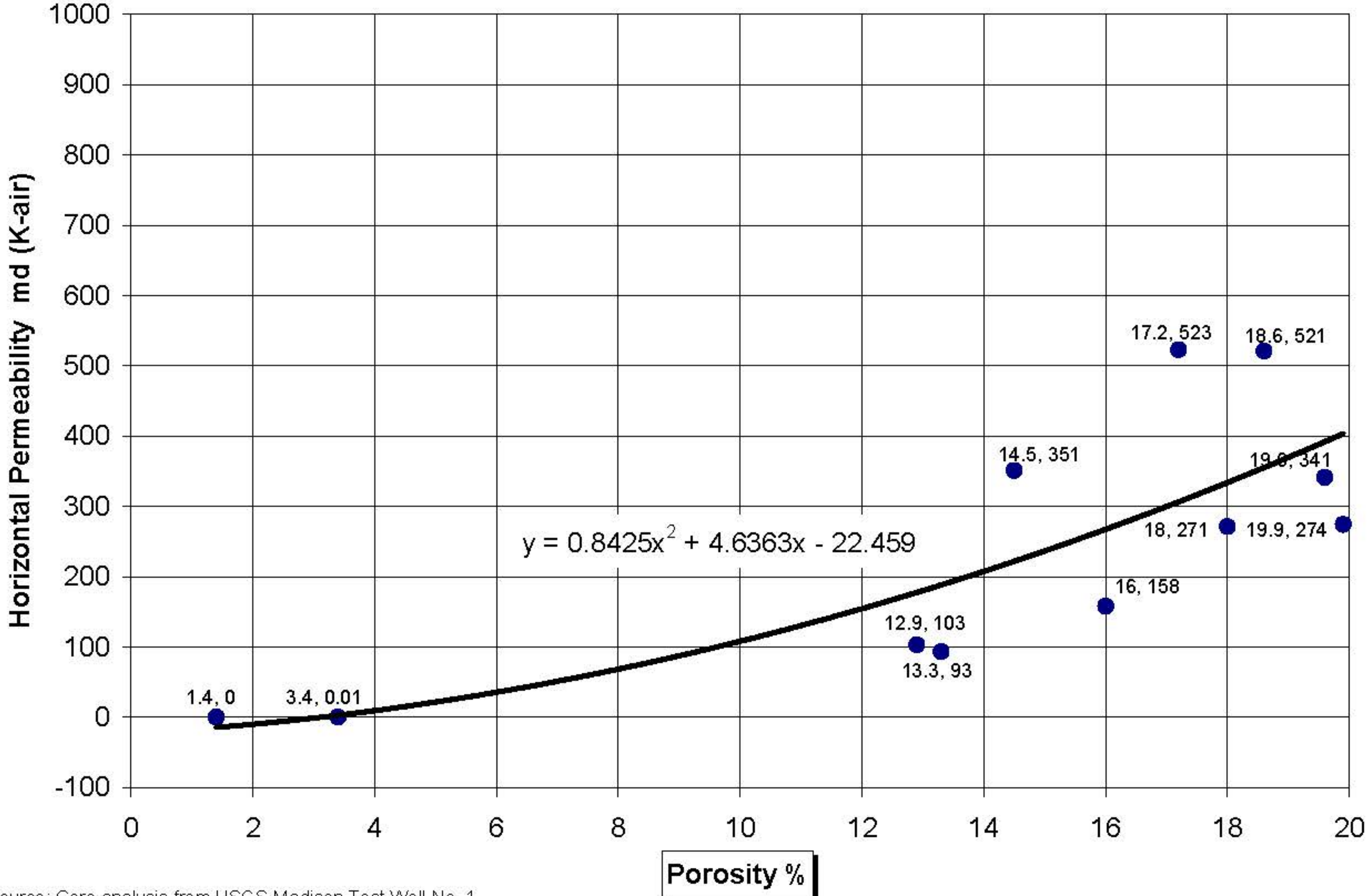
