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PROPOSED ENHANCED OIL RECOVERY PROJECT
(Phase I)

UNDERGROUND INJECTION OF CARBON DIOXIDE GAS

STEVENS RESERVOIRS – T30, 31S, R23, 24E
SECTIONS 33S, 34S, 35S, 2G, 3G, & 4G

ELK HILLS FIELD
KERN COUNTY, CALIFORNIA
DISTRICT 4

ENGINEERING STUDY, GEOLOGIC STUDY, AND INJECTION PLAN

October 2, 2012

SUBMITTED BY
OCCIDENTAL OF ELK HILLS, INC.

SUBMITTED TO
STATE OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

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1724.7 (A) ENGINEERING STUDY

Introduction

Occidental of Elk Hills, Inc. (OEHI) proposes an Enhanced Oil Recovery (EOR) project injecting carbon dioxide gas (CO2) with the intent to extend the economic limit of the Stevens reservoirs within the Elk Hills Unit. The EOR Project will utilize CO2 gas from the Hydrogen Energy California (HECA) project and other sources to mobilize by-passed oil. During normal operations, an average daily rate of up to 135 million standard cubic feet per day (MMSCF/d) of gas will be injected. Future total peak gas injection is expected to be about 550 MMSCF/d when CO2 rich produced gas from the project is combined with source CO2 and re-injected. OEHI is proposing this project based on favorable results achieved in mobilizing oil in a CO2 Injection Pilot performed in the eastern area of this proposed permit, in 35S-T30S-R24E back in 2005. The technology of mobilizing oil with CO2 and alternating with water injection (WAG) is proven and used extensively in other oil fields in the United States.

This application will permit Phase I consisting of 25 patterns. The entire project scoped above will encompass over 200 patterns once fully implemented. Subsequent pattern areas will be submitted for UIC permitting as the project proceeds.

1. Objective

The main objective of the EOR Project is to economically maximize oil recovery within the requested permit area in accordance with all county, state, and federal safety and environmental rules and regulations.

Under gas injection operations a portion of the gas will contact and become miscible with the reservoir oil. The CO2 gas-oil mixture has the favorable properties of lower viscosity, enhanced mobility, and lower interfacial tension as compared to the residual oil by-passed during the water flooding process. In effect, this process mobilizes and recovers oil that would otherwise be trapped within the rock.

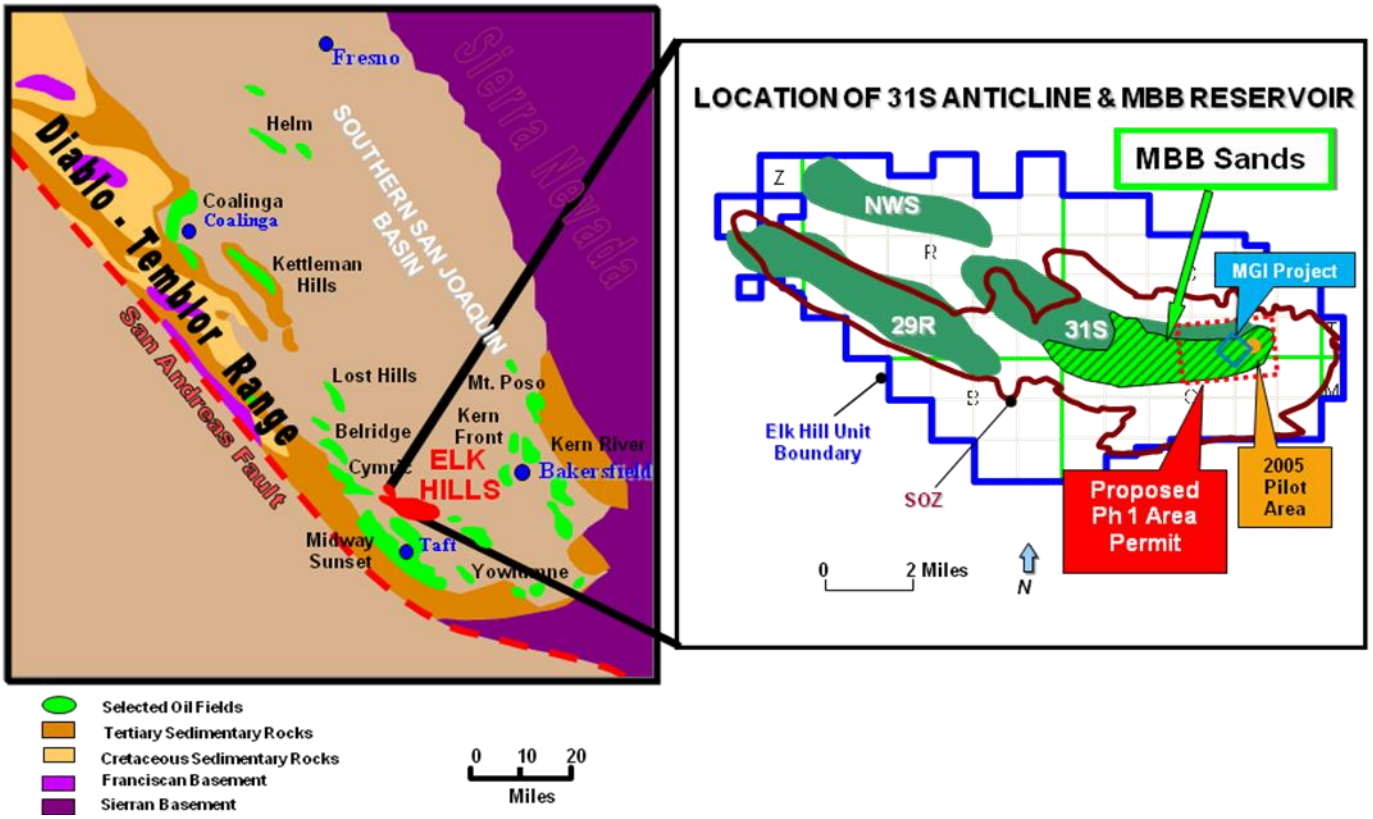
The technique of alternating the current water injection with CO2 gas injection will maintain miscibility, mobilize oil, control gas production, and sweep the CO2 gas-oil mixture to producing wells. This alternating of injectants is known as Water Alternating Gas (WAG), and is used extensively in other oil fields in the United States.

Similar bottom-hole injection pressures developed during water flooding will be maintained during gas injection, and existing wellbores will be utilized where possible.

Project Location

Phase 1 of the EOR Project will be located in parts of Sections 33S, 34S, and 35S of Township 30S Range 24E and Sections 2G, 3G, and 4G of Township 31S Range 24E. All six sections are located within Elk Hills Unit boundaries as indicated in Figure 1.

