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Casper Field Office

Salt Creek Phases III/IV Environmental Assessment

#WYO60-EA06-18

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List of Acronyms and Abbreviations

ACEC	Area of Critical Environmental Concern
ACGIH	American Conference of Industrial Hygienists
ACHP	Advisory Council on Historic Preservation
APC	Anadarko Petroleum Corporation
APD	Application for Permit to Drill
ACEPMs	Applicant Committed Environmental Protection Measures
AUM	animal unit month
BLM	Bureau of Land Management
BOPD	barrels of oil per day
BWPD	barrels of water per day
CBLs	Cement Bond Logs
CBNG	coalbed natural gas
CCVB	Casper, Wyoming Convention and Visitors Bureau
cfm	cubic feet per minute
cfs	cubic feet per second
CO	carbon monoxide
CO_2	carbon dioxide
dba	decibels, A-weighted
DMR	Discharge Monitoring Report
EA	environmental assessment
EPA	Environmental Protection Agency
EOR	Enhanced Oil Recovery
ESD	Ecological Site Description
GPS	Global Positioning System
H_2CO_3	carbonic acid
H_2S	hydrogen sulfide
Howell	Howell Petroleum Corporation
HP	high pressure
HUD	Department of Housing and Urban Development
IDLH	Immediately Dangerous to Life and Health
kV	kilovolt
LACT	Lease Automatic Custody Transfer
LOS	levels of service
LP	low pressure
$\mu g/m^3$	micrograms per cubic meter
µS/cm	micro seimans per centimeter
mcf	million cubic feet
MCFD	thousand cubic feet per day
mg/L	milligram per liter
MMCFD	million cubic feet per day
MMBO	million barrels of oil
NAAQS	National Ambient Air Quality Standards
NCW&P	Natrona County Weed and Pest
NCSD	Natrona County School District

List of Acronyms and Abbreviations

NEPA	National Environmental Policy Act
NESC	National Electric Safety Code
NHPA	National Historic Preservation Act
NIOSH	National Institute for Occupational Safety and Health
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NSS	Native Species Status
NO_X	nitrogen oxide
NRCS	Natural Resources Conservation Service
NWMP	Noxious Weed Management Plan
O_2	oxygen
OSHA	Occupational Safety and Health Administration
pCi/L	picoCurie per liter
PEL	Permissible Exposure Limit
PLS	pure live seed
PM	particulate matter
POD	Plan of Development
PP&L	Pacific Power & Light
ppm	parts per million
ppmv	parts per million by volume
ppmvd	parts per million dry volume basis
PRRA	Platte River Resource Area
psi	pounds per square inch
psig	pounds per square inch gauge
RMP	Resource Management Plan
RMU	Resource Management Unit
ROW	right-of-way
ROWs	rights-of-way
ROWA	Routine Oilfield Water Analysis
SCES	Salt Creek Emergency Services
SCLOU	Salt Creek Light Oil Unit
SCSU	Salt Creek South Unit
SHPO	State Historic Preservation Office
SPCCP	Spill Prevention, Control and Countermeasure Plan
SR	State Route
STEL	Short-term Exposure Limit
SWPPP	Storm Water Pollution Prevention Plan
SO_2	sulfur dioxide
TLV	Threshold Limit Value
TWA	time weighted average
UAA	Use Attainability Analysis
U.S.	United States
USFWS	U.S. Fish and Wildlife Service

List of Acronyms and Abbreviations

V	volt
VOCs	volatile organic compounds
VRM	Visual Resource Management
VRU	vapor recovery unit
WAQS&R	Wyoming Air Quality Standards and Regulations
WAG	water alternating gas
WC2	Wall Creek 2
WDEQ	Wyoming Department of Environmental Quality
WDOE	Wyoming Department of Employment
WDOR	Wyoming Department of Revenue
WGFD	Wyoming Game and Fish Department
WOGCC	Wyoming Oil and Gas Conservation Commission
WOR	water-oil ratios
WYPDES	Wyoming Pollution Discharge Elimination System
WQC	Water Quality Criterion
WyGISC	Wyoming Geographic Information Science Center

1.0 Introduction

Howell Petroleum Corporation (Howell), a subsidiary of Anadarko Petroleum Corporation (APC), proposes to commence Phases III and IV of its ongoing carbon dioxide (CO_2) Enhanced Oil Recovery (EOR) Project within Salt Creek Oil Field, which is located in Natrona County, Wyoming. The first two phases of EOR in this field (Phases I and II) have been completed, with associated increases in oil recovery rates reported. In the next two phases, Howell intends to continue its injection of CO_2 into the Wall Creek 2 (WC2) formation in an effort to further increase oil recovery. This Environmental Assessment (EA) examines the proposed implementation of Phases III and IV.

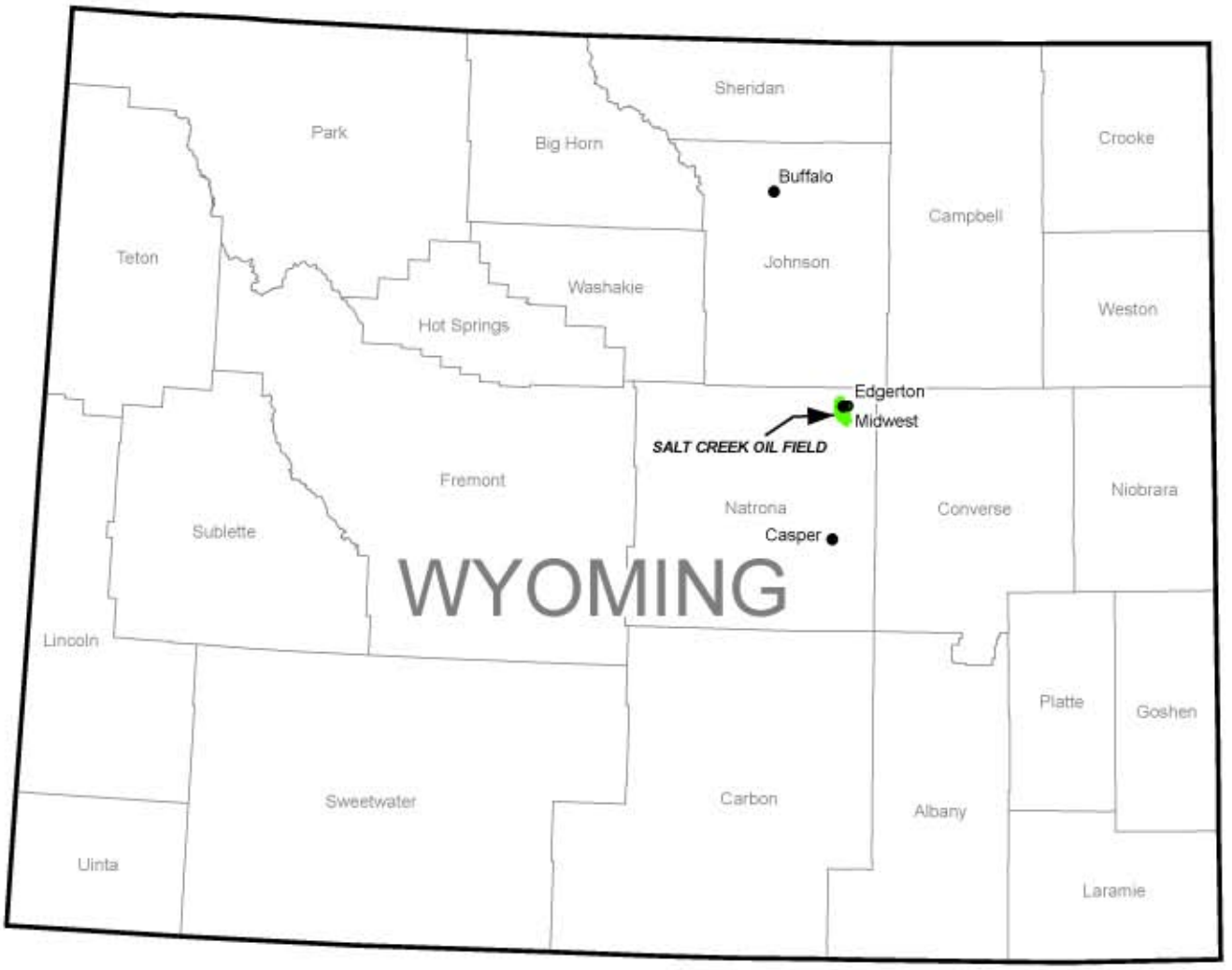
Salt Creek Oil Field is located in northern Natrona County approximately 45 miles northeast of Casper, Wyoming primarily on land administered by the Bureau of Land Management (BLM) (Figure 1-1). The field boundaries contain the towns of Midwest and Gas Plant Camp, while the town of Edgerton lies immediately to the east of the field. The entire Salt Creek Oil Field encompasses 34.3 square miles of predominately semi-arid grasslands and shrublands and a portion of the Salt Creek watershed. Salt Creek flows in a northerly direction into the Powder River near Sussex, Wyoming. During Phases I and II, Howell injected CO_2 in the northern and western portions of the field, while Phases III and IV would involve injection of CO_2 in the northeast/central portion of the field (Figure 1-2).

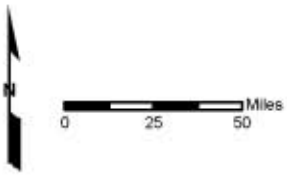
In November of 2003, the BLM prepared the *Salt Creek Environmental Assessment CO_2 Enhanced Oil Recovery Project* (EA # WY-060-04-001; hereafter referred to as the "Phase I EA") (BLM 2003a) to assess the potential environmental impacts of permitting full-field development of Salt Creek Oil Field using CO_2. The Phase I EA addressed the full-field development of the CO_2 project for 10 expansion phases, as proposed by Howell, and analyzed the detailed development for the first phase of the expansion (i.e., Phase I). In April 2004, BLM prepared the *Environmental Assessment of Howell Petroleum Corporation's CO_2 Phase II Expansion, CO_2 Enhanced Oil Recovery Project, Salt Creek Oil Field* ("Phase II EA") (BLM 2004a) to examine the site-specific development scenario associated with the Phase II expansion.

This EA will address the detailed development of both Phases III and IV. The proposed expansion into Phases III/IV would utilize existing infrastructure within Salt Creek Oil Field to the extent possible. Existing flow lines, access roads, and power distribution lines would be used or upgraded. Chapter 2.0 details the proposed drilling development and use of ancillary facilities.

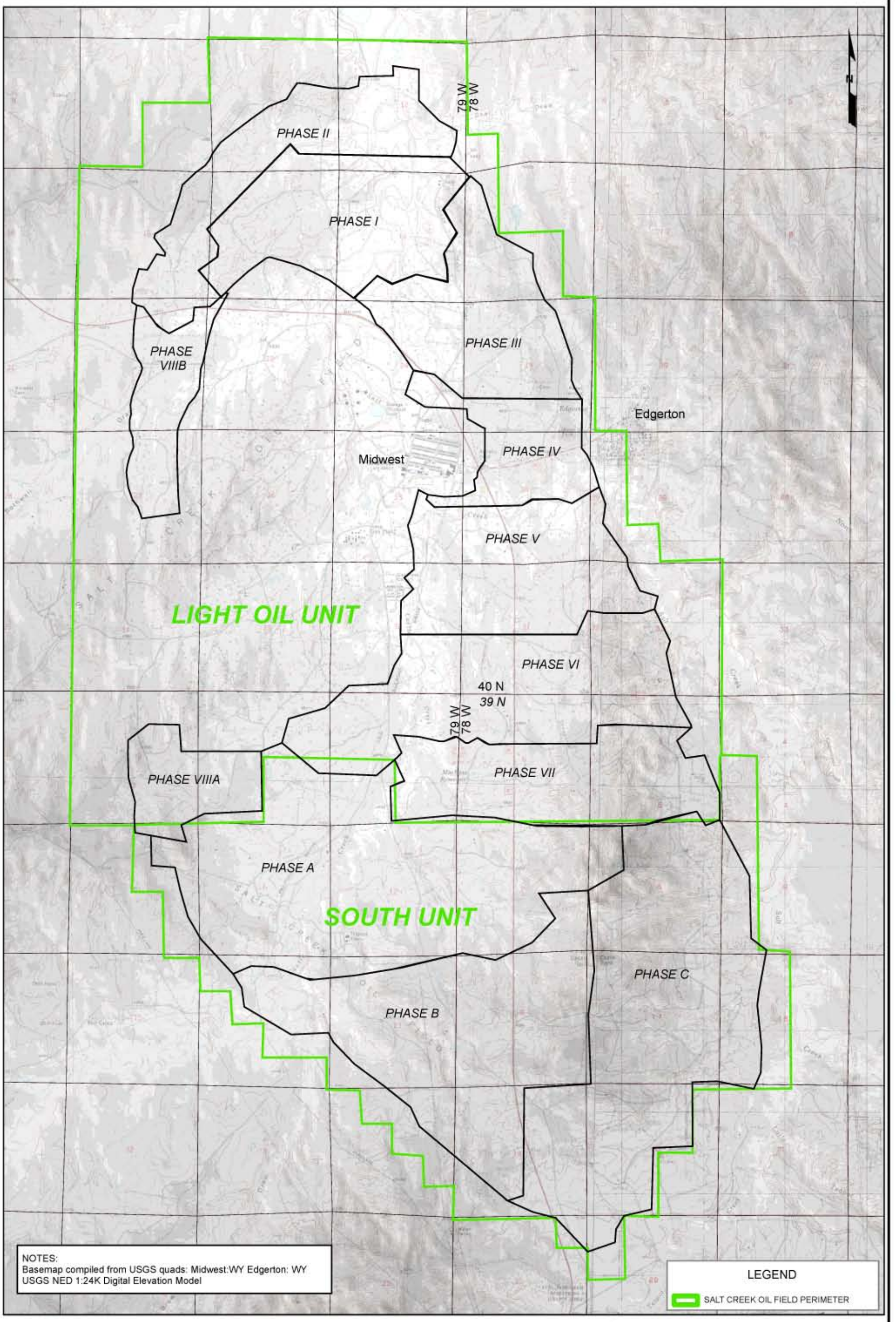
1.1 Existing Development

Salt Creek Oil Field (Figure 1-2) produces oil and gas from 11 horizons with the majority of the recovery coming from the largest of these reservoirs, the Wall Creek 2 (WC2). Wall Creek is the local nomenclature for the Upper Cretaceous Frontier Formation, the most prolific producing horizon of Salt Creek Oil Field. Existing infrastructure in the area includes access roads, pipelines, storage tanks, gas re-compression facilities, electric distribution lines, oil and gas production wells, CO_2 and water injection wells, and other related facilities. Current produced oil volumes from Salt Creek Oil Field are approximately 7,000 barrels of oil per day (BOPD), of





SALT CREEK PHASES III/IV EA	GENERAL LOCATION SALT CREEK OIL FIELD
	FIGURE 1-1



SALT CREEK PHASES III/IV EA	SALT CREEK EOR PHASE BOUNDARIES
	FIGURE1-2

which 4,000 BOPD are recovered from the waterflood process and 3,000 BOPD recovered from the CO_2 flood in the Phases I and II areas.

1.1.1 Historical Development and Use

The presence of oil in the Salt Creek area has been know since the late 1800s in part because of the natural oil seeps that occurred in the area. Some of these natural oil seeps still exist, and Howell collects oil from the seeps using vacuum trucks and other production techniques. Initial development of Salt Creek Oil Field commenced in 1889 with the majority of primary development occurring between 1915 and 1930. Early records indicate that oil was found at depths as shallow as 22 feet in 1911.

The Salt Creek Light Oil Unit (SCLOU) was formed on September 1, 1939 and was operated by Stanolind Production, which later became Amoco Production Company. Howell acquired Salt Creek Oil Field and succeeded Amoco as operator in 1998. Howell and APC subsequently merged in December 2002. The Salt Creek South Unit (SCSU), also operated by Howell, is located directly south of the SCLOU and encompasses the remainder of Salt Creek Oil Field (Figure 1-2).

Oil production at Salt Creek Oil Field comes from several geologic horizons at varying depths. The most prolific horizon, both in areal coverage and volume, is the WC2 horizon, which was discovered in 1917. Production levels for the field peaked in the late 1920s when over 85,000 BOPD were recovered, and have since declined to the current levels. Cumulative production for Salt Creek Oil Field from all horizons is estimated to be in excess of 670 million barrels of oil (MMBO).

