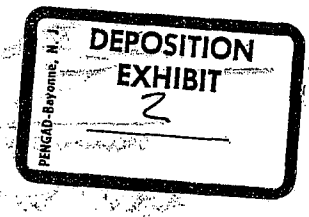
5



LANCE OIL & GAS COMPANY, INC.

DELEGATION OF AUTHORITY CERTIFICATE

I, Krista M. Crabtree, Assistant Secretary of Anadarko Petroleum Corporation, a Delaware corporation, do hereby certify that James J. Kleckner is Vice President of Lance Oil & Gas Company, Inc., (the "Company") and as such is a Responsible Corporate Officer as defined in 40 Code of Federal Regulations (CFR) 122.22(a)(1) and/or a Responsible Official as defined in 40 CFR 70.2.

I, James J. Kleckner, as a Responsible Corporate Officer and/or Responsible Official of the Company do hereby designate James A. Alsup, Bradley T. Miller, David P. Howell, John A. Broman, Douglas R. Nath, and T.R. Scott as Duly Authorized Representatives and are authorized to sign environmental permits and/or compliance reports on behalf of the Company.

James J. Kleckner
Vice President

WITNESS my hand this 31 day of July, 2007

Krista M. Crabtree
Assistant Secretary

CBM Associates, Inc.
920 E. Sheridan St. • Laramie, WY 82070 • Office: (307) 742-4991 • Fax: (307) 745-1582

GROUNDWATER & SURFACE WATER HYDROLOGY · WATER RESOURCE MANAGEMENT · ENVIRONMENTAL PERMITTING & COMPLIANCE

August 1, 2007

Ms. Jennifer Zygmunt
Wyoming Department of Environmental Quality
Water Quality Division
122 W. 25th Street, Herschler Bldg. 4-W
Cheyenne, Wyoming 82002

RE: **WYPDES Permit Renewal for WY0049697 Echeta Road Unit**
Lance Oil & Gas, Inc. an Anadarko Petroleum Company

Dear Ms. Zygmunt:

Lance Oil & Gas, Inc. (Lance) hereby submits the enclosed WYPDES permit renewal application for its WY0049697 Echeta Road Unit coal bed natural gas (CBNG) facility. Enclosed for your consideration are the following:

- WYPDES Permit Renewal Application for CBNG Water Discharge
- Tables 1A & 1B: Outfall Information
- Table 2: Well Information
- Table 3: Reservoir Information
- Table 4: Bonding Information
- Table 5b: Reservoir Water Budget Estimate and Explanation
- Flow Data Table
- Water Quality Data
- Compliance Evaluation and Exceedance Summary Table
- Facility Map

With this renewal, Lance would like to add one reservoir Floyd 14-23-5376, please see Table 3 Reservoir Information. Lance requests that discharge from outfall 006 be allowed to flow from Floyd 14-23-5376 into the Willow Tree reservoir. CBNG effluent will be contained within Willow Tree reservoir during dry operating conditions.

Lance requests similar irrigation protection limits for outfalls 001 – 012 to those recently proposed in draft option 2 permits on the Spotted Horse Creek and Middle Prong Wild Horse Creek drainages. These permits require an end-of-pipe effluent limit for EC only. In addition, these permits require monitoring for compliance with an EC standard and a chemical relationship between EC and SAR at irrigation monitoring points. In order to adequately monitor potential irrigation water quality Lance is requesting to add 4 Irrigation Monitoring Points (IMPs 6-9), downstream of its on-channel reservoirs as shown in Tables 1A & 1B and facility map. Lance will continue to treat discharge from outfall 013 to meet current permit end-of-pipe limits of EC 2,350 umhos/cm and SAR 15, and comply with the assimilative capacity sodium based schedule.

As shown in the attached Compliance Evaluation, Lance requests to replace total recoverable aluminum requirements with dissolved aluminum requirements and raise the total recoverable arsenic limit in accordance with the antidegredation policy and new Chapter 1 standard.

Lance is committed to not exceeding the permitted flow rate 0.84 MGD by monitoring well flow rates and altering discharges as necessary.

If you have any permit related questions, please call me at 307-742-4991, or e-mail at jdriscoll@cbmainc.com. Direct all correspondence to:

Lance Oil & Gas, Inc.
an Anadarko Petroleum Company
Attention: Timothy S. Kalus
1400 E. Lincoln St.
Gillette, Wyoming 82716

Sincerely,
CBM Associates, Inc.

Jason Driscoll
Environmental Specialist

/mbb

Enclosures: Permit Renewal Documents

cc: Lance Oil & Gas, Inc. – Gillette
CBM Associates, Inc. – Gillette

SUBMIT ONE HARD COPY AND ONE ELECTRONIC COPY

WYOMING POLLUTANT DISCHARGE ELIMINATION SYSTEM

APPLICATION FOR PERMIT TO SURFACE DISCHARGE PRODUCED WATER FROM COAL BED METHANE NEW DISCHARGES, RENEWALS, OR MAJOR MODIFICATIONS

For Agency Use Only
Application Number
WY00_____
Date Received:
_____
(mo/day/yr)

Revised: 06-22-06

Revised form last updated: 04-25-07

PLEASE PRINT OR TYPE *(Submission of illegible materials will result in return of the application to the applicant)*

1. Check the box corresponding to the type of application being applied for:

   ☐ New CBM permit

   ☒ CBM permit renewal Permit number WY0049697 Expiration Date: 1/31/2008

   ☐ CBM permit major modification Permit number Expiration Date:

2. Identify the river basin in which the discharge will occur:
   ☐ Belle Fourche ☐ Cheyenne ☒ Powder ☐ Little Powder ☐ Tongue

   ☐ Other (identify) _____

3. Select permit option(s): *if more than one option is selected, the applicant must describe which option applies to which outfall.*

   ☐ Option 1A – Discharge is contained within a class 4 water body: Containment within an off-channel pit (class 4C) OR containment within a headwater reservoir situated within a class 4 channel and capable of containing all effluent plus up to a 50-year / 24-hour storm event.

   ☐ Option 1B – Discharge is contained within a class 3 water body: Containment within a natural closed basin or playa lake (class 3A) OR containment within a headwater reservoir situated within a class 3 channel and capable of containing all effluent plus up to a 50-year / 24-hour storm event.

   ☒ Option 2 – This option includes any on-channel discharge (including discharge into an on-channel reservoir) that does not meet the impoundment requirements specified in options 1A or 1B above.

   If applying for outfalls under Option 2, will discharges from the facility proposed in this application require the use of assimilative capacity credits for salt and sodium in the Powder River?

   ☒ Yes ☐ No

   Outfall 013 treats and discharges into Wild Horse Creek, Lance is in the final stages of calculating assimilative capacity credits and will be submitting this information to WDEQ in a timely fashion. Outfalls 001-012 discharge can be contained in reservoirs up to a storm event, and are not held to capacity credits.

4. General Facility Location: Township(s): 53 N Range(s): 75 & 76 W

   Immediate Receiving Stream(s): HUC 10 – 1009020208; Wild Horse Creek

5. Name of the facility producing the discharge (this is the facility name that will appear on the WYPDES permit)

   Echeta Road Unit

6. Company, Contact Name, mailing address, e-mail address, and telephone number of the individual or company which owns the facility producing the discharge, and the person (consultant) responsible for permit submission.

Company Contact Name Timothy S. Kalus	*Consultant Contact Name* Jason Driscoll
Company Name Lance Oil & Gas, Inc. an Anadarko Petroleum Company	*Company Name* CBM Associates, Inc.
Mailing Address 1400 E. Lincoln St.	*Mailing Address* 920 E. Sheridan Street
City, State, and Zip Code Gillette, WY 82716	*City, State, and Zip Code* Laramie, WY 82070
Telephone Number 307-685-5742	*Telephone Number* 307-742-4991
E-Mail Address Tim.Kalus@anadarko.com	*E-Mail Address* jdriscoll@cbmainc.com

7. If submitting a major modification or permit renewal, please describe all requested permit modifications (i.e. add 2 outfalls, add 23 wells, move outfall 001 500 feet...):

- **Update Qrt/Qrt for outfall 013 and IMP3 as listed in Tables 1A & 1B.**
- **Add one reservoir Floyd 14-23-5376. As listed in Tables 1A, 1B, 3 and 4. Lance requests that discharge from outfall 006 be allowed to flow from the Floyd 14-23-5376 into Willow Tree reservoir. CBNG effluent will be contained within Willow Tree reservoir during dry operating conditions.**
- **Add IMPs 6 – 9 as listed in Tables 1A and 1B Outfall Information.**
- **Retain current flow limit of 0.84 MGD. See the attached Table 5b Water Budget that shows Lance's ability to manage this flow.**
- **Replace total recoverable aluminum requirements with dissolved aluminum requirements.**
- **Raise the total recoverable arsenic limit in accordance with the antidegredation policy and new Chapter 1 standard.**
- **Remove the end-of-pipe SAR limit at outfalls 001-012. Instead, and as done in recent Public Notice permits, apply a fixed EC limit and a Hanson-derived SAR limit at irrigation monitoring points. Effluent from these outfalls will be contained during dry operating conditions.**
- **Keep current end-of-pipe EC and SAR limits of 2350 umhos/cm and 15 respectively for outfall 013. This is a treat and direct discharge outfall.**

*NOTE: Major modification applications requesting to increase the permitted flow for a facility will be processed as RENEWALS. Major modification applications for permits within six months of their expiration date will also be processed as RENEWALS.

8. Name(s) and mailing address(es) of owner(s) of the surface rights on whose land the discharge occurs (in cases where the land is owned by the state or federal government but surface rights are leased to a private individual, provide lessee's name and address)

Landowner Name Floyd Land & Livestock Inc., Fred Floyd	*Landowner Name* Rick G. Floyd
Mailing Address 2600 Echeta Road	*Mailing Address* 2482 West Echeta Road
City, State, and Zip Code Gillette, WY 82716-9182	*City, State, and Zip Code* Gillette, WY 82716-9184

9. For all facilities relying on reservoirs of any type as part of their water management plan, complete the attached Table 5a (for option 1A or 1B facilities) and/or Table 5b (for option 2 facilities). The water budget should demonstrate, considering total projected discharge inflows, natural precipitation, evaporation and infiltration, the amount of the discharge that will be contained within the reservoirs, and the circumstances and volume of effluent that could potentially be discharged. If applying for an Option 1A or 1B permit, the water balance must demonstrate that the containment unit will be adequately sized to contain all projected discharge and storm water runoff from a 50 year, 24 hour storm event.

   Please see attached water balance Table 5b: Twenty-Four-Hour, Reservoir Water Budget Estimate for Option 2 Facilities and Explanation.

10. For Option 2 facilities with planned reservoir releases to the Powder River, include analyses of expected water quality within the reservoirs. Reservoir water quality analyses must include all constituents, with the appropriate detection limits and units, listed in the table included with question #19 of this application.

    Not applicable. Reservoirs will not discharge except in the event of a storm event which causes the reservoirs to overtop.

11. Attach a description and a clear, legible, detailed topographic map of the discharging facility. Include the following:
    a. A legend
    b. Well locations
    c. Ponds – **Ponds are not pertinent to the water management of this facility.**
    d. Reservoirs
    e. Stock tanks - **Stock tanks are not pertinent to the water management of this facility.**
    f. Discharge points (outfalls)
    g. Immediate receiving streams
    h. Water quality monitoring stations
    i. Irrigation compliance points – **Referred to as Irrigation Monitoring Points.**
    j. Location of nearest downstream irrigator.
    k. Section, Township, and Range information
    l. If proposing to use class 4C off-channel pits, include footprint outline of the proposed pits. To denote setback distance, include a distance marker from closest side of pit to the nearest water feature, floodplain, or stream alluvium. Identify latitude and longitude in decimal degrees (using a minimum of 6 decimal places) for each end point of the setback distance marker. **Off-Channel Impoundments are not being used in this facility.**

    If any of the above are not applicable please indicate in the description and include a brief explanation as to why the item is not applicable)

    Please see attached Permit Map for items a, b, d, f, g, h, i, j, and k.

12. Describe the control measures that will be implemented to prevent significant damage to or erosion of the receiving water channel at the point of discharge.

Produced water will be discharged slowly through a vertical, notched, large diameter riser pipe and allowed to flow down the side the corrugated pipe to dissipate energy. The discharged water will the flow and pass over rip-rap or scoria placed at gentle slope prior to entering the receiving stream channel impoundment.

13. Describe the control measures that will be implemented to achieve water quality standards and effluent limits. If proposing to utilize a treatment process, provide a description of the treatment process.

    Lance will utilize an EMITS facility. Please refer to the modification of this permit dated October 7, 2005 for a detailed treatment description.

14. Outfall locations must be established as part of a preliminary field reconnaissance survey using GPS or conventional survey equipment and documented in Table 1. Please document the type of equipment used, the expected accuracy of your measurements, and a brief rationale for locating the outfalls at the requested sites below.

    Outfall locations were selected initially from a map review. The initial locations were selected considering pipeline locations, terrain, and ease of access for monitoring. Landowner input was obtained to site the outfalls where they would be most useful to the landowner's ranching operations. The final locations of the outfalls were identified by field GPS using a Garmin GPS unit (potential accuracy of 20 meters or less).

15. Complete the attached Table 1. Provide all the information requested in the table for each proposed discharge point or monitoring point. If proposing changes (a major modification) to an existing facility, clearly indicate the desired changes on the table. Additional tables may be attached. Use the format provided. Option 2 permits, except those located in the Belle Fourche or Cheyenne River Basins, must include water quality monitoring station locations. Option 1B headwater reservoir discharges (reservoirs other than playa lakes capable of 50 year 24 hour stormwater runoff containment) must include flow monitoring station locations. Option 1A and 1B permits must include containment unit monitoring station locations. Information related to reservoirs is only required if the facility's water management plan includes reservoir containment.

    Please see attached Tables 1A and 1B: Outfall Information: Note that IMP 3 is being removed and IMPs 6-9 are being added.

16. Complete the attached Table 2. Provide all the information requested in the table for each well associated with this proposed discharge authorization. If proposing changes (a major modification) to an existing facility, clearly indicate the desired changes on the table. Additional tables may be attached. Use the format provided.

    Please see attached Table 2: Well Information.

17. Complete the attached Table 3. Provide all the information requested in the table for each reservoir proposed for containment of CBM produced water. Specified locations refer to the approximate center of the reservoir. If proposing changes (a major modification) to an existing facility, clearly indicate the desired changes on the table. Additional tables may be attached. Use the format provided. Information related to reservoirs is only required if the facility's water management plan includes reservoir containment.

    Please see attached Table 3: Reservoir Information: Note that, one reservoir Floyd 14-23-5376 is being added. Lance requests that discharge from outfall 006 be allowed to flow from Floyd 14-23-5376 into Willow Tree reservoir. CBNG effluent will be contained within Willow Tree, the most downstream reservoir, during dry operating conditions.

18. Complete the attached Table 4. Provide all information requested in the table related to reservoir bonding requirements for each reservoir proposed for the containment of CBM produced water. If proposing any changes (a major modification) to an existing facility, clearly indicate the desired changes on the table. Additional tables may be attached. Use the format provided. Information related to reservoirs is only required if the facility's water management plan includes reservoir containment.

Please see attached Table 4: Bonding Information.

19. Provide the results of water analyses for a sample collected from a location representative of the quality of the water being proposed for discharge for all of the chemical parameters listed in the table below. The sample must be collected from well(s) or outfall(s) within a twenty mile radius of the proposed facility's location, and from the same coal formation(s) and the same approximate depth(s) as proposed in this application. If filing an application for a permit renewal or modification, the representative sample must be collected from the facility being proposed for renewal or modification. Explain why this sample is representative of the produced water to be discharged.

Refer to the following sample identification table and the corresponding lab analysis for representative water quality. The sample collected 5/30/2004 is from outfall WY0049697_004. This sample includes total recoverable aluminum instead of dissolved aluminum. Total recoverable aluminum value in the sample is less than 50 ug/L and within the dissolved aluminum limit of 750 ug/L.

Sample ID	Sample Date	Qtr/Qtr	Sec	Twn	Rng	Formation
DP_WY0049697_004_ET3	04/30/2004	NESW	25	53	76	Wall, Anderson, Gates, Wemer

Samples from co-mingled coal seams are acceptable as long as the sample(s) meet the following criteria:

A. all of the coal seams being proposed for development are represented in the co-mingled sample, with no contribution from coal seams not being proposed for development at the new facility.
B. the ratio of each coal seam's contribution is approximately the same in the sample and the proposed development,
C. documentation is provided to verify the criteria listed in A. and B.

The analyses must be conducted in accordance with approved EPA test procedures (40 CFR Part 136). Include a signed copy of your lab report that includes the following:

a. detection limits
b. results of each of the chemical parameters at the chemical state given below
c. quarter/quarter, section, township and range of the sample collection location
d. Time and date of sample collection
e. Time and date of analysis for each parameter
f. Analyst's initials for each parameter
g. Detection limit for each parameter as achieved by the laboratory
h. WYPDES permit number and outfall number, where the sample was collected.
i. Origin of produced water (coal seam and legal location of sample collection location)

If more than one coal seam is being proposed for development, the permittee must submit a lab analysis and complete information characterizing water quality from each coal seam being proposed for development. If the permittee is proposing to include discharges from a coal seam not previously developed at this facility, the permittee must submit a lab analysis and complete information characterizing water quality from the new coal seam being proposed for development. A mixing analysis may be required if the representative water quality analysis from the new coal seam indicates that the inclusion of the new effluent source may result in degradation of existing effluent quality. Analyses must be provided in the units listed below.

Parameter* (See notes following the table on chemical states)	Required Detection Limits and Required Units
Alkalinity, Total	1 mg/l as $CaCO_3$
Aluminum, Dissolved	50 µg/l
Arsenic, Total Recoverable	1 µg/l
Barium, Total Recoverable	100 µg/l
Bicarbonate	10 mg/l
Cadmium, Dissolved	5 µg/l
Calcium, Dissolved	50 µg/l, report as mg/l
Chlorides	5 mg/l
Copper, Dissolved	10 µg/l
Dissolved Solids, Total	5 mg/l
Fluoride, Dissolved	100 µg/l
Hardness, Total	10 mg/l as $CaCO_3$
Iron, Dissolved	50 µg/l
Lead, Dissolved	2 µg/l
Magnesium, Dissolved	100 µg/l, report as mg/l
Manganese, Dissolved	50 µg/l
Mercury, Dissolved	1 µg/l
pH	to 0.1 pH unit
Radium 226, Total Recoverable	0.2 pCi/l
Radium 228, Total Recoverable**	0.2 pCi/l
Selenium, Total Recoverable	5 µg/l
Sodium Adsorption Ratio	Calculated as unadjusted ratio
Sodium, Dissolved	100 µg/l, report as mg/l
Specific Conductance	5 micromhos/cm
Sulfates	10 mg/l
Zinc, Dissolved	50 µg/l

**Discharges into drainages other than the Powder River geologic basin may require analysis of additional parameters, please contact the WDEQ for a separate list.*

***This parameter is only required for those discharges located within one stream mile of a class 2 water.*

20. For new facilities, provide the expected (estimated) flow volume from each well in gallons per day, and provide the rationale behind the flow volume estimate. For existing facilities, provide actual flow data from all wells within the last six months.

Flow: 6,798 gpd/well; Average flow from January through June 2007.

Rationale: Please see attached Flow Data Table.

21. For applications for new facilities, are any of the required chemical constituents in the laboratory analysis present in concentrations above Wyoming Water Quality Standards?

Not applicable, this is an existing facility.

☐ YES ☐ NO

If the answer to question # 21 is yes, answer 21.a. – 21.b below. If no, proceed to question 23.

a. Which constituents? **Not applicable.**

b. Has this constituent been addressed in the response to question 13? **Not applicable.**

22. For applications for existing facilities, has the facility ever exceeded permit limits or water quality standards?

☒ YES ☐ NO

If the answer to question 22 is yes, answer 22.a. – 22.c. If no, proceed to question 23.

a. Which constituents?

- **Total barium (Ba)**
- **Dissolved chloride (Cl)**
- **Dissolved copper (Cu)**
- **Electrical conductivity (EC)**
- **Dissolved iron (Fe)**
- **Field pH**
- **Total radium 226 (Ra 226)**
- **Sodium adsorption ratio (SAR)**

b. Has the exceedance been addressed?

See Compliance Evaluation and Exceedance Summary Table.

c. Describe how the exceedance was addressed.

See Exceedance Summary Table.

23. Is there active irrigation in the drainage downstream of the discharge? *(Please note that this response includes both artificially and naturally irrigated bottomlands as defined in the Draft Agricultural Use Protection Policy for the interpretation and implementation of Chapter 1, Section 20 of the Wyoming Water Quality Rules and Regulations).*

Lance acknowledges the presence of downstream irrigation from its Echeta Road Unit facility. Based on the Section 20 Compliance Analysis for Proposed Discharges by Petro-Canada to Wild Horse Creek, Campbell County, WY; KC Harvey, LLC, November 2005, the WDEQ has determined end of pipe limits protective of irrigation on Wild Horse Creek to be SAR = 15 and EC = 2350 micromhos/cm. Lance will continue to treat discharge from outfall 013 to meet these limits and comply with a dissolved sodium schedule. However, flow from outfalls 001-012 is contained in downstream reservoirs that are not authorized to discharge except in response to a storm event. Lance requests that end-of-pipe effluent EC and SAR limits for outfalls 1-12 be implemented similar to recently proposed permits including; WY0038377 on Spotted Horse Creek and WY0054330 on the Middle Prong Wild Horse Creek drainage. These permits require an end-of-pipe effluent limit for EC only. In addition, these permits require monitoring for compliance with an EC standard and a chemical relationship between EC and SAR at designated irrigation monitoring points. Lance requests that these effluent limits be effective only when flow can be hydrologically connected to the Echeta Road facility.

☒ YES ☐ NO

If yes, at a minimum, the WYPDES Program requires submission of the following information:

1. Location(s) of irrigation diversions and/or sub-irrigated acreage; See the attached Permit Map
2. Type(s) of Crops grown under irrigation;
3. Description of Irrigation Practices
4. A topographic map showing irrigated acreage, any structures, ownership of irrigated acreage. See the attached Permit Map

For items 1-4, see the Section 20 Compliance Analysis for Proposed Discharges by Petro-Canada to Wild Horse Creek, Campbell County, WY; KC Harvey, LLC, November 2005.

In addition to the minimum information described above, the WYPDES Program may require additional information should the permittee request site-specific effluent limits protective of irrigation uses. Contact the WYPDES Program for more information regarding requirements for site-specific SAR, TDS, and EC limits.

Lance reserves the right to reference additional data as it becomes available.

24. Provide name(s) and address(es) for all downstream irrigators between the outfalls and the mainstem.

Irrigator Name Floyd Land & Livestock Inc., Fred Floyd	*Irrigator Name* Clabaugh Ranch Inc., Kenny Clabaugh
Mailing Address 2600 Echeta Road	*Mailing Address* PO Box 12
City, State, and Zip Code Gillette, WY. 82716	*City, State, and Zip Code* Avada, WY 82831

25. Provide a listing of all active permits or construction approvals received or applied for by the applicant for the site described in this permit application in accordance with *Chapter 2, Section 5.T. of the Wyoming Water Quality Rules and Regulations.*

Please see Table 2 for API numbers.
Please see Table 3 for SEO numbers.
Statewide permit to Construct No. 04-454.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations. I am requesting 13 outfalls in this application.

James A. Alsup	General Manager, Operations
*Printed Name of Person Signing** T. Reed Scott	*Title* General Manager - Business Services
*Signature**	*Date* 8/2/07

*All permit applications must be signed in accordance with *Section 14, Chapter 2 of the Wyoming Water Quality Rules and Regulations*, "for" or "by" signatures are not acceptable.

Section 35-11-901 of Wyoming Statutes provides that:

Any person who knowingly makes any false statement, representation, or certification in any application ... shall upon conviction be fined not more than $10,000 or imprisoned for not more than one year, or both. Permittees are required to retain records of all data used to complete permit applications in accordance with *Chapter 2, Section 5, Part 5.V.vii of the Wyoming Water Quality Rules and Regulations.*

Mail this application to:

WYPDES Permits Section
Department of Environmental Quality/WQD
122 West 25th Street, Herschler Building, 4W
Cheyenne, WY 82002

Permits issued under the WYDPES Program are subject to an annual 100$ permit fee for as long as permit is active. The annual billing cycle is based on the state's fiscal year from July 1 to June 30. There is no need to pay the fee with the application. All permit fees are invoiced after June 30th of each year.