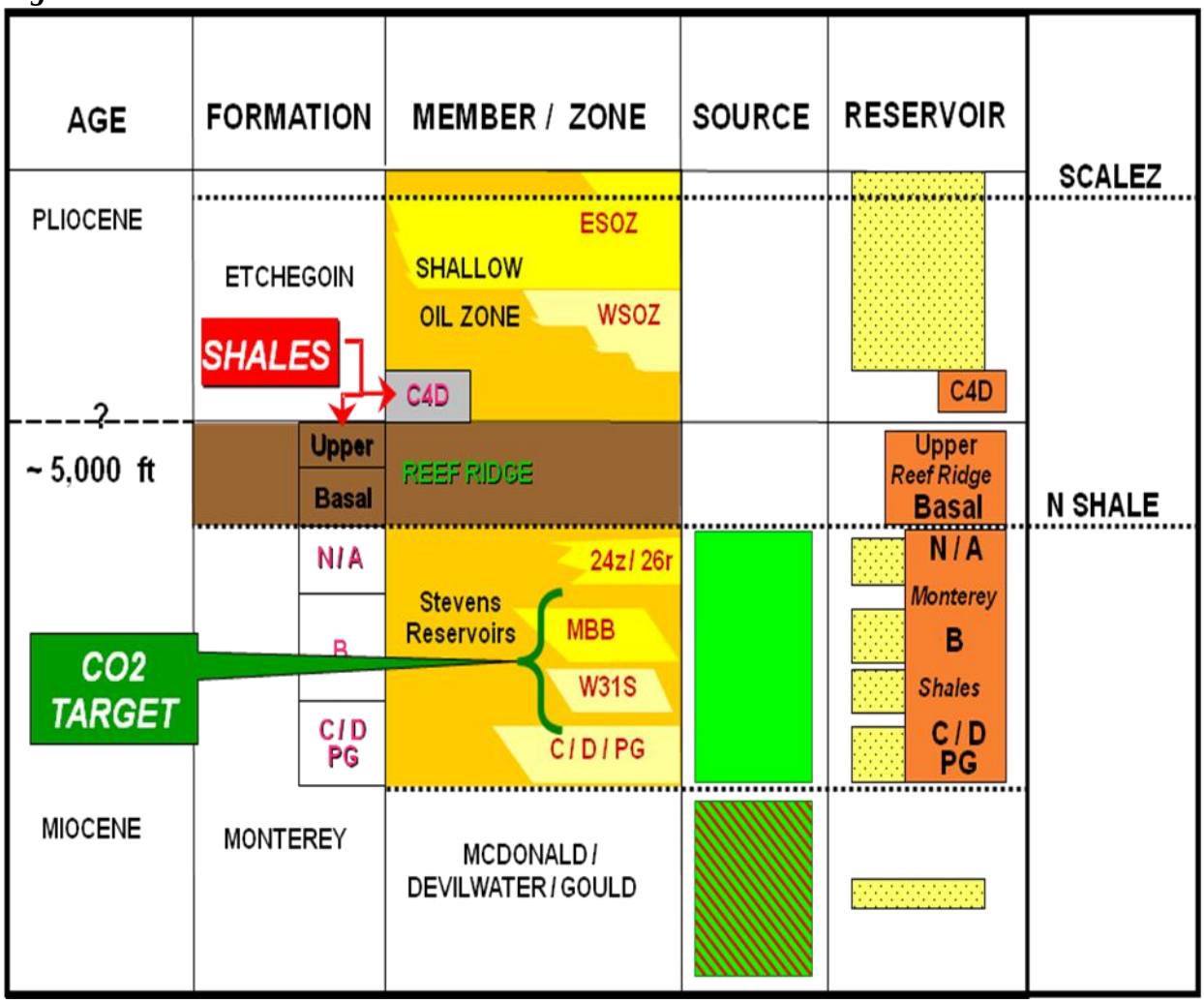
Figure 1



2. Reservoir Characteristics

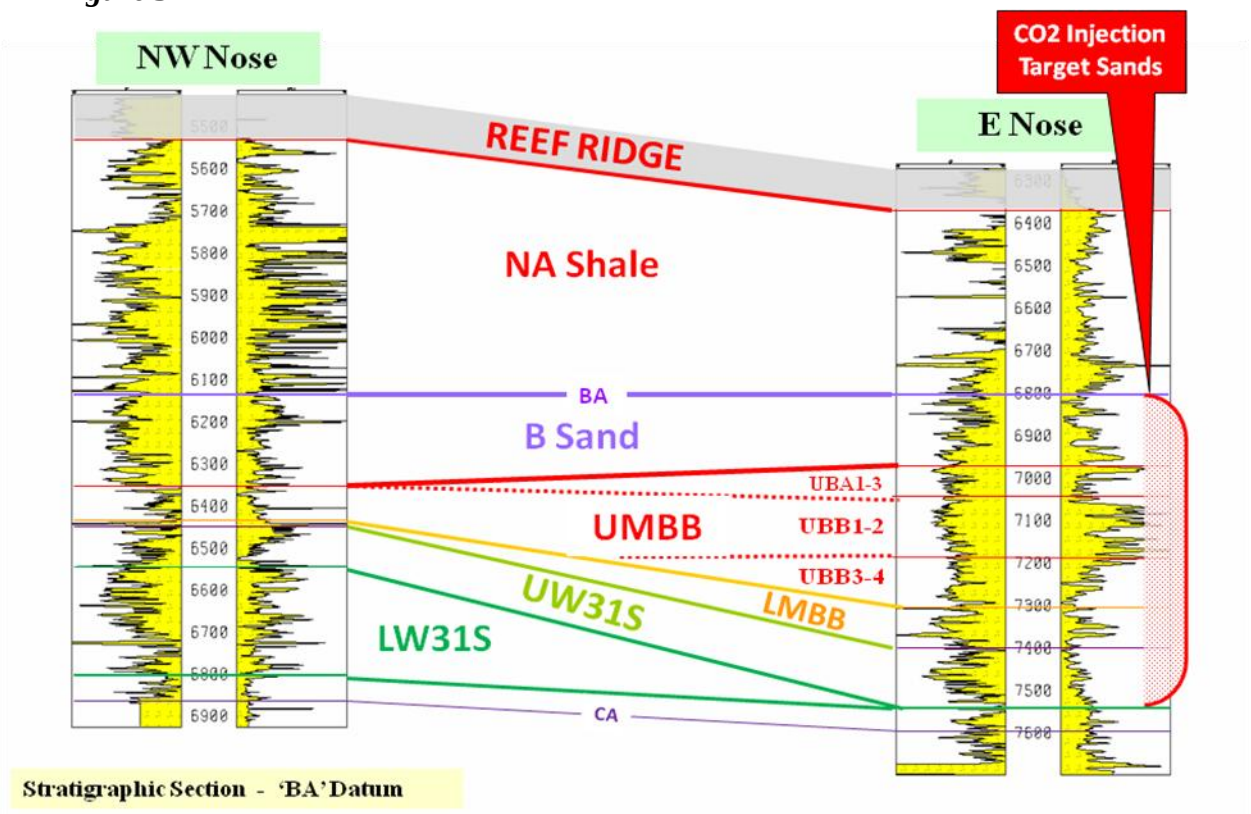
The EOR Project will be conducted in the Stevens reservoir interval as shown in the stratigraphic section in Figure 2.