Historically, Salt Creek Oil Field produced under primary depletion (driven by high pressures inherent to the reservoir) until gas re-injection was implemented from 1926 through 1961. Waterflooding was tested at Salt Creek as early as 1961 and was implemented field-wide in 1971. The WC2 has been under active waterflood since 1961.

Approximately 754 production wells and 568 injection wells were active in the SCLOU waterflooding operations. The SCSU contains an additional 76 production and 75 injection wells. The mature state of the waterflood operations has resulted in very high water-oil ratios (WOR) for the current producing wells. For every barrel of oil produced, over 99 barrels of water must be produced and re-injected (a 0.6% oil-cut). The extensive waterflood facilities required to maintain this operation are the largest of any field in the state, rendering the field economics susceptible to minor fluctuations in oil price and operating costs.

1.1.2 Phases I and II

Within Salt Creek Oil Field, oil production has declined steadily from a peak of 85,000 BOPD in the 1920s to approximately 4,000 BOPD prior to CO_2 injection. In an effort to reverse the declining trend of oil production, Howell constructed an extension of the Shute Creek to Bairoil pipeline to deliver up to 250 million cubic feet (mcf) of CO_2 to be used for tertiary waterflood operations in the field. Howell introduced the state-of-the-art tertiary EOR technology by injecting the CO_2 to increase oil production that would otherwise not be recoverable by existing

waterflood operations. With the implementation of Phases I and II, oil recovery in Salt Creek Oil Field has increased from 4,000 to 7,000 BOPD. Howell estimates that by the end of 2006 more than half of the total field production will be the result of CO_2 flooding operations in Phases I and II.

The locations of Phases I and II (Figure 1-2) were based on factors such as proximity to local communities and populations; geologically representative areas; and existing roads, facilities, and wells. The surface disturbances for Phases I and II are summarized in Table 1-1.

In the Phase I area, a small amount of the CO_2 injected during Phases I and II seeped to the surface in the NE ¼ of Section 14. These seeps are limited in extent and comprise only approximately 0.008% of the total CO_2 injected within the area currently under CO_2 flood. Howell has been working to identify the source, migration pathways and subsurface behavior of CO_2 and has developed a CO_2 mitigation plan. Howell is currently planning, installing, and field-testing multiple mitigation approaches in the Phases I and II areas. Once these approaches have been field verified, Howell will have the ability to implement mitigation efforts to address CO_2 events should they occur in the future. This process is summarized in Chapter 2 (Section 2.1.3, CO_2 Seep Containment Plan).

1.2 Purpose and Need

The phased expansion (Phases III/IV) of the CO_2 EOR project would continue to replace the current secondary EOR technology involving waterflooding, thereby increasing oil production by another 3,700 BOPD or 22 MMBO over the life of the project. Use of the combined waterflood and tertiary EOR could ultimately recover as much as 150 MMBO for the entire Salt Creek Oil Field, extending operations for another 30 to 40 years and the economic life of the field. For comparison, if only the waterflood technology is employed, economically feasible oil extraction would be projected to continue for another 16 years.

1.3 Authorizing Actions

Necessary permits and authorizations from the BLM would be issued pursuant to the Mineral Leasing Act of 1920, as amended, and the Federal Land Policy and Management Act of 1976, as amended, and would be subject to the rules and regulations in 43 CFR 2800 and 43 CFR 3100. Section 1.3 of the Phase I EA contains a complete discussion on Authorizing Actions applicable to continued development of Salt Creek Oil Field and is incorporated herein by reference. Table 1 in Section 1.3 of the Phase I EA also provides a brief synopsis of potentially applicable permit requirements by federal, state, and local agencies that have jurisdiction over different aspects of the proposed Phases III/IV.

1.4 Public Involvement

Howell held a town meeting in Midwest on July 26, 2005 to present the proposed development for the Phases III/IV and answer questions regarding the development. Approximately 50 people attended the meeting. Topics discussed included: 1) future phase development within Salt Creek Oil Field, 2) CO_2 seeps from the Phases I/II development, 3) CO_2 Seep Containment Plan developed by Howell, and 4) monitoring plans for the town of Midwest.

Table 1-1 Phases I and II Surface Disturbance

Action	Estimated (acres)			Actual
	Previous Disturbed	**New Disturbance**	**New Long-Term Disturbance**	**Measured (acres)**
Wells	121	40	10	97
LACTs	0.8	0.01	0	0.2
Waterflood Boosters	0	0.5	0.5	1.5
Headers	223	0.8	0.8	218
Trunk Lines	62	33	0	101
Temporary Use Areas	0	0	0	11.5
Compressor Station	2.1	0.9	0.9	7.1
Production Main Lines	18.1	18.1	0	13.4
Electrical Lines	2.2	4.8	0	6
Total Phases I and II Disturbances	**429**	**98**	**12**	**456**
Total New Long-Term Disturbance				**12**

2.0 Proposed Actions and Alternatives

2.1 Proposed Action

Howell is proposing development of Phases III/IV of Salt Creek Oil Field CO_2 EOR Project in Natrona County, Wyoming (Figure 2-1). Phases III/IV would involve continued injection of CO_2 into the WC2 formation. If approved, construction for Phases III/IV would begin in February 2006 and extend to December 2006 with injection of CO_2 to begin in the third quarter of 2006.

2.1.1 Project Overview

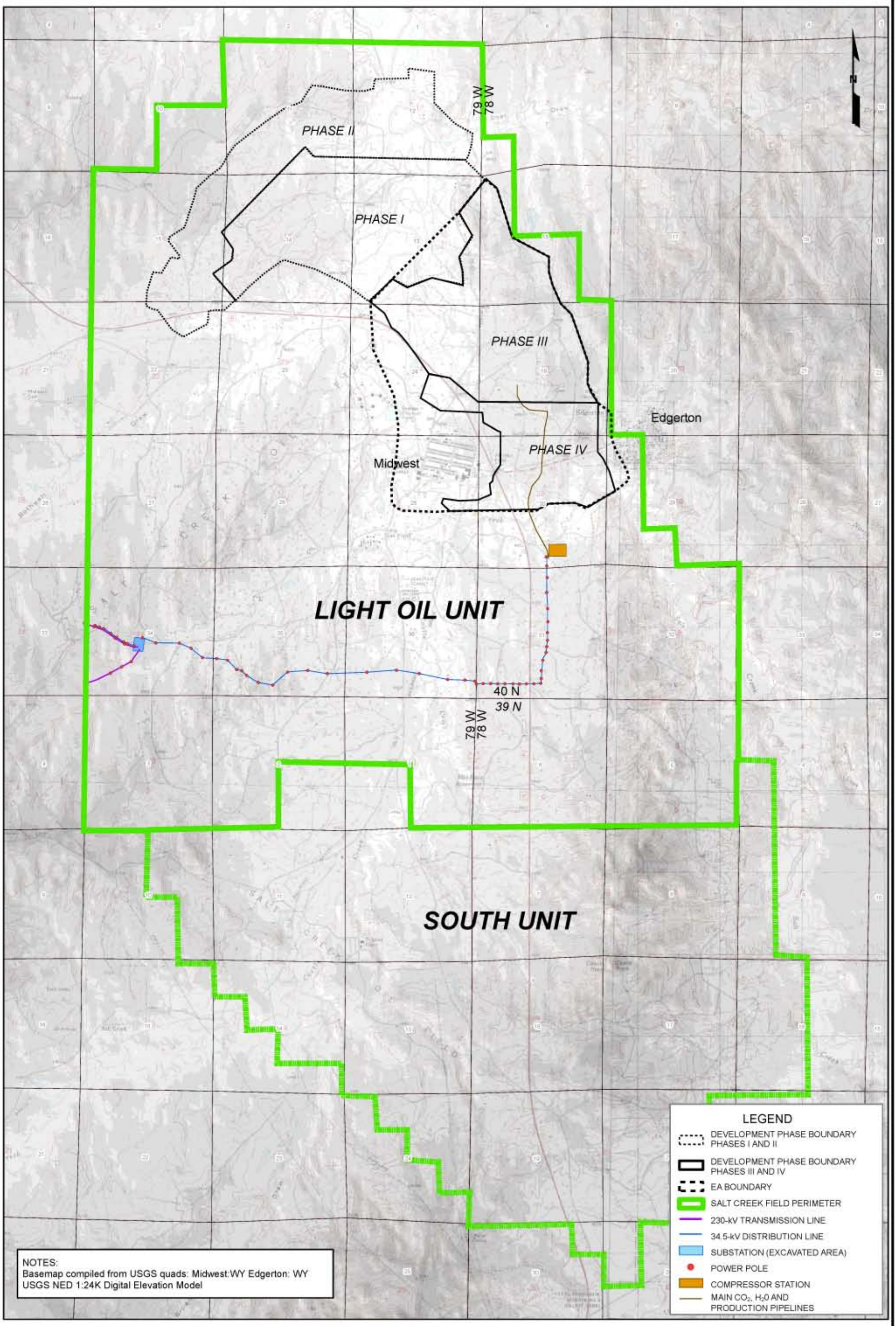
This EA analyzes the proposed Phases III/IV expansion, encompassing approximately 2,182 acres of tertiary EOR development using CO_2 injection. CO_2 EOR involves the alternating injection of CO_2 and water into the reservoir rock to displace liquid hydrocarbons towards production wells where it is withdrawn and further processed. CO_2 produced with the oil would be separated and recycled to the CO_2 injection system for re-injection. The proposed Phases III/IV CO_2 injection project would be similar to existing waterflood activities; therefore, many of the existing facilities and infrastructure would be used as part of the Proposed Action. Phases III/IV field development facilities would include injection and production wells, injection and production pipelines, production test and treating facilities, recycle compressors (including one new compression station), injection manifold headers, and a new electrical substation and associated electrical lines. Existing wells would be utilized to the extent possible to limit the number of new wells.

The use of CO_2 has been pilot tested within Salt Creek Oil Field and is being successfully implemented for Phases I and II. Howell currently estimates Phases III/IV would produce approximately 3,700 additional BOPD or 22 MMBO over the life of the project using CO_2 injection, in accordance with the production forecast shown in Figure 2-2. An overview of reservoir modeling results for Salt Creek Oil Field suggest that CO_2 EOR could ultimately increase daily production rates by a magnitude of 5 for all project phases, and ultimately increase oil recovery from the entire field by as much as 150 MMBO, extending the life of the field 30 to 40 years.

2.1.1.1 CO_2 Flooding Process

CO_2 flooding is a proven technology that was first attempted in the Mead Strawn Field near Abilene, Texas in 1964. Most commercial CO_2 injection projects have been undertaken since 1980 with an increasing number of projects implemented since then.

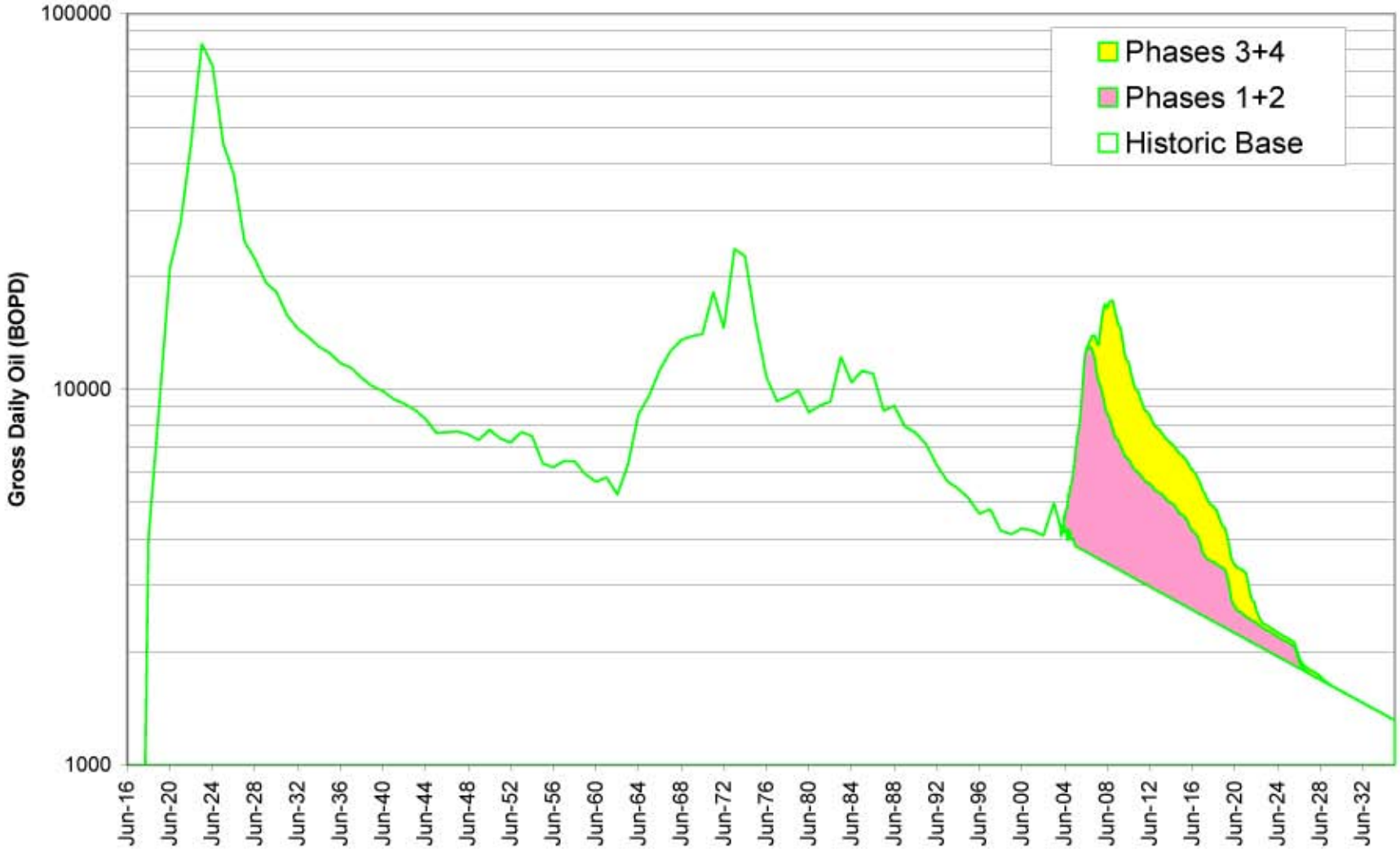
EOR using CO_2 injection removes oil left behind by both conventional production techniques and secondary recovery efforts in reservoir rock through either miscible or immiscible interactions with liquid hydrocarbons. Fluids that are miscible will completely mix together into a single fluid, whereas immiscible fluids will not mix together but remain as separate fluids (e.g., oil and water). Under certain conditions of temperature, pressure, and composition, CO_2 can be injected into reservoir rock as a liquid and will become miscible with oil, thereby reducing the viscosity of the fluid and improving the ability of oil to flow through the reservoir rock.