Table 1A - Outfall Information: WY0049697 - Echeta Road Unit

Desired Changes	Discharge Point (Outfalls) #	Immediate Receiving Stream	Mainstem	Distance to Closest 2AB Channel & Mainstem (Miles)	Qrtr / Qtr	Sec	Twn (N)	Rng (W)	NAD 83 Latitude*	NAD 83 Longitude*	County	Reservoir Name and Type
—	001	Wyo Draw	Powder River	24.19	SWNE	23	53	76	44.557600	-105.968880	Campbell	Rick's (On-Channel)
—	002	Wilson Draw	Powder River	26.24	SWNE	25	53	76	44.544752	-105.946466	Campbell	Boone (On-Channel)
—	003	South Lacy Draw	Powder River	26.17	NESW	25	53	76	44.542271	-105.951052	Campbell	N & S Lacy (On-Channel)
—	004	Wilson Draw	Powder River	25.67	SWNW	25	53	76	44.545023	-105.956726	Campbell	004 (On-Channel)
—	005	Chad Draw	Powder River	28.84	SWSW	31	53	75	44.522748	-105.937028	Campbell	Chad (On-Channel)
Add Reservoir	006	Mose Draw	Powder River	23.97	SWSW	23	53	76	44.551520	-105.977660	Campbell	Floyd 14-23-5376 and Willow Tree (On-Channel)
—	007	Croton Draw	Powder River	23.65	SWNW	23	53	76	44.559270	-105.978240	Campbell	Rick's Little (On-Channel)
—	008	Well Draw	Powder River	27.39	NWSW	30	53	75	44.540583	-105.934907	Campbell	James (On-Channel)
—	009	T.F. Draw	Powder River	24.86	NWNW	24	53	76	44.562800	-105.958470	Campbell	Ty (On-Channel)
—	010	R.F. Draw	Powder River	24.64	NENE	23	53	76	44.563690	-105.961350	Campbell	Jason (On-Channel)
—	011	J.F. Draw	Powder River	25.64	SWNE	24	53	76	44.558820	-105.946410	Campbell	Ryan (On-Channel)
—	012	Tributary to Wild Horse Creek	Powder River	24.62	SESE	23	53	76	44.550120	-105.963241	Campbell	Bull Pen (On-Channel)
Update Qrt/Qrt from	013	Wild Horse Creek	Powder River	23.84	NESW	23	53	76	44.555427	-105.977985	Campbell	—
Update Qrt/Qrt to	013	Wild Horse Creek	Powder River	23.84	NWSW	23	53	76	44.555427	-105.977985	Campbell	—

Table 1A - Outfall Information: WY0049697 - Echeta Road Unit

Desired Changes	Station Name	Station Description	Qrtr / Qtr	Sec	Twn (N)	Rng (W)	NAD 83 Latitude*	NAD 83 Longitude*	Notes regarding water quality monitoring station types
–	DPR	Downstream Powder River Water Quality Monitoring Station	NWSE	34	55	77	44.696945	-106.112944	–
–	IMP1	Irrigation Monitoring Point	NWNE	23	53	76	44.563125	-105.965718	–
–	IMP2	Irrigation Monitoring Point	NWSW	23	53	76	44.554053	-105.978107	–
Update Qrt/Qrt from	IMP3	Irrigation Monitoring Point	NWSW	23	53	76	44.555602	-105.972576	–
Update Qrt/Qrt to	IMP3	Irrigation Monitoring Point	NESW	23	53	76	44.555602	-105.972576	–
–	IMP4	Irrigation Monitoring Point	SWNW	23	53	76	44.559513	-105.978903	–
–	IMP5	Irrigation Monitoring Point	NWSW	23	53	76	44.555397	-105.978992	–
Add	IMP6	Irrigation Monitoring Point	SENE	26	53	76	44.545733	-105.962399	–
Add	IMP7	Irrigation Monitoring Point	NWSW	25	53	76	44.541709	-105.954608	–
Add	IMP8	Irrigation Monitoring Point	SWSW	25	53	76	44.538450	-105.955352	–
Add	IMP9	Irrigation Monitoring Point	SESE	36	53	76	44.521738	-105.938632	–
–	TRIB1	Tributary Water Quality Monitoring Station	SESE	16	54	77	44.650442	-106.122148	–
–	UPR	Upstream Powder River Water Quality Monitoring Station	NWSW	16	54	77	44.650361	-106.128360	–

** Note Lat longs are presented in NAD 83, whereas previous permit versions had NAD 27.*

Table 1B - Outfall Information: WY0049697 - Echeta Road Unit

Discharge Point (Outfalls) #	Immediate Receiving Stream	Mainstem	Distance to Closest 2AB Channel & Mainstem (Miles)	Qtr / Qtr	Sec	Twn (N)	Rng (W)	NAD 83 Latitude*	NAD 83 Longitude*	County	Reservoir Name and Type
001	Wyo Draw	Powder River	24.19	SWNE	23	53	76	44.557600	-105.968880	Campbell	Rick's (On-Channel)
002	Wilson Draw	Powder River	26.24	SWNE	25	53	76	44.544752	-105.946466	Campbell	Boone (On-Channel)
003	South Lacy Draw	Powder River	26.17	NESW	25	53	76	44.542271	-105.951052	Campbell	N & S Lacy (On-Channel)
004	Wilson Draw	Powder River	25.67	SWNW	25	53	76	44.545023	-105.956726	Campbell	004 (On-Channel)
005	Chad Draw	Powder River	28.84	SWSW	31	53	75	44.522748	-105.937028	Campbell	Chad (On-Channel)
006	Mose Draw	Powder River	23.97	SWSW	23	53	76	44.551520	-105.977660	Campbell	Floyd 14-23-5376 and Willow Tree (On-Channel)
007	Croton Draw	Powder River	23.65	SWNW	23	53	76	44.559270	-105.976240	Campbell	Rick's Little (On-Channel)
008	Well Draw	Powder River	27.39	NWSW	30	53	75	44.540583	-105.934907	Campbell	James (On-Channel)
009	T.F. Draw	Powder River	24.86	NWNW	24	53	76	44.562800	-105.958470	Campbell	Ty (On-Channel)
010	R.F. Draw	Powder River	24.64	NENE	23	53	76	44.563690	-105.961350	Campbell	Jason (On-Channel)
011	J.F. Draw	Powder River	25.64	SWNE	24	53	76	44.558820	-105.946410	Campbell	Ryan (On-Channel)
012	Tributary to Wild Horse Creek	Powder River	24.62	SESE	23	53	76	44.550120	-105.963241	Campbell	Bull Pen (On-Channel)
013	Wild Horse Creek	Powder River	23.84	NWSW	23	53	76	44.555427	-105.977985	Campbell	

Table 1B - Outfall Information: WY0049697 - Echeta Road Unit

Station Name	Station Description	Quarter / Quarter	Sec	Twn (N)	Rng (W)	NAD 83 Latitude*	NAD 83 Longitude*	Notes regarding water quality monitoring station types
DPR	Downstream Powder River Water Quality Monitoring Station	NWSE	34	55	77	44.696945	-106.112944	–
IMP1	Irrigation Monitoring Point	NWNE	23	53	76	44.563125	-105.965718	–
IMP2	Irrigation Monitoring Point	NWSW	23	53	76	44.554053	-105.978107	–
IMP3	Irrigation Monitoring Point	NESW	23	53	76	44.555602	-105.972576	–
IMP4	Irrigation Monitoring Point	SWNW	23	53	76	44.559513	-105.978903	–
IMP5	Irrigation Monitoring Point	NWSW	23	53	76	44.555397	-105.978992	–
IMP6	Irrigation Monitoring Point	SENE	26	53	76	44.545733	-105.962399	–
IMP7	Irrigation Monitoring Point	NWSW	25	53	76	44.541709	-105.954608	–
IMP8	Irrigation Monitoring Point	SWSW	25	53	76	44.538450	-105.955352	–
IMP9	Irrigation Monitoring Point	SESE	36	53	76	44.521738	-105.938632	–
TRIB1	Tributary Water Quality Monitoring Station	SESE	16	54	77	44.650442	-106.122148	–
UPR	Upstream Powder River Water Quality Monitoring Station	SWSE	16	54	77	44.650361	-106.128360	–

** Note Lat longs are presented in NAD 83, whereas previous permit versions had NAD 27.*

Table 2 - Well Information: WY0049697 - Echeta Road Unit

Change	Well Name	API Number	Coal Seam	Well Depth	Location (QQ, Section, Township, Range)	Discharges to Outfall #*
*AWAO - All wells permitted to discharge to all outfalls						
—	Clabaugh Ranch State 12-16-5376	49-033-26143	Wall	1538	SWNW 16-53-76	AWAO
—	Clabaugh State 23-16-5376	49-033-23641	Wall	1534	NESW 16-53-76	AWAO
—	Clabaugh State 34-16-5376	49-005-48719	Wall	1563	SWSE 16-53-76	AWAO
—	Floyd L & L 12-23-5376G	49-005-47988	Gates	1337	SWNW 23-53-76	AWAO
—	Floyd L & L 12-23-5376W	49-005-48002	Werner	1017	SWNW 23-53-76	AWAO
—	Floyd L & L 12-23-5376A	49-005-48004	Anderson	796	SWNW 23-53-76	AWAO
—	Floyd L & L 14-23-5376G	49-005-47997	Gates	1349	SWSW 23-53-76	AWAO
—	Floyd L & L 14-23-5376W	49-005-47974	Werner	1044	SWSW 23-53-76	AWAO
—	Floyd L & L 14-23-5376A	49-005-48003	Anderson	865	SWSW 23-53-76	AWAO
—	Floyd L & L 21-23-5376W	49-005-47975	Werner	1075	NENW 23-53-76	AWAO
—	Floyd L & L 21-23-5376A	49-005-48008	Anderson	944	NENW 23-53-76	AWAO
—	Floyd L & L 21-23-5376G	49-005-47996	Gates	1495	NENW 23-53-76	AWAO
—	Floyd L & L 23-23-5376W	49-005-47976	Werner	922	NESW 23-53-76	AWAO
—	Floyd L & L 23-23-5376G	49-005-47995	Gates	1333	NESW 23-53-76	AWAO
—	Floyd L & L 23-23-5376A	49-005-48009	Anderson	793	NESW 23-53-76	AWAO
—	Floyd L & L 32-23-5376A	49-005-48010	Anderson	900	SWNE 23-53-76	AWAO
—	Floyd L & L 32-23-5376G	49-005-47994	Gates	1410	SWNE 23-53-76	AWAO
—	Floyd L & L 32-23-5376W	49-005-47977	Werner	1024	SWNE 23-53-76	AWAO
—	Floyd L & L 34-23-5376G	49-005-47985	Gates-Wall	1235	SWSE 23-53-76	AWAO
—	Floyd L & L 34-23-5376A	49-005-48015	Anderson	777	SWSE 23-53-76	AWAO
—	Floyd L & L 34-23-5376W	49-005-47981	Werner	910	SWSE 23-53-76	AWAO
—	Floyd L & L 41-23-5376G	49-005-47984	Gates	1440	NENE 23-53-76	AWAO
—	Floyd L & L 41-23-5376A	49-005-48016	Anderson	935	NENE 23-53-76	AWAO
—	Floyd L & L 41-23-5376W	49-005-47982	Werner	1075	NENE 23-53-76	AWAO
—	Floyd L&L Fed 43-23-5376WA	49-005-56921	Wall	1666	NESE 23-53-76	AWAO
—	R Floyd 12-24-5376A	49-005-48017	Anderson	966	SWNW 24-53-76	AWAO
—	R Floyd 12-24-5376G	49-005-47983	Gates	1432	SWNW 24-53-76	AWAO
—	R Floyd 12-24-5376W	49-005-47973	Wall-Gates	1065	SWNW 24-53-76	AWAO
—	R Floyd 14-24-5376W	49-005-47970	Werner	1035	SWSW 24-53-76	AWAO
—	R Floyd 14-24-5376G	49-005-47971	Wall-Gates	1397	SWSW 24-53-76	AWAO
—	R Floyd 14-24-5376A	49-005-47972	Anderson	898	SWSW 24-53-76	AWAO
—	R Floyd Fed 21-24-5376WA	49-005-56923	Wall	1868	NENW 24-53-76	AWAO
—	R Floyd Fed 23-24-5376WA	49-005-57609	Wall	1761	NESW 24-53-76	AWAO
—	R Floyd 32-24-5376G	49-005-47966	Gates	1473	SWNE 24-53-76	AWAO
—	R Floyd 32-24-5376W	49-005-47964	Werner	1153	SWNE 24-53-76	AWAO
—	R Floyd 32-24-5376A	49-005-47968	Anderson	1021	SWNE 24-53-76	AWAO
—	Federal 34-24-5376WA	49-005-57785	Wall	1725	SWSE 24-53-76	AWAO
—	R Floyd Fed 43-24-5376WA	49-005-57608	Wall	1977	NESE 24-53-76	AWAO
—	Floyd L&L 12-25-5376G	49-005-47965	Gates	1256	SWNW 25-53-76	AWAO
—	Floyd L&L 12-25-5376A	49-005-47963	Anderson	825	SWNW 25-53-76	AWAO
—	Floyd L&L 12-25-5376W	49-005-47967	Werner	970	SWNW 25-53-76	AWAO
—	Floyd L&L 14-25-5376A	49-005-47969	Anderson	790	SWSW 25-53-76	AWAO
—	Floyd L & L 14-25-5376G	49-005-47992	Gates	1294	SWSW 25-53-76	AWAO
—	Floyd L & L 14-25-5376W	49-005-47998	Werner	960	SWSW 25-53-76	AWAO
—	Floyd L & L 21-25-5376W	49-005-47999	Werner	1025	NENW 25-53-76	AWAO
—	Floyd L & L 21-25-5376G	49-005-47991	Gates	1316	NENW 25-53-76	AWAO
—	Floyd L & L 21-25-5376A	49-005-48007	Anderson	910	NENW 25-53-76	AWAO
—	Floyd L & L 23-25-5376W	49-005-48000	Werner	973	NESW 25-53-76	AWAO
—	Floyd L & L 23-25-5376G	49-005-47990	Gates	1308	NESW 25-53-76	AWAO
—	Floyd L & L 23-25-5376A	49-005-48006	Anderson	793	NESW 25-53-76	AWAO
—	Floyd L & L 32-25-5376W	49-005-48001	Werner	987	SWNE 25-53-76	AWAO
—	Floyd L & L 32-25-5376G	49-005-47989	Gates	1298	SWNE 25-53-76	AWAO
—	Floyd L&L 32-25-5376A-R	49-005-50972	Anderson	897	SWNE 25-53-76	AWAO

Table 2 - Well Information: WY0049697 - Echeta Road Unit

Change	Well Name	API Number	Coal Seam	Well Depth	Location (QQ, Section, Township, Range)	Discharges to Outfall #*
*AWAO - All wells permitted to discharge to all outfalls						
—	Floyd L & L 34-25-5376G	49-005-47993	Gates	1288	SWSE 25-53-76	AWAO
—	Floyd L & L 34-25-5376A	49-005-48011	Anderson	864	SWSE 25-53-76	AWAO
—	Floyd L & L 34-25-5376W	49-005-47978	Werner	1008	SWSE 25-53-76	AWAO
—	Floyd L & L 41-25-5376W	49-005-47979	Werner	1075	NENE 25-53-76	AWAO
—	Floyd L & L 41-25-5376A	49-005-48012	Anderson	952	NENE 25-53-76	AWAO
—	Floyd L & L 41-25-5376G	49-005-47987	Gates	1433	NENE 25-53-76	AWAO
—	Floyd L & L 43-25-5376A	49-005-48013	Anderson	858	NESE 25-53-76	AWAO
—	Floyd L & L 43-25-5376W	49-005-47980	Werner	982	NESE 25-53-76	AWAO
—	Floyd L & L 43-25-5376G	49-005-47986	Gates	1348	NESE 25-53-76	AWAO
—	Floyd State 12-26-5376WA	49-005-54322	Anderson-Werner-Wall	1375	SWNW 26-53-76	AWAO
—	Floyd L&L 21-26-5376W	49-005-47950	Werner	1005	NENW 26-53-76	AWAO
—	Floyd L&L 21-26-5376G	49-005-47946	Gates	1310	NENW 26-53-76	AWAO
—	Floyd L&L 21-26-5376A	49-005-48014	Anderson	870	NENW 26-53-76	AWAO
—	Floyd L&L 32-26-5376W	49-005-47953	Werner	950	SWNE 26-53-76	AWAO
—	Floyd L&L 32-26-5376G	49-005-47952	Gates	1276	SWNE 26-53-76	AWAO
—	Floyd L&L 32-26-5376A	49-005-47951	Anderson	816	SWNE 26-53-76	AWAO
—	Floyd L&L 41-26-5376G	49-005-47955	Gates	1264	NENE 26-53-76	AWAO
—	Floyd L&L 41-26-5376W	49-005-47957	Werner	940	NENE 26-53-76	AWAO
—	Floyd L&L 41-26-5376A	49-005-47954	Anderson	809	NENE 26-53-76	AWAO
—	Floyd L&L 43-26-5376A	49-005-47959	Anderson	767	NESE 26-53-76	AWAO
—	Floyd L&L 43-26-5376W	49-005-47962	Werner	954	NESE 26-53-76	AWAO
—	Floyd L&L 43-26-5376G	49-005-47961	Gates	1228	NESE 26-53-76	AWAO
—	Floyd L&L Fed 32-34-5376WA	49-005-58236	Wall	1887	SWNE 34-53-76	AWAO
—	Floyd L&L Fed 41-34-5376WA	49-005-56922	Wall	1784	NENE 34-53-76	AWAO
—	Floyd L&L Fed 12-35-5376WA	49-005-56924	Wall	1761	SWNW 35-53-76	AWAO
—	Floyd 14-35-5376WA	49-005-54318	Wall	1685	SWSW 35-53-76	AWAO
—	Floyd State 21-35-5376WA	49-005-54321	Wall	1464	NENW 35-53-76	AWAO
—	Floyd L&L Fed 23-35-5376WA	49-005-56925	Wall	1771	NESW 35-53-76	AWAO
—	Floyd State 32-35-5376WA	49-005-54319	Wall	1447	SWNE 35-53-76	AWAO
—	Floyd L&L Fed 34-35-5376WA	49-005-56926	Wall	1803	SWSE 35-53-76	AWAO
—	Floyd State 41-35-5376WA	49-005-54320	Anderson-Wall-Werner	1275	NENE 35-53-76	AWAO
—	Floyd L&L Fed 43-35-5376WA	49-005-56927	Wall	1630	NESE 35-53-76	AWAO
—	State 12-36-5376W	49-005-48684	Werner	1002	SWNW 36-53-76	AWAO
—	State 12-36-5376G	49-005-48681	Gates	1280	SWNW 36-53-76	AWAO
—	State 12-36-5376A	49-005-48675	Anderson	822	SWNW 36-53-76	AWAO
—	State 13-36-5376W	49-005-49002	Werner	1040	NWSW 36-53-76	AWAO
—	State 13-36-5376G	49-005-49001	Gates	1328	NWSW 36-53-76	AWAO
—	State 13-36-5376A	49-005-49000	Anderson	870	NWSW 36-53-76	AWAO
—	State 21-36-5376W	49-005-48682	Werner	965	NENW 36-53-76	AWAO
—	State 21-36-5376G	49-005-48679	Gates	1285	NENW 36-53-76	AWAO
—	State 21-36-5376A	49-005-48677	Anderson	822	NENW 36-53-76	AWAO
—	State 23-36-5376W	49-005-48683	Werner	1002	NESW 36-53-76	AWAO
—	State 23-36-5376G	49-005-48680	Gates	1310	NESW 36-53-76	AWAO
—	State 23-36-5376A	49-005-48676	Anderson	812	NESW 36-53-76	AWAO

Total Number of Wells: 97

Table 3 - Reservoir Information: WY0049697 - Echeta Road Unit

Desired Changes	Reservoir Name	Reservoir Storage Volume (acre/feet)	SEO Permit #	SEO Reservoir Requirements	Location				Geographic Location*	
					Qtr/ Qtr	Sec	Township (N)	Range (W)	NAD 83 Latitude	NAD 83 Longitude
—	004	9.1	P171495	—	SWNW	25	53	76	44.545514	-105.958111
—	Boone	12	P15146S	—	SENW	25	53	76	44.546230	-105.952206
—	Bull Pen	0.32	P17104S	—	NENE	26	53	76	44.549770	-105.963784
—	Chad	8.16	P15098S	—	SWSW	31	53	75	44.522344	-105.937145
—	James	1.73	P15159S	—	NWSW	30	53	75	44.540417	-105.935571
—	Jason	1.35	P15148S	—	NENE	23	53	76	44.563506	-105.962940
—	N & S Lacy	13.8	P15147S	—	NESW	25	53	76	44.541508	-105.952771
—	Rick's	1.98	P15149S	—	NESW	23	53	76	44.556695	-105.969967
—	Rick's Little	5.58	P15137S	—	SWNW	23	53	76	44.559451	-105.978298
—	Ryan	2.2	P15150S	—	SWNE	24	53	76	44.558860	-105.946834
—	Ty	5.04	P15151S	—	NWNW	24	53	76	44.562403	-105.959207
Add	Floyd 14-23-5376	0.19	34/5/38S	—	SWSW	23	53	76	44.551928	-105.977857
—	Willow Tree	7.96	P15138S	—	NWSW	23	53	76	44.563639	-105.976778

*Geographic location for on-channel impoundments represents the approximate of Center of Dam - Center of Channel, location for off-channel impoundments represents the approximate center of the impoundment.

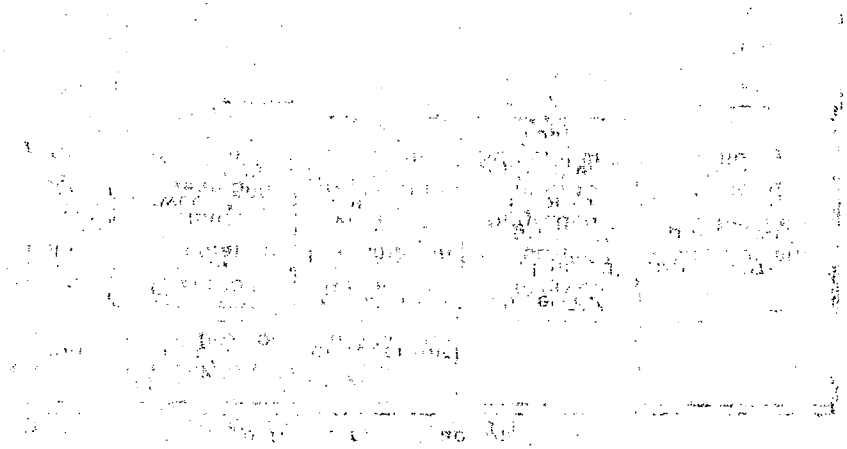


Table 4 - Bonding Information: WY0049697 - Echeta Road Unit

			Please check only one "reservoir reclamation volume" box for each reservoir				
Desired Changes	Reservoir Name	Reservoir Bonding Authority	Reservoir Reclamation Volume* less than 5000 cubic yards?	Reservoir Reclamation Volume* between 5000 and 10,000 cubic yards	Reservoir Reclamation Volume* greater than 10,000 cubic yards	Reservoir constructed/ upgraded** prior to September 1, 2005	Bond Currently posted with bonding authority?
–	Rick's Little	WDEQ	–	–	X	Y	Yes
–	Rick's	WDEQ	X	–	–	Y	Yes
–	N & S Lacy	WDEQ	–	–	X	Y	Yes
–	Willow Tree	WDEQ	–	X	–	Y	Yes
Add	Floyd 14-23-5376	WDEQ	X	–	–	Y	Yes
–	Ty	WDEQ	–	–	X	Y	Yes
–	Ryan	WDEQ	–	X	–	Y	Yes
–	Bull Pen	WDEQ	X	–	–	N	Yes
–	Boone	WDEQ	X	–	–	Y	Yes
–	004	WDEQ	–	X	–	Y	Yes
–	Jason	WDEQ	X	–	–	Y	Yes
–	James	WDEQ	X	–	–	Y	Yes
–	Chad	WDEQ	–	–	X	Y	Yes

* "Reservoir Reclamation Volume" is the volume of backfill and/or topsoil needed to fill the reservoir upon reclamation, in cubic yards. This can also be measured in the amount of material that was excavated to create the reservoir. Please note that reservoir information is not required if reservoir containment is not part of the facility's water management plan - for instance, information about existing "incidental" downstream reservoirs is not required.

** "Reservoir constructed/upgraded" information relates to the September 2005 memo regarding topsoil storage on-site. A 'NO' response in this column represents that either the reservoir is not constructed or that it requires upgrades which would require topsoil stockpiling on site. A 'Yes' response in this column represents that the reservoir has been constructed prior to September 2005 and any upgrades, if required, do not require the stockpiling of topsoil.