Figure 2



The project will be initiated in the B-Sand, Upper and Lower Main Body B (MBB) sands, and Upper and Lower Western 31S (W31S) sand sub intervals of the Stevens 31S reservoirs as displayed in Figure 3. Any CO2 or mobilized oil that migrates into the NA Shale above the main Stevens Sands will be captured at the producers open in the Shale zone. That production would then be routed to the CO2 project facilities.

Figure 3



The average reservoir properties of the B intervals are shown below in Table 1.

Table 1

	Avg Gross Interval (Ft)	Avg. Porosity (%)	Avg. Perm (K md)	Original Avg. Temp (F)	Original Avg. Press (PSIG)	Current Avg. Temp (F)	Current Avg. Press (PSIG)
B-Sand	175	18	13	215	3200	215	2600
UBA1-3	140	16	64	215	3210	215	3200
UBB1	75	18	85	215	3210	215	3600
UBB2	46	17	48	215	3230	215	3600
UBB3	100	16	40	215	3240	215	3800
UBB4	38	16	25	215	3250	215	3900
LMBB	115	15	26	215	3280	215	3800
U&LW31S	500	13	27	215	3400	215	3700

Source of data is core and log data, from wells in project area.

3. Reservoir Fluid Data

The average fluid properties contained in the above shown reservoir intervals are displayed in Table 2:

Table 2

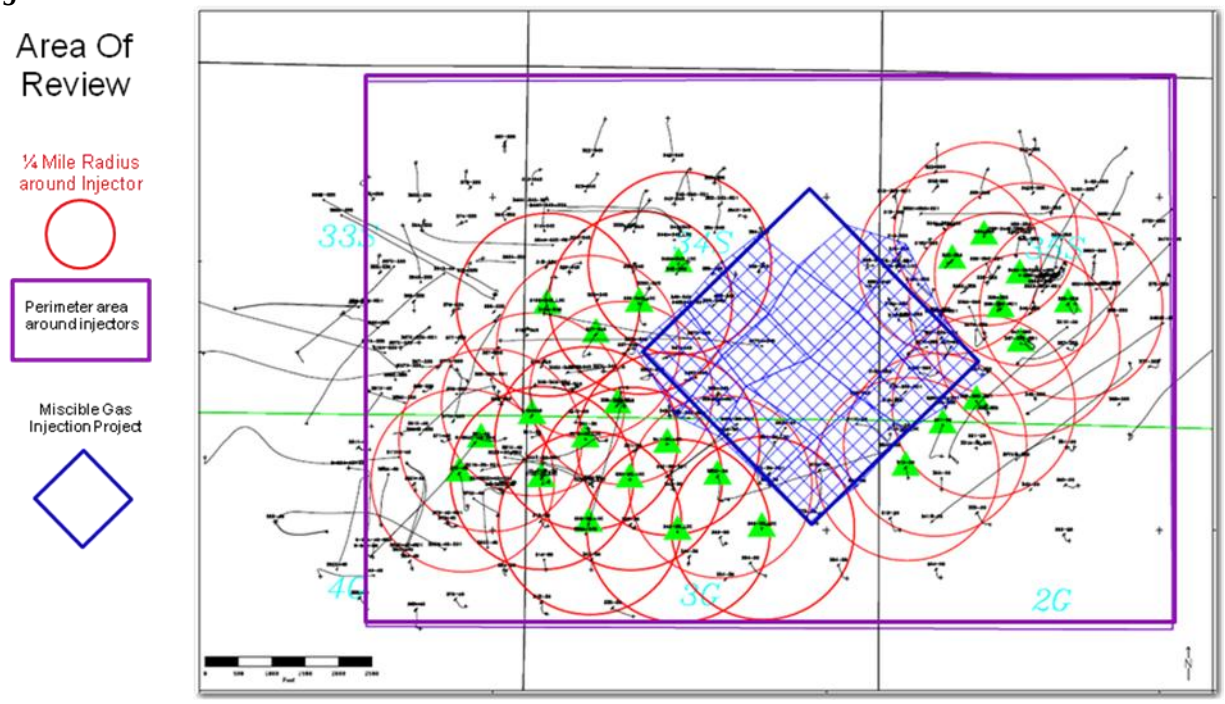
Oil Gravity (API)	Viscosity (cp)	Original Water Salinity (ppm TDS)	Current Water Salinity (ppm TDS)	Gas Gravity
36	0.4	30,000	15,017	0.82

Note: The original Stevens water salinity has been reduced by the injection of Tulare water (5,700 ppm Total Dissolved Solids) for waterflooding purposes in the past.

4. Area of Review/Casing Diagrams

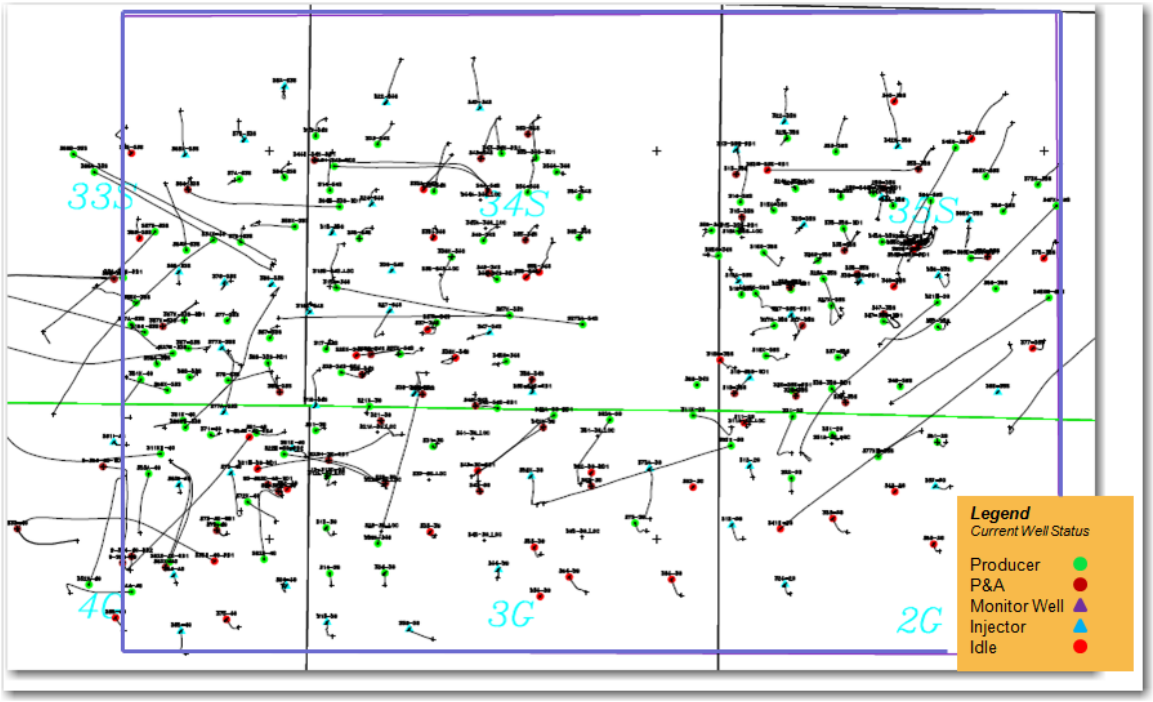
Figures 4a&b *(and Appendix A & B)* illustrate and outline the proposed permit area and the status of all wells that penetrate the confining Reef Ridge shale interval.