SALT CREEK PHASES III/IV EA

PHASES III/IV BOUNDARIES

FIGURE 2-1



SALT CREEK PHASES III/IV EA	OIL PRODUCTION FORECASTS
	FIGURE: 2-2

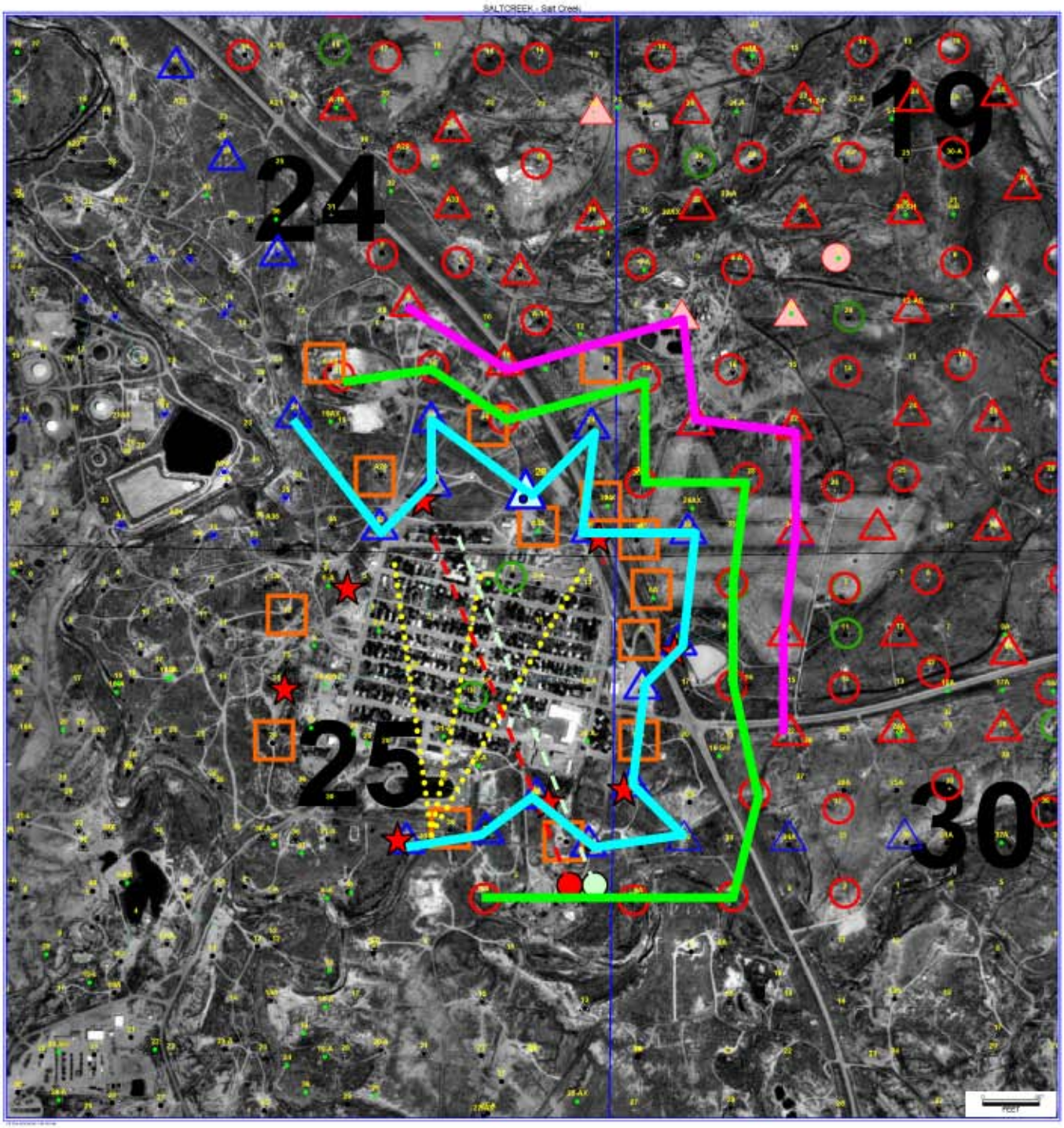
Subsequent water injection then removes oil that was left behind by previous secondary recovery techniques, such as waterflooding.

Howell conducted industry standard laboratory tests (i.e., slim-tube experiments) to determine the temperature and pressure conditions at which CO_2 miscibility is predicted to occur for the WC2 within Salt Creek Oil Field. For the WC2, miscibility is predicted to occur at pressures above 1,200 pounds per square inch (psi) with temperatures at 100º F. Howell has determined that the maximum bottomhole injection pressure at the depth of the WC2 (1,800 feet) is 1,500 psi with an average reservoir pressure of 1,300 psi and an average temperature of 105º F. The WC2 reservoir pressure is sufficient to allow for operation of the CO_2 flood above minimum miscibility pressure. In order to maintain sufficient reservoir pressure, production wells would be configured as flowing wells and back pressure would be maintained on the formation through surface chokes. This operational set-up would allow Howell operations personnel to monitor and adjust well conditions, as necessary, in an effort to maximize oil recovery.

Phase III is located north of the populated areas of Midwest and Edgerton. The Phase IV area examined in the EA surrounds the town of Midwest and to the west of Edgerton (Figure 2-1). Although the towns of Midwest and Edgerton are located in or adjacent to Phases III/IV, the Proposed Action does not entail CO_2 injection beneath the towns. Howell proposes to isolate and monitor the populated areas, as part of the Proposed Action, installing water injection wells around the towns of Midwest and Edgerton and the updip portion of the WC2 reservoir to inhibit CO_2 migration in the WC2 underlying the towns. To achieve reservoir isolation, Howell would implement a two-fold system utilizing both low-pressure production wells to gather the CO_2 and high-pressure water injection wells to divert any CO_2 migration. This process would create a low-pressure sink that would draw CO_2 from the periphery of the development area and prevent it from migrating outside of the development area. The pressure sink effect would be enhanced through the use of a ring of high-pressure water injection wells that would be installed between the development area and the towns. This water injection would provide a “curtain” of high-pressure resistance to force any CO_2 back towards the production wells. This high-pressure water injection ring or water curtain would be located along the northern, eastern, and southern perimeters of Midwest. In addition to this two-fold system for reservoir isolation, Howell would shut-in any active WC2 wells located between the water injection ring and the towns of Midwest and Edgerton in an effort to ensure a uniformly high reservoir pressure underneath the towns. Figure 2-3 illustrates the layout of the water curtain and production system around Midwest.

In the reservoir area west of Midwest, Howell intends to continue its existing waterflood operations, although the injection and production in this area would be at levels slightly lower than those proposed for the CO_2 flood development to the east.

Numerous measures would be undertaken to monitor the effectiveness of the CO_2 confinement techniques. First, the pressures in the reservoir would be monitored routinely and checked against production and injection volumes to alert Howell to any potential fluid losses outside of the development area. Second, any active WC2 and WC1 wells in the waterflood areas would be monitored for the presence of CO_2. This would serve as a direct subsurface indicator of a possible breach in the water curtain. Finally, Howell would undertake temperature surveys in the



Shut-in Monitoring Well

Proposed New CO_2 Injection Well

Proposed New Production Well

High Pressure CO_2 Injection Well

High Pressure Water Injection Well

Low Pressure Production

Low Pressure Production Well

High Pressure CO_2 Injection

Niobrara Shale Well

Fiber Optic Monitor Well

WC1 Hzt'l Monitor Well

WC2 Hzt'l Monitor Well

Horizontal Bores

High Pressure Water Injection Well

SALT CREEK PHASES III/IV EA	CO_2 CONTAINMENT PLAN FOR MIDWEST

FIGURE: 2-3

monitoring wells to check for any anomalous cooling effects, which might indicate the presence of CO_2 and a possible breach in the water curtain.

Howell also would design a "Monitor Fence" to be installed around each town. This Monitor Fence would be designed using the same geologic process Howell would use for CO_2 seeps. The Monitor Fence would consist of monitoring wells designed to measure downhole temperature and pressure in the WC2, WC1, and overlying shale formations and surface air monitors. These systems would be integrated into Howells' automation system and operational practices. The Monitor Fence plan is more fully described below and illustrated on Figure 2-3.

The monitoring wells would include approximately eight new Niobrara shale wells spaced around the perimeter of Midwest that would be utilized to help detect the presence of CO_2 within the shale. These wells would be drilled to an approximate depth of 800 feet from existing well pads minimizing any potential new disturbance. The shale wells would be monitored for surface pressure, surveyed periodically for downhole temperature anomalies, and utilized to help capture CO_2 that might escape from the main development area.

Additional pressure and temperature monitors would be installed in approximately 14 existing abandoned wells utilizing fiber optic technology. The fiber optics cable would be cemented in place as part of the abandonment process but would be accessible for electronic monitoring. The fiber optics cable would provide real-time pressure and temperature data along the entire length of the cable. Howell is preparing to test this technology and would implement it if it proves successful.

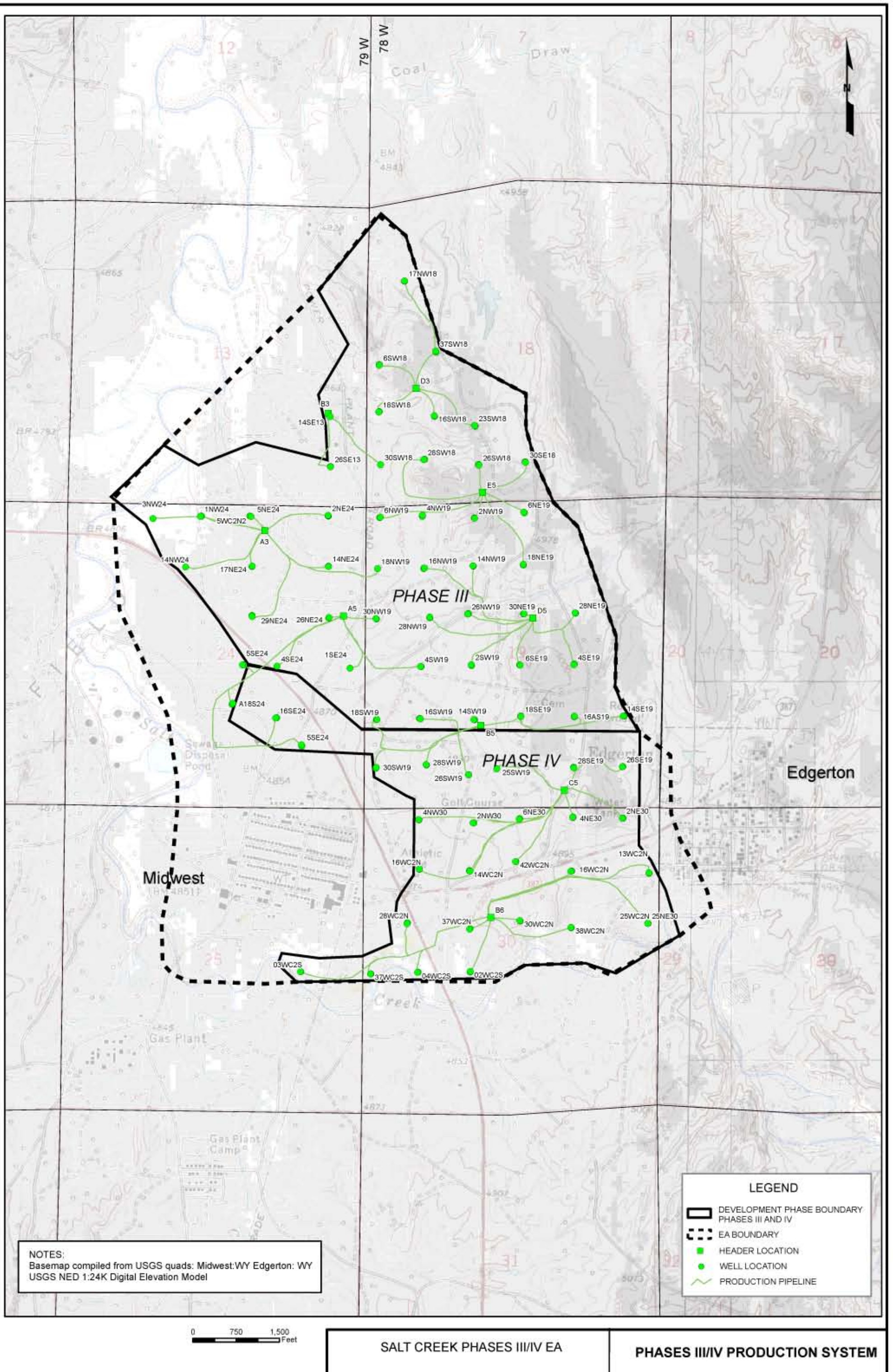
Horizontal monitoring wells would be drilled south of town in the WC2 and WC1 formations extending under the town of Midwest. Howell would apply for permits to drill three horizontal bores under the town of Midwest approximately 40 to 80 feet below surface. These bores would be drilled if CO_2 migration is detected by the Monitor Fence. The horizontal monitoring wells and bores would be utilized to capture and contain CO_2 that might escape from the main development area through the water curtain (see Figure 2-3).

Surface air monitors designed to detect the presence of potentially harmful concentration levels of H_2S and CO_2 are currently in place around the towns of Midwest and Edgerton. Howell intends to evaluate the current placement and requirements for any additional air monitors.

Howell is developing an emergency response plan, in coordination with the towns of Midwest, Edgerton, and local and county emergency services personnel. This plan would be integrated into Howell's operational procedures. Once completed, Howell will furnish a copy to BLM for its records.

2.1.1.2 Well Utilization Plan

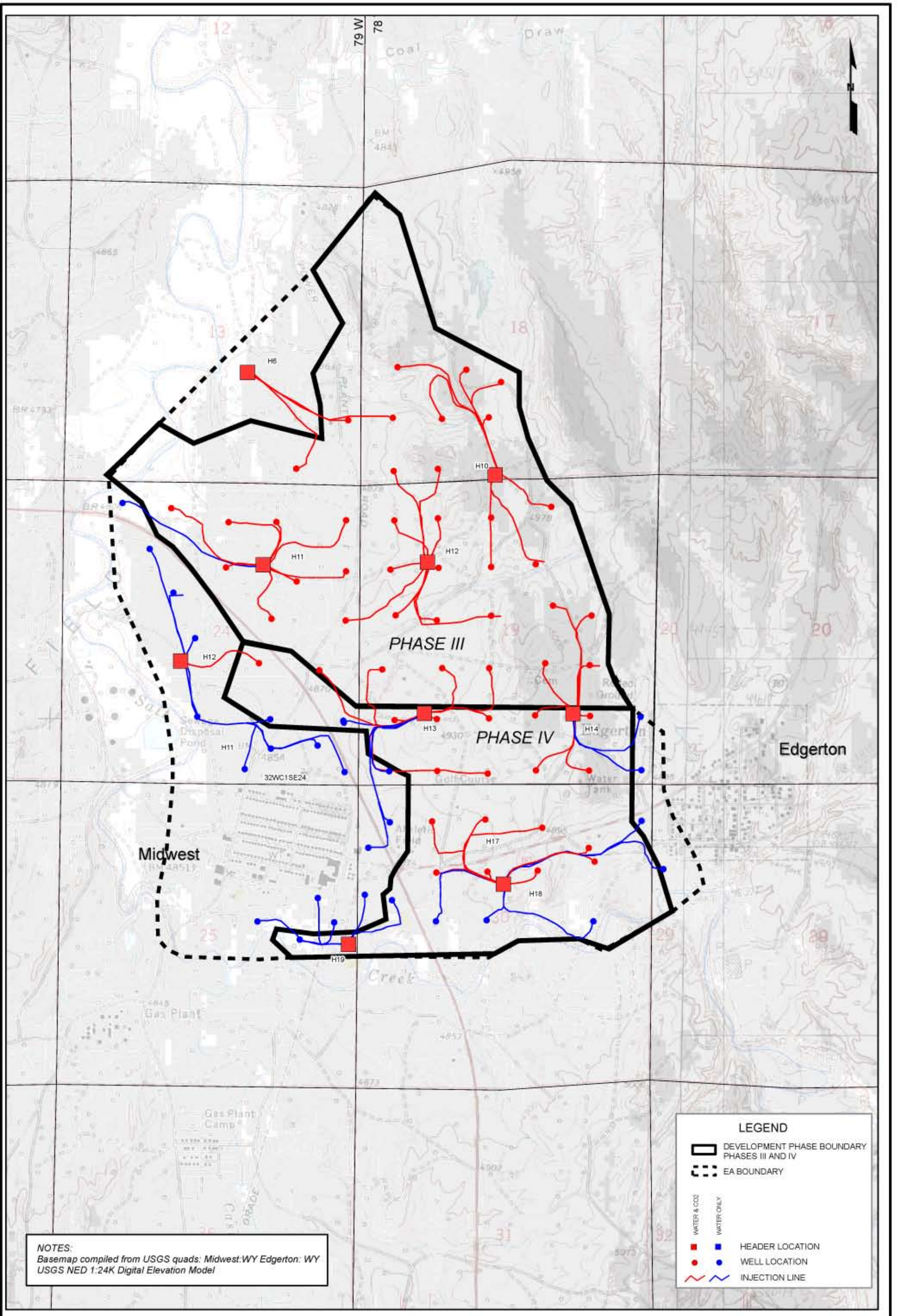
The Proposed Action for developing Phases III/IV with the CO_2 flood would maximize the use of existing wellbores, both active and abandoned, thereby minimizing the disturbance of additional surface area. The plan would require approximately 92 injection wells and



SALT CREEK PHASES III/IV EA

PHASES III/IV PRODUCTION SYSTEM

FIGURE 2-5



SALT CREEK PHASES III/IV EA

PHASES III/IV INJECTION SYSTEM

FIGURE 2-4

75 production wells for a total of 167 wells (Figures 2-4 and 2-5). Up to 8 additional new wells may be required to replace existing wells, totaling 14 new wells estimated. Table 2-1 provides a summary of wells proposed for use in the Phases III/IV areas.