Table 5b: Annual, Twenty-four-hour, Reservoir Water Budget Estimate for Option 2 Facilities:

WY0049697 - Echeta Road Unit

Reservoir(s) can contain all CBM discharge during dry (no precipitation or storm runoff) operating conditions - YES

Calendar Year	Total Number of Wells Discharging to Outfall(s)	Discharge rate per well (gallons per minute)[1]	Total Number of Reservoir(s)	Total All Reservoir(s) Surface Area (acres)	Total All Reservoir(s) Freeboard Capacity (acre feet)[2]	CBM Inflows (acre feet)	Potential Outflows (acre feet)			Excess Capacity (All Reservoir(s) Freeboard Capacity) – (Total CBM Inflow – Total Outflow)
						Total CBM Discharge to Reservoir(s)[3]	Evaporation[4]	Infiltration[5]	Total Outflow	
Year 1	86	6.78	13	15.80	33.58	2.58	0.00	0.78	0.78	31.78
Year 2	97	6.01	13	15.80	27.42	2.58	0.00	0.73	0.73	25.57
Year 3	97	6.01	13	15.80	36.39	2.58	0.00	0.46	0.46	34.26
Year 4	97	6.01	13	15.80	43.41	2.58	0.00	0.29	0.29	41.12
Year 5	97	6.01	13	15.80	49.33	2.58	0.00	0.18	0.18	46.93

FOOTNOTES

[1] Discharge rate per well equals permitted flow rate (0.84 MGD) * (10^6 gallons/million gallon) / (total wells) / (24hrs/day) / (60 minutes/hr).

[2] Freeboard Capacity is calculated using a CBMA developed water management tool which utilizes well completions schedules, water production decline rates, reservoir infiltration decline rates, summer irrigation rates, treated discharge rates, and monthly evaporation rates. This value reflects the day where the water level in the reservoirs is projected to be at its highest given the projected production rates which are generally less than the permitted flow rate.

[3] Daily CBNG discharge equals (total wells) * (discharge rate per well) * (60 minutes/hr) * (24 hrs/day) / (325851.43 gallons/acre-ft) which equals the permitted flow rate in order to show a worst case scenario.

[4] See attached explanation document for source and formula/rationale for total daily evaporation (all evaporation rates are based upon the surface area of the stored volume of CBNG water rather than the entire surface area).

[5] See attached explanation document for source and formula/rationale for total daily infiltration (all infiltration rates are based upon the stored volume of CBNG water rather than the entire capacity).

ADDITIONAL COMMENTS

Total number of contributing CBNG wells differs, in some years, from the total number of wells listed in Table 2: Well Information because as the project develops, more wells will be brought online.

Some evaporation rates may equal zero because the most conservative day of the year falls in the winter where evaporation is negligible.

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GROUNDWATER & SURFACE WATER HYDROLOGY • WATER RESOURCE MANAGEMENT • ENVIRONMENTAL PERMITTING & COMPLIANCE

Infiltration and Evaporation Rates from Reservoirs

Potential infiltration loss rates can be estimated for CBNG containment reservoirs based on a series of hydrologic studies conducted by the USGS for small stock ponds in the Powder River region of Wyoming. Pertinent findings of available literature for this region of Wyoming are as follows.

USGS Water Supply Paper 1531. *Hydrology of the Upper Cheyenne River Basin: Part A. Hydrology of Stock-Water Reservoirs in Upper Cheyenne River Basin*, by R.C. Culler, 1961. Fifty-four reservoirs with an average surface area of 2.12 acres were monitored for four years, 1951 - 1954. Reported evaporation and seepage loss rates are shown in Table 1.

Table 1: Evaporation and seepage losses from 1951 – 1954 in the Cheyenne River Basin

Year	Evaporation (feet/month)	Seepage (feet/month)
1951	0.41	1.28
1952	0.38	0.80
1953	0.44	0.76
1954	0.41	0.82

The stock-water reservoirs in the Culler study were typically much older bodies of water than CBM-related reservoirs. A newly constructed CBM-related reservoir should have a much higher seepage rate than the seepage rates of reservoirs addressed in the Culler study, especially if the reservoir bottom was excavated relatively deeply according to standard practice.

The following references provide additional guidance:

USGS Water Resources Series No. 47, *Characteristics of Wyoming Stock-Water Ponds and Dike Spreader Systems*, by Verne E. Smith, July 1974. The authors discuss the hydrology of stock-water ponds, evapotranspiration, and seepage. While this study was conducted for stock ponds, the governing concepts are pertinent to CBM water management requirements in small reservoirs.

USGS Water Resources Investigations 82_4105, *Evapotranspiration Rates at Selected Sites in the Powder River Basin, Wyoming and Montana*, by L.W. Lenfest, 1987. This report provides the results of studies at twelve sites where the authors evaluated the effects of alluvial valley width on measured evapotranspiration.

Overall, the above references combined with recent field observations conducted by Hugh Lowham (USGS-retired) provide a reasonably consistent estimate of combined evaporation and seepage losses in newly constructed small reservoirs. Hugh Lowham, P.E., has summarized available data and field observations to yield the following estimates for total loss rates of newly constructed small reservoirs in the Powder River area:

Very small reservoir (2 acre-feet storage volume):	40 gpm
Small reservoir (10 acre-feet storage volume):	80 gpm
Medium, reservoir (20 acre-feet storage volume):	200 gpm
Large Reservoir (200 acre-feet storage volume):	400 gpm

Note that these rates represent *initial combined evapotranspiration and infiltration losses*. Generally, initial infiltration rates decrease with time as a result of: 1) Gradual deterioration of the soil structure. 2) Partial sealing of the wetted soil profile by the formation of surface crust. 3) Detachment and migration of pore-blocking particles. 4) And swelling of clay particles (Hillel, 2004). Steady-state infiltration rates (I_s) can be estimated by dividing initial loss rate estimates, as shown above, by a factor of 3.

Potential evapotranspiration rates for the Powder River Basin have been estimated from evaporation pan studies. Data for evaporation rates in Wyoming are available online from the Western Regional Climate Center (http://www.wrcc.dri.edu/htmlfiles/westevap.final.html#WYOMING). Mean evaporation rates were obtained from studies conducted during an 81-year period (1925-2005) of four-foot Class A evaporation pans at the Gillette 9 ESE Station. Actual lake evaporation rates can be calculated by multiplying observed pan loss rates by a pan coefficient factor of 0.70 (Viessman and Lewis, 2003). Mean and adjusted evaporation values are shown in the Table 2:

Table 2: Powder River Basin Evaporation Rates

Month	Evaporation Mean (inches)	Adjusted Evaporation Mean (inches)
January	0	0
February	0	0
March	0	0
April	4.52	3.16
May	6.4	4.48
June	7.5	5.25
July	9.88	6.92
August	9.44	6.61
September	6.18	4.33
October	4.36	3.05
November	2.39	1.67
December	0	0
Average	4.24	2.97
Average/year	50.67	35.47

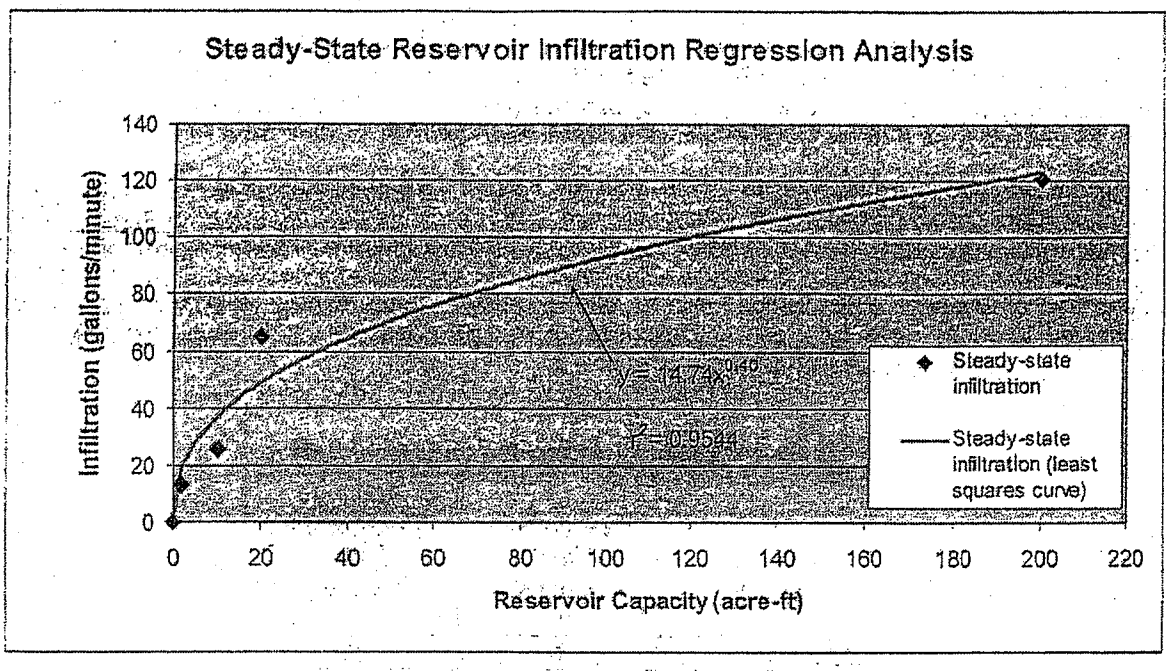
Subtracting average evaporation rates from the Lowham initial total loss rates and dividing by the steady state factor of 3 gives the resulting steady-state infiltration rates, shown below.

Very small reservoir (2 acre-feet storage volume, 0.67 acres of surface area):	12.92 gpm
Small reservoir (10 acre-feet storage volume, 1.36 acres of surface area):	25.84 gpm
Medium, reservoir (20 acre-feet storage volume, 2.49 acres of surface area):	65.15 gpm
Large Reservoir (200 acre-feet storage volume, 20.45 acres of surface area):	120.84 gpm

Curve fitting these data points on a graph yields the following power equation (see graph):

$$y = 14.74x^{0.40}$$

Where y is the steady-state infiltration rate in gallons per minute, and x is the reservoir capacity in acre-ft.



While this equation provides a good approximation of predicted reservoir infiltration, it should be noted that all of the studies cited in this paper exhibit highly variable infiltration rates that are due, at least in part, to site-specific variations in geology and soils. Although this variability may not be fully predictable, the inclusion of additional site-specific data should better constrain actual seepage and evapotranspiration losses at a particular location once a new reservoir is constructed and operated.

References Cited:

Hillel, Daniel. 2004. *Introduction to Environmental Soil Physics*. Academic Press, San Diego, CA. pp. 259-262.

USGS Water Resources Investigations 82_4105, *Evapotranspiration Rates at Selected Sites in the Powder River Basin, Wyoming and Montana*, by L.W. Lenfest, 1987.

USGS Water Resources Series No. 47, *Characteristics of Wyoming Stock-Water Ponds and Dike Spreader Systems*, by Verne E. Smith, July 1974.

USGS Water Supply Paper 1531. *Hydrology of the Upper Cheyenne River Basin: Part A. Hydrology of Stock-Water Reservoirs in Upper Cheyenne River Basin*, by R.C. Culler, 1961.

Viessman, Warren Jr., Gary L. Lewis. 2003. *Introduction to Hydrology – 5th ed.* Prentice Hall, Upper Saddle River, NJ. pp. 155

Western Regional Climate Center. Wyoming Monthly Average Pan Evaporation. Retrieved April 6, 2007 from http://www.wrcc.dri.edu/htmlfiles/westevap.final.html#WYOMING

Flow Data Table WY0049697 Echeta Road Unit

Month	*Total Facility Flow (MGD)	*Total Facility Flow (gpd)
January 2007	0.85	849,100.0
Febuary 2007	0.85	854,700.0
March 2007	0.60	604,000
April 2007	0.56	564,100
May 2007	0.52	520,000
June 2007	0.56	564,600.0
*Average Facility Flow	**0.66**	**659,417**

* Tota and Average Facility Flow are based on actual discharge from outfalls 001, 002, 003,009 and 013 measured January - June 2007.

LABORATORY ANALYTICAL REPORT

Client: Lance Oil and Gas
Site Name: Echeta_Road_Unit
Project: NPDES
Samp FRQ/Type: IN_A_S1_M
Client Sample ID: DP_WY0049697_004_ET3
Location: NESW_25_53N_76W

Lab ID: G04050016-002
Report Date: 05/19/04
Collection Date: 04/30/04 16:40
DateReceived: 05/03/04
Sampled By: Toby Westbrook
Matrix: AQUEOUS
Tracking Number: 30984

Analyses	Result	Units	Qualifiers	RL	QCL	Method	Analysis Date / By
FIELD PARAMETERS							
pH, field	7.42	s.u.				FIELD	04/30/04 16:40 / ***
*** Performed by Sampler							
MAJOR IONS							
Bicarbonate as HCO3	1610	mg/L		5		A2320 B	05/03/04 19:11 / mli
Chloride	15	mg/L		1		E300.0	05/04/04 18:45 / mli
Fluoride	0.6	mg/L		0.1		E300.0	05/04/04 18:45 / mli
Sulfate	ND	mg/L		1		E300.0	05/04/04 18:45 / mli
Calcium	45	mg/L		1		E200.7	05/04/04 23:21 / rlh
Magnesium	26	mg/L		1		E200.7	05/04/04 23:21 / rlh
Potassium	31	mg/L		1		E200.7	05/04/04 23:21 / rlh
Sodium	464	mg/L	D	2		E200.7	05/04/04 23:21 / rlh
MAJOR IONS - MILLIEQUIVALENTS							
Calcium, meq	2.27	meq/L		0.05		E200.7	05/04/04 23:21 / rlh
Magnesium, meq	2.11	meq/L		0.08		E200.7	05/04/04 23:21 / rlh
Sodium, meq	20.2	meq/L	D	0.07		E200.7	05/04/04 23:21 / rlh
METALS, DISSOLVED							
Boron	163	ug/L	D	200		E200.7	05/04/04 23:21 / rlh
Cadmium	ND	ug/L		0.1		E200.8	05/06/04 19:37 / jw
Chromium	1	ug/L		1		E200.8	05/06/04 19:37 / jw
Copper	ND	ug/L		1		E200.8	05/06/04 19:37 / jw
Iron	115	ug/L		30		E200.7	05/04/04 23:21 / rlh
Lead	ND	ug/L		2		E200.8	05/06/04 19:37 / jw
Manganese	52	ug/L		10		E200.7	05/04/04 23:21 / rlh
Mercury	ND	ug/L		0.08		E200.8	05/06/04 19:37 / jw
Nickel	ND	ug/L		10		E200.8	05/06/04 19:37 / jw
Silver	ND	ug/L		3		E200.8	05/06/04 19:37 / jw
Zinc	16	ug/L		10		E200.7	05/04/04 23:21 / rlh
METALS, TOTAL							
Barium	2040	ug/L		100		E200.7	05/06/04 03:54 / rlh
METALS, TOTAL RECOVERABLE							
Aluminum	ND	ug/L		50		E200.7	05/06/04 03:49 / rlh
Antimony	ND	ug/L		5		E200.8	05/06/04 19:30 / jw
Arsenic	0.1	ug/L		0.1		E200.8	05/06/04 19:30 / jw
Beryllium	ND	ug/L		0.03		E200.8	05/06/04 19:30 / jw

Report Definitions: RL - Analyte reporting limit. QCL - Quality control limit. D - RL increased due to sample matrix interference. MCL - Maximum contaminant level. ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Client: Lance Oil and Gas
Site Name: Echeta_Road_Unit
Project: NPDES
Samp FRQ/Type: IN_A_S1_M
Client Sample ID: DP_WY0049697_004_ET3
Location: NESW_25_53N_76W

Lab ID: G04050016-002
Report Date: 05/19/04
Collection Date: 04/30/04 16:40
DateReceived: 05/03/04
Sampled By: Toby Westbrook
Matrix: AQUEOUS
Tracking Number: 30984

Analyses	Result	Units	Qualifiers	RL	QCL	Method	Analysis Date / By
METALS, TOTAL RECOVERABLE							
Selenium	ND	ug/L		5		E200.8	05/06/04 19:30 / jw
Thallium	ND	ug/L		1		E200.8	05/06/04 19:30 / jw
NON-METALS							
Alkalinity, Total as CaCO3	1320	mg/L		5		A2320 B	05/03/04 19:11 / mli
Conductivity @ 25 C	2210	umhos/cm		1		A2510 B	05/03/04 16:20 / ser
Cyanide, Total Automated	ND	ug/L		5		E335.3	05/04/04 11:40 / kp
Hardness as CaCO3	219	mg/L		10		A2340 B	05/11/04 17:01 / cw
Phenolics, Total Recoverable	ND	ug/L		10		E420.2	05/11/04 10:04 / kp
Sodium Adsorption Ratio (SAR)	13.6	unitless		0.1		Calculation	05/11/04 17:01 / cw
Solids, Total Dissolved TDS @ 180 C	1370	mg/L		20		A2540 C	05/04/04 12:04 / mli
Total Petroleum Hydrocarbons	ND	mg/L		1.0		SW1664A	05/04/04 11:52 / aps
DATA QUALITY							
A/C Balance	-2.84	%				A1030 E	05/11/04 16:54 / cw
Anions	26.8	meq/L		0.01		A1030 E	05/11/04 16:54 / cw
Cations	25.3	meq/L		0.01		A1030 E	05/11/04 16:54 / cw
RADIOCHEMICAL							
Radium 226	0.9	pCi/L		0.2		E903.0M	05/17/04 15:36 / df
Radium 226 precision (±)	0.3	pCi/L				E903.0M	05/17/04 15:36 / df

Report Definitions: RL - Analyte reporting limit. QCL - Quality control limit. MCL - Maximum contaminant level. ND - Not detected at the reporting limit.

CBM Associates, Inc.
920 E. Sheridan St. • Laramie, WY 82070 • Office: (307) 742-4991 • Fax: (307) 745-1582

GROUNDWATER & SURFACE WATER HYDROLOGY • WATER RESOURCE MANAGEMENT • ENVIRONMENTAL PERMITTING & COMPLIANCE

July 24, 2007

Wyoming Department of Environmental Quality
Water Quality Division
122 West 25th Street
Herschler Building, 4W
Cheyenne, Wyoming 82002

RE: COMPLIANCE EVALUATION for WYPDES Permit Application
Lance Oil & Gas Company, Inc.
Renewal for: Echeta Road Unit, WY0049697

Dear Water Quality Division,

This letter outlines specific requests for WYPDES permit requirement updates and provides information to address 'Item 22' in the application for a renewal of the above-referenced WYPDES permit.

Specific Requests for WYPDES Permit Updates
In addition to those items referenced on the cover letter of this application, Lance Oil & Gas Company, Inc. requests that this renewal:

- Replace total recoverable aluminum requirements with dissolved aluminum requirements;
- Raise the total recoverable arsenic limit in accordance with the antidegredation policy and new Chapter 1 standard, and;
- Remove the end-of-pipe SAR limit at outfalls 001-012. Instead, and as done in recent Public Notice permits, apply a fixed EC limit and a Hanson-derived SAR limit at an irrigation monitoring point.

Item 22 of WYPDES Application
This permit has exceeded permit limits and/or water quality standards prior to submission of this application. CBM Associates, Inc. (CBMA) provides the following information, but cannot claim it is 100% accurate or all inclusive of exceedances.

22.a:
This permit has exceeded permit and/or water quality standards for the following constituents:

- Total barium (Ba)
- Dissolved chloride (Cl)
- Dissolved copper (Cu)
- Electrical conductivity (EC)
- Dissolved iron (Fe)
- Field pH
- Total radium 226 (Ra 226)
- Sodium adsorption ratio (SAR)

22.b and 22.c:
The attached Exceedance Summary Table outlines sampling, mitigation, and compliance activities for the above constituents since CBMA became aware of the potential or verified water quality concerns. The table specifically outlines the exceeding parameter, sample results, dates of correspondence to the WDEQ, and resolution methods.

Additional Note:
CBMA is concerned that older data, which may not be representative of current water quality or facility conditions, may be used to set permit monitoring and limit requirements. Based on the age of this permit, CBMA requests to work with WDEQ regarding any older data that WDEQ believes to be of concern during the permitting renewal process.

Thank you for your consideration. If you have any questions regarding past exceedances or exceedances that WDEQ considers outstanding, please feel free to contact me at (307) 742-4991 or clore@cbmainc.com.

Sincerely,
CBM Associates, Inc.

Caroline Lo Ré Brewer

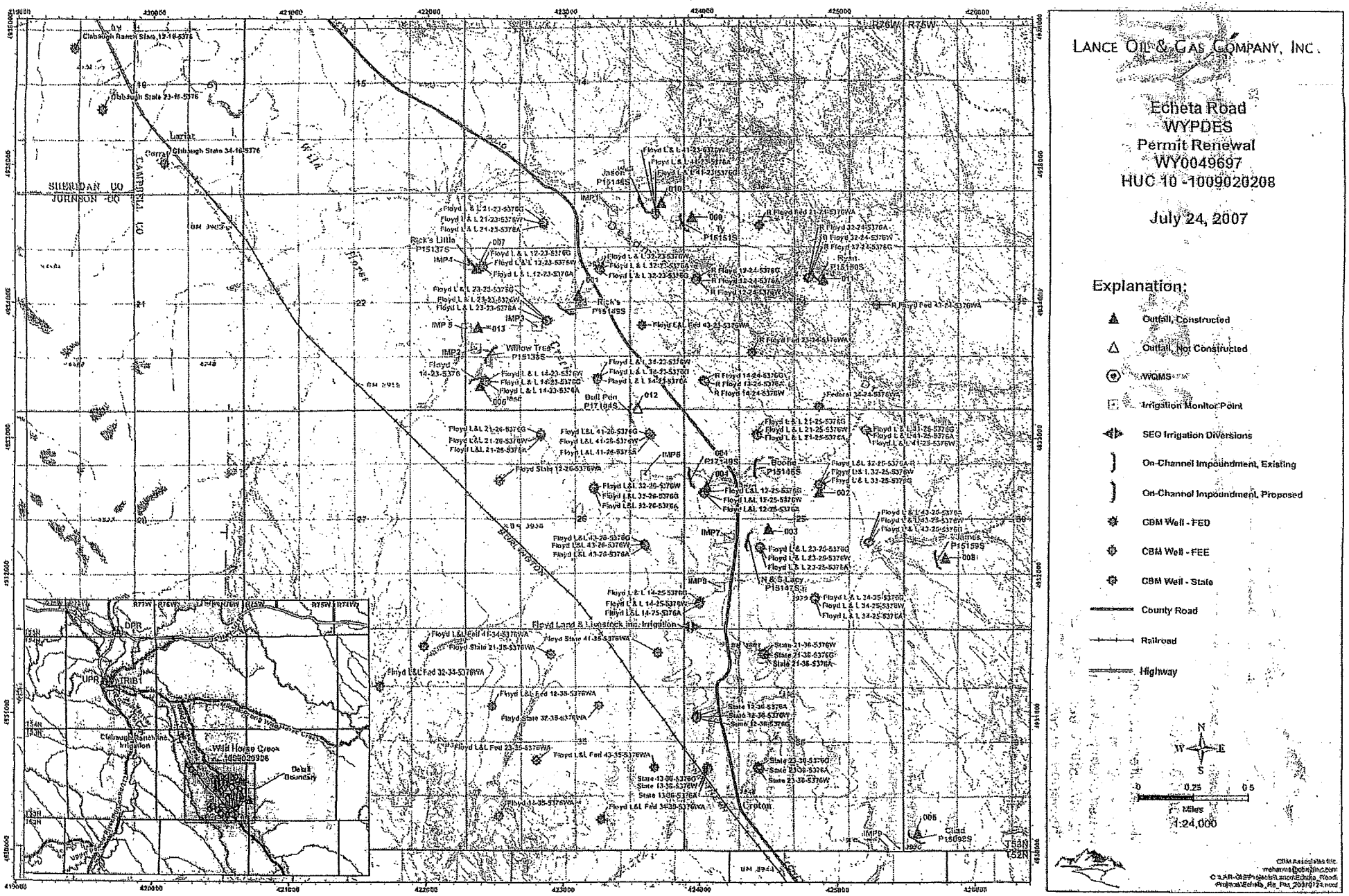
Caroline Lo Ré Brewer
Environmental Compliance Professional

dr/CB

CH2M Hill Companies, Ltd.