Figure 4a



Note wells within the blue grid but outside of the AOR circles in red were previously permitted as part of the OEHI Miscible Gas Injection project (permit# 22800035) and not repeated in this application.

Figure 4b



Appendix K includes a table that lists wells and their zone tops that penetrate the injection zone within the AOR. Casing Diagrams for those wells are included. These diagrams address items 5.a through 5.h as requested in the California Code Regulations 1724.7.

Appendix C includes a table and well spot map of wells within the AOR that do not penetrate the Reef Ridge Shale.

Wells shown on the well spot maps included in the application with the letters "LOC" as part of the well name are proposed new drill well sites that will be permitted for drilling in the future.

5. Planned well work program

The proposed EOR Project will involve the use of a total of 25 injectors and 34 producing wells. Table 3 shows wells names, current status, and planned initial well work for each pattern well.

In addition to the pattern wells in table 3, OEHI will attempt to re-enter 82-382D-4G-RD1, API# 402954085 and seal off the open hole section across the Reef Ridge Shale. An NOI will be submitted detailing the plan.

Table 3 Proposed Permit Pattern Wells

Well Name	API No.	Current Status	Project Status	Purposed Well Work
312-2G	402927980	Active Injector	Injector	Add Perfs/Acid Stim
312E-3G			Injector	New Drill
315B-34S			Injector	New Drill
318-34S	403003445	Active Injector	Injector	Add Perfs/Acid Stim
321-2G	402979858	Producer	Injector	Convert to Injector
321A-3G			Injector	New Drill
323-3G			Injector	New Drill
325-35S	402981460	Active Injector	Injector	Add Perfs/Acid Stim
327-34S	402984186	Active Injector	Injector	Add Perfs/Acid Stim
332-3G			Injector	New Drill
334-35S	402927775	Producer	Injector	Convert to Injector
336-34S			Injector	New Drill
336-35S-RD1	402927776	Active Injector	Injector	Add Perfs/Acid Stim
338-34S-RD1	402985062	Active Injector	Injector	Add Perfs/Acid Stim
338-35S-RD1	402927777	Producer	Injector	Convert to Injector
341-3G			Injector	New Drill
343-3G			Injector	New Drill
345A-34S			Injector	New Drill
345A-35S	403021082	Producer	Injector	Convert to Injector
347-35S-RD1	402980060	Producer	Injector	Convert to Injector
352X-3G	402984529	Active Injector	Injector	Add Perfs/Acid Stim
356-35S	403022319	Active Injector	Injector	Add Perfs/Acid Stim
363-3G			Injector	New Drill
372-4G	403016902	Active Injector	Injector	Add Perfs/Acid Stim
381-4G	402981809	Producer	Injector	Convert to Injector
311-3G	402952693	Active Producer	Producer	Add Perfs/Acid Stim
313-2G	402957942	Active Injector	Producer	Convert to Producer
313-3G	402954298	Active Producer	Producer	Add Perfs/Acid Stim
315-34S	402955592	Active Injector	Producer	Convert to Producer
317-34S	402952983	Active Producer	Producer	Add Perfs/Acid Stim
322-2G	402927981	Active Producer	Producer	Add Perfs/Acid Stim
322A-3G			Producer	New Drill
324-3G	402929020	Active Producer	Producer	Add Perfs/Acid Stim
324A-35S			Producer	New Drill
326-34S	402927660	Active Injector	Producer	Convert to Producer
328-34S-RD1	402954413	Active Producer	Producer	Add Perfs/Acid Stim
331-3G	402953296	Active Producer	Producer	Add Perfs/Acid Stim
331A-2G			Producer	New Drill
333-35S	402959060	Active Producer	Producer	Add Perfs/Acid Stim
333-3G	402953880	Inactive Injector	Producer	Convert to Producer
335-34S	402953715	Inactive Injector	Producer	Convert to Producer
335-35S-RD1	402958896	Active Producer	Producer	Add Perfs/Acid Stim
342-3G-RD1	402929021	Inactive Producer	Producer	Return to Production
344-3G	402929022	Active Injector	Producer	Convert to Producer
344A-34S			Producer	New Drill
344X-35S	403033248	Active Injector	Producer	Add Perfs/Acid Stim
346-35S	402927779	Inactive Producer	Producer	Add Perfs/Acid Stim
348-35S	402927780	Active Producer	Producer	Add Perfs/Acid Stim
353-3G	402955610	Inactive Producer	Producer	Return to Production
355-35S	402955740	Inactive Producer	Producer	Return to Production
357-35S	402953114	Active Producer	Producer	Add Perfs/Acid Stim
362I-4G	402929069	Active Injector	Producer	Convert to Producer
364-3G	402955611	Inactive Producer	Producer	Return to Production
366-35S	402927781	Active Producer	Producer	Add Perfs/Acid Stim
371-4G	402953633	Active Producer	Producer	Add Perfs/Acid Stim
373-4G-RD1	402952246	Active Producer	Producer	Add Perfs/Acid Stim
382-4G	402929071	Active Producer	Producer	Add Perfs/Acid Stim
386-33S	402927617	Active Injector	Producer	Convert to Producer
388-33S-RD1	402927618	Active Producer	Producer	Add Perfs/Acid Stim

1724.7 (B) GEOLOGIC STUDY

1. Structural Contour Map

Figure 5 (*and Appendix D*) displays a TVDss structural contour map on the top of the Reef Ridge Shale, which is the Stevens cap rock (confining zone). All maps in Figures 5-8 and appendices A,B, D-K display wells which penetrate the Reef Ridge Shale. For each sub-unit within the injection zone, a larger scale of structural contour maps is located in Appendix E.