Howell plans to equip all injection, production, and monitoring wells similarly. Beginning at the surface, each well would have a new wellhead configuration, including a new single-master valve, bonnet, and casing head. Downhole tubing would be protected with CO_2-resistant material, such as an internal coating or a fiberglass lining. Nickel-plated packers equipped with stainless steel on-off tools would be set approximately 50 feet above the pay zone perforations. Internally and externally protected tail pipe would extend below the packer along with at least one profile nipple constructed of CO_2-resistant materials. Corrosion-inhibited water would be circulated into the tubing-casing annulus for casing protection. A generic schematic illustrating a typical wellbore configuration was provided as Figure 7, in Chapter 2 of the Phase I EA. Injection wells would be permitted, as required through the Wyoming Oil and Gas Conservation Commission (WOGCC). Mechanical integrity tests or packer tests would be performed and reported, as required, to the WOGCC.

Injection and flow to or from the well would be controlled with remotely actuated chokes. The automation controls and chokes would be installed at the header with protection from extreme weather conditions provided by a small building. Pressure transducers would be mounted on both the tubing and casing to continuously monitor wellbore conditions. Excessive casing pressure, an indication of a potential tubing or packer failure, would trigger an automatic alarm. This automation would allow for more efficient well operation through continuous monitoring and would reduce vehicle activity.

The following subsections describe the three basic types of wells to be utilized for the Proposed Action:

- Existing wells
- New wells
- Plugged and abandoned wells to be re-opened

Existing Wells. Many of the existing wells in Salt Creek Oil Field would require additional cement behind the casing to adequately contain the CO_2 within the WC2 and isolate the other horizons. Each wellbore, active and abandoned, that penetrates the WC2 formation would be evaluated for zonal isolation by previously run or new cement bond logs. Remedial well work would be conducted utilizing the processes and procedures approved and implemented for the Phases I/II areas.

Existing wells not to be used as either production or injection wells would either be equipped to serve as monitoring wells or be shut in. The shut in wells would be used for emergency backup in the case of the unlikely event of a catastrophic failure of an active well.

Table 2-1 Summary of Phases III/IV Well Utilization

Utility	Phase III	Phase IV	Total
Monitoring	4	5	9
Injection (CO_2)	42	19	61
Injection (Water)	3	23	26
Injection (New)	3	2	5
Production	42	32	74
Production (New)	1	0	1
Plugged & Abandoned	67	119	186
Temporarily Abandoned	1	6	7
Waterflood	0	15	15
Grand Total	**163**	**221**	**384**

New Wells. Howell's plan to complete the Phases III/IV pattern development includes the drilling of 6 new wells, although up to 8 additional wells may be required (14 new wells estimated). Each well would be drilled to an approximate depth of 2,500 feet from the surface, and an individual Application for Permit to Drill (APD), site plans, and plats would be submitted to the BLM for each well, as required. Howell also would obtain an APD to drill 8 shallow shale wells, a WC1 horizontal and a WC2 horizontal well under the town of Midwest in conjunction with the "Monitor Fence" plan, as described in Section 2.1.1.1. New wells would be constructed according to plans previously approved and implemented in the Phases I/II areas and would provide the basis for downhole tubular design and site construction methods.

Abandoned Wells. Howell plans to re-enter and reactivate approximately 80 previously abandoned wellbores in the Phases III/IV area. Howell also anticipates having to re-plug approximately 142 additional existing abandoned wells. The work procedures for re-entry would follow plans and procedures approved and implemented for the Phases I/II areas.

2.1.1.3 Facility Plan

The surface facilities required for the implementation of Phases III/IV would be similar to those installed under Phases I/II and would include much of the existing waterflood facilities. The primary differences would be the use of materials that are compatible with CO_2 and can withstand higher working pressures. Figures 2-4 and 2-5 show the layout of the Phases III/IV injection and production systems, respectively. These figures illustrate the proposed flow line and injection line layout, as well as locations for production test and treating facilities, recycle compressors, and injection manifold headers. Under Phases III/IV, the existing system would be expanded to accommodate newly proposed production and injection wells. New manifolds would be added for the collection of wellhead production, well testing, and the distribution of injection CO_2 and water. New pipeline sections would be added in order to connect the new manifolds to tie-in points already established in the existing gathering/distribution system. Most of the current gathering and injection systems for existing waterflood activities would be replaced by the new system. A new CO_2 recycle compression station would be constructed to expand the current capacity and would include pipelines connecting to the existing compressor station from Phase I (see Figure 2-1).

The proposed routing of the injection and production lines reflects the use of existing corridors, ROWs, and linear features (e.g., roads). As part of the Proposed Action, Howell would continue to install production and injection lines within the same corridor and follow existing ROWs to the extent practical. Additionally, as with all other phases of the development, Howell would use a Construction Supervisor to ensure that construction and development practices adhere to BLM's guidelines and regulations, such as ROW placement. Howell has either employed contract labor and/or dedicated company personnel to fulfill the role of Construction Supervisor, whose main focus, on behalf of the Project Manager, is to provide on-site company representation and administer the selected installation contractor. This oversight would ensure:

- The scope of work is completed as per the original design, costs, specifications, and applicable permits.
- The work is conducted per Howell's safety and environmental guidelines, regulatory permit requirements, and the Salt Creek MSUP.
- Necessary departures from the original scope are approved and properly documented.

Howell's proposed expansion for Phases III/IV includes the continued utilization of existing roads and the existing Lease Automatic Custody Transfer (LACT) 4 and LACT 5 production facilities. It is not anticipated that the produced water discharge volumes at the LACTs would be significantly altered by the new process; therefore, additional discharge points would not be required. Future produced water quality is expected to be generally consistent to that currently being produced and would be subject to existing permit discharge limits and conditions established by the Wyoming Department of Environmental Quality (WDEQ) under the established WYPDES program. Howell is committed to continuing to meet the requirements of its existing discharge permits per WDEQ requirements and procedures and to implement necessary actions to ensure continued compliance.

Production System. New state-of-the-art fiberglass production flow lines would be installed for each production well to connect the wells to existing test and bulk separation facilities (satellite facilities). The existing equipment at these collection facilities would be replaced or upgraded to be compatible with CO_2 production. Gas and CO_2 production would be separated and collected in the high-pressure (HP) system at approximately 350 psi. Oil and water would be transported to existing processing facilities via new fiberglass flow lines, which would be constructed, where feasible, along existing roads and existing flow lines.

Produced oil and water arriving at the LACT 5 processing facility would flow into existing internally coated low-pressure (LP) separators designed to remove water and additional entrained gas. The separated oil and water would be placed into the existing gunbarrels (i.e., large oil tanks) and water tanks, respectively. Hot water would be introduced into the separated oil to enhance further oil-water separation and help break up any emulsions formed during production. Gas separated at the LP separator would be collected with the existing flash gas electrical compressor located within the processing facility and compressed into the 350-psi HP gathering system. Gas separated at the gunbarrels and vapors from the oil and water tanks would be

collected by the existing vapor recovery unit (VRU) and discharged to the flash gas compressor for collection into the HP gathering system.

Existing and new electric recycle compressors would collect the HP gas (350 psi) from a common trunk line and recompress the CO_2 to 1,400 psi, discharging into the main CO_2 supply trunk line that feeds the injection distribution system. The current production facility areas were selected as the sites for compression based on the access to a sufficient power supply and the availability of previously disturbed surface area.

Implementation of Phases III/IV would include the installation of 10 additional production test headers or stations and the construction of a new compressor station (see Figure 2-5 and 2-1, respectively). As with previous field expansions, wellhead production volumes would be transported to the manifold stations via new fiberglass flow lines. Commingled production from the manifold stations would be routed to the LACT 5 facilities through internally coated steel flow lines. Each of the production manifold stations also would include the appropriate well testing facilities, where wellhead production would be separated into its components streams and measured.

Injection System. The WAG injection process would continue to be used for Phases III/IV. The WAG process involves alternating injection wells between water and gas injection on either a time or volume basis. Cycles could be as rapid as weekly or as long-term as annually, depending on the particular oil reservoir being flooded.

The injection system design for Phases III/IV follows the same basic approach as with previous Salt Creek development phases, including the use of centralized injection flow control at the manifold stations. As with other phases, the injection manifold stations would distribute either CO_2 or water to individual wells using remotely actuated valves to select the injected fluid. Well injection volumes would be metered at the manifold station, one meter per well. A total of 10 new injection manifolds would be added under this proposed expansion. Injection fluids (i.e., CO_2 and water) would be delivered to each manifold station via newly constructed pipeline segments connected to the existing water and CO_2 distribution systems (see Figure 2-4 and Table 2-2).

Gas System. As with Phases I/II, produced CO_2 gas for Phases III/IV would be collected and recycled back to the high-compression gas injection system for re-injection. The required recycle and flash gas compression and dehydration of produced gas associated with Phases III/IV would be supported by a new recycle station and by the existing facilities installed during previous phases. Howell's current forecast projects the requirement for additional recycle compression beyond existing capacity of the LACT 5 station by the end of 2006. A new compressor station would be located approximately 3 miles south of the LACT 5 station on the east side of Highway 387 across from the LACT 10 production facility (see Figure 2-1). The compressors would be electrically driven motors requiring a facility substation and distribution lines for power supply (see Figure 2-1). This small electrical substation at each recycle compression facility simply steps down the distribution voltage of 35,500 volts from the

Table 2-2 Estimated Surface Disturbance Area for EOR Phases III/IV

Category	Description	Quantity	Previously Disturbed	New Disturbance	Long-term New Disturbance	Temporary Use Disturbance	Comments
		Used	(acres)	(acres)	(acres)	(acres)	
Wells							
	Work on Existing	157	56.3	0.0	0.0	0.0	
	Rework of PA Wells	186	66.7	0.0	0.0	0.0	A
	New Drill Wells (6)	14	0.0	5.0	5.0	15.1	A, B
	Monitoring Wells						
	Niobrara	8	2.9	0.0	0.0	0.0	
	Monitoring Wells	14	5.0	0.0	0.0	0.0	
	Horizontal Monitors	2	0.7	0.0	0.0	0.0	
	Horizontal Bores	3	1.1	0.0	0.0	0.0	K
	Access Roads to New Wells	24			2.0		
Subtotal			**132.7**	**5.0**	**7.0**	**15.1**	
Injection Headers			**91.7**	**5.7**	**0.5**	**0**	C, D
Production Headers			**79.7**	**5.1**	**0.0**	**0**	A, C, E
Trunk Lines							
	CO_2 Trunk Lines	19	17.8		0.0	0.0	F. G, H
	H_2O Trunk Lines	21	19.8		0.0	0.0	
	Production Trunk Lines	11	14.8		0.0	5.7	
	Suction Line to Compressor	1	0.0	8.6	0.0	0.0	
Subtotal			**52.4**	**8.6**	**0.0**	**6**	
Compressor Station							
	LACT 10 Station	1	0.0	7.7	7.7	5.7	
Subtotal			**0.0**	**7.7**	**7.7**	**6**	
Electrical							
	Substation	1	0.0	5.6	5.6	5.7	
	New Roads	1		0.7	0.7		
Subtotal			**0.0**	**6.3**	**6.3**	**6**	
Electrical Lines							
	PP&L's T-line to Substation	12	0.0	13.8	0.002	7.3	J
	Dist Line to West Feed	20	0.0	0.004	0.004	4.5	J
	Dist Line to Center Feed	40	0.0	0.008	0.008	9.0	J
	Dist Line to Compressor	116	0.0	0.02	0.02	26.6	J

Table 2-2 Estimated Surface Disturbance Area for EOR Phases III/IV

Category	Description	Quantity	Previously Disturbed	New Disturbance	Long-term New Disturbance	Temporary Use Disturbance	Comments
	Production Headers (Poles)	80	0.0	0.02	0.02	14.7	F, I
	Injection Headers (Poles)	80	0.0	0.02	0.02	14.7	
	New Roads to Facilities	3	0.0	0.02	0.02	0.0	
Subtotal		**348**	**0**	**14**	**0.1**	**77**	
Staging Area		1	0.0	0.0	0.0	5.7	
Totals			**356.5**	**52.3**	**21.6**	**114.9**	
Total New Disturbance				**167.2**			
Total New Short-Term Disturbance				**145.6**			

Comments:

A - Well count increased to allow for additional unplanned wells.
B - After drilling, production would actually only use a 125' x 125' pad. (250 x 250) – (125 x 125) = 375 x 125 (1.07 acres of temporary disturbance).

C - 3-inch fiberglass lines would run on existing ROWs except for new wells and headers.

D - The only long-term new disturbance would be for the injection header building locations and new wells.

E - Production headers would be replacements for current waterflood headers except for C6 and B7.

F - Assume no long-term disturbance for all trunk lines and flow lines, as they would be reclaimed.

G - When two or more lines have the same ROW, they would be co-trenched to minimize the disturbance area.

H - 40-foot ROWs would apply, extending to a maximum of 80-foot ROWs where multiple, larger-diameter steel lines would be required.

I - Allow for 8 poles per header, 9-square-foot (3'x3') long-term disturbance per pole.

J - Allow 9-square-foot long-term disturbance per pole; approximate 200-foot spacing between poles.
K - Horizontal bores would only be installed if CO_2 migration is detected. The three horizontal bores may be bored from one existing well location.

electric distribution line to the working voltage of 4,160 volts to power the individual recycle compressors. A smaller transformer also steps down the distribution voltage to 480 volts for the supporting utility systems. This "stepdown substation" would be similar to that installed at the LACT 5 Compressor Station during Phase I.

The design, construction, and operation of the new compressor station would be similar to the LACT 5 station with one unit installed during 2006 and expansion capability for up to five 40 million cubic feet per day (MMCFD) units. The CO_2 gathering and injection trunk lines would be extended from LACT 5 to transport produced gas and recycled CO_2 injection gas to and from the LACT 10 compression station. Recycled CO_2 injection gas would be commingled with the discharge from LACT 5 into a common pipeline for distribution into the field. Howell also has updated its scenarios of releases and air dispersion modeling analyses of CO_2 and H_2S through a model calibration effort (see Appendix A).

The proposed CO_2 trunk line extending from the new compressor station north into the Phase IV area would be constructed similarly to the existing trunk line constructed for Phase I. The new pipe would cross the Salt Creek drainage (see Figure 2-1); however, Howell proposes to “bridge” the channel with the pipe, avoiding direct surface disturbance to the stream bed, channel, or associated riparian areas. As detailed in Section 2.1.6.2 of the Phase I EA (BLM 2003a), Howell also would minimize excessive sediment load to surface water drainages and avoid wetlands, streams, and riparian areas. Where such areas are unavoidable, the appropriate permits would be obtained and every effort would be made to minimize suspended sediment and potential contaminant loads to surface water. Construction at drainages would be limited to periods of low flow, and channel crossings would be made perpendicular to the channel.

2.1.1.4 Ancillary Facilities

Access Roads

Given the existence of an extensive network of access roads in Salt Creek Oil Field, a minimal number of new access roads would be required for the Phases III/IV development. New access roads only would be necessary for the 6 to 14 new drill wells under the Proposed Action, resulting in approximately 2 acres of new surface disturbance for a maximum of 14 new wells. Howell would continue an ongoing program conducted in cooperation with BLM to identify and reclaim unused, redundant, and/or unnecessary roads throughout the life of the Phases III/IV Project.

Electrical Substation and Connecting Lines

A new electric substation would be constructed as part of the Proposed Action to meet the electrical requirements of Phases III/IV development, including the new recycle compressor station located across from LACT 10. The substation, identified as Claim Jumper Switchyard, would be located southwest of the town of Midwest in Section 34 (see Figure 2-1) and would consist of two portions, one owned by Howell and the other by Pacific Power & Light (PP&L). The total disturbance area would be 350 feet x 700 feet, or 5.6 acres. Each portion of the substation would be fenced separately, and each would contain the equipment necessary to safely supply electrical power to Salt Creek Oil Field. The substation would be accessed from the

existing road, with only a short section of new road being necessary. Power would be supplied to the electrical substation from PP&L's main 230-kV transmission line with a separate return line to the main line (see Figure 2-1), totaling approximately 1.0 mile of transmission line ROW. PP&L would be responsible for the construction and operation of the 230-kV transmission and 34.5-kV distribution underbuild to the Claim Jumper Switchyard from their main line. An additional 6.7 miles of new, 34.5-kV distribution lines would extend from the substation into Salt Creek Oil Field to service the new compressors. Howell would own, operate, and maintain the 34.5-kV distribution lines from the substation into Phase IV. Electric lines would be constructed in accordance with the standards for raptor (i.e., bird of prey) protection outlined in APLIC (1996) and referenced in the Master Surface Use Plan (MSUP) for Salt Creek and South Salt Creek Units.