Lance Oil & Gas Company, Inc.
WYPDES Permit WY0049697: Exceedance Summary Table

Permitted Station	Permit Name	Exceeding Constituent	Sample Date	Sample Result	Date Reported to WDEQ	Compliance Attained Y/N	Resolution Method / Additional Information	Resample Date	Resample Result	Date Reported to WDEQ	Compliance Attained Y/N	Resolution Method / Additional Information	Resample Date	Resample Result	Date Reported to WDEQ	Compliance Attained Y/N	Resolution Method / Additional Information	Additional Comments
DP_WY0049697_001	Echeta Road Unit	Fe, dissolved	2/17/05	434 µg/L	3/10/05	No	Submit modification to raise limit	1/3/06	202 µg/L	2/21/06	Yes	Complete. In compliance. In addition, LOG submitted modification to raise limit						
DP_WY0049697_001	Echeta Road Unit	SAR	4/17/07	23 8 unitless	5/31/07	No	Refurbish using gypsum-feed treatment pathway and standard field techniques.	5/15/07	22 2 unitless	6/13/07	No	LOG has already initiated refurbishment efforts using a gypsum-feed treatment pathway.	6/15/07 7/2/07	13.5 unitless 12.5 unitless	Draft to WDEQ in Progress	Yes	Two consecutive sample results indicate passive treatment is effective. The next routine sample event will be used to fully resolve.	
DP_WY0049697_001	Echeta Road Unit	EC	6/15/07 7/2/07	2410 umhos/cm 2630 umhos/cm	7/23/07	No	Further enhance existing passive treatment pathway.											
DP_WY0049697_002	Echeta Road Unit	Fe, dissolved	4/30/04	311 ppb	5/22/04	No	Resample to confirm	NEA	N/A	12/22/04	No	Update letter to WDEQ to indicate that modification is in progress that will request limit be raised.	1/3/06	256 µg/L	2/21/06	Yes	Complete. In compliance. In addition, LOG submitted modification to raise limit.	
DP_WY0049697_003	Echeta Road Unit	Fe, dissolved	3/23/04	316 ppb	4/19/04	No	Resample to confirm	5/17/04	94 µg/L	6/8/04	Yes	Complete. In compliance						
DP_WY0049697_004	Echeta Road Unit	Ba, total recoverable	4/30/04	2040 µg/L	5/22/04	No	Resample to confirm	7/22/04	2210 µg/L	9/8/04	No	Construct passive treatment pathway	7/22/04	2210 µg/L	5/25/05	No	Passive treatment pathway constructed, but outfall has not flowed in order to verify effectiveness.	
Continued from line above:			11/9/05	456 ppb	12/20/05	Yes	Complete. Passive treatment successful											
DP_WY0049697_004	Echeta Road Unit	Fe, dissolved	11/9/05	351 µg/L	12/20/05	No	LOG submitted modification to raise limit	1/3/06	142 µg/L	2/21/06	Yes	Complete. In compliance. In addition, LOG submitted modification to raise limit						
DP_WY0049697_005	Echeta Road Unit	Fe, dissolved	7/18/05	577 µg/L	2/9/05	No	Submit modification to raise limit.	1/3/06	117 µg/L	2/21/06	Yes	Complete. In compliance. In addition, LOG submitted modification to raise limit						
DP_WY0049697_005	Echeta Road Unit	Ra 226, total	7/15/04	1 5 ± 0.2 pCi/L	8/31/04	No	Resample to confirm	1/18/05	0 4 ± 0.3 pCi/L	2/8/05	No	Complete. In compliance						
DP_WY0049697_005	Echeta Road Unit	Ra 228, total	1/4/06	2 6 ± 0.7 pCi/L	2/24/06	No	Resample twice to confirm	1/4/06	2 6 ± 0 7 pCi/L	4/3/06	Yes	In compliance. Modification signed 2/23/06 raised limit						
DP_WY0049697_009	Echeta Road Unit	SAR	4/17/07	27 1 unitless	5/31/07	No	Refurbish using gypsum-feed treatment pathway and standard field techniques.	5/15/07	13.8 unitless	Draft to WDEQ in Progress	Yes	LOG will collect two additional samples to confirm compliance is maintained						
DP_WY0049697_013	Echeta Road Unit	Cl, dissolved	10/23/06	53 mg/l	11/16/06	No	Submitted modification to raise limit	10/30/06	28 mg/l	11/16/06	Yes	Submitted modification to raise limit	3/20/07	23 mg/l	5/3/07	Yes	Complete. Modification effective 3/23/2007 raised limit.	
DP_WY0049697_013	Echeta Road Unit	Cu, dissolved	5/4/06	180 µg/L	6/19/06	No	Copper sulfate was being used to control algal growth in pond. Has been discontinued. Outfall will be resampled once a month for two months to verify compliance.	6/27/06 7/20/06	3 µg/L 8 µg/L	8/21/06	Yes	LOG will consider resolved unless notified by WDEQ						6/19/06 notification to WDEQ referenced outfall 001. It should have referenced outfall 013. WDEQ was notified of error on 7/24/06
DP_WY0049697_013	Echeta Road Unit	pH, field	5/4/06	6.47 s.u	6/19/06	No	Exceedance caused by excess of CO2. Degasifier has been installed to control. Outfall will be resampled once a month for two months to verify compliance.	6/27/06 7/20/06	8.01 s.u 6.97 s.u	8/21/06	Yes	LOG will consider resolved unless notified by WDEQ						6/19/06 notification to WDEQ referenced outfall 001. It should have referenced outfall 013. WDEQ was notified of error on 7/24/06.
DP_WY0049697_013	Echeta Road Unit	SAR	7/20/06	7.5 unitless	10/27/06	No	Gypsum-feed cause of exceedances. LOG submitted modification 8/2/06 to go to NaHEC-based limits. Supplemental information submitted to WDEQ on 10/18/06 to include outfall 013. Upon approval, gypsum feed system will be removed and compliance will be maintained through the appropriate treatment/raw water blend. Continue weekly sampling to monitor. Update DEQ with new exceedances, as required by permit	8/29/06 9/25/06	9.8 unitless 13.5 unitless	10/27/06	No	Action plan described on 10/27/06 applies. Continue weekly sampling to monitor. Update DEQ with new exceedances, as required by permit Samples in compliance on 7/11, 7/13, 7/17, 7/24, 8/15, 8/22, 8/29, 9/5, 9/13, 9/21.	10/19/06 10/23/06	7.7 unitless 14 unitless	11/29/06	No	Action plan described on 10/27/06 applies. Continue weekly sampling to monitor. Update DEQ with new exceedances, as required by permit Samples in compliance on 10/10 and 10/30	
DP_WY0049697_013	Echeta Road Unit	SAR	11/15/06	13.7 unitless	1/9/07	No	Action plan described on 10/27/06 applies. Continue weekly sampling to monitor. Update DEQ with new exceedances, as required by permit. Samples in compliance on 11/3, 11/21, and 11/27.	12/4/06	9.5 unitless	3/5/07	Yes	Currently in compliance. Gypsum-feed cause of past exceedances. Upon approval of modification to go to NaHEC-based limits, gypsum feed system will be removed and compliance will be maintained through the appropriate treated raw water blend. Continue weekly sampling. Compliance data for 12/4/06, 12/18/06, 12/27/06, 1/2/07, 1/12/07, 1/16/07 and 1/23/07 also reported.	2/5/07 2/15/07 2/21/07 3/5/07 3/20/07	9.1 unitless 9.2 unitless 12 unitless 10.7 unitless 9.8 unitless	4/23/07	Yes - Upon approval of modifications.	Modifications signed 3/23/2007, 3/28/2007 raised limit to 15. All data since initial sample meets new limit requirements, so LOG will consider resolved.	
DP_WY0049697_013	Echeta Road Unit	EC	1/16/07	2050 umhos/cm	3/5/07	No	Gypsum-feed cause of exceedance. LOG submitted modification 8/2/06 to go to NaHEC-based limits. Supplemental information submitted to WDEQ on 10/18/06 to include outfall 013. Upon approval gypsum feed system will be removed and compliance will be maintained through the appropriate treated raw water blend. Continue weekly sampling to monitor. Update DEQ with new exceedances, as required by permit	2/5/07 3/1/07 3/20/07	2160 umhos/cm 2110 umhos/cm 1960 umhos/cm	4/23/07	Yes - Upon approval of modifications	Modifications signed 3/23/2007, 3/28/2007 raised limit to 2350. All data since initial sample meets new limit requirements, so LOG will consider resolved.						


LANCE OIL & GAS COMPANY, INC.
Echeta Road
WYPDES
Permit Renewal
WY0049697
HUC 10 -1009020208
July 24, 2007
Explanation:
Outfall, Constructed
Outfall, Not Constructed
WQMS
Irrigation Monitor Point
SEO Irrigation Diversions
On-Channel Impoundment, Existing
On-Channel Impoundment, Proposed
CBM Well - FED
CBM Well - FEE
CBM Well - State
County Road
Railroad
Highway
N
W
E
S
0
0.25
0.5
Miles
1:24,000
SHERIDAN CO
JOHNSON CO
R76W
R75W
Wild Horse Creek
HUC 1009020936
Debit Boundary
Floyd Land & Livestock Inc. Irrigation
Croton

CBM Associates, Inc.
920 E. Sheridan St. • Laramie, WY 82070 • Office: (307) 742-4991 • Fax: (307) 745-1582
GROUNDWATER & SURFACE WATER HYDROLOGY • WATER RESOURCE MANAGEMENT • ENVIRONMENTAL PERMITTING & COMPLIANCE

August 20, 2007

Ms. Jennifer Zygmunt
Wyoming Department of Environmental Quality
Water Quality Division
122 W. 25th Street, Herschler Bldg. 4-W
Cheyenne, Wyoming 82002

RE: Supplemental Information to WYPDES Permit Renewal for WY0049697 - Echeta Road Unit
Lance Oil & Gas, Inc. an Anadarko Petroleum Company

Dear Ms. Zygmunt:

Lance Oil & Gas, Inc., an Anadarko Petroleum Company (Lance) hereby submits the enclosed supplemental information to the Renewal for Echeta Road Unit – WY0049697 dated August 1, 2007. Enclosed are the following:

- Water Quality data

With this letter Lance wishes to supplement water quality data that was included in its WY0049697 Renewal application, dated August 1, 2007, with the attached water quality samples. Lance feels that the attached samples more accurately represent the water quality produced at its Echeta Road Unit facility. This sample, collected 3/23/2004 from outfall WY0049697_009, is representative of the Wall, Anderson, Gates and Werner coal seams. The SAR exceedance for this outfall is being addressed as noted in the Exceedance Summary Table included in the August 1, 2007 Renewal application. A second attached sample, from WY0049697_009 dated 6/15/2007, shows SAR results following outfall refurbishment.

If you have any permit related questions, please call me at 307-742-4991 or e-mail at jdriscoll@cbmainc.com. Direct all correspondence to:

Lance Oil & Gas, Inc.
an Anadarko Petroleum Company
Attention: Timothy S. Kalus
1400 E. Lincoln St.
Gillette, Wyoming 82716

Sincerely,
CBM Associates, Inc.

Jason Driscoll
Environmental Specialist

/mbb

Enclosures: Supplemental Information to Renewal Documents
cc: Lance Oil & Gas, Inc. – Gillette
CBM Associates, Inc. – Gillette

ENERGY LABORATORIES, INC. * 1105 West First Street * Gillette, WY 82716
Toll Free 866.686.7175 * 307.686.7175 * Fax 307.682.4625 * gillette@energylab.com

LABORATORY ANALYTICAL REPORT

Client: Lance Oil and Gas
Site Name: Echeta_Road_Unit
Project: NPDES
Samp FRQ/Type: A_S1_M_1
Client Sample ID: DP_WY0049697_009_ET30
Location: NWNW_24_53N_76W

Lab ID: G04030379-003
Report Date: 04/15/04
Collection Date: 03/23/04 15:00
DateReceived: 03/24/04
Sampled By: Todd Adams
Matrix: AQUEOUS
Tracking Number: 28448

SUPPLEMENTAL

Analyses	Result	Units	Qualifiers	RL	QCL	Methods	Analysis Date / By
FIELD PARAMETERS							
pH, field ***	7.91	s.u.				Field	03/23/04 15:00 / ***
*** Performed by Sampler							
MAJOR IONS							
Bicarbonate as HCO3	1550	mg/L		5		A2320 B	03/25/04 10:06 / mli
Chloride	10	mg/L		1		E300.0	03/25/04 16:24 / mli
Fluoride	0.7	mg/L		0.1		E300.0	03/25/04 16:24 / mli
Sulfate	ND	mg/L		1		E300.0	03/25/04 16:24 / mli
Calcium	25	mg/L		1		E200.7	03/26/04 20:48 / rlh
Magnesium	14	mg/L		1		E200.7	03/26/04 20:48 / rlh
Potassium	13	mg/L		1		E200.7	03/26/04 20:48 / rlh
Sodium	492	mg/L	D	2		E200.7	03/26/04 20:48 / rlh
MAJOR IONS - MILLIEQUIVALENTS							
Calcium, meq	1.27	meq/L		0.05		E200.7	03/26/04 20:48 / rlh
Magnesium, meq	1.16	meq/L		0.08		E200.7	03/26/04 20:48 / rlh
Sodium, meq	21.4	meq/L	D	0.07		E200.7	03/26/04 20:48 / rlh
METALS, DISSOLVED							
Boron	136	ug/L		100		E200.8	03/29/04 15:36 / jw
Cadmium	ND	ug/L		0.1		E200.8	03/29/04 15:36 / jw
Chromium	3	ug/L		1		E200.8	03/27/04 03:42 / jw
Copper	ND	ug/L		1		E200.8	03/27/04 03:42 / jw
Iron	54	ug/L		30		E200.7	03/26/04 20:48 / rlh
Lead	ND	ug/L		2		E200.8	03/27/04 03:42 / jw
Manganese	19	ug/L		10		E200.7	03/26/04 20:48 / rlh
Mercury	ND	ug/L		0.06		E200.8	03/27/04 03:42 / jw
Nickel	ND	ug/L		10		E200.8	03/27/04 03:42 / jw
Silver	ND	ug/L		3		E200.8	03/27/04 03:42 / jw
Zinc	51	ug/L		10		E200.7	03/26/04 20:48 / rlh
METALS, TOTAL							
Barium	700	ug/L		100		E200.7	03/30/04 01:06 / rlh
METALS, TOTAL RECOVERABLE							
Aluminum	ND	ug/L		50		E200.7	03/30/04 01:02 / rlh
Antimony	ND	ug/L		5		E200.8	03/29/04 18:13 / jw
Arsenic	ND	ug/L	D	0.2		E200.8	03/29/04 18:13 / jw
Beryllium	ND	ug/L		0.03		E200.8	03/29/04 18:13 / jw
Selenium	ND	ug/L		5		E200.8	03/29/04 18:13 / jw

Report Definitions: RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix interference.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

ENERGY LABORATORIES, INC. * 1105 West First Street * Gillette, WY 82716
Toll Free 866.686.7175 * 307.686.7175 * Fax 307.682.4625 * gillette@energylab.com

LABORATORY ANALYTICAL REPORT

Client: Lance Oil and Gas
Site Name: Echeta_Road_Unit
Project: NPDES
Samp FRQ/Type: A_S1_M_I
Client Sample ID: DP_WY0049697_009_ET30
Location: NWNW_24_53N_76W

Lab ID: G04030379-003
Report Date: 04/13/04
Collection Date: 03/23/04 15:00
DateReceived: 03/24/04
Sampled By: Todd Adams
Matrix: AQUEOUS
Tracking Number: 28448

Analyses	Result	Units	Qualifiers	RL	QCL	Method	Analysis Date / By
METALS, TOTAL RECOVERABLE							
Thallium	ND	ug/L		1		E200.8	03/29/04 18:13 / jw
NON-METALS							
Alkalinity, Total as CaCO3	1270	mg/L		5		A2320 B	03/25/04 10:06 / mli
Conductivity @ 25 C	2130	umhos/cm		1		A2510 B	03/24/04 16:42 / daa
Cyanide, Total Automated	ND	ug/L		5		E335.3	03/29/04 14:19 / kp
Hardness as CaCO3	122	mg/L		10		A2340 B	04/02/04 12:30 / cw
Phenolics, Total Recoverable	ND	ug/L		10		E420.2	03/26/04 12:14 / kp
Sodium Adsorption Ratio (SAR)	19.4	unitless		0.1		Calculation	04/02/04 12:30 / cw
Solids, Total Dissolved TDS @ 180 C	1390	mg/L		20		A2540 C	03/25/04 09:59 / mli
Total Petroleum Hydrocarbons	ND	mg/L		1.0		SW1664A	03/26/04 13:13 / aps
DATA QUALITY							
A/C Balance	-2.96	%				A1030 E	04/02/04 12:28 / cw
Anions	25.7	meq/L		0.01		A1030 E	04/02/04 12:28 / cw
Cations	24.2	meq/L		0.01		A1030 E	04/02/04 12:28 / cw
RADIOCHEMICAL							
Radium 226	0.3	pCi/L		0.2		E903.0M	03/29/04 14:10 / df
Radium 226 precision (±)	0.2	pCi/L				E903.0M	03/29/04 14:10 / df

SUPPLEMENTAL

Report Definitions: RL - Analyte reporting limit. MCL - Maximum contaminant level.
QCL - Quality control limit. ND - Not detected at the reporting limit.

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Toll Free 866.686.7175 * 307.686.7175 * FAX 307.682.4625 * gillette@energylab.com

LABORATORY ANALYTICAL REPORT

Client:	Lance Oil and Gas	Revised Date:	07/16/07
Site Name:	Echeta_Road_Unit	Report Date:	07/02/07
Project:	WYPDES	Collection Date:	06/15/07 12:00
Client Sample ID:	DP_WY0049697_009_ET60	DateReceived:	06/18/07
Location:	NWNW_24_53N_76W	Sampled By:	Gayla Essen
Samp FRQ/Type:	M_R1	Matrix:	Aqueous
Lab ID:	G07060575-002	Tracking Number:	512499

Analyses	Result	Units	Result	Units	Qualifier	Method	Analysis Date / By
MAJOR IONS, DISSOLVED							
Calcium	82	mg/L	4.08	meq/L		E200.7	06/23/07 19:05 / eli-t
Magnesium	11	mg/L	0.89	meq/L		E200.7	06/23/07 19:05 / eli-t
Sodium	500	mg/L	21.7	meq/L		E200.7	06/23/07 19:05 / eli-t
NON-METALS							
Conductivity @ 25 C	2260	umhos/cm				A2510 B	06/18/07 11:09 / slm
Sodium Adsorption Ratio (SAR)	13.8	unitless				Calculation	07/02/07 14:35 / tlc

SUPPLEMENTAL

Report Definitions: RL - Analyte reporting limit. QCL - Quality control limit. MCL - Maximum contaminant level. ND - Not detected at the reporting limit.

From: Jennifer Zygmunt
To: Driscoll, Jason; Egenhoff, Dena
Date: 12/4/2007 12:16 PM
Subject: Re: LOG: Echeta Road WY0049697

Jason,
because the direct discharge outfall on this permit is above irrigation, we have to put in an SAR limit at the EOP in order to protect for that irrigation use, specifically for preventing a reduction in soil infiltration. We can put in an EOP limit for dissolved sodium as well, but we will not remove the SAR limit (in this case, the SAR formula) from the outfall. This is standard for direct discharge outfalls above irrigation. The sodium load contributed from the outfall will still be counted for assimilative capacity.

Let me know if this doesn't answer your question completely.

Jennifer

>>> "Jason Driscoll" <jdriscoll@cbmainc.com> 12/4/2007 11:15 AM >>>

Jennifer and Dena,

I understand you are now proceeding with the above mentioned renewal. My client brought up an issue which I would like to offer up to you guys. When this permit was being modified in July of 2006, we requested that sodium limits be applied. This was denied and I cannot remember why, or find any correspondence explaining why. LOG and CMBA were wondering if you would reconsider this. Now that ASCAP is being implemented, we feel that developing production schedules and working with credits, a sodium schedule for this permit will be extremely beneficial to everyone involved.

Could you please consider this and let me know what you think. Thank you for your time.

Jason Driscoll
Environmental Specialist
CBM Associates, Inc.
920 E. Sheridan
Laramie, WY 82070
Main: (307)742-4991
Fax: (307) 745-1582
jdriscoll@cbmainc.com
www.cbmainc.com

SUPPLEMENTAL

6

Department of Environmental Quality

To protect, conserve and enhance the quality of Wyoming's environment for the benefit of current and future generations.

Dave Freudenthal, Governor

John Corra, Director

April 27, 2006

Jake Strohman
Petro-Canada Resources USA, Inc.
3801 North Hwy 14-16
Gillette, WY 82719

RE: Technical Review - WY0051985 (Wild Horse Creek)

Mr. Strohmen:

The Water Quality Division (WQD) has completed its technical review of the above referenced consolidated application. Following is a summary of our conclusions regarding this application.

Tier 1 EC/SAR Evaluation (Default Effluent Limits)

Based on the information in the application, the most sensitive irrigated plant species identified downstream within the Wild Horse Creek drainage appears to be Smooth Bromegrass, with a published soil EC tolerance of 2,250 µmhos/cm (Hanson, et al. 1999). The value of 2,250 µmhos/cm as a soil EC threshold for Smooth Bromegrass was derived by taking the mid-point value between 1,500 to 3,000 µmhos/cm, which constitutes the "Moderately Sensitive" range for 100% crop yield (Figure 13.3, Agricultural Salinity Assessment and Management, American Society of Civil Engineers, 1996). A soil EC threshold of 2,250 µmhos/cm results in a default effluent limit of 1,500 µmhos/cm, using the conversion factor of $EC_{soil} = 1.5 \times EC_{water}$. The default SAR limit, given an effluent limit of 1,500 µmhos/cm, would be 8, based on current WQD practice. Therefore, under a default scenario, the appropriate end-of-pipe effluent limits for this permit would be EC = 1,500 µmhos/cm and SAR = 8.

Tier 2 EC/SAR Evaluation (Background Soil Conditions)

Based on the soil studies conducted for Petro-Canada within the downstream irrigated areas (Floyd Ranch), it appears that the default effluent limits noted above would be more stringent than necessary to protect the irrigation use. The submitted soil EC data indicates a sample population mean of 4,084 µmhos/cm for root zone EC, with a standard deviation of 1,594 for the 32 samples analyzed. This equates to a 95% confidence interval of +/- 552 µmhos/cm. Taking the lower confidence limit (the more conservative end of mean range) results in an estimated mean root zone EC of 3,532 µmhos/cm for the entire irrigated area. This yields an end-of-pipe effluent limit of 2,350 µmhos/cm, using the 1.5 conversion factor described above. Regarding SAR, the submitted soil data indicates a mean background SAR of 5 within this downstream irrigated area. This would be lower than necessary to protect the irrigation use, based on current WQD policy. Therefore, the SAR limit under a tier 2 protection scenario would default to 10. Under this scenario, the permitted end-of-pipe effluent limits would be EC = 2,350 µmhos/cm and SAR = 10.

SUPPLEMENTAL

Tier 3 EC/SAR Evaluation (Special Circumstances)

Data was also presented for Exchangeable Sodium Percentage (ESP) of the sampled soils. WQD has plotted the SAR and ESP data, and found the following relationship for this site:

$$ESP = 0.0366*(SAR)^2 + 0.1194*(SAR) + 2.008$$

This equation has an R^2 correlation value of 0.84, using the ESP/SAR data from this site. An R^2 value of 0.84 is not ideal, but the equation is useable if a margin of safety is incorporated. Typically, soils are considered non-sodic and generally exhibit adequate permeability when their ESP is at or below 15%. Using the above equation, an ESP of 15% would equate to an allowable SAR of 17 in the soil. However, given the R^2 value of 0.84, it would be more appropriate to cap the desired ESP at 12%, which would correspond to an allowable SAR of 15 in the soil. WQD does not use a standard concentration factor of 1.5 to convert soil SAR to applied water SAR, in the same way that EC is converted. Thus, the allowable SAR, given its relationship to ESP at this irrigated site, would be 15. Under this scenario, the permitted end-of-pipe effluent limits would be EC = 2,350 µmhos/cm and SAR = 15.

Other Site-Specific Considerations

Recently, Petro-Canada's ag technical consultant for this project (KC Harvey, LLC) recommended to WQD that only the Floyd spreader dam fields and Martin field be evaluated, while the Snyder and Tubbs field data should be eliminated from evaluation in the study. The basis for this recommendation was apparently that the Snyder and Tubbs fields would not constitute an existing irrigation use under WQD's current agricultural use protection policy. While the Snyder and Tubbs fields combined would amount to 21 acres of sub-irrigated agricultural land, KC Harvey, LLC points out that each of these fields is less than 20 acres on its own, and not in close enough proximity to one another to constitute protected acreage under WQD's current policy. WQD recognizes that these two fields are marginal with regard to their protected status as an existing irrigation use. However, in order to proceed with the consultant's recommended approach (dropping the Snyder and Tubbs fields from the evaluation), WQD would need written confirmation from the landowner that these two fields are not in need of irrigation water quality protection. Once Petro-Canada submits that documentation from the landowner to WQD, WQD can re-calculate appropriate effluent limits from the remaining data accordingly.