Figure 5

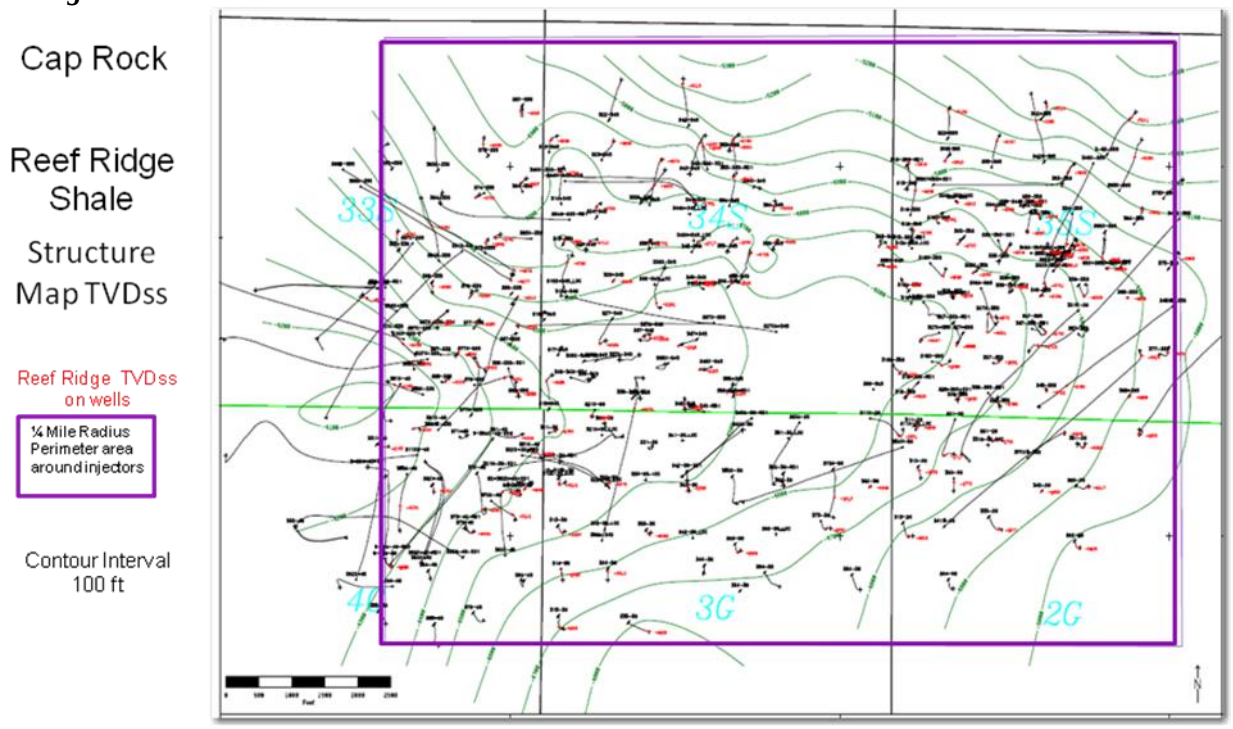
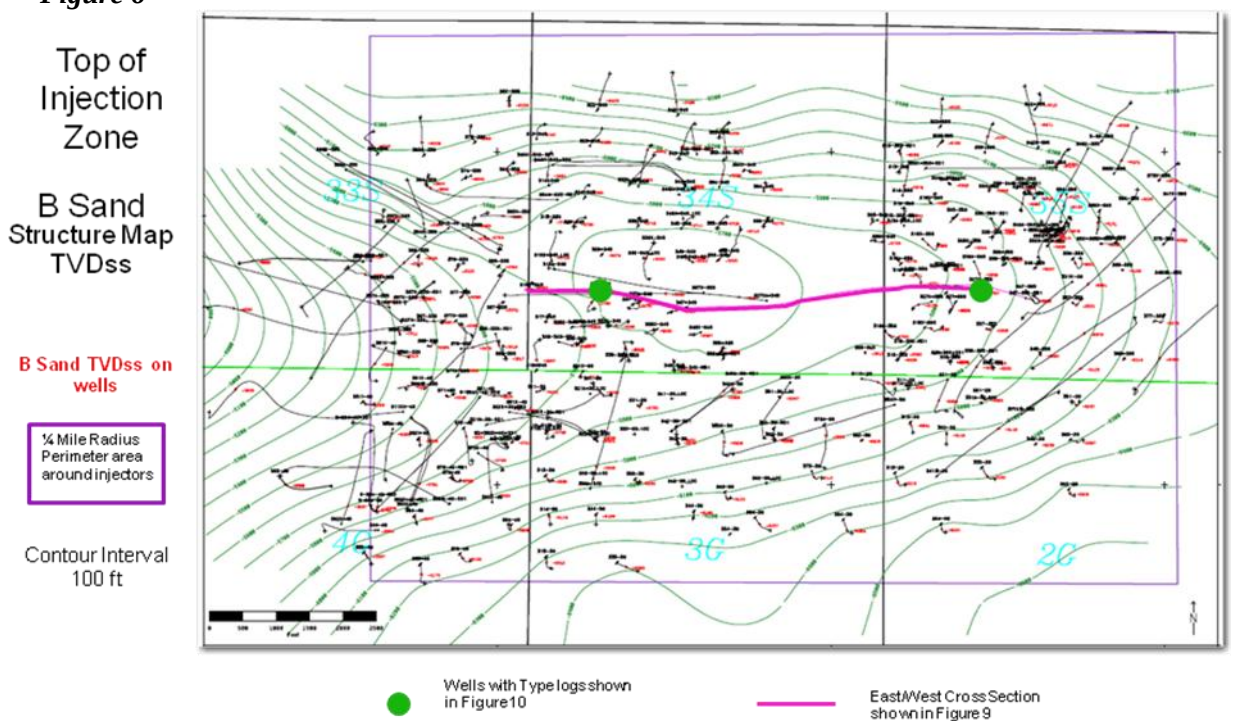


Figure 6 (*and Appendix I*) displays a TVDss structural contour map on the top of the Stevens B-Sand, an East/West Cross Section line (see Figure 9), and location of wells showing type log detail (see Figure 10).