2.1.2 Disturbance Estimates

Operations that would result in surface disturbance would include the re-working of existing wells on previously disturbed sites and construction of 1) drilling pads for new wells, 2) new flow lines and injection lines, 3) limited new access roads, and (4) production facilities. Surface disturbance would be either short-term (during construction and site reclamation) or long-term (during or beyond the life of the project).

New construction for Phases III/IV would be sited to incorporate existing facilities to the greatest extent possible. Table 2-2 provides a summary of disturbance estimates for Phases III/IV.

New wells would initially require a 250-foot x 250-foot pad for drilling operations. After completion, the well pads would be reclaimed, resulting in a 125-foot x 125-foot pad. Total long-term disturbance from new drilling activities would be approximately 5.0 acres.

New production collection buildings and flow lines would replace existing facilities and parallel the existing lines and roads to the extent possible. Fiberglass flow lines (3 inches in diameter) would be buried approximately 36 to 48 inches below the ground surface. New injection header buildings would be located on existing disturbance, where possible, and would consist of 20-foot x 30-foot pre-fabricated metal buildings. The total long-term disturbance for new buildings is projected to be approximately 0.5 acre.

The new compression station would be located to take advantage of existing roads and designed similarly to the existing facility located adjacent to LACT 5. The total long-term disturbance is estimated to be 7.75 acres based on a 450-foot x 750-foot footprint similar to actual acreage utilized at the LACT 5 station. The trunk line extensions would be installed within a common corridor utilizing a 60-foot construction ROW. Long-term disturbance for the trunk line extensions would be 5.0 acres assuming a 90% revegetation success rate.

Trunk lines are typically steel pipelines that either distribute or collect fluids for separation/processing or injection. These lines vary in size from 6 to 12 inches in diameter and would be trenched and buried 36 to 48 inches below the ground surface. Typically, 40-foot ROWs would be required for flow lines; however, the larger-diameter, steel trunk lines should require an 80-foot ROW to allow for multiple lines in the same corridor and to provide flexibility for pipe construction (e.g., poly liner installation, below-grade welding). This ROW requirement

parallels the approach and methods implemented for the Phase II EOR development. Areas would be reclaimed in accordance with Howell's reclamation plan, assuming a 90% revegetation success rate for long-term disturbances associated with trunk lines and flow lines.

Estimated surface disturbance associated with new access roads to the 6 to 14 new well sites would be approximately a maximum of 2 acres. New electric power lines to new production and injection header stations would result in an estimated 77.0 acres of short-term disturbance and 0.1 acre of residual long-term disturbance. This long-term estimate is based on approximately 9 square feet of remaining surface disturbance in the long term for each of the estimated 160 new power distribution poles.

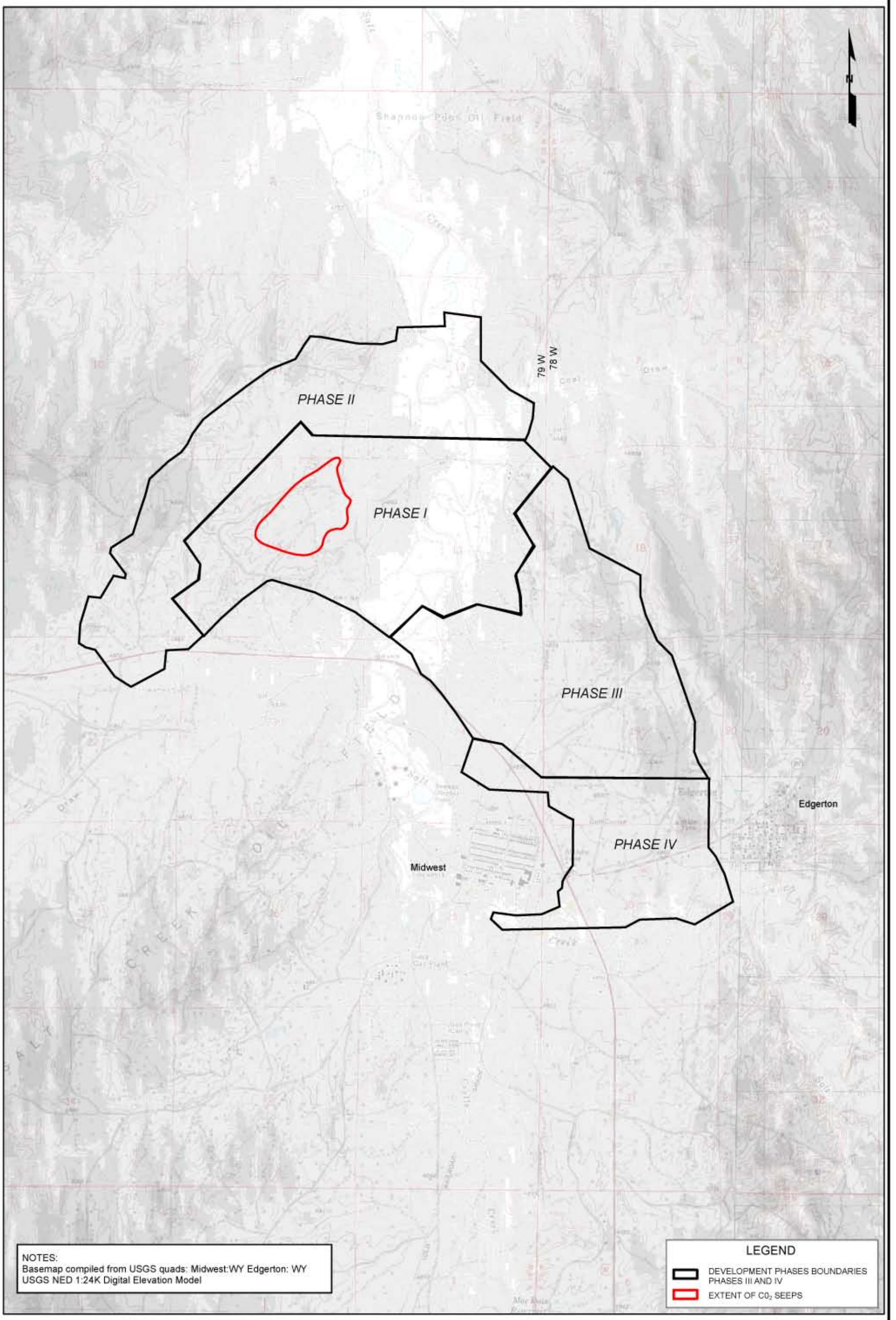
Total disturbance estimates for Phases III/IV would be 145.6 acres for new disturbance that would be reclaimed in the short term and 21.6 acres of new disturbance that would result in long-term surface disturbance (see Table 2-2).

2.1.3 CO_2 Seep Containment Plan Summary

During 2004 and 2005, minor amounts of the CO_2 injected into the WC2 reservoir seeped to the surface in a small, confined area within Phase I (T40N, R79W NE ¼ S14) (Figure 2-6). Of the 150 MMCFD of CO_2 injected, an average of 12 thousand cubic feet per day (MCFD) has been recorded surfacing only in this limited area of Phase I, which equates to 0.008% of the total CO_2 injected. Howell initially eliminated a number of the seeps by performing remedial well work and continues its efforts to ultimately eliminate all of the seeps occurring from the CO_2 injection in the WC2. However, to ensure the integrity of the Proposed Action, Howell is proposing to implement a number of containment and monitoring procedures. In addition to these measures, Howell also completed a dispersion modeling analysis to determine potential downwind concentrations occurring as a result of the reservoir seep or a well blowout. (see Appendix A).

Howell is developing a process based on geological review to identify areas potentially susceptible to CO_2 seepage. The first step in this identification process is to identify major faults by integrating the surface and subsurface features. The surface geology is mapped using outcrop locations in conjunction with fault and fracture characterization. The subsurface geology is mapped using wireline well data and 3D seismic information. The fault and fracture characterization typically includes the following: orientation, geometry, mineralization, density, and offset. This geologic information will then be used to help predict areas where CO_2 seeps may occur.

Remedial Work on Existing Wells: Remedial well work on existing wells is the first step to reducing or eliminating CO_2 seeps. Howell intends to examine all existing wells located within the Phases III/IV areas in an effort to determine which wells need to be repaired and, if warranted, perform such repairs. Howell also may take additional steps such as pressure testing the casing to ensure well integrity, or conducting a cement bond evaluation.



0 1,250 2,500 Feet

SALT CREEK PHASES III/IV EA	CO_2 SEEP AREA FOR PHASE I
	FIGURE 2-6

Subsurface Containment: In the event well remediation does not fully address CO_2 seepage, Howell would implement the following steps, as necessary:

- Install shallow vertical wells (between 100 and 800 feet below ground surface) that would be completed in naturally fractured zones.
- Install a horizontal bore that would be drilled approximately 20 to 80 feet below a CO_2 seep.
- Install drains in or near natural draws, as this appears to be the primary area where the CO_2 seeps surface.

For both the shallow vertical wells and horizontal bore, Howell would install pumps at the lowest available point to remove shale fluids displaced by the CO_2. These fluids would be collected and processed, along with the CO_2 flood-produced fluids at a nearby LACT battery. Liquids collected by drains in or near natural ravines would be removed by vacuum truck and transported to a nearby LACT battery for processing. CO_2 recovered during these procedures would be gathered into a low-pressure system and compressed by blowers into the main CO_2 recycle system. Howell is currently fencing prominent CO_2 seeps to restrict human and animal access directly into the seep area.

Howell plans to continue to investigate and evaluate new technology and will update the existing CO_2 Seep Containment Plan design, as necessary. In this ongoing effort, Howell also will continue efforts to integrate subsurface 3-D seismic data and surface geology mapping. Any such changes would be integrated into the Plan. Howell will continue to communicate directly with the BLM and the towns of Midwest and Edgerton regarding any changes to the Plan.

2.1.4 Applicant Committed Environmental Protection Measures

Howell initially developed a number of Applicant Committed Environmental Protection Measures (ACEPM) for Phase I (BLM 2003). These measures also applied to Phase II and will be committed to as part of Phases III/IV. Additional protection measures developed and incorporated into the Phases III/IV Project include the following:

2.1.4.1 CO_2 Seep Containment Plan

The CO_2 Seep Containment Plan is summarized above in Section 2.1.3. This measure was developed to address existing seeps for the Phase I expansion and potential future CO_2 seeps, if warranted. To the extent required, this measure shall be applied during development of Phases III/IV.

2.1.4.2 Livestock Grazing Coordination Measure

Howell would coordinate with the grazing lessee for the Phases III/IV area to discuss and review options to minimize grazing impacts from the Proposed Action with the overall goal of resting reclaimed areas from grazing for a 2-year period, where practicable and feasible. Options may

include: 1) temporary fencing of reclaimed areas; 2) providing alternate grazing pastures; or 3) providing supplemental livestock feed. Howell and the grazing lessee would develop a mutual agreement as to the specific option or options to be implemented.

2.2 No Action Alternative

The "No Action" alternative would involve continued waterflood operations throughout Salt Creek Oil Field and continued CO_2 EOR in the existing Phases I/II areas. Currently, about 7,000 BOPD is being produced, with about 3,000 BOPD attributed to CO_2 injection activities. Oil production is expected to increase marginally by the end of 2006, as Phases I/II production from CO_2 injection activities comes to full production estimates. An estimated 50 MMBO remains to be recovered under the No Action Alternative for the entire field, as compared to an estimated 22 MMBO recovered by CO_2 EOR in the Phases III/IV area only and compared to 150 MMBO by CO_2 EOR for the entire Salt Creek Oil Field. Assuming stability of current oil prices, Salt Creek Oil Field would likely be shut within the next 10 to 20 years under the No Action Alternative.

2.3 Alternatives Considered but Eliminated from Detailed Analysis

EOR techniques have long been utilized by the oil industry to increase hydrocarbon yields from oil and gas bearing structures. To date, various types of waterflood procedures have been used and is the current EOR approach employed throughout Salt Creek Oil Field. In the last 20 years, the use of CO_2 as an EOR agent has become increasingly popular because, under certain conditions, it is much more effective at recovering additional trapped oils than waterflooding.

Implementation of Phases I/II by Howell has demonstrated that CO_2 flooding of the WC2 formation within Salt Creek Oil Field substantially increases recovery of remaining oil reserves. These evaluations, however, did not identify alternative EOR techniques that would be economically viable and effective within this field. Additionally, Howell considered the use of horizontal wells to reduce the number of wells used in the EOR project. Due to high permeability of the WC2 formation, horizontal wells would not develop sufficient sweep efficiency, resulting in poor recovery of oil. Therefore, this option is not technically sound for use in the WC2 formation and thereby also not an environmentally viable project alternative.

3.0 Affected Environment

3.1 Air Quality

3.1.1 Climate and Meteorology

The climate for the Salt Creek region is classified as a continental semi-arid cool steppe area. The summers are short and warm, while the winters are long and cold. The average monthly temperature in Midwest ranges from 23.7˚F in January to 72.0˚F in July. The average daily temperature for the Powder River Basin to the north of the project area ranges between 5–10˚F for a low and 30-35˚F as a high in mid-winter, and an average daily temperature of 55–60˚F for a low and 80-85˚F as a high in the summer. The region's frost-free period occurs between late May and early September. Refer to Section 3.1.1 of the Phase I EA for additional information related to the climate and meteorology described for the Salt Creek area (BLM 2003a).

3.1.2 Ambient Air Quality

The ambient air quality in the project area and the region is generally good, and the region encompassing Salt Creek Oil Field is classified as "attainment" with respect to Ambient Standards established by the Wyoming Air Quality Standards and Regulations (WAQS&R) and National Ambient Air Quality Standards (NAAQS). State and federal ambient air quality standards listed in Table 3-1 set upper limits for concentrations of designated "criteria" air pollutants for public accessible areas. "Criteria pollutants" include: inhalable particulate matter (PM_{10}), fine particulate matter ($PM_{2.5}$), nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), and ozone or ozone precursors (volatile organic compounds [VOCs]). The State of Wyoming also has established ambient air quality standards for hydrogen sulfide (H_2S), which is prevalent in very low ambient concentrations throughout Salt Creek Oil Field.

Existing sources of emissions of criteria pollutants in the project area and region include:

- Oil and gas production and processing operations; e.g., engine-driven compressors, pumps and generators, gas processing, dehydration units; other stationary fuel fired sources: PM_{10}/$PM_{2.5}$, NOx, SO_2, CO, VOCs, and H_2S.
- Dust (PM_{10}) from traffic on unpaved roads, sand application on paved roads during the winter, construction activities, and windblown deposition.
- Combustion emissions from mobile sources (gasoline and diesel vehicles): PM_{10}/$PM_{2.5}$, NOx, SO_2, CO, and VOCs.
- Fugitive emissions (equipment leaks) from process equipment: H_2S and VOCs.
- Mining (primarily coal in Campbell county): PM_{10}.
- Coal-fired power plants.
- Regional transport of pollutants from areas upwind of the project area.

No air quality monitoring stations exist in or near Salt Creek Oil Field and no ambient air quality data specific to the project area are available. However, Argonne National Laboratory compiled and reviewed ambient air quality data measured throughout northeastern Wyoming and southeastern Montana (Argonne 2002), in support of the Powder River Basin (PRB) Oil and Gas Project, which encompasses all or parts of Johnson, Campbell, and Sheridan counties adjacent to northeast Natrona County and Salt Creek Oil Field. Background concentrations of regulated pollutants compiled for northeast Wyoming (Argonne 2002) are provided in Table 3-1.

As discussed in Section 3.2.1 of the Phase I EA (BLM 2003a), ambient concentrations of H_2S in the project area have been demonstrated to be negligible and the WDEQ has not required H_2S monitoring since 2000.

Table 3-1 Ambient Air Quality Standards and Published Background Concentrations of Regulated Air Pollutants in Northeast Wyoming

Pollutant	Averaging Time	Wyoming Ambient Air Standards (μg/m^3)	NAAQS (μg/m^3)	Assumed Background Concentrations (μg/m^3)
PM_{10}	Annual	50	50	30
	24-Hour	150	150	105
$PM_{2.5}$	Annual	15	15	8
	24-Hour	65	65	20
NO_x	Annual	100 (0.05 ppmv)	100	11
SO_2	Annual	60 (0.02 ppmv)	80	16
	24-Hour	260 (0.1 ppmv)	365	89
	3-Hour	1,300 (0.5 ppmv)	1,300	325
CO	8-Hour	10,000 (9 ppmv)	10,000	6,600
	1-Hour	40,000 (35 ppmv)	40,000	15,000
Ozone	8-Hour	157 (0.08 ppmv)	157	-

Source: Argonne 2002

3.1.3 Carbon Dioxide Seeps

As discussed in Section 2.1.3, small CO_2 seeps have surfaced in a confined area of the NE ¼ of Section 14 in the Phase I area. These surface seeps are composed of liquids (i.e., water and crude oil), CO_2, and lesser concentrations of H_2S. The seep phenomenon was not anticipated and was not examined in the Phase I or Phase II EAs (BLM 2003a, 2004a).