Conclusion

Sufficient data has been submitted to support end-of-pipe effluent limits of EC = 2,350 µmhos/cm and SAR = 15 for this permit. In the absence of any additional information regarding the downstream irrigation use on Wild Horse Creek, WQD intends to propose these limits in the upcoming draft of consolidated permit WY0051985.

If you have any questions, please contact me at (307) 777-5504.

Sincerely,

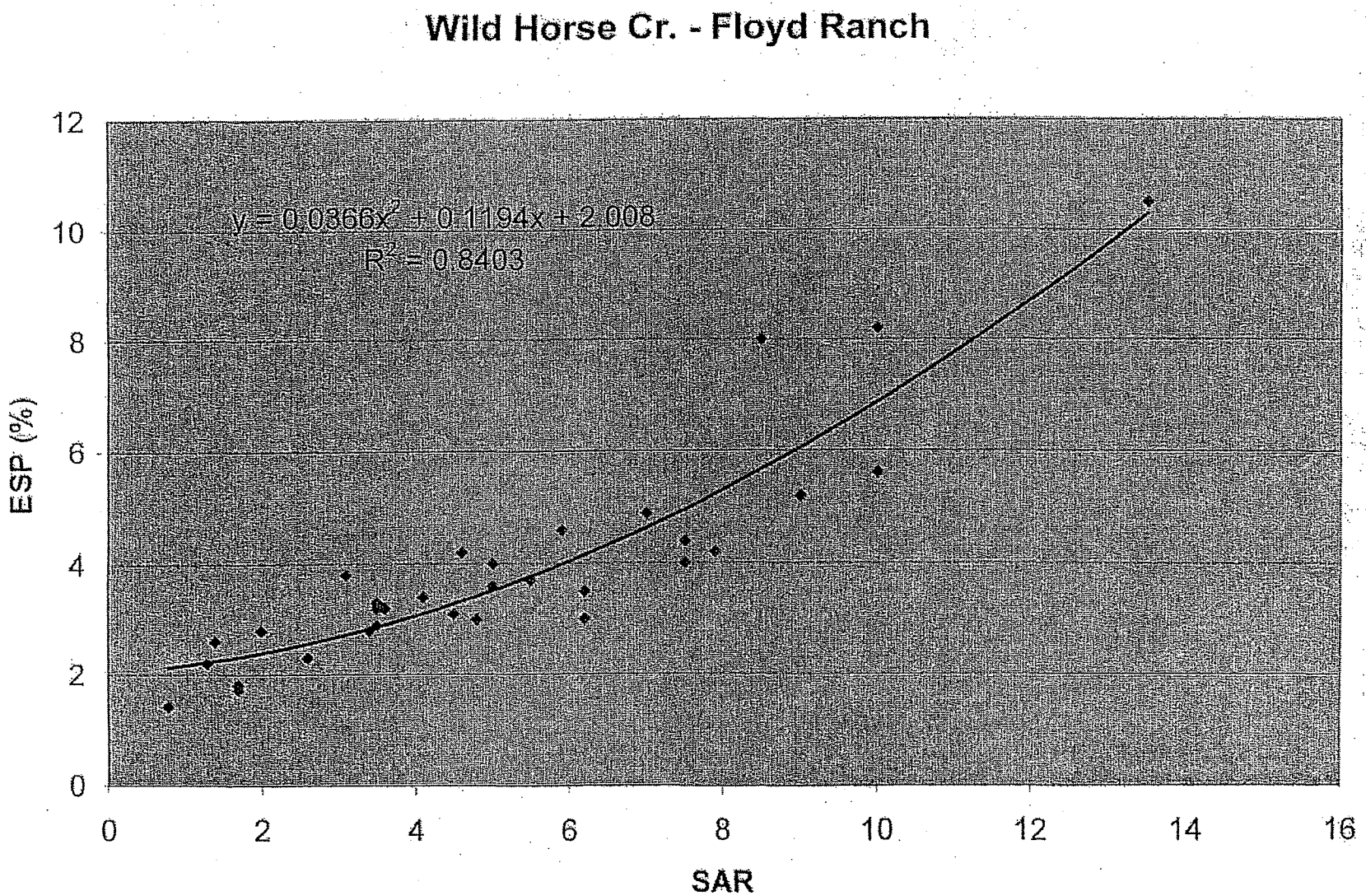
Jason Thomas
Wyoming Department of Environmental Quality
Water Quality Division

CC: Leah Krafft

Soil Data: Floyd Ranch, Wild Horse Creek
Derived From: KC Harvey, LLC 2005

	Soil Depth (inches)						
Field Name	Upper	Lower	EC (µmhos/cm)	SAR	ESP (%)	Na (meq/l)	Na (mg/l)
Martin	0	12	6600	13.5	10.5	60.5	1391
	12	24	6500	10	8.2	50.7	1166
	24	36	4100	5.9	4.6	28.6	658
	36	48	4600	4.6	4.2	21.6	497
Tubbs	0	12	1400	0.8	1.4	2.1	48
	12	24	3300	2	2.8	8.9	205
	24	36	4600	4.8	3	23.3	536
	36	48	6100	10	5.6	49.7	1143
Snyder	0	12	1400	1.7	1.8	3.9	90
	12	24	2400	1.3	2.2	5.1	117
	24	36	4300	3.4	2.8	16.1	370
	36	48	5500	7	4.9	33.8	777
Floyd A	0	12	2900	3.5	2.9	12	276
	12	24	3900	3.5	3.3	15.8	363
	24	36	4200	4.1	3.4	19.1	439
	36	48	4700	5	3.6	24.8	570
Floyd B	0	12	1500	3.5	3.2	10.8	248
	12	24	3600	3.1	3.8	13.2	303
	24	36	4300	5	4	23.3	536
	36	48	4400	4.5	3.1	22.4	515
Floyd C	0	12	3400	2.6	2.3	10.9	251
	12	24	5100	6.2	3.5	29.8	685
	24	36	5100	7.5	4.4	37.7	867
	36	48	6800	9	5.2	48.4	1113
Floyd D	0	12	3400	3.6	3.2	14.7	338
	12	24	4700	6.2	3	28.9	664
	24	36	5300	7.5	4	36.8	846
	36	48	6300	7.9	4.2	41.8	961
Floyd E	0	12	2300	1.7	1.7	6.5	149
	12	24	900	1.4	2.6	5.6	129
	24	36	2500	5.5	3.7	25.7	591
	36	48	4600	8.5	8	43.7	1005
		Average	4084	5	3.9	24	558
		STD DEV	1594	3	2	16	358
		Confidence Interval (+/-)	552				
		Lower Bound	3532				
		Upper Bound	4636				
		EC Limit = Lower Bound/1.5	2355				

SUPPLEMENTAL


Wild Horse Cr. - Floyd Ranch
y = 0.0366x² + 0.1194x + 2.008
R² = 0.8403
ESP (%)
SAR
0
2
4
6
8
10
12
14
16

7

EXPERT SCIENTIFIC OPINION ON THE TIER-2 METHODOLGY

Report to the Wyoming Environmental Quality Council

Jan M.H. Hendrickx
New Mexico Tech
Socorro, NM 87801

Bruce A. Buchanan
Buchanan Consultants, Ltd.
Farmington, NM 87499

May 2009

EXECUTIVE SUMMARY

All Wyoming surface waters are protected to some extent for agricultural uses. The primary agricultural uses are stock watering or irrigation. The uses are protected under the AGRICULTURAL USE PROTECTION POLICY (AUPP) which was finalized August 2006 in conjunction with the Triennial Review of the Chapter 1 Surface Water Standards. The policy is contained in Chapter 1, Section 20 of the AUPP. This policy is under consideration by the Wyoming Environmental Quality Council (WEQC) for adoption as an Appendix to the Chapter 1 rules. Until a final decision is rendered on the rulemaking, the provisions of the policy remain in effect for establishing effluent limits on discharges that may affect agricultural use.

The purpose of this report is to provide an expert, scientific opinion regarding the methods proposed for estimation of the EC (Electrical Conductivity) and SAR (Sodium Adsorption Ratio) of produced Coal Bed Methane (CBM) water. These produced waters are discharged into ephemeral drainages in Wyoming such that degradation of the receiving water will not affect crop production.

Chapter 2 lists the services to be provided by the contractors and specifically formulates two specific questions by the Council: *Question A.* Whether the Tier 2 methodology as set forth in Appendix H section c(vi)(B) is reasonable and scientifically valid for determining the EC and SAR of water that can be discharged into an ephemeral drainage in Wyoming so that degradation of the receiving water will not be of such an extent to cause a measurable decrease in crop production. *Question B.* Whether the method set forth in Appendix H section c(vi)(B) for determining EC and SAR for permitting the discharge of produced water is reasonable, sufficiently defined and scientifically defensible for the conditions in Wyoming, and provides a uniform testing procedure that is reasonably accurate and unbiased for the determination of soil EC from which you can reasonably infer the quality of the water EC and SAR that historically flowed within the drainage that will support the establishment of effluent limits for discharge permits in a given drainage that will not cause a measurable decrease in crop production.

Chapter 3 educates the reader on the causes of soil salinity focusing on the relation between soil salinity and the quality of irrigation water. Major causes for soil salinity are soil characteristics, ground water table depth, climate, presence of saline seepages, and irrigation management but not the quality of the irrigation water. No evidence has been found in the peer-reviewed literature in support of the assumption on which Tier 2 is based: "soil salinity in artificially and naturally irrigated lands in ephemeral drainages is *entirely* determined by pre-existing background water quality".

In Chapter 4 a succinct review of the testimony to the Council is discussed under three headings: Assumption for Tier 2 Methodology, Soil Testing Procedure for Unbiased Determination of Soil EC and SAR, and Managed and Unmanaged Irrigation with CBM Waters.

Finally, in Chapter 5 the expert scientific opinions are presented in answer to the two questions A and B by the Council. *Scientific Expert Opinion A.* The Tier 2 methodology as set forth in Appendix H section c(vi)(B) is not reasonable nor scientifically valid for determining the EC and SAR of water that can be discharged into an ephemeral drainage in Wyoming so that degradation of the receiving water will not be of such an extent to cause a measurable decrease in crop production. *Scientific Expert Opinion B.* The method set forth in Appendix H section c(vi)(B) for determining electrical conductivity (EC) and sodium adsorption ratio (SAR) for permitting the discharge of produced water is not reasonable nor sufficiently defined nor scientifically defensible for the conditions in Wyoming. It does not provide a uniform testing procedure that is reasonably accurate and unbiased for the determination of soil EC from which you can reasonably infer the quality of the water EC and SAR that historically flowed within the drainage that will support the establishment of effluent limits for discharge permits in a given drainage that will not cause a measurable decrease in crop production.

Scientific Expert Opinion on Way Forward. Since it is not scientifically defensible to use Tier 2, the question is how to move forward. The use of Tier 1 can be continued since it is conservative and has been accepted by the community. If the water quality

requirements of Tier 1 cannot be met, the Irrigation Waiver seems the preferred alternative since it requires an irrigation management plan that provides reasonable assurance that the lower quality water will be confined to the targeted lands. In this manner, the Irrigation Waiver will deal with the issue of water quantity. Given the large scale on which CBM water is produced it seems justifiable to implement an aggressive applied and basic research program to develop guidelines on how to use CBM water in a beneficial manner.

TABLE OF CONTENTS

1. PURPOSE

All Wyoming surface waters are protected to some extent for agricultural uses. The primary agricultural uses are stock watering or irrigation. The uses are protected under the AGRICULTURAL USE PROTECTION POLICY (AUPP) which was finalized August 2006 in conjunction with the Triennial Review of the Chapter 1 Surface Water Standards. The policy is contained in Chapter 1, Section 20 of the AUPP. This policy is under consideration by the Wyoming Environmental Quality Council (WEQC) for adoption as an Appendix to the Chapter 1 rules. Until a final decision is rendered on the rulemaking, the provisions of the policy remain in effect for establishing effluent limits on discharges that may affect agricultural use.

The purpose of this AUPP report is to provide an expert, scientific opinion regarding the methods proposed for estimation of the EC (Electrical Conductivity) and SAR (Sodium Adsorption Ratio) of produced water. These produced waters are discharged into ephemeral drainages in Wyoming such that degradation of the receiving water will not affect crop production.

This report contains five chapters. Chapter 1 discusses the purpose of this report. Chapter 2 describes the services to be provided by the contractor and is followed by Chapter 3 that educates the reader on the causes of soil salinity focusing on the possible effects of EC and SAR of precipitation, irrigation, and flood waters. Chapter 4 presents highlights of the submittals and testimony presented to the Council while Chapter 5 presents the contractors' expert scientific opinions.

2. SERVICES TO BE PROVIDED BY CONTRACTOR

Drs. Buchanan and Hendrickx have been contracted to review the AGRICULTURAL USE PROTECTION POLICY and basically determine if making the policy a rule is reasonable and scientifically valid. Three specific services have been requested by the Wyoming Environmental Quality Council.

Service One:

Review the following:

A. Appendix H Section c(vi)(B) of the Rule as proposed by the DEQ on 11/20/2008 (see Appendix A).

B. Transcripts of the testimony received by the Council on October 24th and 28th, 2008.

C. Section 20 of the Rule as proposed by DEQ on November 11, 2008 (see Appendix A).

D. Written submittals, responses to comments, and other documents submitted to the Council under Docket No. 08-3101.

Service Two:

Based upon Contractor's training, education, and work experience provide, in written form, a report outlining Contractor's expert scientific opinion regarding:

A. Whether the Tier 2 methodology as set forth in Appendix H section c(vi)(B) is reasonable and scientifically valid for determining the EC and SAR of water that can be discharged into an ephemeral drainages in Wyoming so that degradation of the receiving water will not be of such an extent to cause a measurable decrease in crop production.

B. Whether the method set forth in Appendix H section c(vi)(B) for determining EC and SAR for permitting the discharge of produced water is reasonable, sufficiently defined and scientifically defensible for the conditions in Wyoming, and provides a uniform testing procedure that is reasonably accurate and unbiased for the determination of soil EC from which you can reasonably

infer the quality of the water EC and SAR that historically flowed within the drainage that will support the establishment of effluent limits for discharge permits in a given drainage that will not cause a measurable decrease in crop production.

Service Three:

Consult with DEQ to the degree necessary to achieve the goals of Section 2 of the Contract. Communicate any suggested improvements or procedures to EQC and DEQ.

Drs. Buchanan and Hendrickx have reviewed all documents listed under Service One and present a review summary in Chapter 4. They have made one consultation with DEQ in the form of eight questions on the subject of the permitting process. The clear response by Mr. John Wagner of DEQ to these questions was very helpful. Their expert scientific opinions are presented in Chapter 5.

The basic processes of soil salinization are reviewed in Chapter 3 since they are the scientific basis of the opinion. Moreover, these processes need to be understood –at least a conceptual level– in order to successfully implement the expert scientific opinion into a fair and balanced system for discharge permits of produced waters into ephemeral drainages in Wyoming.

3. WHAT CAUSES SOIL SALINITY?

Soil salinity is the amount of soluble salts in a soil (Soil Science Glossary Terms Committee, 2008)[1] but the term is often used in the sense that the salt content of the soil is too high for satisfactory crop production[2]: the soil is saline or salty. Important natural sources of salts in arid and semi-arid regions are atmospheric deposition (wet and dry) (Bresler et al., 1982; Scanlon, 1991), mineral weathering (Bresler et al., 1982; Rhoades et al., 1974), "fossil" salts (built up in poorly drained flood-plain or playa sediments) (Bresler et al., 1982; Carter and Robbins, 1978), seepage from uplands (Stephanie J. Moore, 2008), and upwelling from deep ground water brines (Hogan et al., 2007; Phillips et al., 2003; Stephanie J. Moore, 2008). Four common anthropogenic salt sources are: irrigation water (Rhoades et al., 1973; Rhoades et al., 1974), fertilizers (Darwish et al., 2005), discharge of treated sewage water (Gonçalves et al., 2007; Mills, 2003), and discharge of saline waters during coalbed methane (Ganjegunte et al., 2005) or oil and gas extraction (Hendrickx et al., 2005a). Most soil salinity is caused by mineral weathering and application of waters containing salt on irrigated lands. The importance of each source of salinity depends on soil type, climate and irrigation management (Bresler et al., 1982; Keren, 2000).

Salinity is common in arid and semi-arid areas where evapotranspiration exceeds annual precipitation as is the case in Wyoming. Evapotranspiration is defined as the evaporation of water from soil combined with the transpiration of water from plants. Since salts do not vaporize at atmospheric pressure, they are left behind during the processes of evapotranspiration and accumulate in the soil. Soil salinity will affect crop growth when the concentration of soluble salts in the root zone exceeds a critical threshold level (Hanson et al., 2006). For the purpose of this report three common scenarios of salt accumulation in the root zone of semi-arid lands will be described: soil water chloride profiles in semi-arid uplands with deep ground water tables where the only source of

[1] Scientific references are listed in Appendix xx.
[2] http://waterwiki.net/index.php/Soil_salinity on May 8, 2009.

water is precipitation, soil salinity in semi-arid riparian lands with shallow ground water tables, and soil salinity in irrigated fields.

Scenario I: Soil Salinity in Semi-arid Uplands with Deep Ground Water Tables. Figure 1 shows the chloride distribution with depth in two desert soil profiles in southern New Mexico. Although the chloride concentration of the incoming precipitation is the same for both profiles, the chloride content at depth is 1000 times larger in the profile that does not receive run-on water. Similar differences do occur due to changes in land use (Hendrickx and Walker, 1997; Stephens, 1995), soil and bedrock characteristics (Heilweil and Solomon, 2004), or geomorphic setting (Hendrickx and Walker, 1997; Johnston, 1987; Scanlon, 1991; Scanlon, 1992). For example, in Australia the chloride concentration in soil profiles beneath native *Eucalyptus* vegetation is about 4000 mg/l versus 1000 mg/l under fields cleared from native vegetation 12 years previously. The lower water use of the crops that replaced the native vegetation lead to an increased recharge and salt leaching (Walker et al., 1991). Thus, **in semi-arid uplands with deep ground water tables no unique relationship exists between salt concentration of precipitation and soil salinity.**

Scenario II: Soil Salinity in Semi-arid Riparian Lands with Shallow Ground Water Tables. In riparian areas soil salinity is often variable and can change over short distances (Amezketa and Lersundi, 2008; Hendrickx et al., 1994; Hendrickx et al., 1997; Sheets et al., 1994). For example, in the Horse Creek riparian area on the Rottman Ranch, Hawk Springs, Wyoming, soil samples indicated an "extremely high variability" of soil salinity depending on soil age and texture, topography, and depth to ground water[3]. Salinization in these areas is caused by discharge of groundwater to the atmosphere, a process that can result from three different mechanisms: (i) deep-rooted plants tap directly into the ground water to acquire water for transpiration, (ii) capillary rise from

[3] http://wsare.usu.edu/pro/fieldrep_00/pdf/refinal/aw96014.pdf on May 15, 2009.

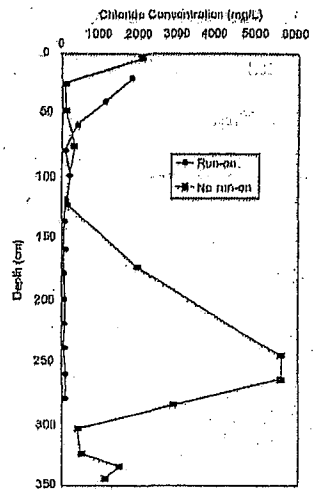


Figure 1. Soil water chloride profiles in two nearby loam soil profiles with a deep ground water table in southern New Mexico receiving precipitation with a chloride concentration of less than 5 mg/liter (Eppes and Harrison, 2003; Hogan et al., 2007). Despite the low chloride concentration of the precipitation the maximum chloride concentration in the "no run-on" profile exceeds 5000 mg/liter.

the ground water table to the soil surface where the water evaporates, or (iii) capillary rise to the bottom of the root zone where it becomes available for transpiration by vegetation. The dissolved salts in the evaporated and transpired water are left behind and accumulate in the soil. The rate of salt accumulation depends on the quantity or rate of ground water discharge as well as the quality or salt concentration of the ground water (Rose, 2004).

A dry sponge in contact with water will suck up the water and even make it flow upwards due to capillary forces. In the same way, water can flow from the ground water table to the soil surface or the bottom of the root zone. The resulting discharge rate depends on the depth of the ground water, the texture and sequence of different soil horizons, and the rooting depth (Hoffman and Durnford, 1999; Weeks et al., 1987). For example, during a seven year study near Buckeye, Arizona, the annual evapotranspiration of salt cedar varied from 2150 mm with ground water level at 1.5 m to less than 1000 mm with ground water level at 2.7 m (Van Hylckama, 1974). A computer simulation based on field observations during the 1999 growing season in the Bosque del Apache (Socorro, New Mexico) evaluated the effect of soil texture, ground water depth, and rooting depth on ground water discharge. The average discharge in a virtual homogeneous clay profile was 49 cm versus 19 cm in a virtual homogeneous sand profile; the average discharges from

ground water depth 100, 200, and 500 cm were 66, 31, and 5 cm; the average discharges with rooting depths 30 and 300 cm were 21 and 47 cm, respectively (Moayyad et al., 2003). Several authors have shown that discharge from ground water tables less than 5 m (15 feet) deep can be considerable (Hendrickx et al., 2003; Jolly et al., 1993; Moayyad et al., 2003) while it typically can be ignored when the ground water table falls below 10 m[4] but not always (Hoffman and Durnford, 1999).

During a soil reclamation project in a riparian area close to Albuquerque (Caplan et al., 2001), the authors of this report evaluated soil salinity dynamics in a non-flooded riparian area combining a detailed soil salinity survey using electromagnetic induction (Hendrickx and Kachanoski, 2002; Hendrickx et al., 1994; Sheets et al., 1994), extensive soil descriptions and laboratory analyses of representative riparian soils, ground water depth measurements, ground water quality measurements, and simulations with the forward model for prediction of electromagnetic induction responses (Borchers et al., 1997; Hendrickx and Kachanoski, 2002; Hendrickx et al., 2002) as well as simulations with the model HYDRUS1D for prediction of soil water contents and soil water salt concentrations (Šimůnek et al., 2008). Although all soils in this riparian area received their water from the river (salt concentration about 200-400 ppm) and precipitation, the soil salinity profiles are widely different (Hong, 2002). Figure 2 shows Profile 1 with almost no salt accumulation while Profile 6 has accumulated a considerable amount of salts since the construction of Cochiti reservoir around 1970 that prevented flooding of our riparian study area. The difference in soil salinity is caused by the interaction between soil texture, capillary rise, and ground water level fluctuations. Thus, this case study is strong evidence that no unique relationship exists between the historic salt concentrations in the Rio Grande and current soil salinity profiles in riparian areas with shallow ground water tables. Soil salinity depends on soil texture and ground water table depth rather than on historic water quality in the Rio Grande. Similar trends are observed in the River Murray region of Australia[5]. Thus, **in semi-arid riparian areas with**

[4] http://www.clw.csiro.au/research/rivers/flows/floodplain/timescales.html on May 15, 2009.
[5] http://www.clw.csiro.au/research/rivers/flows/floodplain/timescales.html on May 15, 2009.