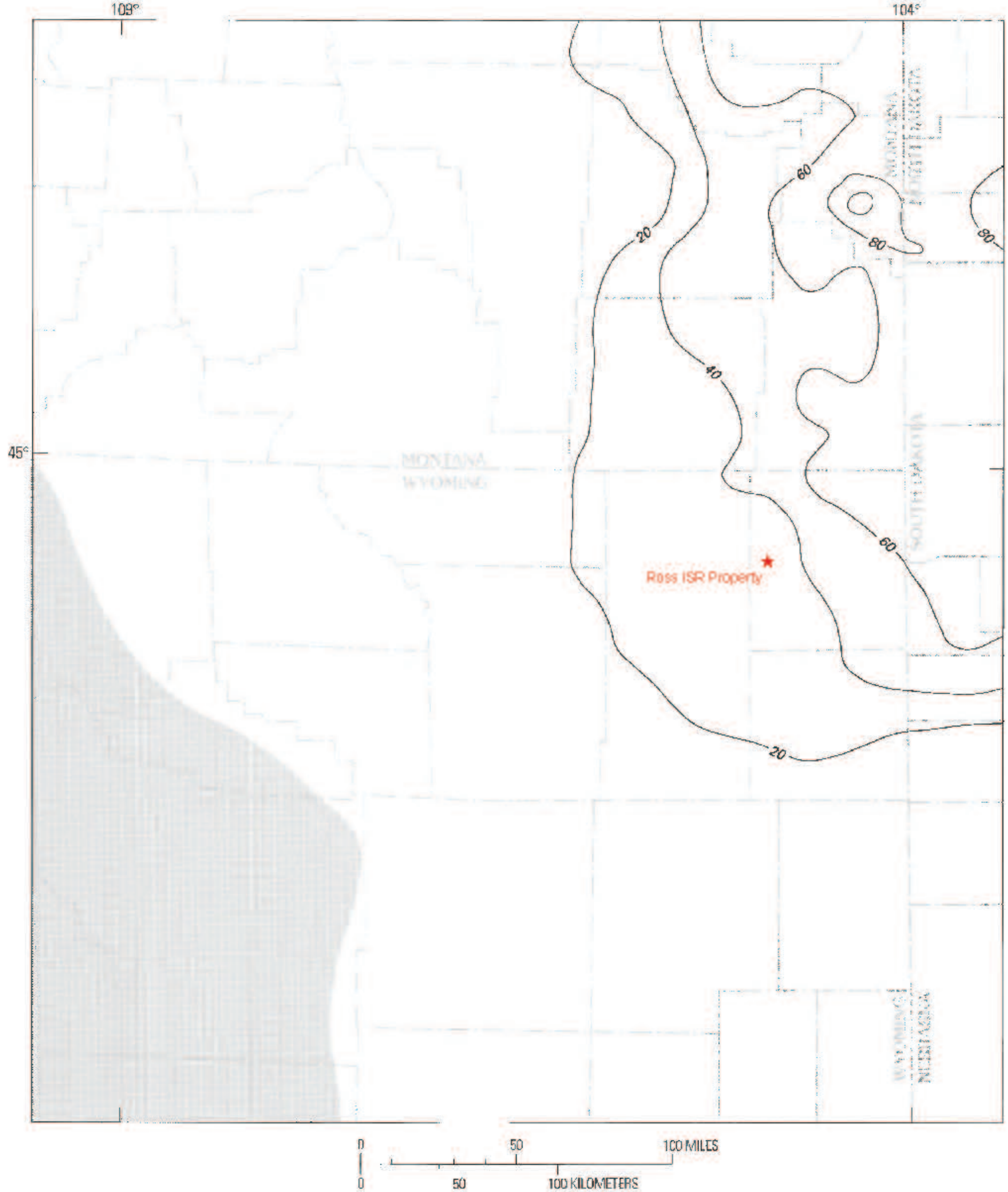