CO_2 is not a regulated pollutant, but it is a greenhouse gas and an asphyxiant in high concentrations. If present in confined spaces or areas of low and confining features, such as natural draws, gullies, or ditches, concentrations of CO_2 could increase to potentially hazardous levels in some circumstances (Cameron-Cole 2005a).

Concentrations of H_2S measured in current seeps have not exceeded the ambient standards (Cameron-Cole 2005a). The Cameron-Cole study did not quantify concentrations of VOCs emitted and dispersed from the selected seeps. In response, substantial resources and technologies have been implemented to assess surface impacts from the active seeps and to identify the source and path of CO_2 from the subsurface to the surface, as described in the following sections.

Data from a representative sample of surface seeps were collected to determine the input parameter ranges and distributions for an air dispersion modeling analyses (Cameron-Cole 2005a). Six seeps were studied, in addition to measurements of gas concentrations that were taken in one draw downgradient of several active seeps.

Field measurements collected during the study included:

- Location of selected representative seep locations (latitude/longitude) using Global Positioning System (GPS).
- Measurements of physical characteristics of selected seeps:
    - Approximate size (radius) of surface disturbances.
    - Gas flow rate in cubic feet per minute (cfm).
- Sampling and analysis of CO_2 and H_2S concentrations from seep discharge points.
- Perimeter monitoring (real-time) of ambient ground-level gas concentrations (i.e., CO_2, H_2S, and oxygen [O_2]).
- On-site ambient and meteorological data (e.g., temperature, relative humidity).
- Monitoring (real-time) of ground-level gas concentrations (CO_2, H_2S, and O_2) at the base of a drainage.
    - Multiple active seeps located in a draw upslope of monitoring stations.

Field measurements showed the highest CO_2 and H_2S concentrations occurred during nighttime conditions, when both ambient temperatures and wind speeds were low. The maximum reported CO_2 concentration at ground level near one of the sampled seeps was approximately 24,500 parts per million dry volume basis (ppmvd) (Cameron-Cole 2005a).

Specifically, field measurements taken at the base of the drainage up to approximately 500 feet downgradient of several small seeps reported maximum measured CO_2 concentrations of 25,000 ppmvd (Cameron-Cole 2005a, Figure 4). It should be noted that the large number of CO_2 data points falling precisely at the 25,000 ppmvd scale on the time series scatter plot of measured CO_2 concentration (Cameron-Cole 2005a, Figure 4) infers that the range of the instrument may have been exceeded and that the actual downdraw CO_2 concentrations may have exceeded 25,000 ppmvd during some periods during the test.

Based on the field measurement data, Cameron-Cole performed air dispersion modeling designed to determine the critical parameters leading to high ground-level CO_2 concentrations and to predict the dispersion of dense gas concentrations over distances from the seep. The dispersion modeling results confirmed the results of the air monitoring, in that the highest ground-level CO_2 concentrations occurred during calm, stable conditions, and that the highest concentrations were predicted to occur close to the release point, with concentrations decreasing with increasing distance from the release. The modeling results also indicated that concentrations decrease significantly between ground level and the breathing zone (5 feet [1.5 meters] above ground), as would be expected with a heavier-than-air release under calm conditions. It should be noted, however, that the modeling results should be interpreted while

considering the limitations of the model used. The greatest limitation is that the model assumes that the underlying terrain is flat, so it cannot predict relative build-up of concentration in ground depressions or any channeling effects due to gullies or ravines.

3.2 Geology

The topography of Salt Creek Oil Field is characterized by dissected, rolling upland plains with low to moderate relief (badlands, broad valleys, deep eroded gullies, and isolated hills). Elevations in the project area range from 4,750 to 5,150 feet. Refer to Section 3.1.2.1 of the Phase I EA (BLM 2003a) for a detailed description of the topography of the Salt Creek area.

Salt Creek Oil Field is located within the transitional zone between the Powder River Basin to the northeast and the Casper Arch to the southwest. The structural framework is the result of the Late Mesozoic Laramide Orogeny. Site geology ranges from the Cody Formation, which forms all outcrops throughout the project area, and the Frontier Formation, which includes the petroleum reservoir rocks of Salt Creek Oil Field. Hydrocarbons are produced from 11 individual units of the Frontier, particularly from the Wall Creek 2 (WC2) formation. A more detailed description of project area geology, including a representative well log that illustrates the relationship among different geologic strata, can be found in the Phase I EA (BLM 2003a, Figure 11).

3.2.1 Source and Path of CO_2 Migration to Surface

The integrity of the WC2 reservoir is well documented. The reservoir initially contained a gas cap with reservoir pressures exceeding 1,000 pounds per square inch gauge (psig). The integrity of the producing formation(s) is not suspect. Field studies show the source of the CO_2 seeping to the surface is from wells of poor integrity, where CO_2 migrates to the surface via existing localized geological structures (e.g., faults, fractures).

The following actions help define the model for CO_2 seeps:

- Historical Well File Research
  - Undocumented well locations
  - Well integrity evaluations
- Temperature Logging
- Noise Logging
- Fluid Tracer Logging
- Gas Tracer Logging
- Surface Geology Study
- Subsurface Geology Study
  - Passive Seismic Survey
  - Active Seismic Survey

Extensive studies of surface and subsurface geology are currently underway, not only in the localized area of the seeps, but the entire field, including the Phases III/IV area.

3.2.2 Well Location and Evaluation of Well Integrity

There are observed gaps in well spacing where there may be undocumented wells, including locations in and around populated areas. For example, in an array of regularly spaced wells, there are areas where a well is not evident where expected, based on historical well locations. Howell has undertaken efforts to locate undocumented wellbores that may exist throughout the field using:

- Magnetic detection techniques (aerial and surface)
- Radon, methane, and CO_2 detection (spectroscopy)
- Well file research

Howell has reviewed historical documentation and Cement Bond Logs (CBLs) to identify wells in need of repair. Wells with documented CBLs may not be re-worked, but many wells, including injection/production wells, and plugged and abandoned wells with damaged or inferior cement jobs or plugs have been re-worked or re-plugged. In some circumstances, new casing strings have been run.

3.2.3 Well Work Practices and Reliability

The reliability of well integrity (e.g., elimination of leaks) from well work has and is expected to continue to improve through advancements in practices/techniques for re-completing existing wells (e.g., squeeze cementing) and for wells to be plugged and abandoned. Howell anticipates that additional reliability also would be realized from deployment of improved well completion tools (e.g., packers). Packers are downhole tools used in well completions to isolate the annulus from the production casing, enabling controlled production, injection, or well treatment. A typical packer assembly incorporates a means of securing the packer against the casing or liner wall and a means of creating a reliable hydraulic seal to isolate the annulus, typically by means of an expandable elastomeric element. Through experience gained during development of Phase I and early Phase II, Howell has substantially improved well work practices resulting in improved reliability with respect to well integrity.

3.3 Water Resources

3.3.1 Surface Water

3.3.1.1 Flow

The project area is located within the Salt Creek drainage. Salt Creek flows in a northerly direction from headwaters in the Pine Ridge south of the project area. It flows approximately 50 miles to its confluence with the Powder River near Sussex, Wyoming. Total drainage area is 759 square miles. Among the principal tributaries to Salt Creek are Castle Creek, Meadow Creek, and Teapot Creek. All the tributaries to Salt Creek are ephemeral or intermittent except where produced water discharges from oil and gas extraction activities provide permanent flows (lower Teapot Creek, lower Castle Creek, and Meadow Creek). Salt Creek itself originally was an intermittent stream (WDEQ 2002). However, for over 80 years it has received produced

water discharges from Salt Creek Oil Field, Naval Petroleum Reserve No. 3 Field (Teapot Dome), and several smaller oil fields. Particularly since the introduction of extensive waterflooding in the early 1970s Salt Creek has been a perennial stream, seldom dropping below approximately 13 cubic feet per second (cfs).

Current stream flows in Salt Creek vary from 13 cfs to well over 2000 cfs during storm events. Annual average flow (including storm events) for the period of record (1976-1993) was 44 cfs, although minimum monthly means (i.e., not including unusual storm events) range from less than 10 cfs (January and September) to about 18 cfs (June). Seasonality is damped by the presence of approximately 13 cfs of year-round flow from the combined produced water discharges in the basin. The minimum flows in Salt Creek, therefore, consist almost entirely of produced water (RETEC 2004).

Salt Creek contributes significant water volumes to the Powder River, ranging from 10 to 30% of total flow during spring, when the Powder River carries large volumes of snowmelt from the Bighorn Mountains, to an average of 50% of the total flow from July through September. During low flow periods, Salt Creek may contribute up to 95% of the flow in the downstream reaches of the Powder River, providing critical minimum flow in the river (RETEC 2004).

On an annual basis, Salt Creek is estimated to contribute from 27,000 acre-feet (in dry years) to 45,000 acre-feet (in wet years) to the Powder River (RETEC 2004). Of this contribution, an estimated 45% is produced water in dry years and 20% in wet years. Salt Creek produced water discharges from all sources, therefore, provide a significant contribution to Salt Creek water resources.

3.3.1.2 Water Quality

Salt Creek is classified as a Class 2C stream by the WDEQ. Class 2C waters maintain beneficial uses for propagation of non-game fish, agriculture, wildlife, industrial, and recreation. It does not support game fish or human consumption use.

The Phase I EA (BLM 2003a) presented a detailed overview of water quality issues associated with produced water discharges to Salt Creek. Since that time, additional studies have occurred in Salt Creek that provide further detailed information and are summarized below.

A review of water quality issues in Salt Creek (RETEC 2004) for a Use Attainability Analysis (UAA) in support of a petition for a site-specific Water Quality Criterion (WQC) for chlorides concluded that all beneficial uses are being met under current conditions. Salt Creek is on the State 303(d) list for impaired waters because chloride levels exceed the chronic WQC of 230 mg/L. The UAA cited above concluded that the ambient chloride concentrations resulting from produced water discharges, which typically result in chloride concentrations around 1000 mg/L and occasionally reach 1,500 mg/L, did not cause impairment or loss of beneficial uses. The UAA, therefore, has recommended a site-specific WQC for chlorides of 1,600 mg/L for Salt Creek, and 984 mg/L for the reach of Powder River below the confluence. The WDEQ is proposing to establish this site-specific water quality criteria for chlorides in Salt Creek.

The UAA also evaluated other potential water quality concerns and noted no significant concerns related to other pollutants resulting from produced water discharges. However, the UAA noted

that the "natural" water quality of Salt Creek is frequently elevated in sulfates and other dissolved solids, as well as elevated suspended sediment loads due to the erodible soils in the area.

Produced water discharges to Salt Creek occur from 21 Wyoming Pollution Discharge Elimination System (WYPDES) permits issued to seven producers: APC/Howell (Salt Creek Field, Meadow Creek Field, and Sussex Field), U.S. Department of Energy (Teapot Dome Field), Manx Petroleum, Chapman Oil, Sage Petroleum, Natural Gas Processing, and WyOil and Mining. Over 75% of the total produced water in Salt Creek results from Howell's Salt Creek Oil Field, with another 20% from the Department of Energy's Teapot Dome Field. The remaining producers collectively account for a few percent of the total volume (RETEC 2004).

Eight active WYPDES permits are held by Howell in Salt Creek Oil Field. Two of these permits (LACT 4 and LACT 5) are currently influenced by CO_2 EOR for Phases I and II. Table 38 of the Phase I EA (BLM 2003a) shows the discharge volumes for each of the LACTs. The interim numeric discharge limitations outlined by the WYPDES permits are to be applied as final limits by 2006 and are listed in Table 3-2. Note, however, that the chloride limitation is subject to revision following the establishment of the site-specific WQC for chloride. Selenium also has been monitored in the discharges and reported in the Discharge Monitoring Reports (DMR), although no effluent limit has been set.

Table 3-2 Interim and Final Effluent Limits for Howell LACT Discharges[1]

Parameter	Units	Discharge Limitation (Daily Maximum)
Oil and Grease	mg/L	10 (interim and final)
Specific Conductance	µS/cm	7,500 (interim and final)
Total Radium	pCi/L	60 (interim and final)
Chloride	mg/L	230 (Note: this limit is not in force at this time)
pH	Units	Within 6.5 – 8.5 (interim and final)

[1]Interim limits applicable at this time. Final limits applicable from 2006.

Review of historic discharge data, collected prior to the injection of any CO_2 at Salt Creek Oil Field, indicates that exceedances of the effluent limits have not occurred since 1998 for oil and grease (13.3 mg/L, LACT 11A, July 1998) and 2002 for specific conductivity (7,660 µS/cm and 7,683 µS/cm, LACT 11A, February and August 2002, respectively). As discussed in the UAA (RETEC 2004), the proposed chloride effluent limit is exceeded in most discharges, and has prompted the petition for a site-specific standard for chlorides in Salt Creek based on the observation that aquatic life uses are not impaired at ambient levels and the contribution of the produced water provides beneficial effects on water quality, quantity, and aquatic habitat.

A recent inspection of Howell discharges by WDEQ discovered exceedances of the effluent limit for TDS (5,000 mg/L) in the discharges from LACTs 4, 5, and 10. LACTs 4 and 5 are associated with ongoing Phases I and II EOR. LACT 10 is not currently associated with the CO_2 EOR project. While the WYPDES permits contain an effluent limit for TDS, Howell is not required to routinely analyze its discharges for this parameter. A review of data from other sources indicates that the TDS concentration may have exceeded the effluent limit prior to the start of CO_2 injection. Howell/Anadarko recently met with WDEQ to discuss the TDS issue, and

Howell has several options for addressing this compliance issue, including: (1) request that WDEQ establish a higher, site-specific TDS effluent limit; (2) inject or treat the higher TDS discharges; (3) consolidate separate discharges to lower the mixed TDS concentration to below the effluent limit. Ultimately WDEQ will require Howell to take appropriate measures to protect Salt Creek water quality.

3.3.2 Groundwater

The Phases III/IV Project area is located within the Non-Glaciated Central region that occupies a large area in the eastern and northeastern parts of the state. Hydraulic interconnection and flow paths between hydrogeologic units are not well understood. Generally, the groundwater system can be divided into an upper topographically controlled system from the ground surface down to 200 feet, and a lower system between 200 and 1,200 feet that has a general northward flow. Water-bearing characteristics of the aquifer system in Natrona County are discussed in more detail in Section 3.1.4.2 of the Phase I EA (BLM 2003a).

The majority of groundwater development in the project area is from deep Tertiary and Paleozoic aquifers because of the better quality and higher yield than the shallow alluvial aquifers. Since 1995, there has been a decline in the fresh groundwater withdrawal due to declining regional population and less use by industry, mining, and irrigation. Populated areas within the study area, including Midwest, Edgerton, and Gas Plant Camp, receive their water from the Casper Regional Water System, which is located in the Platte River Basin outside of the Phases III/IV study area. The Casper Regional Water System derives its water primarily from groundwater wells located along the Platte River basin in the winter and supplements that supply with treated water from the Platte River in the summer. Water from this system is delivered to the project area via pipeline.

In general, the quality of water in the alluvial aquifers within the project area is not potable, but may be suitable for livestock and marginally suitable for irrigation and/or industrial use. The quality of water in Tertiary units in the project area is variable and has different uses. The concentration of manganese in the Wasatch-Fort Union aquifer system is relatively high and the level of sulfates can exceed the Environmental Protection Agency's (EPA's) standard for drinking water. The Lance-Fox Hills aquifer system has total dissolved solids at less than 3,000 mg/L in some areas but has elevated sodium and bicarbonate levels that make this water generally unsuitable for irrigation. The Lower Hydrologic Unit composed of the Madison Limestone and Tensleep Sandstone often are used for public water supplies in the region, although in some areas the water quality from these aquifers may not be suitable for drinking and domestic use. Data available for the Madison Limestone and Tensleep Sandstone in the project area indicate that waters from these aquifers are not suitable for drinking in the areas where these wells were sampled.

3.4 Human Health & Safety and Ecological Risks

3.4.1 Human Health and Safety Risk

The Salt Creek Phases III/IV Project is located within an active oil field. The risks associated with surface and injection/production facilities are well understood and manageable (Damen et al. 2003). The area is open to the public, and public roadways are present throughout the area.