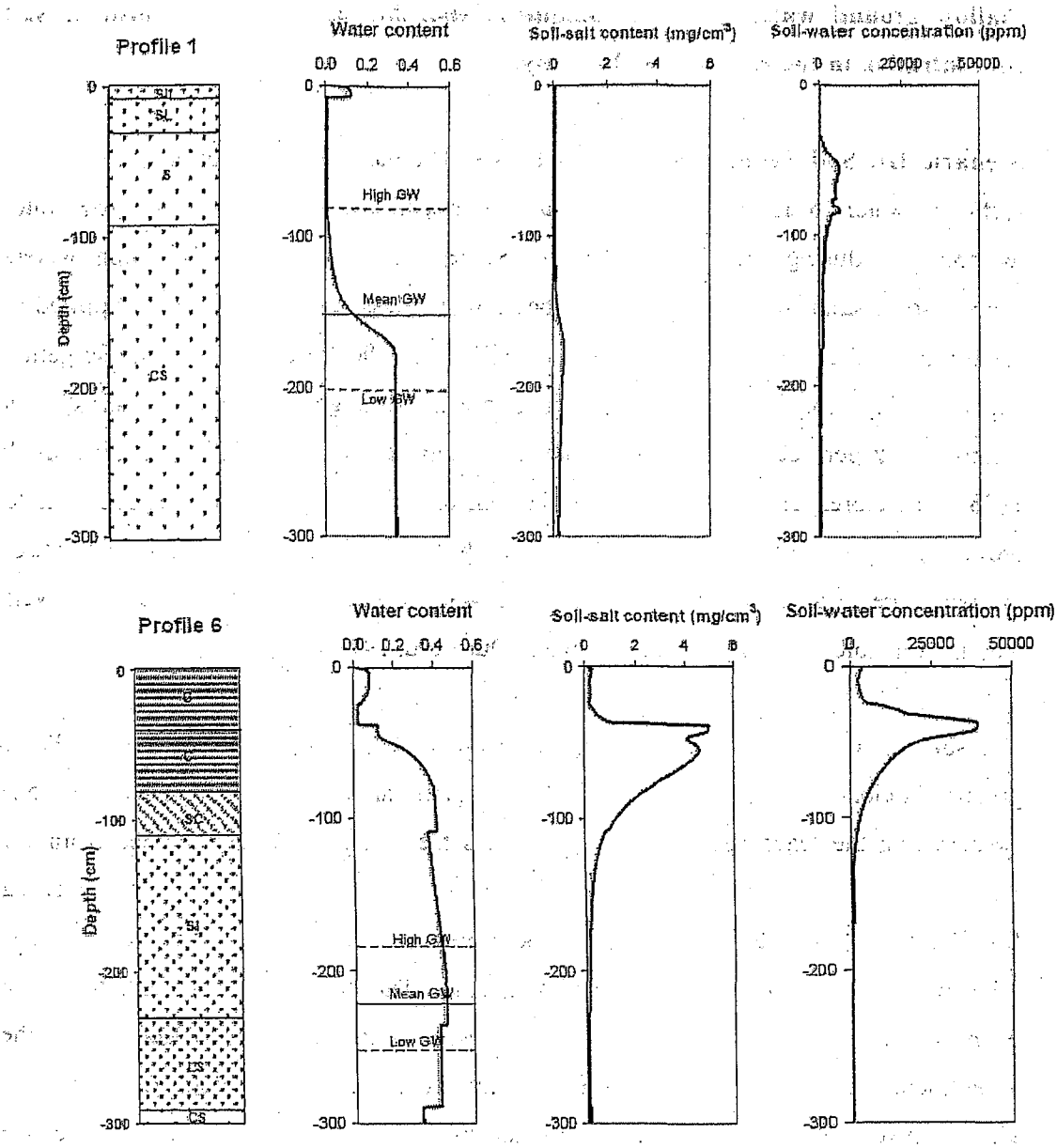


Figure 2. Soil stratigraphy and texture of representative profiles 1 and 6 with the simulated profiles of the water content, soil-salt content, and soil-water concentration. Initial ground water and time-independent bottom solute boundary conditions are 200 ppm. (SIL: silty loam, SL: sandy loam, S: sand, L: loam, LS: loamy sand, CS: coarse sand). The simulated salinity profiles have been confirmed in the field with electromagnetic induction measurements (Hong, 2002).

shallow ground water tables no unique relationship exists between historic salt concentration in the river and soil salinity.

Scenario III: Soil Salinity in Irrigated Fields. The purpose of irrigation is to provide sufficient water to agricultural lands in arid and semi-arid regions to meet crop water requirements during the growing season. Since even good-quality irrigation waters contain some salts, soil salinization will be certain unless sufficient water is supplied to leach the salts below the root zone. As a matter of fact 100 cm of good-quality irrigation water, i.e. a typical amount normally applied in a single irrigation season, contains about 5 tons of salt per hectare which is sufficient to salinate an initially salt-free soil (Hillel, 1998). Therefore, leaching of salt at the bottom of the root zone should be adequate to prevent salt accumulation in the root zone. Most irrigation projects need a drainage infrastructure to accomplish the leaching necessary to keep the root zone at salt levels that are tolerable for the crops (Hoffman and Durnford, 1999).

The soil salinity of irrigated fields depends mainly on the farmer's management. For a given irrigation water quality the farmer can regulate salinity conditions in the root zone by adjusting the leaching fraction which equals the volume of water drained from the field divided by the volume of water applied by irrigation. The larger the leaching fraction, the more water is drained, and the more salts are removed from the root zone (Hanson et al., 2006; Hillel, 1998; Hoffman and Durnford, 1999; Rose, 2004). For example, the senior author of this report used electromagnetic induction for the assessment of soil salinity in a 37 ha representative experimental drainage area located 35 km southwest of Faisalabad in the Punjab Province of Pakistan. Although the site received the same quality irrigation water on all fields, it had a wide range of salinity conditions from 269 dS/m on abandoned fields to 20 dS/m on pepper fields. Excluding the abandoned fields, the range of mean salinity values for different land uses went from 90 dS/m on fallow fields with irrigation inlet structures to 56 dS/m on fodder fields to 38 dS/m on rice fields and then to 20 dS/m on the pepper fields. These mean values are significantly different at the 5% level (Hendrickx et al., 1992) and demonstrate that irrigation management influences soil salinity to a much greater extent than irrigation

water quality. Thus, on irrigated lands **no unique relationship exists between the water quality in the rivers that supply the irrigation canals and soil salinity.**

Relevance for Tier 2. Tier 2 is based on the assumption that soil salinity in artificially and naturally irrigated lands in ephemeral drainages is entirely determined by pre-existing background water quality. However, the three typical scenarios for causing soil salinity in semi-arid lands described above do not support this assumption. On the contrary, pre-existing background water quality appears to be a minor factor or none at all. Major causes for soil salinity are soil characteristics, ground water table depth, climate, presence of saline seepages, and irrigation management (Hillel, 1998; Hoffman and Durnford, 1999; Hogan et al., 2007; Rose, 2004). No evidence has been found in the peer-reviewed literature in support of the assumption on which Tier 2 is based. We welcome to be informed of any scientific evidence in support of this assumption.

The Tier 2 assumption is scientifically flawed for several reasons: (i) effluent water quality that is better than the pre-existing background water quality could still cause severe soil salinity (Hillel, 1998), (ii) effluent water quality that is worse than the pre-existing background water quality may be used beneficially on artificially irrigated lands (Rhoades, 1999; Tanji, 1997), and (iii) soil salinity varies with time and can even change suddenly when riparian areas flood or when farmers irrigate fallow or abandoned lands. Therefore, a Tier 2 analysis will not result in a scientifically defensible assessment of water quality (EC and SAR) that can be released in an ephemeral drainage without irrigation management.

4. REVIEW OF TESTIMONY AND SUBMITTALS TO THE COUNCIL

The testimony and submittals to the Council have been an important source of information on the history of Section 20 of the AUPP as well as the issues faced by industry and landowners to deal with CBM water. In this section we will highlight and comment on relevant testimony for the formulation of our expert scientific opinion on the Tier 2 methodology as set forth in Appendix H section c(vi)(B). Our review and discussion is organized under three headings: Assumption for Tier 2 Methodology, Soil Testing Procedure for Unbiased Determination of Soil EC and SAR, and Managed and Unmanaged Irrigation with CBM Waters.

Assumption for Tier 2 Methodology. Tier 2 is based on the assumption that soil salinity in artificially and naturally irrigated lands in ephemeral drainages is entirely determined by pre-existing background water quality. Several testimonies consider this assumption flawed. Dr Paige testifies: "we cannot determine background water quality for measuring soil EC and SAR" and "my real problem is with trying to back out background water quality from soil EC and salinity within the soil". Later in the hearing Chairman Boal asks Dr. Munn "I think you're are telling me that it is not a good idea to use soil samples to come up with those [background water quality] numbers" and his answer is "That is my professional assessment".

On the other hand Mr. Harvey's testimony is in support of the Tier 2 methodology. He states "The relationships amongst salinity, sodicity, water, plants, and especially the soil are dynamic. They are very complex and dynamic systems, and we need flexibility in a rule ... to deal with this" and "the proposed rule, ... I believe is conservative and protective. I'm ... here to support it." He explains "There is no Tier 2 comparison between managed irrigation with coal-bed natural gas water and WYPDES discharge scenarios. ... Managed irrigation scenarios ... do not fall under the Tier 2 process ... It is a different environment. We're applying water in a managed manner evenly over a field using separate center pivot equipment or other such equipment. Discharge into channel,

it's just a different situation". He continues "The Tier 2 process ... is meant to derive conservative limits for unmanaged irrigation after discharge to the channel".

Since 2005 Mr. Harvey has been involved in "most of the Section 20 reports and analyses that are used to derive EC and SAR effluent limits". His method for deriving pre-existing background water quality from current soil salinity is based on the assumption "that the 1.5 concentration factor from water to soil EC is appropriate and conservative in the rule, and I am supporting DEQ's use of it". He adds "the 1.5 concentration factor was agreed to by all parties the first day of drafting this policy, that now is a proposed rule ... It's been the basis of all of the Tier 2-based WYPDES permits to date". Mr. Harvey's testimony did not provide scientific support for the number 1.5 to be used as the concentration factor for artificially and naturally irrigated lands in Wyoming's ephemeral drainages. However, Dr. Munn stated "the idea [of Tier 2] is ... we can use relationships from managed irrigation fields ... to back-calculate background water [quality] and the number chosen is 1.5" and "1.5 is an arbitrary number based on an assumption of an arbitrary leaching fraction ... in irrigated fields in southern California as a conversion between the applied water salinity and what you will see [i.e. soil salinity] in the root zone".

Experts' Opinion. In Chapter 3 scientific evidence has been presented that pre-existing water quality in a drainage cannot be derived from current soil salinity. The testimony to the Council has been mixed with Paige and Munn recognizing that no link exists between back-ground water quality in an ephemeral drainage and soil salinity while Harvey makes the case that such a relationship does exist and can be used for prediction of back-ground water quality. However, no scientific evidence was found to support the latter position.

In 1976, Ayers and Westcott published the first edition of a FAO (Food and Agriculture Organizations of the United Nations) Irrigation and Drainage Paper (Ayers and Westcot, 1994)[6] as a field guide for evaluating the suitability of water for irrigation. Two of their recommendations have

[6] http://www.fao.org/docrep/003/T0234E/T0234E00.HTM on May 16, 2009.

Leaching Fraction (LF)	Applied Water Needed (Percent of ET)	Concentration Factor [2] (X)
0.05	105.3	3.2
0.10	111.1	2.1
0.15	117.6	1.6
0.20	125.0	1.3
0.25	133.3	1.2
0.30	142.9	1.0
0.40	166.7	0.9
0.50	200.0	0.8
0.60	250.0	0.7
0.70	333.3	0.6
0.80	500.0	0.6

Table 1. Concentration factors for predicting root zone soil water salinity from irrigation water salinity and the leaching fraction from Ayers and Westcott (1994) (Ayers and Westcot, 1994).

been used for the development of Tier 2: (i) the concentration factors for predicting root zone soil salinity from irrigation water salinity and the leaching factor (Table 3 of Ayers and Westcott) and (ii) the relative rate of water infiltration as affected by salinity (EC) and sodium adsorption ratio (SAR) (Figure 21 of Ayers and Westcott (1994) as adapted from Rhoades (1977) (J.D., 1977) and Oster and Schroer (1979) (Oster and Schroer, 1979)). Table 1 presents Table 3 of Ayers and Westcott; it presents concentration factors as a function of leaching factors.

The concentration factors (X) have been developed by Ayers and Westcott to calculate average root zone soil salinity (EC_{soil}) from irrigation water salinity (EC_w):

$$EC_{soil} = EC_w \times X \qquad [1]$$

In Tier 2 Eq. [1] has been inversed as

$$EC_w = \frac{EC_{soil}}{X} \qquad [2]$$

Eq. [1] is based on several assumptions: (i) the crop water use pattern is such that 40 percent of the water is taken up from the upper quarter of the root zone, 30 percent from the next quarter, 20 percent from the next, and 10 percent from the lower quarter, (ii) actual crop evapotranspiration is known so that the water manager can determine the irrigation application for a desired leaching fraction, and (iii) no capillary rise from a

shallow ground water table. The crop water use pattern in the root zone and the absence of capillary rise are reasonable assumptions for managed irrigated lands in California but are uncertain assumptions in the artificially and naturally irrigated lands in ephemeral drainages in Wyoming. Not knowing past actual evapotranspiration rates and water applications from the ephemeral drainages to the irrigated lands makes it next to impossible to estimate a leaching fraction. An irrigator who knows the crop water use pattern and the actual evapotranspiration can use Table 1 and Eq. [1] to estimate the unknown leaching fraction necessary to maintain a favorable root zone soil water salinity. In other words, Eq. [1] is used to estimate one unknown variable, the leaching fraction. On the other hand, a regulator who only knows the root zone soil water salinity will face great difficulties using Eq. [2] to estimate the pre-existing back-ground water quality in the drainage. Instead of one unknown, the regulator must estimate three unknowns: crop water use pattern in the root zone of the heterogeneous artificially and naturally irrigated lands of an ephemeral drainage, the average amount of water delivered by the drainage to the irrigated land, and the average actual evapotranspiration of the crop during those deliveries. An error in any of these estimates will lead to an error in the concentration factor and, therefore, the pre-existing back-ground water quality. Even when capillary rise is ignored the regulator is faced with the problem of solving one equation with three unknowns. For all these reasons, the use of Eq. [2] in Tier 2 cannot be scientifically defended; it is incorrect.

Tier 2 also depends on Figure 21 of Ayers and Westcott (1994) as adapted from Rhoades (1977) (J.D., 1977) and Oster & Schroer (1979) (Oster and Schroer, 1979) that estimate how salinity (EC) and sodium adsorption ratio (SAR) affect the relative rate of water infiltration. This figure is known as the "Hanson" diagram to the Council. Use of this figure has resulted in protecting the infiltration capabilities of the soils in ephemeral drainages but its use has little impact on root zone soil water salinity. The latter factor depends on soil type, climate, ground water table depth, and irrigation management as discussed in the previous sections.

Dr. Vance has expressed concern about using Figure 21 of Ayers and Westcott (1994) to assess how the relative infiltration rate of soils with smectitic clays is affected. Since these clays have low infiltration rates under the best conditions, a relative decrease will have much more impact on soil salinization than a relative decrease in soils with higher infiltration rates. The validity of Figure 21 for soils containing smectitic clays should be further explored.

Soil Testing Procedure for Unbiased Determination of Soil EC and SAR

Different testimonies referred to different procedures of soil sampling in the ephemeral drainages. The experts did not agree on one most optimal method for salinity surveys in the drainages. None referred to the new salinity monitoring approach that is increasingly used all over the world: this approach is based on a continuous survey of the entire area using electromagnetic induction followed by soil coring at selected validation sites.

Experts' Opinion. In the previous section we explained that the prediction of pre-existing back-ground water quality in the drainage using soil salinity samples is scientifically not correct. Yet, for the management of CBM waters on artificially and naturally irrigated lands it will be necessary to conduct salinity surveys that result in reliable soil salinity maps.

The proposed procedure in Appendix H section c(vi)(B) for determining EC and SAR is ambiguous since samples are taken at semi-random sites meaning that within specific terrain zones soils will be randomly sampled. The term *terrain zone* is not defined in any way and could be interpreted to mean a number of different landscape characteristics. The examples given range from units identified by landscape characteristics (channel bottom, first terrace, etc) and land use characteristics (sub and non-sub irrigated reaches). Another issue is the proposed number of required soil sample sites (from 3 to 7 depending on acreage) that would make it very difficult to characterize the soil landscape or to evaluate the natural variation of soil properties. Use of the proposed procedure by different capable soil scientists would yield different salinity maps and cause a challenge for the regulatory agencies. Therefore, we recommend the use of a continuous high-

density survey method based on electromagnetic induction that will leave no ambiguity in the final soil salinity map and is transparent for all stakeholders.

Currently, three basic procedures are available for the measurement of soil salinity: (i) soil extraction for measurement of the soil salinity as grams of salt over grams of dry soil, (ii) soil water extraction for measurement of the soil water salinity as grams of salt over grams of water, and (iii) indirect measurement of the soil water salinity by measuring the apparent electrical conductivity of the soil. Since soil extraction and soil water extraction methods are time consuming and expensive, faster indirect methods for measurement of soil salinity have been developed. These methods measure the apparent soil electrical conductivity and need a calibration function for determination of the salinity of soil water (Hendrickx and Kachanoski, 2002).

Electrical conductivity methods have been used for several decades (Rhoades and Halvorson, 1977; Rhoades and Oster, 1986; Rhoades et al., 1976) but advances in equipment, computers, and Global Positioning Systems have all come together now into a system that allows the measurement of soil apparent electrical conductivity at a reasonable cost (Hendrickx and Kachanoski, 2002). Of special interest is the electromagnetic induction method since it doesn't require contact with the soil (McNeill, 1980) and allows for quick and reliable measurements either on foot in difficult terrain (Hendrickx et al., 1997; Hendrickx et al., 1992; Sheets and Hendrickx, 1995) or on a vehicle in flat agricultural lands (Corwin and Lesch, 2003) (Figure 3). The method has been successfully used for the detection of produced oil-and-gas waters in the arid vadose zones of New Mexico (Hendrickx, 2003; Hendrickx et al., 1994; Hendrickx et al., 2005b). Often the electromagnetic induction (EMI) measurements alone are sufficient to prepare maps of soil salinity. Taking measurements at different heights above the soil surface and using inverse methods, it is even possible to determine the depth profile of apparent soil electrical conductivity (Borchers et al., 1997; Hendrickx et al., 2002). However, for regulatory purposes or for the management of lands irrigated with challenging water qualities it is necessary to relate the EMI measurements to EC and/or SAR. Therefore, the U.S. Salinity Laboratory in Riverside CA has developed a software

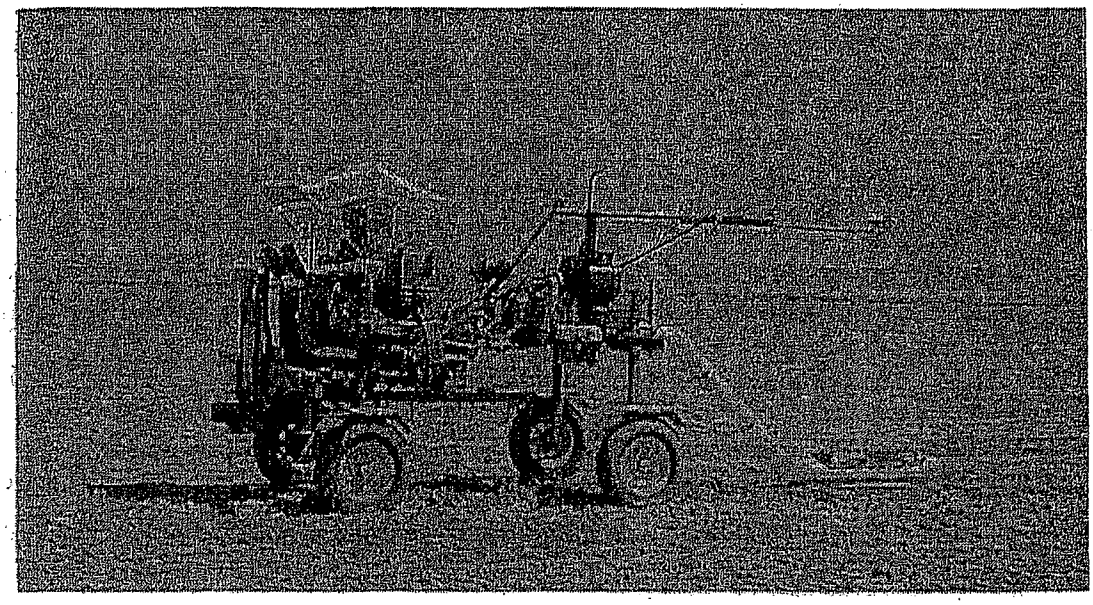


Figure 3. Mobile dual-dipole electromagnetic induction equipment for the continuous measurement of apparent soil electrical conductivity (Corwin and Lesch, 2003).

package, ESAP-95, to select optimal sites for calibration of the relationship between the apparent soil electrical conductivity measured with EMI and the EC of the soil water at different depths measured in the laboratory (Lesch et al., 2000). The soil samples can be easily taken with a soil coring device in the back of a 1-ton pickup with a 2-inch diameter device that can go down 4 to 6 feet or deeper if soil conditions permit. The theoretical background of ESAP-95 is presented by Lesch and his colleagues (Lesch et al., 1995a; Lesch et al., 1995b). Several applications of this software have been reported in the scientific literature (Amezketa, 2007; Amezketa and Lersundi, 2008; Corwin and Lesch, 2003; Corwin et al., 2006) as well as by consulting companies[7].

Managed and Unmanaged Irrigation with CBM Waters

In several testimonies reference was made to unmanaged and managed irrigation. Mr. Harvey summarizes best the management aspect of Tier 2: "The Tier 2 process ... is meant to derive conservative limits for unmanaged irrigation after discharge to the channel" while Chairman Boal expresses succinctly the idea on which Tier 2 is based:

[7] Soil and Water West, Inc. personal communication March 2009.

"Tier 2 is the option that if we know the water quality, the background water quality, then the discharge can be no worse than the known".

The testimony of landowners typically refers to water quantity rather than water quality. Ms. West states: "We have as much water as we want, and way more water than we want. ... We have had a great deal of flooding. We have lost 80 acres of prime hay meadow. ... Please do not implement this Tier 2". Ms. Barlow states: "In 2003 a large reservoir above my property contained CBM water, upper flowed and flooded the bottomland of my property for three months. ... The carpet of native grass was replaced for the first three years by bare soils, and now there is a few unpalatable weeds". Mr. Swartz quantifies: "June 2008 they dumped water at 102 to 136 cubic feet per second. ... DEQ likes to say ... We are not concerned with quantity. We're only concerned with quality. State engineer says we aren't concerned with quality, we're only concerned with quantity. And I'm getting the runaround and I don't like it". These statements confirm Dr. Munn's observation "In many cases, you're are going from ephemeral to a perennial flowing system".

Landowners who don't have to deal with damage by flooding are quite positive. Mr. Brug states: "I'd like to see the regulations surely not get any stiffer, because if it was, some of these instances I wouldn't be able to use more water". Mr. Litton observes: "We've got eight miles of bottomlands, which we hayed at one time. We don't anymore. But it has some methane water running the length of it, and spreads out for some places a quarter of a mile wide. And yet over this past seven years that we've been letting water on there, we still see no signs of salt showing up. Just a point of the quality of water that we have". Ms. Faye Mackey testifies: "I'm here to speak not only for my ranch, but the 581,250 acres, landowners represented here on the map in blue. ... These ranches use our water beneficially for our livestock, wildlife habitat, irrigation, and even some domestic water. ... There is no waste of water here. ... This water, and my ability to direct its use on my ranch, is essential to my current agriculture operation. ... There's no one-size-fits-all solution. We, as ranchers, know our soil types. We look at whether we can irrigate on a mister or pivot system, and industry has been very helpful in this, testing the soils and ...

taking water samples at different intervals ... There have been studies by industry in these areas of irrigation that the native grass is approximately five times thicker with CBM produced water than without the application of this water. Mr. Eitel's opinion: "If you set up real stringent rules, that one-size-fits-all, it just doesn't work in our area". Mr. Shepperson states: "I am in favor, as a landowner, of your Tier 2 regs. ... There's so much variability in the sites, ...So the variabilities of sites, you've got to have the flexibility to deal with these things site by site. And keep that in the regs, please. ... keep the negotiations between the landowner and industry open. Allow for that. Let us negotiate with industry on our ranches, but, boy, keep your oversight, too, on your rules".

Experts' Opinion. Several landowners clearly have suffered flood damage by unmanaged releases of CBM water and not recognizing the duration and volume of CBM waters to be received. Although these issues are serious, they can be resolved by proper engineering of CBM water release infrastructure and by developing management plans for the use of CBM water on artificially and naturally irrigated lands. As a matter of fact, the landowners who are enthusiastic about receiving CBM waters express a common concern against stiffer regulations that would prevent them to manage their CBM water in a flexible manner adapting to the natural variability of their ranches.

The amount of CBM water in Wyoming and other states is very large. For example, the Bureau of Land Management forecasts 51,000 wells in the Powder River Basin operating and producing gas and water by 2010. These 51,000 wells are expected to produce nearly 700 million gallons of CBM water per day[8]. These water supplies are sufficient to irrigate about 75,000 acres. However, to realize the potential benefits of CBM water it is necessary to manage both water quality and water quantity on the artificially and naturally irrigated lands receiving this water. There is general agreement that beneficial use of marginal waters for irrigation is possible if principles and strategies of salinity management are considered at on-farm and project-levels (Ayers and Westcot, 1994; Rhoades, 1999; Tanji, 1997). Mr. Harvey has presented some nice examples how marginal water can be made productive in Wyoming on managed irrigated lands.

[8] Petition 05-3102 before Wyoming Environmental Quality Council by the Wyoming Outdoor Council.