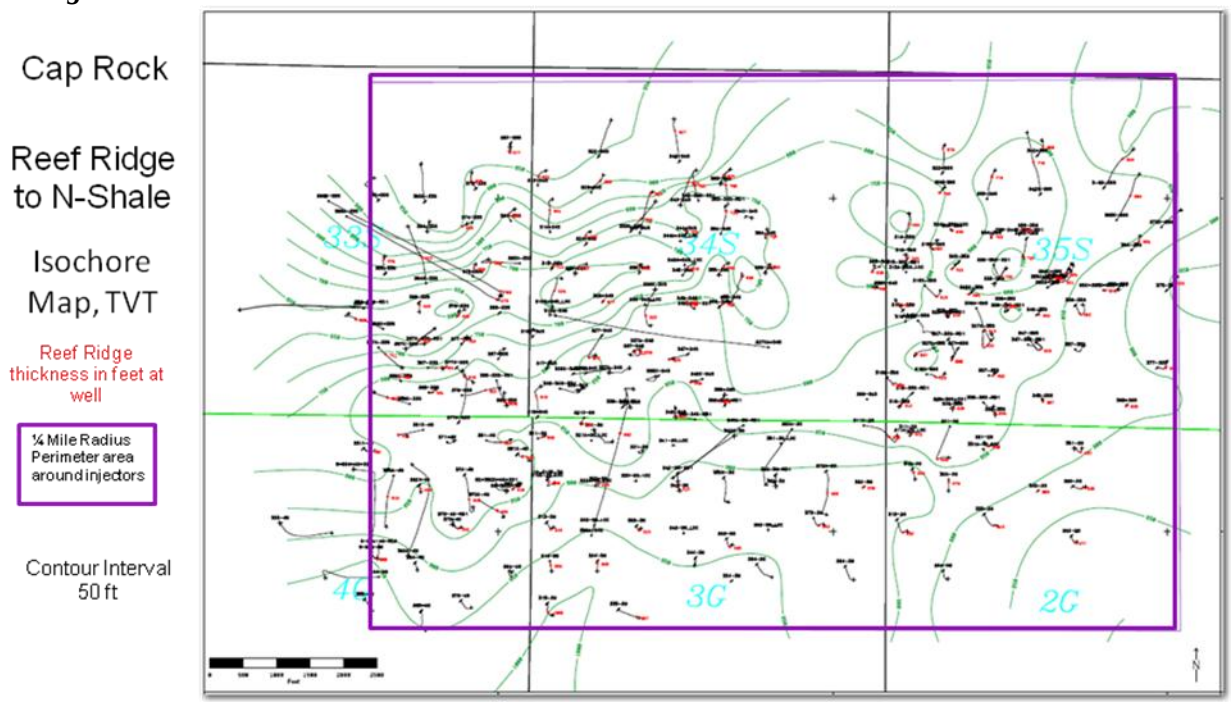
Figure 6



2. Isopachous Map

Figure 7 (*and Appendix F*) shows an isochore map illustrating the thickness of the cap rock above the injection zone. The contoured interval includes from the top of the Reef Ridge Shale to the top of the N Shale.

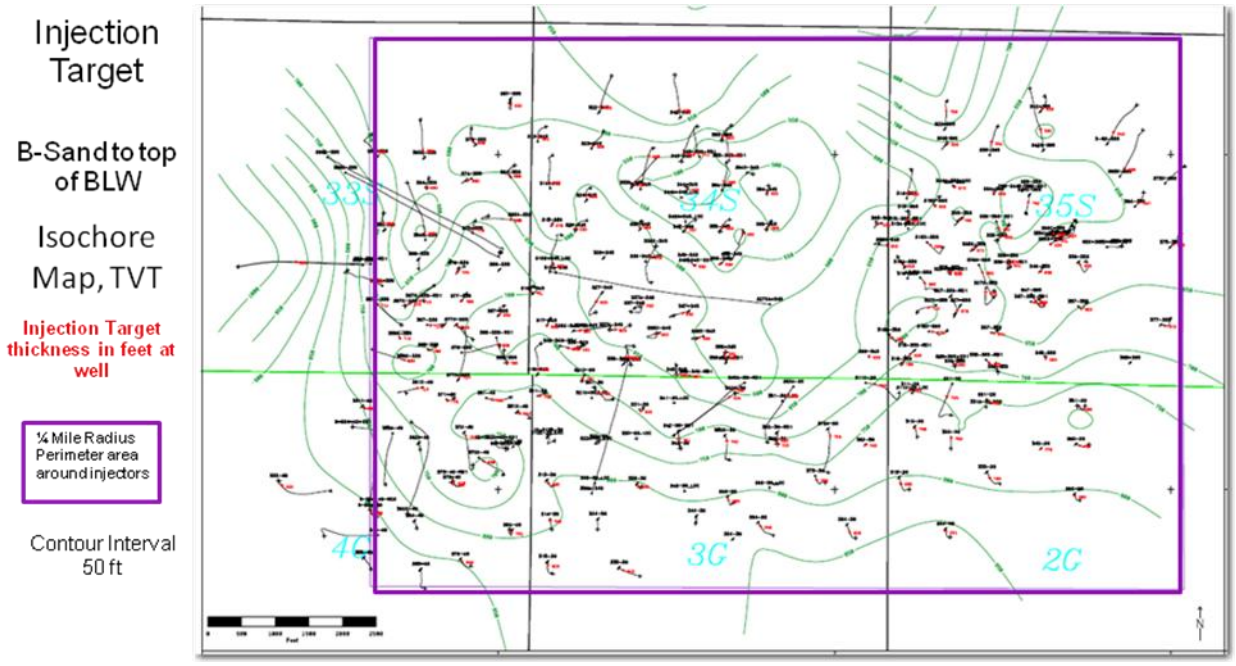
Figure 7



From the above figure, it can be observed that over the proposed permit area the cap rock ranges from 600 to 1,000 feet in thickness.

Figure 8 (*and Appendix F*) displays an isochore map of the target injection zone from the top of the B Sand to the base of the Lower Western sand or top of the (BLW).