Figure 19
Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years
2010 Ross ISR Class I Permit Application

Figure 20
Horizontal Permeability vs. Porosity in Flathead Formation



Source: Core analysis from USGS Madison Test Well No. 1



From:
Geological Survey Professional Paper 1917
David L. Macke, 1993

N

STRATA ENERGY

Figure 21
Isopach Map,
Ice Box Member of the Winnipeg Group

2010 Ross ISR Class I Permit Application

Scale: See Bar Scale	Date: May 2010
2010_Ross_CIPA_Fig_21.ai	By: JLM Checked: HD

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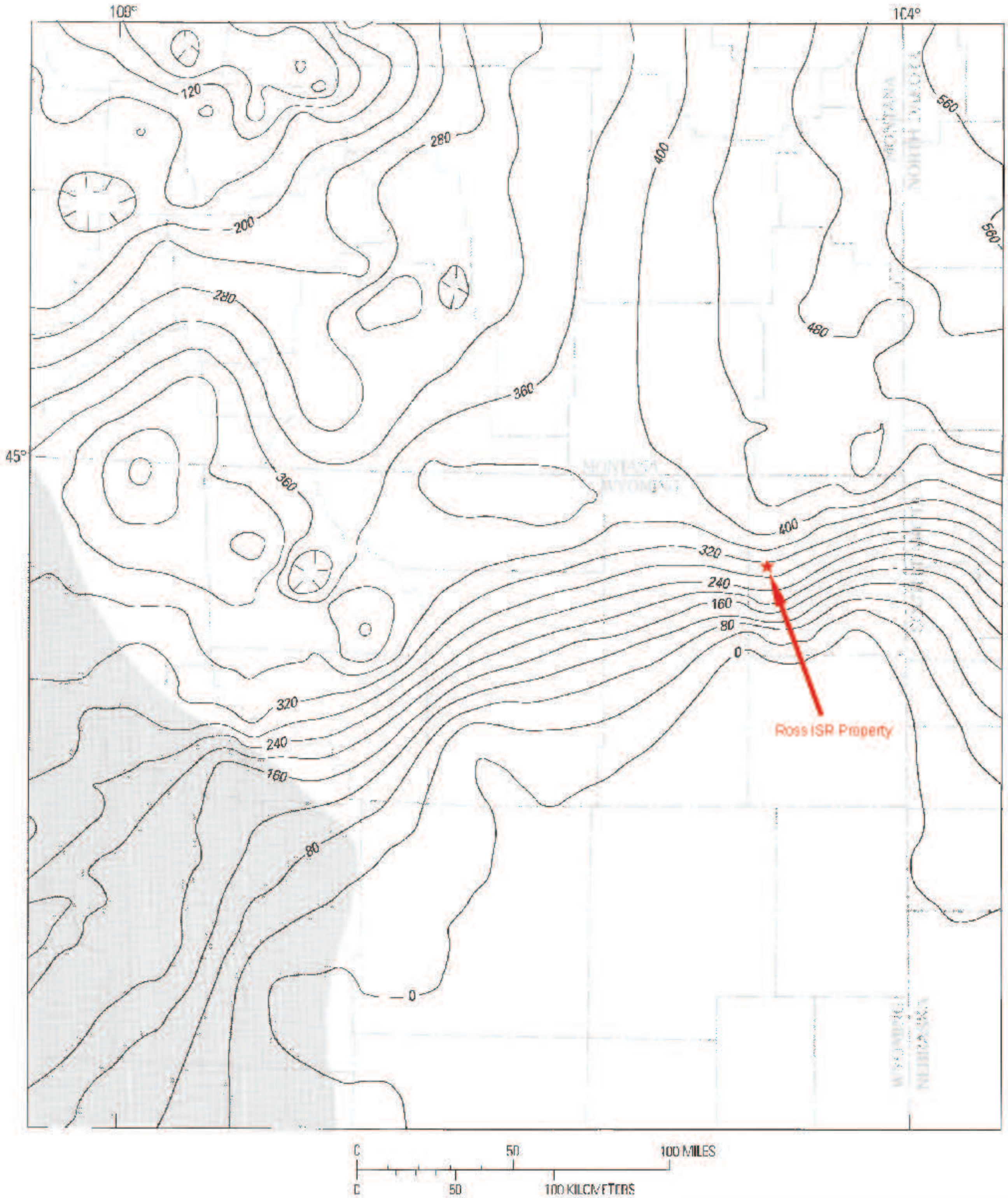

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Figure 22
Isopach Map,
Red River Formation

2010 Ross ISR Class I Permit Application

Scale: See Bar Scale	Date: May 2010
2010_Ross_CIPA_Fig_22.ai	By: JLM / Checked: HD