The most beneficial use of CBM waters can only be realized by managed irrigation taking into account both the quality and quantity of the produced waters. Managed irrigation needs to balance the supply from the CBM wells with the crop water requirements during the year taking into account quality and quantity of the produced waters. This will be a great challenge for engineers in the petroleum industry, landowners, soil and water resource consultants, researchers at the University of Wyoming, and regulators at DEQ. However, the hearings have shown that a large pool of dedicated professionals is ready to face this challenge. Given the broad range of experiences with existing use of produced waters in Wyoming, progress with irrigation management plans and regulations shouldn't take too long.

5. EXPERT SCIENTIFIC OPINIONS

In Chapter 2 expert scientific opinions are requested on two questions A and B. In this chapter we will respond to these questions and formulate a short opinion on the way forward that we consider relevant for the policy contained in Chapter 1, Section 20 of the AUPP.

Question A. Whether the Tier 2 methodology as set forth in Appendix H section c(vi)(B) is reasonable and scientifically valid for determining the EC and SAR of water that can be discharged into an ephemeral drainage in Wyoming so that degradation of the receiving water will not be of such an extent to cause a measurable decrease in crop production.

Scientific Expert Opinion A. The Tier 2 methodology as set forth in Appendix H section c(vi)(B) is not reasonable nor scientifically valid for determining the EC and SAR of water that can be discharged into an ephemeral drainage in Wyoming so that degradation of the receiving water will not be of such an extent to cause a measurable decrease in crop production.

Clarification A. Tier 2 is based on the option that if the background water quality in an ephemeral drainage is known, the quality of the discharge of CBM produced water can be no worse. Tier 2 is based on the erroneous belief that a measurable decrease in crop production only will occur if the quality of the discharge of CBM produced water is worse than the background water quality. In Chapter 3, we have explained that root zone soil salinity does not depend directly on the quality of the irrigation water; it depends on soil characteristics, climate, depth of ground water table, and more importantly irrigation management. The scientific literature provides examples where marginal irrigation water is successfully used for crop production.

Question B. Whether the method set forth in Appendix H section c(vi)(B) for determining EC and SAR for permitting the discharge of produced water is reasonable, sufficiently defined and scientifically defensible for the conditions in

Wyoming, and provides a uniform testing procedure that is reasonably accurate and unbiased for the determination of soil EC from which you can reasonably infer the quality of the water EC and SAR that historically flowed within the drainage that will support the establishment of effluent limits for discharge permits in a given drainage that will not cause a measurable decrease in crop production.

Scientific Expert Opinion B. The method set forth in Appendix H section c(vi)(B) for determining EC and SAR for permitting the discharge of produced water is not reasonable nor sufficiently defined nor scientifically defensible for the conditions in Wyoming. It does not provide a uniform testing procedure that is reasonably accurate and unbiased for the determination of soil EC from which you can reasonably infer the quality of the water EC and SAR that historically flowed within the drainage that will support the establishment of effluent limits for discharge permits in a given drainage that will not cause a measurable decrease in crop production.

Clarification B. See first Clarification A. As explained in Chapter 4 the proposed soil testing procedure would result in ambiguous soil maps. We refer to the recent science literature how an accurate soil salinity map can be made without spending too much.

Scientific Expert Opinion on Way Forward. Since it is not scientifically defensible to use Tier 2, the question is how to move forward. The use of Tier 1 can be continued since it is conservative and has been accepted by the community. Of course, as explained in Chapter 3 using Tier 1 CBM water can still result in increased soil salinity and reduced crop yields if not managed well. The latter aspect is of special importance when the quantity of available water is substantial. Current research in Wyoming and surrounding states may result in a relaxation of the crop threshold values that are currently based on California conditions. Mr. Harvey's testimony suggests that these threshold values may be too strict for Wyoming conditions.

If the water quality requirements of Tier 1 cannot be met, the Irrigation Waiver seems the preferred alternative since it requires an irrigation management plan that provides reasonable assurance that the lower quality water will be confined to the targeted lands. In this manner, the Irrigation Waiver will deal with the issue of water quantity. Given the large scale on which CBM water is produced it seems justifiable to implement an aggressive applied and basic research program to develop guidelines on how to use CBM water in a beneficial manner.

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8

AGRICULTURAL USE PROTECTION POLICY[1]
(Chapter 1, Section 20)

I. Purpose

All surface waters in Wyoming are protected to some extent for agricultural uses. "Agricultural uses" are described in Chapter 1, Section 3 as being either stock watering or irrigation. The standard that applies to the protection of these uses is contained in Chapter 1, Section 20 which states:

> *Section 20.* ***Agricultural Water Supply.*** *All Wyoming surface waters which have the natural water quality potential for use as an agricultural water supply shall be maintained at a quality which allows continued use of such waters for agricultural purposes.*
>
> *Degradation of such waters shall not be of such an extent to cause a measurable decrease in crop or livestock production.*
>
> *Unless otherwise demonstrated, all Wyoming surface waters have the natural water quality potential for use as an agricultural water supply.*

All water quality standards are established for two reasons. The first is to provide a benchmark against which a determination can be made as to whether a waterbody is impaired and requires some kind of corrective action. The second is to provide a basis for establishing permit limits on regulated activities (WYPDES & Section 404 permits). The purpose of this policy is to provide guidelines to be used by the Water Quality Division when translating the narrative goals expressed in the Section 20 standard into appropriate WYPDES permit limits where maintaining agricultural use of the receiving waters is an issue.

Agricultural use of surface water is an opportunistic endeavor. The varying uses as well as the different qualities of the water found in the state are many and the farming and ranching industries have always had to make do with what water is available. The goal expressed in the Section 20 standard is simply to maintain surface water quality at a level that will continue to support the local agricultural uses that have developed around it.

Though the goal is simple, achieving it is not. For the most part, managing water quality for continued agricultural support requires managing the concentration and chemical makeup of dissolved solids. Because of local differences in crop types, soil types and natural water

[1] This policy was finalized in August, 2006 in conjunction with the Triennial Review of the Chapter 1 surface water standards. A modified version of this policy is under consideration by the Wyoming Environmental Quality Council for adoption as an appendix to the Chapter 1 rules. Until a final decision is rendered on that rulemaking, the provisions of this policy remain in effect for establishing effluent limits on discharges that may affect agricultural uses. The only exception is that the formula for calculating SAR limits has been updated to be SAR < $(EC_{ds/M} \times 6.67) - 3.33$.

quality and availability, it isn't possible to establish simple numeric criteria for pollutants such as TDS and SAR that will allow an efficient use of surface water for irrigation purposes. The determination of what is acceptable water quality for irrigation must necessarily involve an evaluation of local agricultural practices and background water quality conditions. For livestock watering uses, it is somewhat less complicated because there are fewer variables to consider.

"Measurable Decrease"

The first part of translating the standard is defining what is meant by *"measurable decrease in crop or livestock production"*. The phrase implies that there is a pre-existing agricultural use of a stream or drainage prior to an application for aWYPDES discharge permit. For livestock watering purposes, a pre-existing use will always be assumed. For irrigation purposes, there needs to be either a current irrigation structure or mechanism in place for diverting water from the stream channel, or a substantial acreage of naturally sub-irrigated pasture within a stream floodplain. Where neither of these conditions exist, there can be no irrigation use, nor loss in crop production attributable to water quality.

Where there are pre-existing agricultural uses, it may often be impossible to measure a loss in crops or livestock that can be attributed to water quality because of the many other factors that will affect actual production. It is also important to be able to predict the probability of a measurable decrease in production rather than relying solely on after-the-fact measurements. Therefore, the implementation of the narrative criteria through WYPDES permits will always involve making reasonable judgments and assumptions.

Effluent limits on historic discharges of produced water will not be affected by this policy in relation to the protection of agricultural uses. Where discharges have been occurring for many years, the permitted quality of those discharges shall be considered to be "background" conditions and be fully protective of the agricultural uses that have developed around them. Therefore, it is not necessary to modify those discharges in order to achieve the goal of "no measurable decrease" in crop or livestock production. It would only be necessary to maintain the existing quality of the discharge. It is important to note, however, that effluent limits on historic discharges may be made where the quality of the discharge is shown to constitute a hazard to humans, livestock or wildlife.

II. Livestock Watering

The basic concept in protecting a livestock watering use is to ensure that water quality is not acutely toxic to livestock or does not contain pollutants in concentrations that would affect growth or reproduction. There are basic effluent limitations provided in the WYPDES permit regulations *(Chapter 2 of the Water Quality Rules and Regulations)* that are intended to ensure that the water is safe for livestock to drink. These limits are:

5000 mg/L TDS;
3000 mg/L Sulfate;
2000 mg/L Chloride;

and each must be achieved at the end-of-pipe prior to mixing with the receiving stream. In addition to the basic effluent limitations the following limits for livestock protection may be incorporated into WYPDES permits when there is reason to believe they may be associated with a discharge:

Selenium	50 µg/L	Total Recoverable
Fluoride	4000 µg/L	Dissolved
Arsenic	20 µg/L	Total Recoverable
Copper	500 µg/L	Dissolved
Cadmium	50 µg/L	Dissolved
Boron	5000 µg/L	Dissolved
Chromium	1000 µg/L	Dissolved
Lead	100 µg/L	Dissolved
Mercury	10 µg/L	Dissolved
Zinc	2500 µg/L	Dissolved

Livestock watering waver

An exception to the limits above may be made whenever the background water quality of the receiving water is worse than the value listed for the associated pollutant or when the livestock producer requests use of the water and thereby accepts any potential risk to his livestock.

III. Irrigation

The interpretation of the Section 20 standard for irrigation is more complex than for livestock watering because there are more variables than just the quality of the water to consider. However, after considering the local circumstances relative to irrigation and crop production, effluent limits can be established on WYPDES permits that will be protective of the pre-existing irrigation uses. The goal is to ensure that pre-existing irrigated crop production will not be diminished as a result of the lowering of water quality.

The basic water quality parameters of concern in regard to irrigation are electrical conductivity (EC) and sodium adsorption ratio (SAR). Protection of irrigation uses where WYPDES permits are involved amounts to deriving appropriate effluent limits for EC and SAR in each instance.

A. Identification and Protection of Irrigation Uses.

Implementation of the Section 20 standard through the WYPDES permitting program involves a sequence of decisions based upon the amount and quality of data that is available to the permit writer. The most basic question is whether a proposed discharge will reach irrigated lands. If the discharge will not reach an irrigated field, either because of natural conditions or water management techniques, it could not affect crop production on that field. For the purposes of this policy, irrigated lands include the following:

1. Artificially Irrigated Lands: Artificially irrigated lands are those where water is intentionally applied for agricultural purposes. Artificially irrigated lands will be identified by the presence of canals, ditches, spreader dikes, spray irrigation systems or any other constructed mechanism intended to divert water from a stream channel for application on adjacent lands.

2. Naturally Irrigated Lands: Naturally irrigated lands are areas of land along stream channels that have enhanced vegetative production due to periodic natural flooding or sub-irrigation. Naturally irrigated lands are those lands where a stream channel is underlain by unconsolidated material and on which the combination of stream flow and channel geometry provides for enhanced productivity of agriculturally significant plants. Naturally irrigated lands may be identified by an evaluation of infra-red aerial photography, surficial geologic maps, wetland mapping, landowner testimony or any combination of that information.

Appropriate effluent limits for EC and SAR will be calculated and applied to WYPDES discharge permits in all instances where the produced water discharge may reach any artificially irrigated lands.

EC and SAR limits will also be applied to WYPDES permits where the produced water discharge may reach stream segments containing sufficient acreage of naturally irrigated land to be considered agriculturally significant. In general, stream segments containing single parcels of naturally irrigated land greater than 20 acres in size or multiple parcels in near proximity that total more than 20 acres shall be considered agriculturally significant. In making this estimation, small drainage bottoms may be excluded from consideration. Two specific criteria which may be used to exclude lands include lack of a persistent active channel and unconsolidated floodplain deposits which are generally less than 50 feet in width.

If there are no pre–existing diversions within reach of a discharge or if the water will be impounded or managed so as not to reach a diversion during the irrigation season, there would be no potential to adversely affect crop production. Likewise, if there are no agriculturally significant, naturally irrigated lands within reach of a discharge there would be no potential to adversely affect crop production. In these circumstances, permit limits would be established to protect other relevant water uses (e.g. livestock watering, wildlife, aquatic life etc.).

B. Data and Information

There is a minimum amount of data that must be collected in every circumstance in order to identify existing irrigation uses and to appropriately set effluent limits on discharges that may affect those uses. Additional information that is beyond the minimum requirements can also be considered to fine tune the permitting decisions in a way that best addresses the various interests for the water.

At a minimum the following information must be obtained:

- Location(s) of irrigation diversions and/or naturally irrigated acreage;
- Crops grown under irrigation;
- Published tolerance values for the most sensitive crop;
- Season of use
- Description of Irrigation Practices

C. Establishing Effluent Limits

A 3-tiered decision making process will be used to establish appropriate effluent limits for EC and SAR whenever a proposed discharge will likely reach irrigated lands. Tier 1 refers to a procedure for setting default EC and SAR limits and is useful in situations where the irrigated crops are salt-tolerant and/or the discharge water quality is relatively good. Tier 2 refers to a process whereby the default limits may be refined to equal background water quality conditions and is intended to be used in situations where the background EC and SAR is worse than the effluent quality. As a final measure, Tier 3 applies where background EC and SAR is better than the effluent quality. The purpose of a Tier 3 analysis is to provide sufficient justification to establish effluent limits that are of a lower quality than the pre-discharge background conditions. Under Tier 3, effluent limits may be established based upon local site conditions and irrigation practices to a level that can be demonstrated to cause no harm to the existing irrigation uses.

1. Tier 1 -Default EC and SAR limits

Default limits for EC and SAR may be used where the quality of the discharge water is relatively good or the irrigated crops are salt-tolerant. The default values shall be based upon the published soil EC tolerance values for the most sensitive crop and shall be calculated as follows:

a. Default EC limits will be based upon 100 percent yield threshold values for soil EC reported by the USDA Agricultural Research Service (ARS) Salt Tolerance Database. In the event that the species of interest is not included in the ARS Salt Tolerance Database, then the following alternative references can be consulted:

(1) Hanson et al. 2006[2]. Agricultural Salinity and Drainage. DANR Pub. 3375, Univ. of Calif. Davis;

(2) Ayers and Westcot. 1985. Water Quality for Agriculture. UN FAO Irrigation and Drainage Pager 29 (revised); and

(3) CPHA. 2002. Western Fertilizer Handbook. 9th Edition. Interstate Pub., Inc., Danville, IL.

The relationship between soil EC values and irrigation water EC values will be: EC (soil) = 1.5 EC (water), i.e., the published soil EC threshold obtained from the appropriate reference will be divided by the soil concentration factor of 1.5 to establish the discharge EC limit.

However, in circumstances where the background water quality of the receiving water(s) is known to be significantly better than would otherwise be required based on a theoretical 100% yield, effluent limits may be set to maintain that higher quality.

b. Default SAR values will be extrapolated from the Hanson et al. (2006)[2] Chart *(see Figure 1, attached)* based upon the default EC value in each circumstance up to a maximum default value of 10. The effluent limit for SAR will be determined in conjunction with EC so that the relationship of SAR to EC remains within the "no reduction in rate of infiltration" zone of Figure 1. The maximum SAR limit is, therefore, set below the line separating the "no reduction in rate of infiltration" zone from the "slight to moderate reduction in infiltration" zone in the Hanson et al. diagram, which is represented by the following equation: $SAR < (6.67 \times EC) - 3.33$[3]. It must be noted that SAR values are tied to the EC concentration and might need to be adjusted to correlate to the actual EC concentration rather than the theoretical maximum.

Use of the Hanson diagram to extrapolate default effluent limits for SAR is capped at a maximum SAR of 10 to minimize the potential for sodium build-up in poorly drained soils. This 10 SAR cap is only intended to apply when utilizing the default procedure and may be modified according to the provisions of section C.2 "Refining EC and SAR Limits", described below.

[2] This reference has been updated to the 2006 version of the Agricultural Salinity and Drainage Manual from the previously cited 1999 version

[3] This Formula has been updated from the previously used $SAR < (EC_{ds/M} \times 7.10) - 2.48$ in accordance with the 2006 Salinity and Drainage Manual.

c. At a minimum, the EC and SAR limits will apply during the irrigation season and when flows are sufficient to support the use. On sub-irrigated lands and passively irrigated lands such as those under spreader dike systems, the irrigation season shall generally be considered to be year-round.

2. Refining EC and SAR limits (Tiers 2&3)

Establishing EC and SAR limits based simply on the most sensitive crop is the most stringent approach and would be protective of the irrigation use in all circumstances. It may be possible to refine those values if additional information is available showing that less stringent effluent limits would be adequately protective. This type of showing can be made by demonstrating that background water quality conditions are of a lower quality than the default values or by demonstrating that because of local soil conditions and irrigation practices there would be no harm to crop production from less stringent EC and SAR limits.

a. Tier 2 - Background Water Quality

If sufficient data is available to demonstrate or calculate that the pre-existing background water quality at the point(s) of diversion is worse than the effluent quality, EC and SAR effluent limits may be based upon those background conditions rather than tolerance values for the most sensitive crop.

(1). Measured Data: Background water quality may be established based upon published pre-discharge historic data. Generally, this data only exists on larger, perennial, mainstem stream channels where historic gauging has taken place. Actual measured data is the most reliable means of establishing background and must be considered on those waters where it is available.

(2). Calculated Background: On intermittent and ephemeral stream channels, pre-discharge water quality data is usually scarce or non-existent and very difficult to collect. In these circumstances, background water quality can be estimated by conducting soil surveys on land that has been historically irrigated from the subject stream.

In the event that soil studies are used as a means to estimate baseline water quality for a given drainage, the following requirements apply:

(i) Sample Site Selection: Soil samples shall be taken at semi-random sites within each contiguous irrigated segment downstream of the proposed discharge. "Semi-random" in this case is intended to mean that the applicant will identify the various major distinguishing terrain zones within each

irrigated segment and select sample sites randomly within each terrain zone. For example, the channel bottom may constitute one terrain zone, the first small terrace above the channel bottom may be another terrain zone, and the adjacent meadow or field may be a single remaining terrain zone, or that meadow / field may actually be comprised of several other known zones such as discharge-affected soils vs. non-affected soils, sub-irrigated reaches vs. non-sub-irrigated reaches, etc..

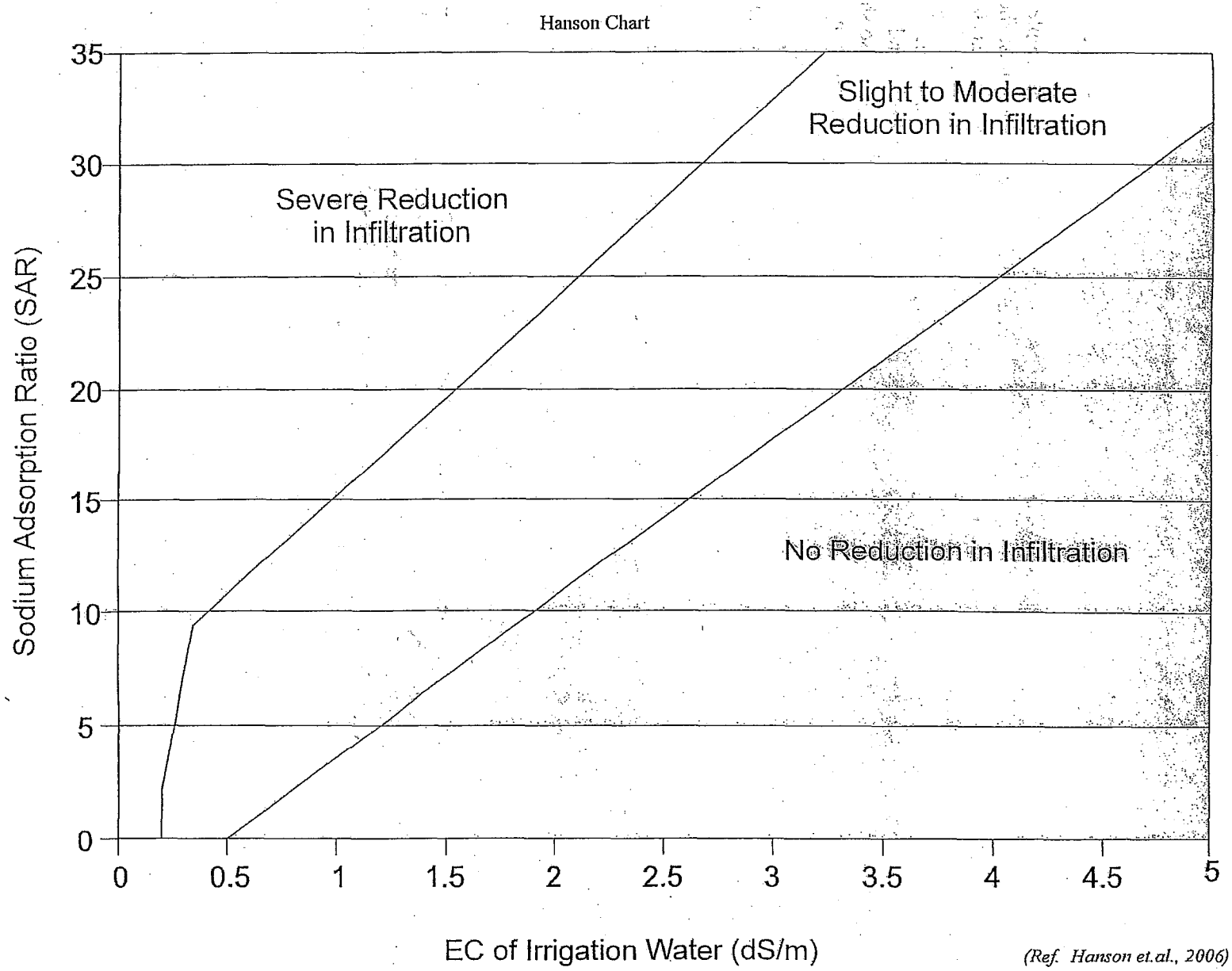
(ii) Number of Sample Sites: Listed below are the minimum number of soil sample sites required for each of the identified terrain zones (based on zone area) within a contiguous irrigated segment:

Zone Area	Minimum Number of Sample Sites
0 – 5 acres	3
5 - 10	5
10 + acres	7

(iii) Sample Collection: Sample sites must be located a minimum of 50 feet apart from one another. Each sample site shall be sampled at a minimum of four depths (0-12", 13-24", 25-36", 37-48"). If alfalfa is present within the terrain zone, each sample site within that terrain zone must be sampled at a total of 6 depths (at the above-noted depths, plus 49-60" and 61-72"). Each 12-inch depth sample must be analyzed either individually or combined (composited) with other corresponding depth samples from the other sample sites within the same terrain zone (i.e., all 0-12" samples from a given terrain zone bulked together and analyzed as a single composite sample).

(iv) Sample Analysis: At a minimum, a saturated paste extract for each sample shall be analyzed for EC. Though not necessary for the estimation of background water conductivity, it is advisable to also analyze the soil samples for pH, SAR, soil texture and exchangeable sodium percentage (ESP) to avoid having to duplicate the sampling if the results indicate that a "no harm analysis" *(item b. below)* needs to be completed. Percent organic matter shall be analyzed in the surface 0-12 inch samples only. In addition, analyses to identify the clay mineralogy types present in the soils may also be warranted.

Figure 1



(Ref. Hanson et.al., 2006)

(v) Soil Report Preparation: At a minimum the applicant shall submit:

i. A map or diagram identifying where each of the soil sample sites were located. At a minimum, the map or diagram must show the basic topography and stream course, irrigation structures *(if present - such as spreader dams or head gates)*, estimated boundaries of the irrigated acreage, surface ownership of the irrigated acreage *(including downstream irrigated areas)* and section / township / range identification. This map must also show any delineated terrain zones, plus elevations of the terrain zones;

ii. An accompanying location table which includes the quarter / quarter, section, township, range, and latitude / longitude for each sample site;

iii. Summary data table showing the analytical results for each of the soil parameters listed above, for each depth, at each sample site.

iv. All associated lab sheets.

b. Tier 3 - No Harm Analysis

The actual effects of EC and SAR on crop production are variable based upon soil type and chemistry and may be mitigated to some extent by managing irrigation practices. EC and SAR effluent limits may also be established based upon a scientifically defensible site specific study that examines local soil characteristics, natural water quality, expected crop yield, irrigation practices and/or any other relevant factor related to crop production.