Figure 8

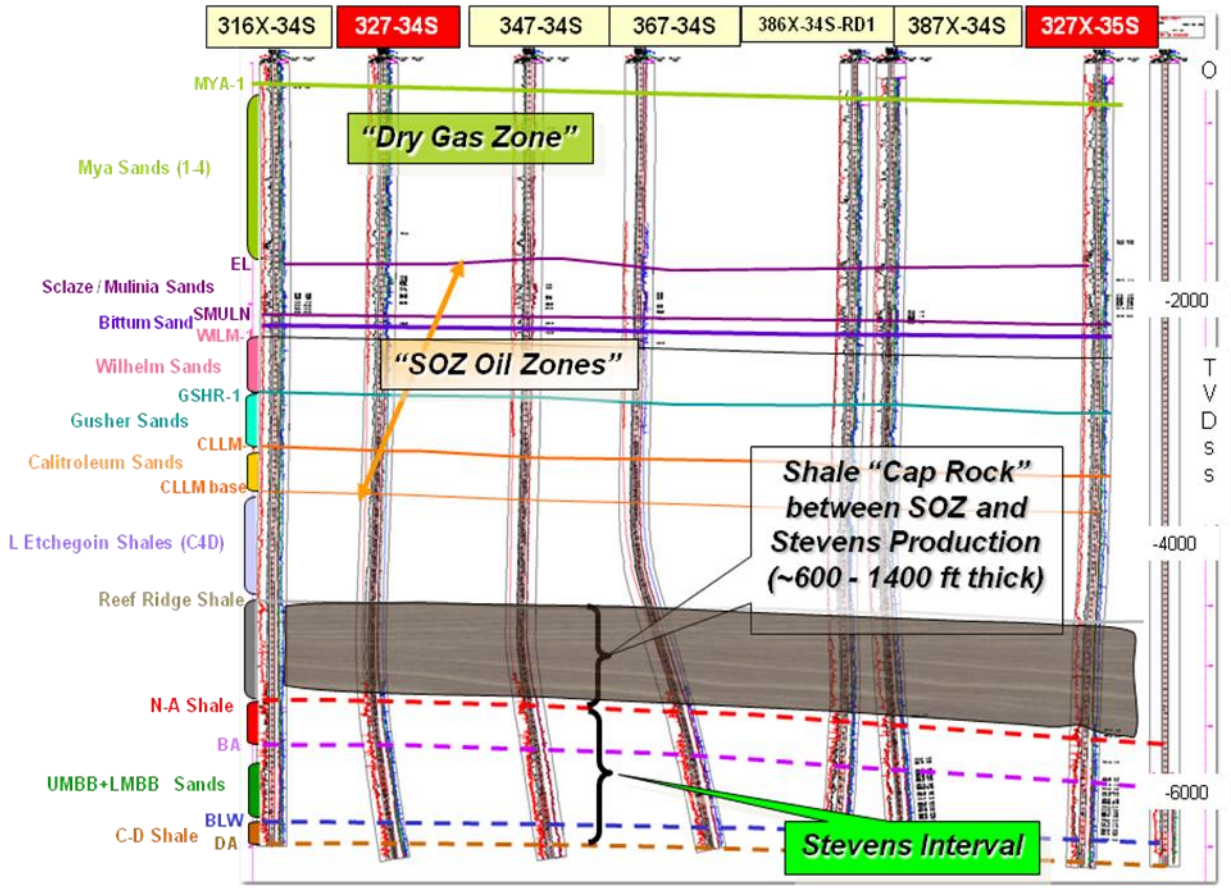


The foregoing and additional isochore maps of all horizons within the zone of proposed injection are located in Appendices F and G on a larger scale.

3. Geologic Cross Section from Surface to Deepest Zone Penetrated

Figure 9 (*and Appendix I*) shows the geologic cross section, which displays a section from the surface to the C-D Shale below the injection target zone.

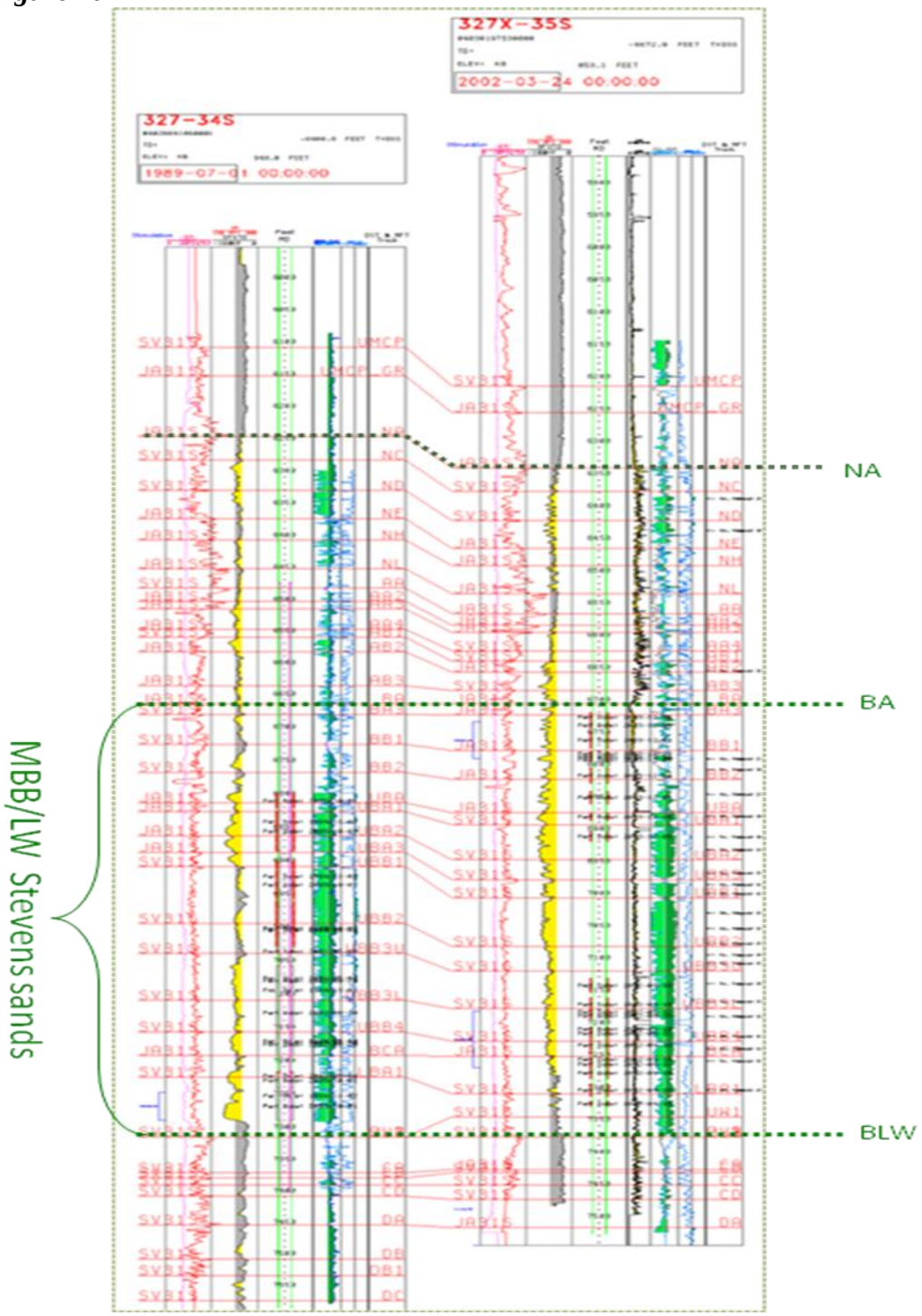
Figure 9



4. Injection Well Electric Log

An electric log from injection wells 327-34S and 327X-35S with geologic sub-unit tops has been provided as a representative type log and is included in Figure 10. See Appendix J for larger version of type log.

Figure 10


327X-35S
2002-03-24 00:00:00
327-34S
1989-07-01 00:00:00
NA
BA
BLW
MBB/LW Stevens sands