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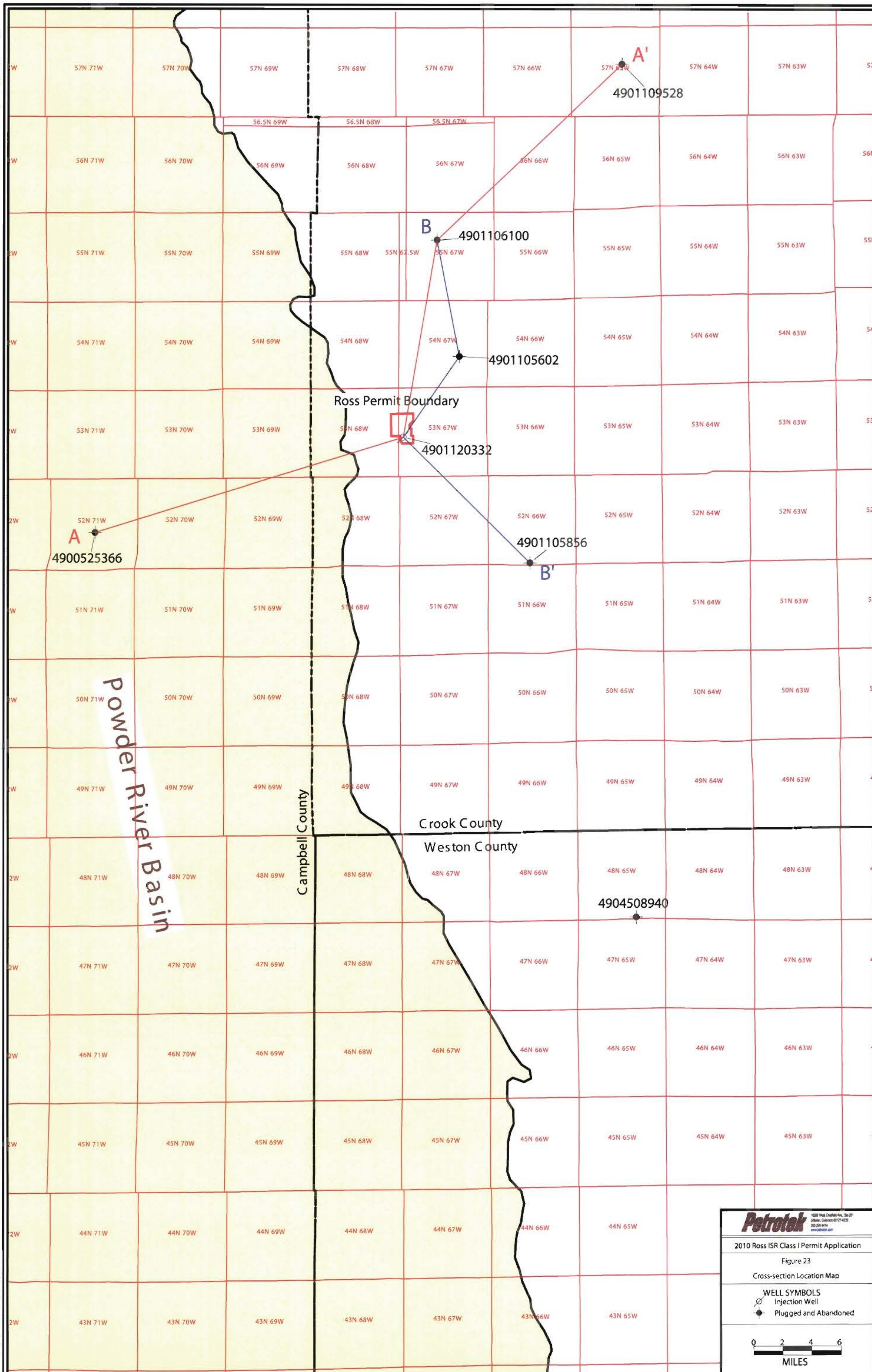
David L. Macke, 1993



A
A'
B
B'
4901109528
4901106100
4901105602
Ross Permit Boundary
4901120332
4900525366
4901105856
4904508940
Powder River Basin
Campbell County
Crook County
Weston County
Petrotek
2010 Ross ISR Class I Permit Application
Figure 23
Cross-section Location Map
WELL SYMBOLS
Injection Well
Plugged and Abandoned
0
2
4
6
MILES