Because of the very site-specific nature of this approach and the number and complexity of variables that may need to be considered, it is not very useful to specify any particular type of analysis in this policy. When taking this approach, however, there is a burden of proof placed upon the applicant to demonstrate through a comprehensive study that levels of EC and/or SAR higher than either the default values or estimated background water quality would most likely not measurably harm an existing irrigation use. This approach will allow a degree of creativity regarding landowner preferences and management. Refined limits for EC and SAR resulting from a "no harm" analysis should incorporate a reasonable margin of safety to account for variables that cannot be precisely measured or modeled.

c. Irrigation Waiver

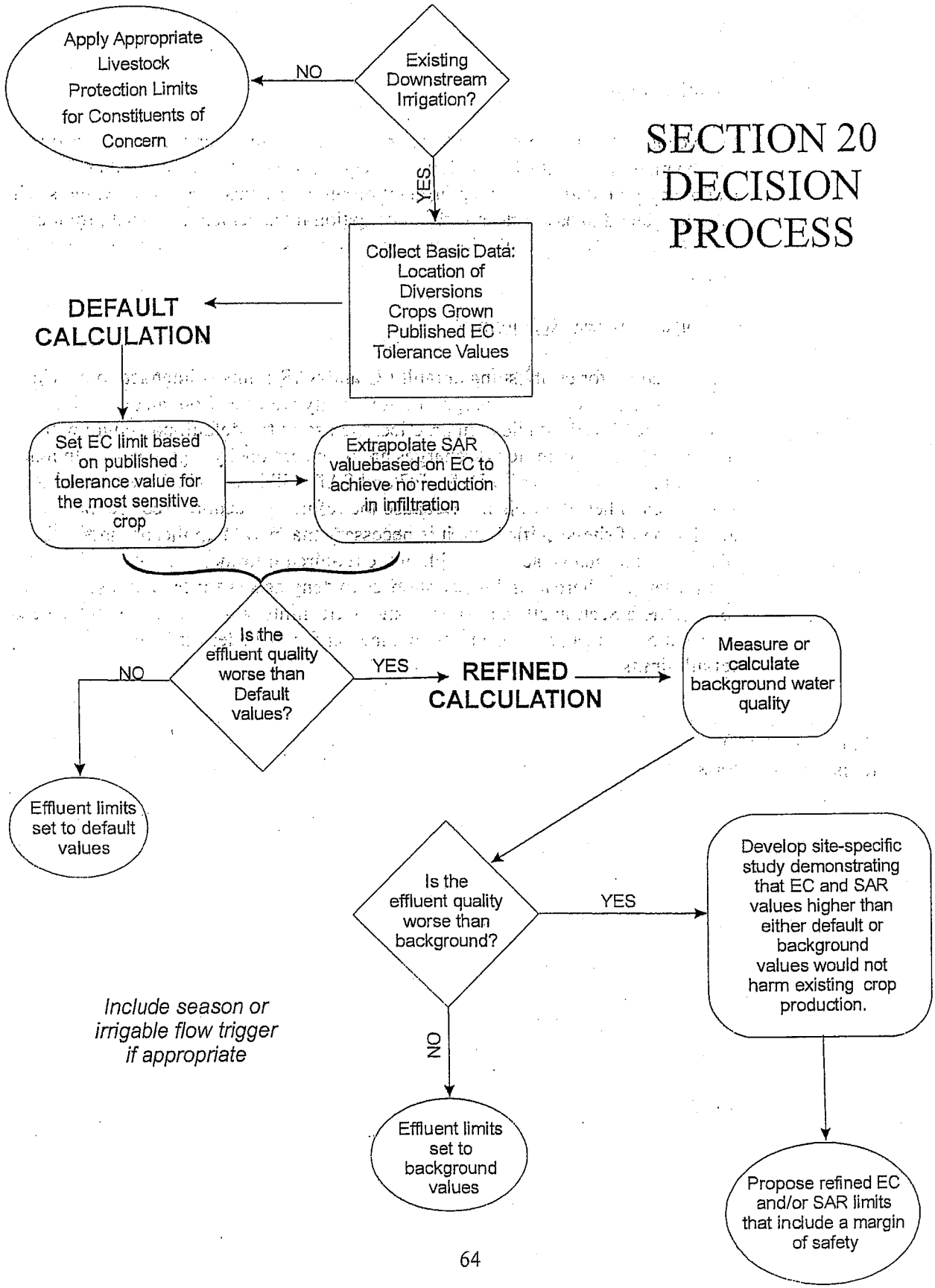
An exception to EC or SAR limits established under the Tier 1, 2 or 3 procedures may be made when affected landowners request use of the water and thereby accept any potential risk to crop production on their lands. Irrigation waivers will only be granted in association with an irrigation management plan that provides reasonable assurance that the lower quality water will be confined to the targeted lands.

d. Reasonable Access Requirement

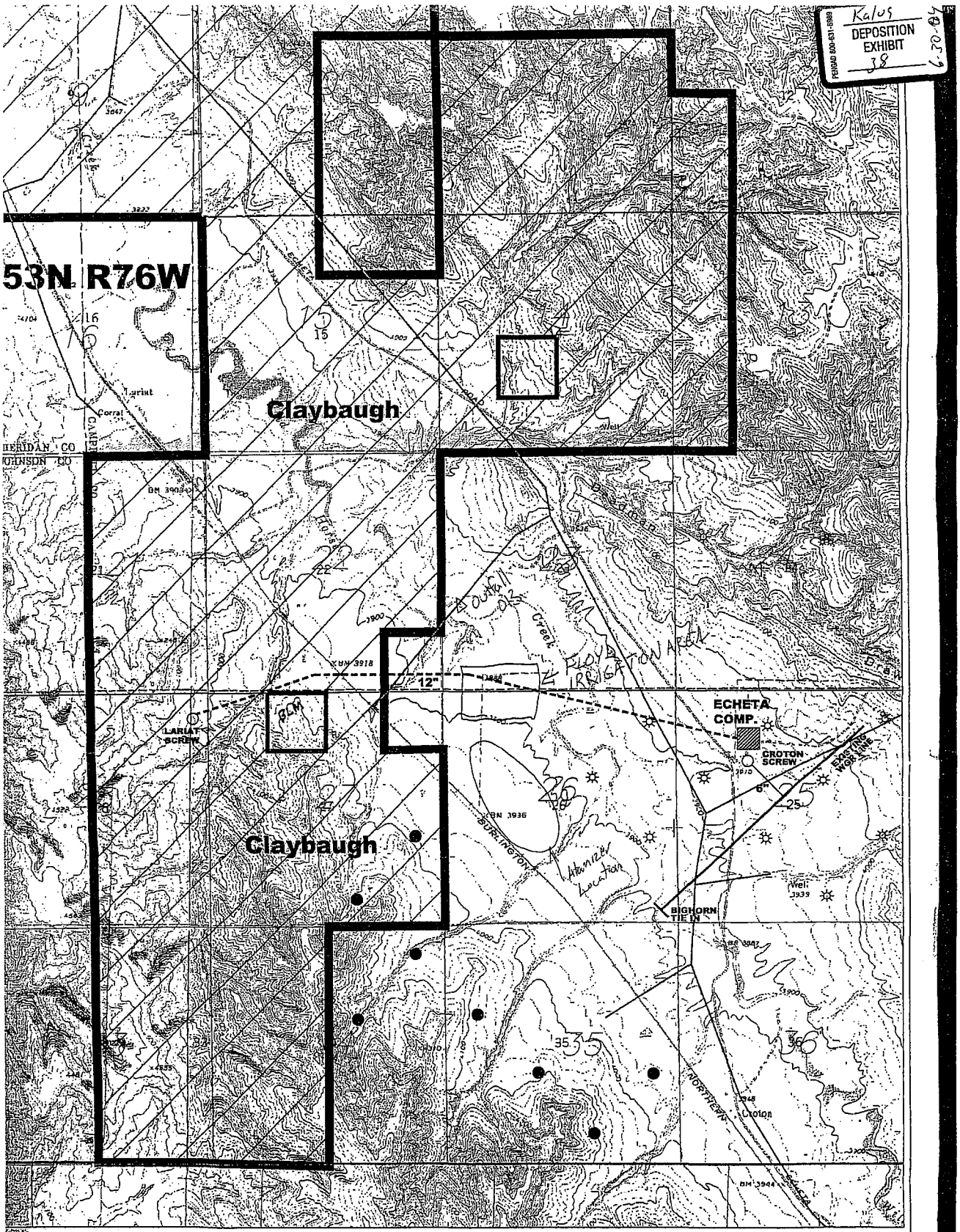
The procedure for establishing default EC and SAR limits is intended to provide the ability to permit the discharge of high quality water without an obligation to conduct site specific studies. In practice, the use of the default procedure will only apply where permitted discharges are of exceptionally high quality. In many applications, appropriate limits for EC and SAR will have to be based on refined procedures rather than default. Because the refined procedures require the acquisition of site-specific data, it is necessary that permit applicants and/or the DEQ have reasonable access to obtain the required information. In circumstances where a landowner chooses to deny access for the purpose of developing a Section 20 analysis, EC and SAR limits will be based upon the best information that can be reasonably obtained and may be less stringent than Tier 1 default limits.

WJD/7-0156.DOC
revised 11/20/2008

SECTION 20 DECISION PROCESS



9



Kalus
DEPOSITION EXHIBIT
38
6-20-04

ALTERNATE WATER DISCHARGE SEE WATER MANAGEMENT PLAN

PROPOSED WATER DISCHARGE W/# OF WELLS

EXISTING 2-TRACK

EXISTING ALL WEATHER

PROPOSED ALL WEATHER

PROPOSED 2-TRACK

G/CG GATE/CATTLE GUARD

DRAWN BY:	PAUL MCELVERY
DATE:	01-31-03
CHK'D BY:	APRV'D BY:
PREPARED BY:	
SCALE:	1" = 2,000'
DWG. #:	NORTH

LANCE OIL & GAS COMPANY, INC.
12200 N. Pecos Street • Denver, Colorado 80234

COALBED METHANE
PLAN OF DEVELOPMENT
CLAYBAUGH RANCH INC.
SHERIDAN/JOHNSON COUNTY, WYOMING

REV	REVISION DESCRIPTION	BY	DATE	CHK'D	DATE

10

7

SERVICES CONTRACT BETWEEN
WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY AND
JAN M. H. HENDRICKX AND BRUCE BUCHANAN

1. Parties. The parties to this Contract are the Wyoming Department of Environmental Quality [DEQ]; whose address is: 122 West 25th Street, 4 West; Cheyenne, WY 82002 and Jan M. H. Hendrickx Ph.D., Professor of Hydrology, whose address is Department of Earth & Environmental Science, New Mexico Institute of Mining and Technology, Socorro, NM 87801; and Bruce Buchanan of Buchanan Consultants, Ltd., whose address is P.O. Box 2549, Farmington, NM 87499-2549. Hereinafter, Dr. Hendrickx and Dr. Buchanan shall be referred to jointly and severally as "Contractor."

2. Purpose of Contract. The purpose of this Contract is to set forth the terms and conditions by which the Contractor shall provide further clarification on the report entitled "Expert Scientific Opinion on the Tier-2 Methodology" and discuss in more detail the DEQ permitting program as it pertains to agricultural use protection. The Contractor shall provide advice to DEQ as to whether and how the findings and recommendations in the expert report may be used to revise DEQ's approach to permitting surface discharges of produced water.

3. Term of Contract and Required Approvals. This Contract is effective when all parties have executed it and all required approvals have been granted [Effective Date]. The term of the Contract is from June 29, 2009 through July 31, 2009. All services shall be completed during this term.

By law, contracts for professional or other services must be approved by the Attorney General and the Procurement Services Division of the Department of Administration and Information, Wyo. Stat. § 9-1-403(b)(v), and all contracts for services costing over one thousand five hundred dollars ($1,500.00) must be approved by the Governor or his designee as well, Wyo. Stat. § 9-2-1016(b)(iv).

4. Payment. The DEQ agrees to pay Contractor for the services described in Attachment A, which is attached and made a part of this Contract. This is a unit price contract and payment shall be based on actual hours worked at a rate of one hundred fifty dollars ($150.00) per hour worked. Any travel required by the Contractor shall be reimbursed at a rate of seventy-five dollars ($75.00) per hour traveled plus the State of Wyoming rate for mileage and actual expenses for lodging, meals and airfare Pursuant to Wyo. Stat. § 9-3-102 and 9-3-103. The total payment under this Contract shall not exceed fifteen thousand dollars ($15,000.00).

Funding for this Contract is provided by the WYPDES Fee Program.

5. Responsibilities of Contractor. The services to be provided by Contractor are described in Attachment A, Scope of Work, which is attached and made a part of this Contract.

6. Special Provisions.

A. Limitation of Payments. The DEQ's obligation to pay the Contractor for services rendered pursuant to this Contract is conditioned upon the availability of State or federal

government funds which are allocated to pay the Contractor. If funds are not allocated and available for the DEQ to pay the Contractor for these services, the DEQ may terminate this Contract at the end of the period for which the funds are available.

The DEQ shall notify Contractor at the earliest possible time if this Contract will or may be affected by a shortage of funds. No liability shall accrue to the DEQ in the event this provision is exercised, and the DEQ shall not be obligated or liable for any future payments due or for any damages as a result of termination under this section. This provision shall not be construed so as to permit the DEQ to terminate this Contract in order to acquire similar services from another party.

B. **Monitor Activities.** The DEQ shall have the right to monitor all Contract related activities of the Contractor and all subcontractors. This shall include, but not be limited to, the right to make site inspections at any time, to bring experts and consultants on site to examine or evaluate completed work or work in progress, and to observe all Contractor personnel in every phase of performance of Contract related work.

C. **Nondiscrimination.** The Contractor shall comply with the Civil Rights Act of 1964, the Wyoming Fair Employment Practices Act (Wyo. Stat. § 27-9-105 *et seq.*), the Americans With Disabilities Act (ADA), 42 U.S.C. 12101-0, *et seq.*, and the Age Discrimination Act of 1975. The Contractor shall not discriminate against any individual on the grounds of age, sex, color, race, religion, national origin or disability in connection with the performance of the Contract.

D. **No Finder's Fees.** No finder's fee, employment DEQ fee, or other such fee related to the procurement of this Contract shall be paid by either party.

7. General Provisions.

A. **Amendments.** Any changes, modifications, revisions or amendments to this Contract which are mutually agreed upon by the parties to this Contract shall be incorporated by written instrument, executed and signed by all parties to this Contract.

B. **Americans with Disabilities Act.** The Contractor shall not discriminate against a qualified individual with a disability and shall comply with the Americans with Disabilities Act, P.L. 101-336, 42 U.S.C. 12101, *et seq.*, and/or any properly promulgated rules and regulations related thereto.

C. **Applicable Law/Venue.** The construction, interpretation and enforcement of this Contract shall be governed by the laws of the State of Wyoming. The Courts of the State of Wyoming shall have jurisdiction over this Contract and the parties, and the venue shall be the First Judicial District, Laramie County, Wyoming.

D. **Assignment/Contract Not Used as Collateral.** Neither party shall assign or otherwise transfer any of the rights or delegate any of the duties set forth in this Contract without the prior written consent of the other party. The Contractor shall not use this Contract, or any portion thereof, for collateral for any financial obligation.

E. **Assumption of Risk.** The Contractor shall be responsible for any loss of State or federal funding, either administrative or program dollars, due to Contractor's failure to comply with State or federal requirements. The DEQ shall notify the Contractor of any State or federal determination of noncompliance.

F. **Audit/Access to Records.** DEQ and any of its representatives shall have access to any books, documents, papers, and records of the Contractor which are pertinent to this Contract. The Contractor shall, immediately upon receiving written instruction from DEQ, provide to any independent auditor, accountant, or accounting firm, all books, documents, papers and records of the Contractor which are pertinent to this Contract. The Contractor shall cooperate fully with any such independent auditor, accountant, or accounting firm, during the entire course of any audit authorized by DEQ.

G. **Availability of Funds.** Each payment obligation of the DEQ is conditioned upon the availability of government funds which are appropriated or allocated for the payment of this obligation. If funds are not allocated and available for the continuance of the services performed by the Contractor, the contract may be terminated by the DEQ at the end of the period for which the funds are available. The DEQ shall notify the Contractor at the earliest possible time of the services which will or may be affected by a shortage of funds. No penalty shall accrue to the DEQ in the event this provision is exercised, and the DEQ shall not be obligated or liable for any future payments due or for any damages as a result of termination under this section. This provision shall not be construed to permit the DEQ to terminate this Contract in order to acquire similar services from another party.

H. **Award of Related Contracts.** DEQ may undertake or award supplemental or successor contracts for work related to this Contract. The Contractor shall cooperate fully with other contractors and DEQ in all such cases.

I. **Certificate of Good Standing.** Contractor shall provide Certificate of Good Standing verifying compliance with the unemployment insurance and workers' compensation programs prior to performing work under this Contract.

J. **Compliance with Law.** The Contractor shall keep informed of and comply with all applicable federal, State and local laws and regulations in the performance of this Contract.

K. **Confidentiality and Publicity.** All documents, data compilations, reports, computer programs, photographs, and any other work provided to or produced by the Contractor in the performance of this Contract shall be kept confidential by the Contractor unless written permission is granted by the DEQ for its release. Any publicity given to the program or services provided herein, including, but not limited to, notices, information, pamphlets, press releases, research, reports, signs, and similar public notices prepared by or for the Contractor, shall identify the DEQ as the sponsoring agency and shall not be released without prior written approval from the DEQ.

L. **Disputes/Remedies.** In seeking to resolve any dispute relating to this Contract, the DEQ does not waive its sovereign immunity. Any dispute or claim arising out of or relating to this Contract may be assigned to non-binding mediation upon mutual agreement of the parties, in accordance with the Wyoming Supreme Court's rules for alternative dispute resolution. The parties to the dispute shall bear their respective costs for the mediation. The rights and remedies of the parties provided for in these clauses are in addition to any other rights and remedies provided by law or under this Contract.

M. **Entirety of Contract.** This Contract, including Attachment A, consists of seven (7) pages, represents the entire and integrated Contract between the parties and supersedes all prior negotiations, representations, and agreements, whether written or oral.

N. **Force Majeure.** Neither party shall be liable for failure to perform under this Contract if such failure to perform arises out of causes beyond the control and without the fault or negligence of the nonperforming party. Such causes may include, but are not limited to, acts of God or the public enemy, fires, floods, epidemics, quarantine restrictions, freight embargoes, and unusually severe weather. This provision shall become effective only if the party failing to perform immediately notifies the other party of the extent and nature of the problem, limits delay in performance to that required by the event, and takes all reasonable steps to minimize delays. This provision shall not be effective unless the failure to perform is beyond the control and without the fault or negligence of the nonperforming party.

O. **Indemnification.** The Contractor shall indemnify, defend, and hold harmless the State, DEQ, and their officers, agents, employees, successors and assignees from any and all claims, lawsuits, losses and liability arising out of Contractor's failure to perform any of Contractor's duties and obligations hereunder or in connection with the negligent performance of Contractor's duties or obligations, including but not limited to any claims, lawsuits, losses or liability arising out of Contractor's malpractice.

P. **Independent Contractor.** The Contractor shall function as an independent contractor for the purposes of this Contract, and shall not be considered an employee of the State of Wyoming for any purpose. The Contractor shall assume sole responsibility for any debts or liabilities that may be incurred by the Contractor in fulfilling the terms of this Contract, and shall be solely responsible for the payment of all federal, State and local taxes which may accrue because of this Contract. Nothing in this Contract shall be interpreted as authorizing the Contractor or its agents and/or employees to act as an agent or representative for or on behalf of the State of Wyoming or the DEQ, or to incur any obligation of any kind on the behalf of the State of Wyoming or the DEQ. The Contractor agrees that no health/hospitalization benefits, workers' compensation and/or similar benefits available to State of Wyoming employees will inure to the benefit of the Contractor or the Contractor's agents and/or employees as a result of this Contract.

Q. **Kickbacks.** The Contractor certifies and warrants that no gratuities, kickbacks or contingency fees were paid in connection with this Contract, nor were any fees, commissions, gifts, or other considerations made contingent upon the award of this Contract. If the Contractor breaches or violates this warranty, the DEQ may, at its discretion, terminate this Contract without liability to the DEQ, or deduct from the Contract price or consideration, or

otherwise recover, the full amount of any commission, percentage, brokerage, or contingency fee.

R. Notices. All notices arising out of, or from, the provisions of this contract shall be in writing and given to the parties at the address provided under this Contract, either by regular mail or delivery in person.

S. **Prior Approval.** This Contract shall not be binding upon either party, no services shall be performed under the terms of this Contract, and the Wyoming State Auditor shall not draw warrants for payment on this Contract, until this Contract has been reduced to writing, approved as to form by the Office of the Attorney General, filed with and approved by the Department of Administration and Information, and approved by the Governor of the State of Wyoming if required by Wyo. Stat. §9-2-1016(b)(iv)(D).

T. **Sovereign Immunity.** The State of Wyoming and the DEQ do not waive sovereign immunity by entering into this Contract, and specifically retain immunity and all defenses available to them as sovereigns pursuant to Wyo. Stat. § 1-39-104(a) and all other State law.

U. Taxes. The Contractor shall pay all taxes and other such amounts required by federal, State and local law, including but not limited to federal and social security taxes, workers' compensation, unemployment insurance and sales taxes.

V. **Termination of Contract.** This Contract may be terminated immediately for cause if the Contractor fails to perform in accordance with the terms of this Contract. This Contract may be terminated, by either party, without cause, upon thirty (30) days prior written notice.

W. **Third Party Beneficiary Rights.** The parties do not intend to create in any other individual or entity the status of third party beneficiary, and this Contract shall not be construed so as to create such status. The rights, duties and obligations contained in this Contract shall operate only between the parties to this Contract, and shall inure solely to the benefit of the parties to this Contract. The provisions of this Contract are intended only to assist the parties in determining and performing their obligations under this Contract. The parties to this Contract intend and expressly agree that only parties signatory to this Contract shall have any legal or equitable right to seek to enforce this Contract, to seek any remedy arising out of a party's performance or failure to perform any term or condition of this Contract, or to bring an action for the breach of this Contract.

X. Time is of the Essence. Time is of the essence in all provisions of the Contract.

Y. Titles Not Controlling. Titles of paragraphs are for reference only, and shall not be used to construe the language in this Contract.

Z. Waiver. The waiver of any breach of any term or condition in this Contract shall not be deemed a waiver of any prior or subsequent breach.

8. Signatures: By signing this Contract, the parties certify that they have read and understood it, that they agree to be bound by the terms of the Contract, that they have the authority to sign it.

This Contract is not binding on either party until approved by the Division of Procurement Services, Department of Administration & Information, and the Governor of the State of Wyoming, if required by Wyo. Stat. § 9-2-1016(b)(iv).

The Effective Date is the date of the signature last affixed to this page.

DEPARTMENT OF ENVIRONMENTAL QUALITY

John V. Corra, Director — Date: 6/12/09

JAN M. H. HENDRICKX, Ph.D.

Jan M. H. Hendrickx, Ph.D. — Date: 6/18/09

BRUCE BUCHANAN, Ph.D.

Bruce Buchanan, Ph.D. — Date: 6/19/09

ATTORNEY GENERAL'S OFFICE: APPROVAL AS TO FORM

Cara B. Chambers #30580
Cara Boyle Chambers, Assistant Attorney General — Date: 6/15/09

ATTACHMENT A
Scope of Work

Purpose of Contract. Contractor shall provide further clarification on the report entitled "Expert Scientific Opinion on the Tier-2 Methodology" and discuss in more detail the DEQ permitting program as it pertains to agricultural use protection. The Contractor shall provide advice to DEQ as to whether and how the findings and recommendations in the expert report may be used to revise DEQ's approach to permitting surface discharges of produced water.

STATEMENT OF INTENT

The DEQ has the responsibility of regulating surface discharges of water produced in conjunction with the field production of oil and natural gas. Under a separate contract with the Wyoming Environmental Quality Council, the Contractor has produced a report containing a scientific analysis and recommendations relative to DEQ's current procedures for establishing effluent limits for the protection of irrigation uses in Wyoming streams. DEQ has an interest in fully understanding the Contractor's intentions and recommendations and to evaluate how they may be best implemented through the discharge permitting program.

Tasks and estimated Time

Task 1. Travel to Gillette, Wyoming and return to place of origin (2 days)

Task 2. Participate in meetings and a field tour of coal bed methane operations in the Powder River Basin with DEQ staff to provide additional detail on the meaning and interpretation of the report entitled "Expert Scientific Opinion on the Tier-2 Methodology". The contactor shall also provide advice to DEQ on the appropriate application of the findings and interpretation of the above-referenced report in the context of DEQ's permitting responsibilities. (3 days)

Task 3. The Contractor shall provide to DEQ a written synopsis of any new recommendations or findings that have been identified in or result from the meeting discussions by July 30, 2009. (1 day)