Visitors and the residents of the towns of Midwest and Edgerton, therefore, have access to public lands within Salt Creek Oil Field, with some restrictions for specific areas, such as drilling sites, treatment facilities, and other extraction-related activities. Potential risks to human health and safety associated with these normal activities, including the possible releases of CO_2 or H_2S or occurrences of industrial accidents, are potentially present under current conditions. Area residents and visitors are typically aware of and accustomed to these industrial risks, and the level of health and safety risk is generally accepted. Industrial management of CO_2 is a well-established process in many industries, and specific risks associated with CO_2 are well understood. Such risks are managed by consistent application of standard safety systems and procedures (Benson 2002).

The town of Midwest is located within the Phase IV Project Area. Although in the past there have been oil extraction activities within the town, and active pumps are presently located close to the residential and commercial areas, there is currently no oil or gas extraction occurring inside the town boundary.

The town of Edgerton is located to the east of the Phase IV project area. In addition, two facilities occur outside of these towns, including the Edgerton Rodeo Grounds located northeast of Edgerton and the Midwest Golf Club located within the Phase IV Project area between Midwest and Edgerton.

3.4.2 Ecological Risk

The Phases III/IV Project area forms part of an operating oil field, which has been active for 116 years. The historic and ongoing oil extraction activities have resulted in changes to the natural communities occurring within the Salt Creek Basin and the plant and animal species associated with these communities. The incremental habitat modifications have resulted in a lower habitat value for area wildlife and native plant communities, although some species have habituated to the increased habitat fragmentation, surface disturbance, and human-related activities in Salt Creek Oil Field and more specifically near the Phases III/IV Project area. Natural resources are discussed further in Sections 3.7, 3.8, 3.9, and 3.10.

3.5 Soils and Reclamation

Comprehensive county-wide information was available from the Natural Resources Conservation Service (NRCS) soil survey for Natrona County (NRCS 1997). In addition, the Phase I EA (BLM 2003a) provides detailed site-specific information for the overall project area.

Soils in the project region are distributed according to primary differences in parent material (both residual and depositional), elevation, effective moisture, and topographic slope and position. Soils in the project region have developed from residual material and alluvium in a climatic regime characterized by cold winters, warm summers, and low to moderate precipitation. Precipitation is generally derived from spring snowmelt and summer thunderstorms, which are often high intensity, short duration events.

Upland soils are derived from residual interbedded shales and sandstones, as well as stream alluvium or colluvial material. Valley or bottomland soils have developed in unconsolidated stream sediments. The soils are generally low in organic matter and are alkaline and saline-

sodic. The saline-sodic nature of the existing soil resource is discussed, in part, in Section 3.2.2 of the Phase I EA (BLM 2003a). General taxonomic classes of soils present in the project area include: Usteric and Ustic Natrargids, Typic and Ustic Torriorthents, Ustic Haplargids, and Ustic Torrifluvents. Overall textural families primarily are fine or clayey but also include fine-loamy, loamy, and coarse loamy. Textures within a given soil profile may vary, as well. Slopes range from nearly level to moderately steep with the deeper soil profiles found in less sloping to flat terrain. Rangeland livestock grazing, wildlife habitat, and oil drilling activities are the dominant historical land uses on these soils.

The Salt Creek drainage historically has been designated an Area of Critical Environmental Concern (ACEC), based in part on the erosion severity in portions of the watershed (Section 3.1.3.5, Phase I EA). No soil map unit within the Phases III/IV project area is listed as sensitive for wind or water erosion by the BLM.

Eight map units are found within the Phases III/IV area, as summarized in Table 3-3 by the NRCS soil complexes, including one for open water. Approximately 63% of the area consists of series that belong to fine or clayey textural families. Slightly over 42% of the map units contain potential issues with saline and/or sodic soils.

Refer to Section 3.1.3.2, Major Soil Types, in the Phase I EA (BLM 2003a) for a complete and detailed description of the soil map units listed above.

Table 3-3 Phases III/IV Soil Units and Complexes

Map Unit No.	Description	Acreage	Percent
112	Arvada-Absted-Slickspots complex, 0 to 6% slopes	901.43	41.6
125	Blackdraw-Lolite-Gullied Land complex, 3 to 20% slopes	228.9	10.6
134	Bowbac-Taluce-Terro complex, 6 to 20% slopes	443.5	20.5
140	Cadoma-Renohill-Samday clay loams, 3 to 12% slopes	201.1	9.3
195	Haverdad-Clarkelen complex, saline, 0 to 3% slopes	238.9	11.0
214	Lolite-Rock outcrop complex, 10 to 40% slopes	34.2	1.6
275	Shingle-Taluce-Rock Outcrop complex, 10 to 40% slopes	115.0	5.3
313	Water	3.0	0.1
	Totals	**2166**	**100.00**

Source: NRCS 1997

3.6 Wetlands

Jurisdictional wetlands and other waters of the U.S. are limited in extent in the Phases III/IV development areas and are restricted to the Salt Creek drainage and Howell's WYPDES discharge channel that empties into Salt Creek. There also is a small wetland area created by Amoco (former operator), which is located adjacent to the discharge channel near its confluence with Salt Creek. Wetlands along the discharge channel and in the created wetland area are

dominated by stands of saltmarsh bulrush (*Bolboschoenus maritimus*). Along the discharge channel, saltmarsh bulrush is restricted to narrow stands immediately adjacent to perennial flow in the drainage. The created wetland area is a small, dry pond that was formerly fed water by the discharge channel. At the time of the July 2005 field survey, it was a dry mudflat dominated by saltmarsh bulrush in the central portions and by inland saltgrass (*Distichlis stricta*) around the periphery. There are no wetlands at the proposed substation and compressor station sites or along the power line corridors. The only wetlands crossed by the compressor station CO_2 trunk line occur along Salt Creek.

Streamside wetlands along Salt Creek are represented by two distinct communities. The lowest streamside terraces, immediately adjacent to surface water in the creek, are dominated by a mix of chairmaker's rush (*Schoenoplectus pungens*) and foxtail barley (*Critesion jubatum*) with occasional stands of sedge (*Carex* sp.) and alkali cordgrass (*Spartina gracilis*). These wetlands correspond to the streamside marsh and riparian grassland types discussed under Riparian Communities in Section 3.7.2.

A transitional wetland community, dominated by salt cedar (*Tamarix chinensis*), inland saltgrass, and poverty sumpweed (*Iva axillaris*) is supported on the next level terrace above the active stream channel, with salt cedar forming relative dense stands in some areas. The uppermost terrace along the stream channel does not support wetlands. The dominant species on this terrace are black greasewood (*Sarcobatus vermiculatus*), silver sagebrush (*Seriphidium canum*), and upland grass and weedy species such as cheatgrass (*Anisantha tectorum*), smooth brome (*Bromopsis inermis*), and clasping peppergrass (*Lepidium perfoliatum*), none of which is classified as a hydrophytic species.

Other drainages within the Phases III/IV Project area and within the power line/CO_2 trunk line corridors are ephemeral, and vegetation species supported within them are dominated almost entirely by upland (non-hydrophytic) species such as big sagebrush (*Seriphidium tridentatum*), silver sagebrush, rubber rabbitbrush (*Chrysothamnus nauseosus*), black greasewood, western wheatgrass (*Pascopyrum smithii*), summer cypress or kochia (*Bassia sieversiana*), yellow sweetclover (*Melilotus officinalis*), Russian knapweed (*Acroptilon repens*), and clasping peppergrass. Further, none of these ephemeral drainages exhibit a defined bed or bank or other distinguishing characteristics that would require their classification as other waters of the U.S.

3.7 Vegetation and Weeds

3.7.1 Vegetation

This section provides a summary of the vegetation resources applicable to the Phases III/IV Project area, as well as the proposed substation and compressor station sites and related power line and CO_2 trunk line corridors. More detailed descriptions of vegetation communities are provided in the Phase I EA (BLM 2003a). Over the past 116 years, much of the project area has been disturbed by oil and gas exploration and development. Many roads cross the project area, and numerous wells (both active and abandoned) have been established in grid patterns throughout the upland areas. Some shoreline degradation occurs along streamside habitats of Salt Creek. The vegetation within the project area consists of a variety of grassland and shrubland types that have developed in response to amounts of available moisture, soil salt

concentrations, and past disturbances. Available moisture ranges from sub-irrigated conditions along the Salt Creek drainage to dry upland shale badlands and grasslands that have developed on shallow sandy soils. Shale and mudstone bedrock outcrops tend to be very saline, and as these upland areas weather, they produce fine-textured sediments that tend to be somewhat less saline. These deposits collect as alluvial fans on upland depositional areas and as fine-grained clayey deposits on stream terraces and in stream channels.

Landscape units within the project area and the surrounding region were mapped in the Phase I EA (BLM 2003a) using a supervised vegetation classification system applied to Landsat 7 imagery (Phase I EA, Appendix 8). The regional map (see Figure 34, Phase I EA) portrays eight vegetation types as well as other landscape units including rivers and streams, commercial/industrial sites, residential areas, major roads, and agricultural areas. In general, the vegetation within the Phases III/IV Project area and adjacent sites can be classified into three general types: riparian communities, lowland communities, and upland communities. The areal extent of all mapped units is provided in Table 3-4.

3.7.2 Riparian Communities

As discussed in Section 3.6, riparian plant communities are supported only along the channel and low floodplain terraces of Salt Creek. The riparian communities consist of the following.

- Open water areas
- Streamside marshes
- Riparian grasslands
- Riparian tall shrublands.

Open water areas consist of the shallow, flowing water of Salt Creek. There are a few emergent wetland plants including bulrushes *(Schoenoplectus sp.)* and a species of naiad *(Najas quadalupensis)*. Stonewort *(Chara sp.)*, a submerged macrophytic algal species, commonly grows in the stream channel. The streamside marsh community corresponds to the lowest streamside terrace wetlands described in Section 3.6. The streamside marsh type typically occurs as a narrow band of wetland vegetation immediately adjacent to the stream channel. In most situations, this zone is less than 10 feet wide. Soil conditions are completely saturated, and

Table 3-4 Areal Extent of Vegetation Communities and Landscape Units Within the Region and Phases III/IV Project Area

	Areal Extent within the Region (Regional Map)		Areal Extent for the Phases III/IV Project	
	Hectares	Acres	Hectares	Acres
Rivers/Steams	632	1561	26	63
Ponds	40	100	0	0
Riparian Forest	1031	2547	0	0
Lowland Shrubland	2635	6509	85	210
Riparian Communities	920	2272	0	0
Upland Forest	303	748	0	0
Upland Shrubland	22975	56748	150	370

Table 3-4 Areal Extent of Vegetation Communities and Landscape Units Within the Region and Phases III/IV Project Area

Upland Grassland	50971	125897	476	1176
Saltbush Badlands	15501	38289	39	96
Barren/Sparsely Vegetated Areas	110	272	11	28
Commercial/Industrial	28	70	9	23
Residential	75	186	42	104
Major Roads	882	2177	45	111
Agriculture	1773	4379	0	0
Total	**97877**	**241755**	**883**	**2182**

Source: Phase I EA (BLM 2003a)

under flood stages, this vegetation type is underwater. The major species in this type is chairmaker's rush. Total vegetation cover is variable depending primarily on the erosive effects of floodwaters. Riparian grasslands are supported as narrow bands of vegetation in sub-irrigated zones located above and parallel to the Salt Creek stream channel. These grasslands grow on terraces above the streamside marsh community but below the drier transitional salt cedar and inland saltgrass wetland areas higher on the floodplain. The major species in riparian grasslands include slender wheatgrass *(Elymus trachycaulus)*, alkali cordgrass, western wheatgrass, and inland saltgrass. Other common, but less dominant species include chairmaker's rush, poverty sumpweed, Russian knapweed, meadow barley *(Critesion brachyantherum)*, and foxtail barley. The riparian tall shrubland type is supported on topographically similar sites that support riparian grassland as well as on somewhat more elevated sites. The understory is similar to riparian grassland, but riparian tall shrubland differs and is characterized by a dominance of salt cedar in the shrub overstory. Along the upper portions of the Salt Creek floodplain, salt cedar grows in linear stands parallel the stream course probably reflecting high water levels of past flood events. Section 3.3.1.1.1 in the Phase I EA (BLM 2003a) provides more detailed riparian community descriptions.

3.7.2.1 Lowland Communities

As the distance from stream channels increases, the land surface rises gently to higher stream terraces and quickly dries out at the surface. Water is still available at depth, but these higher terraces are not sub-irrigated. These upper terraces are characterized by shrublands dominated by black greasewood and silver sagebrush. In many places along Salt Creek, these two shrub types are relatively separate and distinct, but in some places the two dominant species form mixed stands. Black greasewood is commonly found as the dominant on saline soils, especially on floodplain sites where the water table is within the range of the rooting depth for this species. Silver sagebrush shrublands occur on floodplain terraces that are somewhat less saline than the sites dominated by black greasewood.

Some of the upper terraces have low shrub densities, probably the result of past industrial disturbances. Depending on the degree of past disturbance, sites may be dominated by perennial grasses like western wheatgrass or needle-and-thread grass (*Hesperostipa comata*) under conditions of limited disturbance, or by cheatgrass and other annual weeds such as kochia and

clasping peppergrass on sites with greater amounts of disturbance. More detailed descriptions of lowland plant communities are provided in Section 3.3.1.1.2 of the Phase I EA (BLM 2003a).

3.7.2.2 Upland Communities

The vegetation in upland areas throughout the project area is somewhat variable depending on the character of the underlying bedrock formations. Within the project area, much of the upland vegetation has developed on bedrock marine shale, or on alluvial and colluvial materials developed from shale deposits. The bedrock formations tend to support plant communities dominated by Gardner's saltbush (*Atriplex gardneri*), while the alluvial and colluvial materials tend to support mixed shrublands dominated by black greasewood, silver sagebrush, western wheatgrass, and variety of other species.

The saltbush badlands are characterized by sparse vegetation cover with most of the cover attributed to Gardner's saltbush. Relatively few other species can tolerate the high clay content and saline conditions of the saltbush badlands areas. The upland shrubland type occurs in areas that tend to be covered by alluvial or colluvial sediments derived from the shale outcrops in the project area. These substrates appear to be less saline than the bedrock outcrops themselves. Species composition and cover values in the mixed shrubland type are similar to that observed in the greasewood shrubland and silver sagebrush shrubland vegetation types (see Section 3.7.2.1). Upland grasslands in the project area tend to be dominated by western wheatgrass and a variety of annual grasses and forbs including cheatgrass, soft brome (*Bromus mollis*), flixweed (*Descurainia sophia*), tumble mustard (*Sysymbrium altissimum*), yellow sweetclover (*Melilotus officinalis*), and clasping peppergrass. Section 3.3.1.1.3 in the Phase I EA (BLM 2003a) provides more detailed descriptions of the upland communities.

3.7.3 Weeds

In Section 3.3.1.1.4 of the Phase I EA, five species of noxious weeds were identified for the overall project area. These species include the following, as described.

1. Russian knapweed (*Acroptilon repens)*commonly occurs in the riparian grassland type and also in the upper stream terrace communities. This introduced, perennial species readily becomes established on disturbed areas and spreads both by seed and by adventitious shoots from roots growing to a depth of up to 8 feet.

2. Canada thistle (*Breea arvense*) tends to occur in bottomland communities where moisture is more abundant as compared to upland areas. It also was observed along Salt Creek in limited areas. This species spreads by seed and vegetatively.

3. Bull thistle (*Cirsium vulgare*), an introduced biennial reproduces by seed, and is highly competitive. It typically occurs along roadsides and in similar disturbed areas.

4. Halogeton (*Halogeton glomeratus*) is an annual weed from Eurasia that is well adapted to alkaline soils and a semi-arid climate. This species readily invades disturbed or over-grazed areas. It occurs in riparian grasslands, saltbush badlands and disturbed areas. This species is a problem because of its toxicity to livestock, especially sheep. It was observed to a limited extent during the July 2005 surveys.

5. Scotch thistle (*Onopardum acanthium*) occurs in the greasewood shrubland type and in other disturbed areas. This large, introduced biennial thistle is an aggressive species that has become more widespread throughout the Rocky Mountain region over the past 10 years.

Other problem weed species noted in the Phases III/IV Project area during the July 2005 field survey were summer cypress (*Bassia sieversiana)* and Russian thistle (*Salsola australis*), which were observed along roadsides and in disturbed areas.