1724.7 (C) INJECTION PLAN

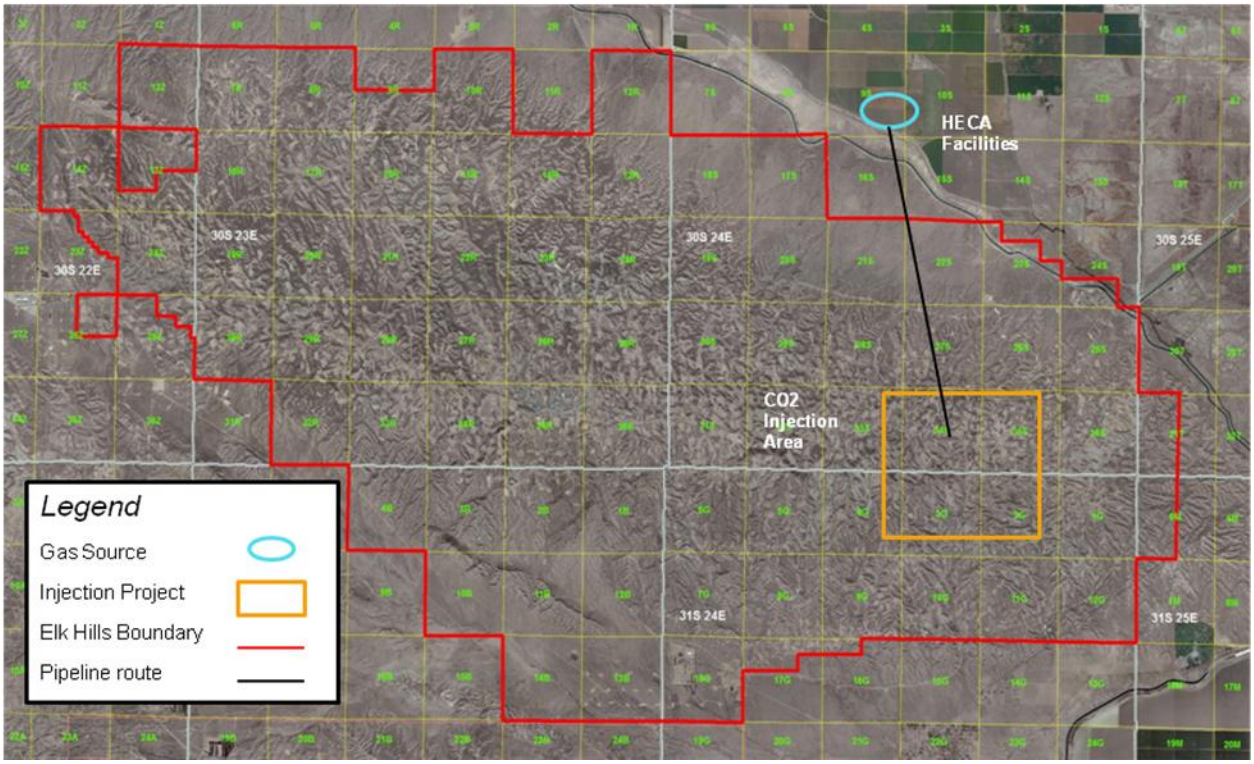
Overview

Initial project plans call for 25 injection wells in the requested permit area. The approximate location of these wells is provided in Appendix A. Each injection well will function as a central injection point surrounded by or between three to five offsetting production wells thereby allowing injected fluids to preferentially remain within each of the injection patterns.

1. Gas Injection Facilities

The finalized placement of the gas pipeline route from the HECA facility has not yet been confirmed; however Figure 11 illustrates the general pipeline route from the proposed HECA facility to the permit area.

Figure 11



2. Maximum Anticipated Surface Injection Pressure and Rate by Well

The maximum anticipated surface wellhead injection pressure (MASP) will not exceed the existing waterflood permit (#22800006) gradient of 0.9 psi per foot of depth. (Note: These calculations assume an average depth to the top perforation of 6850 and static fluid gradients of 0.44 psi/foot (water), 0.33 psi/foot (purchased gas), and 0.26 psi/ft (recycle gas). The actual depth to top perforation and type of injectant being used will result in a specific MASP for each well.)

The maximum injection rate at any injection well is anticipated to be 15 MMSCF of gas per day or 5,000 barrels of water per day. The maximum anticipated injection rate into the requested permit area (including recycled produced gas) is 500 MMSCF of gas per day and 150,000 barrels of water per day. The permit area rates will be injected via a water alternating gas injection schedule to be designed and adjusted at the pattern level based on pattern performance.

3. Proposed Monitoring System

OEHI proposes to equip each injection well with an actuated choke to control injection rate and wellhead pressure. Flow rates will be metered and tubing injection and casing annulus pressures will be monitored. The measured flow rates and pressures will tie into OEHI's existing SCADA surveillance system.

4. Method of Injection

Delivery into each injector will be through internally coated tubing and packers to allow for annular pressure monitoring for wellbore casing integrity. Upgrades will be made to existing surface facilities to ensure adequate capacity for the collection, processing, and distribution of produced and injected fluids (water and/or gas).

5. Cathodic Protection

New lines will be laid above and below ground and cathodic protection will be applied where applicable.

6. Water Treatment method

After entrained gas is removed and any adjustments to the current corrosion mitigation chemical program are addressed no other changes to the water treatment methods being utilized in the active waterflood project covering this same area and injection zone under permit #22800006 will be implemented.

7. Injection Water Analysis

See Appendix H for water analysis summary. Source of water will be produced water from the Stevens reservoirs in the Elk Hills oil field.

8. Injection Gas Analysis

Table 4 below is the current gas composition estimate from the HECA facility. An actual gas analysis will be submitted after the HECA facility starts up.

Table 4

Stream Component:	**Mole %**
	Estimated Analysis
Nitrogen	2.0
Carbon Dioxide	97.0
Methane	1.0

1724.7 (D) NOTICES TO OFFSET OPERATORS

There are no Offset Operators; consequently, there has been no correspondence.

1724.7 (E) OTHER DATA

Summary of Corrosion Mitigation, Monitoring, and Maintenance Plan

A multi-level approach will be implemented to address corrosion potential on well and surface equipment. Surface equipment that will handle the produced and injected flow streams will be designed to handle low pH fluids. Special materials, coatings and chemical inhibition will be used in areas where wet CO2 will be present. Wellheads, tubing strings, and packers will be upgraded on injectors. Producing wellheads will be upgraded where necessary and chemical programs adjusted or implemented to protect tubulars. Cathodic protection will be installed on wells and buried piping systems.

Monitoring programs will be developed that include mechanical integrity practices, fluid analysis, and coupon programs.

Maintenance programs will be developed and followed to contribute to the reliability of the surface facilities and wellbore integrity that will include pressure testing and

inspections during interventions. An automated call-up system will be used to schedule maintenance and inspection tasks.

1724.7 (F) MAPS, DIAGRAMS & EXHIBITS

Appendix A: Area Of Review map showing injectors with ¼ mile radius circles and all wells within the AOR that penetrate the Reef Ridge Shale.

Appendix B: Status map of all well that have penetrated the Reef Ridge Shale indicating active or inactive producers and injectors, and abandoned wellbores.

Appendix C: A Table and Map of wells located above the Reef Ridge Shale and within the AOR.

Appendix D: Maps of structure contours of Reef Ridge Shale, NA Shale, and B Interval (top of injection zone).

Appendix E: Structural contour maps for each sub-unit of the B Interval (BA-BLW).

Appendix F: Isochore maps for the Reef Ridge Shale, NA shale, and B Interval.

Appendix G: Isochore maps for the B Interval sub-units (BA-BLW).

Appendix H: Injection Water Analysis.

Appendix I: Map showing location of referenced well in Cross Section and full vertical Cross Section of producing intervals both above and below target injection zone

Appendix J: Type Log of Injection Target

Appendix K: Wellbore and casing diagrams within a ¼ mile radius of proposed project of all wells penetrating the Reef Ridge Shale (Cap Rock).