While none of the above listed species occurs as overall dominants within the project area, they all pose potential management problems for reclaimed areas. Annual weed species, such as summer cypress and Russian thistle, commonly occur as dominant species in localized areas during the first growing season following seeding. Mowing can be used to control these species. Once perennial grasses become established as a result of revegetation efforts, annual weed species usually begin to decline in numbers as a part of the overall revegetation plant community. Perennial weed species that occur on reclaimed areas are typically more persistent following revegetation and usually need to be controlled through the use of herbicides.

As part of a cooperative and integrated effort among Howell, the BLM, the local lessee, and Natrona County Weed and Pest (NCW&P), the NCW&P prepared a Noxious Weed Management Plan (NWMP) (Appendix B) to provide a comprehensive approach to control the spread of noxious weeds and other invasive species in Salt Creek Oil Field. The NWMP (BLM 2004) identified eight known plant species of Wyoming that are designated as noxious weeds and occurring within the Salt Creek project area boundaries. These species are listed and discussed below.

1. Russian knapweed is a perennial forb with a deep and spreading, black-sheathed root system. It occupies more acreage in the overall project than any other species, and should receive top priority due to its ubiquitous distribution in Salt Creek Oil Field and its ability to reproduce from the small root fragments resulting from cultivation and/or excavation. This species was the most common weed observed in the proposed Phases III/IV Project area in July 2005. It occurred most often in drainage bottoms and on stream terrace positions but could also be found in disturbed uplands typically exhibiting enhanced soil moisture regimes.

2. Salt cedar (*Tamarisk chirensis)* grows as a perennial, deciduous, large woody shrub or small tree. The main problem associated with this species is that each mature tree can draw from the water table, and transpire to the atmosphere, up to 200 gallons of water per day. It is ubiquitous along the Salt Creek channel in the project area.

3. Diffuse knapweed *(Acosta diffusa)* is a highly competitive, introduced, biennial plant that reproduces from seed. It can rapidly spread to form a dense monoculture enabling it to out-compete surrounding vegetation. This species was found along disturbed roadsides in limited portions of the project area. It was notably less common than Russian knapweed.

4. Spotted knapweed (*Acosta maculosa*) is similar to diffuse knapweed. Both plants are biennials, reproduce from prolific seed production, and are similar in appearance.

5. Scotch thistle is a biennial plant reproducing from seed. The plant can grow up to 8 feet tall in a large, multi stemmed stands. Each plant can produce up to 40,000 seeds that can remain viable for over 20 years in the soil. Large stands of scotch thistle are virtually impenetrable and these stands can exclude any wildlife or livestock from foraging in the area. Control is typically most successful when applied in the rosette stage. In July 2005, Scotch thistle was observed to be somewhat common within the Phases III/IV Project area boundaries in both multi-plant stands and as individual plants in widely spaced groupings over dispersed sites.

6. Leafy spurge (*Tithymalus esula*) is an extremely aggressive perennial from Asia with a deep root system, sometimes extending 17 feet into the soil. It reproduces from seed and by vegetative growth. Plants can spread by their roots at the rate of several feet per year. Leafy spurge not only out-competes surrounding vegetation for water and nutrients, but is allellopathic, capable of excluding the establishment of other plant species from the area surrounding it.

7. Field bindweed (*Convolvulus arvensis*) is a vine-like perennial from Europe that infests thousands of acres of land in North America. This plant reproduces from seed and spreading rootstock that can grow to a depth of 10 feet. It is a problem in croplands, borrow ditches, and waste areas. Mechanical control is ineffective as cultivation spreads the plant and mowing encourages growth. Chemical control can be effective if applied at the right time and is a persistent annual treatment until the infestation is controlled.

8. Canada thistle is a native of southeastern Eurasia. It is a colony-forming species that spreads from seed or deep root stocks and is difficult to control due to its ability to reproduce vegetatively.

In addition, summer cypress was commonly observed July 2005 along disturbed roadsides and in facility sites where revegetation had not been completed. Halogeton and Canada thistle also were observed onsite but appeared to be limited in extent.

3.8 Terrestrial Wildlife

Terrestrial wildlife resources commonly associated with the Salt Creek Basin and, more specifically, the proposed Phases III/IV Project are commensurate with the type of native habitat availability, relative carrying capacities of these habitats, and the degree of existing disturbance and activities from past development of Salt Creek Oil Field. As discussed in Section 3.7.1, vegetation occurring within and adjacent to the Phases III/IV Project can be classified into three general types, including upland communities, lowland communities, and riparian communities. The specific vegetation types and landscape units associated with these three communities comprise the primary habitats for terrestrial wildlife species in Salt Creek Oil Field; these types are delineated for the overall project area in Table 3-4. Of these vegetation types and communities associated with Phases III/IV, the riparian shrublands and adjacent riparian

grasslands (i.e., mesic habitats) occurring along Salt Creek provide some of the more valuable habitats for area wildlife, followed by the upland shrublands, grasslands, and rocky substrates. The wildlife species' diversity and abundance correlate directly with these habitat values, with the greatest number of animals typically associated with the riparian habitats and adjacent mesic grasslands. Historic oil exploration and development within Salt Creek Oil Field over the last 116 years has substantially modified the upland habitats and wildlife use by both resident and migratory species.

The following information is a summary of terrestrial wildlife resources expected to occur in and near the proposed Phases III/IV area, proposed Claim Jumper Switchyard, and associated power line corridors. More detailed information regarding wildlife resources associated with the entire Salt Creek Oil Field and surrounding region is presented in the Phase I EA (BLM 2003a).

Big game species that occur in the Phases III/IV Project area are limited to mule deer and pronghorn. Both are relatively common. No designated big game seasonal ranges (e.g., crucial winter range, fawning grounds) or key movement corridors intersect with the Phases III/IV boundaries or ancillary facilities (i.e., substation and power line ROWs). Mule deer occupy much of the upland habitats and also utilize the riparian corridor along Salt Creek. Browse for foraging and thermal protection in the winter (e.g., canopy cover or shallow canyons) are key to mule deer use and survival. Pronghorn are more closely associated with the upland grasslands and open, sagebrush steppe. Pronghorn behavior in Salt Creek Oil Field infers that some of the animals have habituated to increased human presence, noise, and habitat fragmentation associated with the ongoing oil extraction activity.

Two Wyoming Game and Fish Department (WGFD) big game herd units occur within the proposed project area, the North Natrona Mule Deer Herd Unit (#759) and North Natrona Pronghorn Antelope Herd Unit (#746). In accordance to the WGFD 2002 Job Completion Reports, mule deer within this herd unit are approximately 50% below objective. Factors cited as contributing to this decline are deteriorating habitat conditions due to an extended drought. The WGFD is currently evaluating altering the herd unit objective, as this herd has only been at or near objectives twice in the past 12 years. The North Natrona Pronghorn Antelope herd, on the other hand is, estimated to be approximately 16% above objective, although population simulations have fluctuated greatly over the past 12 years. However the perception of field personnel, landowners, and hunters is that the population has declined over the past 4 to 6 years.

Other representative mammals that occur in the Phases III/IV Project area include predators such as the coyote, bobcat, and red fox. These predators typically rely on medium- to small sized prey species, which include two cottontail rabbit species, white-tailed jackrabbit, deer mouse, other rodent species, and the black tailed prairie dog. Other than the prairie dog, which is discussed further in Section 3.10.2, these predator and prey species generally occupy the range of habitat types associated with Phases III/IV, extending from the upland rocky outcrops, shrublands, and open grasslands into the mesic interface between these upland areas and the Salt Creek drainage and the riparian corridor itself. Two mammals predominantly associated with the open water and riparian habitats along Salt Creek in the Phases III/IV area include muskrat and common raccoon. Since larger diameter trees and canopy cover are limited along this area of Salt Creek, beaver are limited, although muskrat occur in Salt Creek, as discussed in Section 3.9.

Resident and migratory bird species that occur or move through the project area are diverse, ranging from raptors, upland game birds, and passerines to waterfowl and other water birds. Generally, bird use is opportunistic in Salt Creek Oil Field, with individuals occupying areas that provide sufficient breeding, foraging, and roosting habitats. The overall number of birds, however, is expected to be lower in the field than in surrounding, undisturbed areas.

Raptors or birds or prey reported for the overall Salt Creek Oil Field include golden eagle, red tailed hawk, prairie falcon, American kestrel, great horned owl, burrowing owl, and northern harrier (Wildlife Consulting Services 2005a, 2005b). Other raptors that may occur in the project area would include the ferruginous hawk, Swainson's hawk, short-eared owl, barn owl, and turkey vulture. Two raptor surveys were conducted for Phases III and IV on April 18-19 and June 20-21, 2005, respectively (ENSR 2005a, 2005b). A third raptor survey was completed for the Salt Creek 3D Geophysical Project (Wildlife Consulting Services 2005a, 2005b). Table 3-5 summarizes the survey results applicable to the Phases III/IV area, and Figure 3-1 provides a general overview of these nest sites. The specific nest site locations have not been provided to protect the nests and their occupants. BLM surveys in spring of 2005 also documented a golden eagle nest site and a nearby smaller (tended) nest less than 0.25 mile north of the proposed Claim Jumper Switchyard in February 2005. These nest sites coincide with Nests #13 and #14, respectively, shown on Figure 3-1 and in Table 3-5 (Wildlife Consulting Services 2005a, 2005b).

The Phase I and Phase II EAs (BLM 2003a, 2004a) contain detailed information on other representative bird species documented for the project area, encompassing a number of passerines or songbirds and both waterfowl and water bird species associated with the Salt Creek drainage and adjacent riparian habitats.

Area amphibian and reptile species are typically associated with the different habitat types. Amphibians are limited to aquatic habitats, primarily along Salt Creek and its tributaries. Documented species include the Woodhouse's toad and chorus frog. Reptiles recorded include three species of snakes, including the wandering garter snake, bull snake, and prairie rattlesnake (BLM 2003a). Rattlesnakes and bull snakes tend to be wide ranging and may be found throughout the upland and riparian habitats. Garter snakes tend to be more prevalent in the riparian areas.

3.9 Aquatic Biology

The aquatic biology of the Salt Creek system is fully described in Section 3.3.2 of the Phase I EA (BLM 2003a). Additional information based on detailed analysis of aquatic biota, aquatic communities, and current conditions of the Salt Creek system also can be found in the Salt Creek UAA (RETEC 2004), and is briefly summarized here. Salt Creek maintains a diverse non-game fish community of nine species of primarily Cyprinid minnows, which collectively are tolerant ofthe periodic low flow, turbid, saline, and alkaline conditions in natural streams of the northern plains. A dam at the location of the former power plant several miles north of the project area is an effective fish migration barrier resulting in lower diversity in the project area upstream of the dam.

Table 3-5 Raptor Nest Locations Documented In and Near Proposed Action

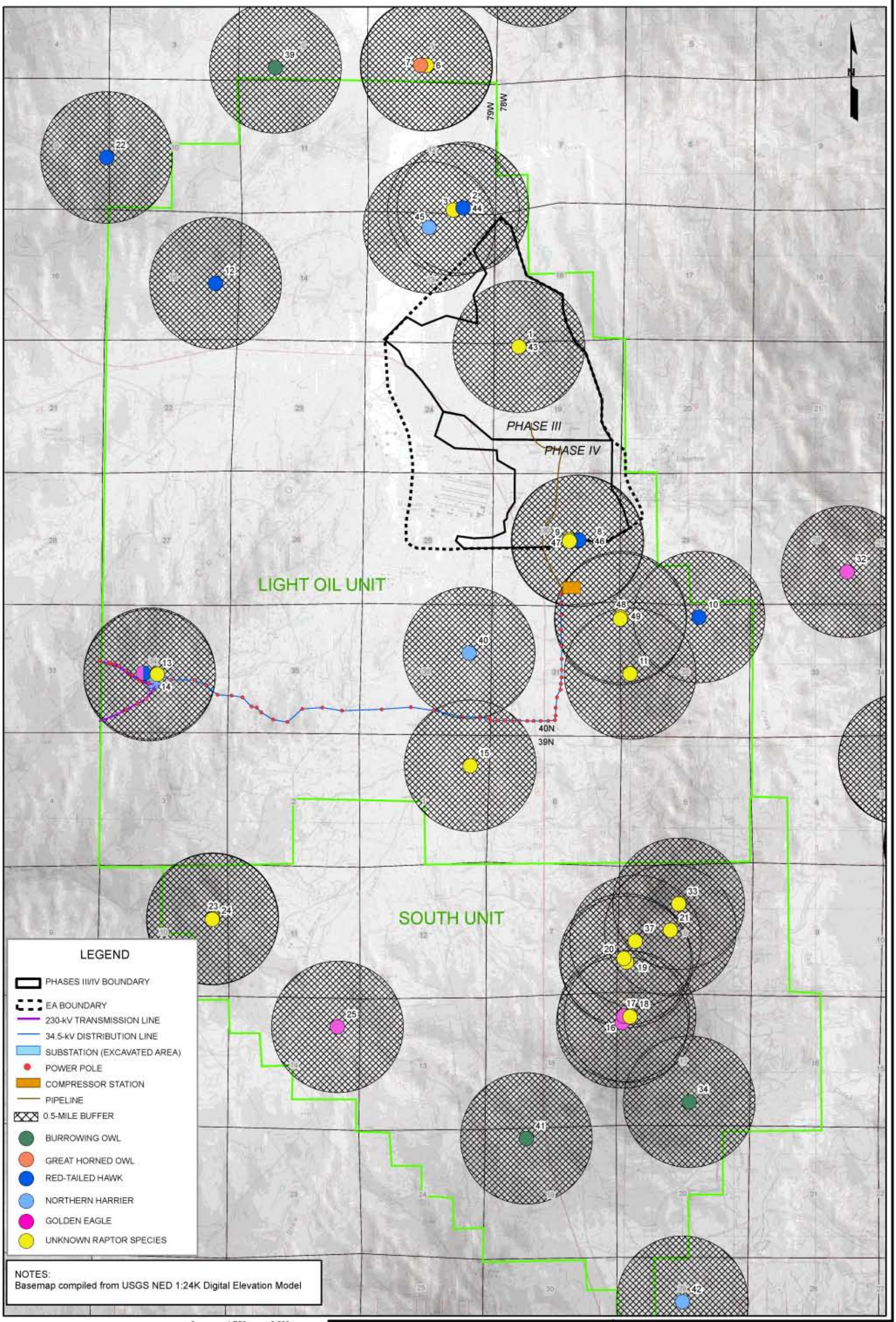
Assigned Nest ID#[1]	Species	Approximate Location[2]	Nest Type and Substrate	Activity Status	Height Above Ground (ft)	Habitat	Comments	Sources
1 43	Unknown	Phase III area	Stick nest on cliff wall	Inactive	50	Sagebrush / Shortgrass Prairie	Nest in fair-poor condition.	Wildlife Consulting Services 2005a; ENSR 2005a
2 44	Red-tailed Hawk	Within 0.5-mile buffer north of Phase III	Stick nest on cliff wall	Active	50	Sagebrush / Shortgrass Prairie	3 adults present; female incubating; artificial nest platform near active cliff nest.	Wildlife Consulting Services 2005a; ENSR 2005a
3	Unknown	Within 0.5-mile buffer north of Phase III	Artificial Nest Structure (ANS)	Inactive	?	Sagebrush / Shortgrass Prairie	Active red-tailed hawk nest on cliff above ANS.	Wildlife Consulting Services 2005a; ENSR 2005a
45	Northern Harrier	Within 0.5-mile buffer north of Phase III	Not identified	Active	--	Riparian / Willow	Nest was not identified, but adult male observed; possible breeding territory.	ENSR 2005a
8 46	Red-tailed Hawk	Phase IV area	Stick nest on cliff wall	Active	40	Sagebrush / Shortgrass Prairie	2 adults present; female incubating in April; 1 nestling observed in June.	Wildlife Consulting Services 2005a; ENSR 2005b
9 47	Unknown	Phase IV area	Stick nest on cliff wall	Inactive	40	Sagebrush / Shortgrass Prairie		Wildlife Consulting Services 2005a; ENSR 2005b
48	Unknown	Within 0.5-mile of compressor station	Stick nest on top of hill	Inactive	0	Sagebrush / Shortgrass Prairie	Remnant nest; likely ferruginous hawk.	ENSR 2005b
49	Unknown	Within 0.5-mile of compressor station	Stick nest on top of hill	Inactive	0	Sagebrush / Shortgrass Prairie	Remnant nest; likely ferruginous hawk.	ENSR 2005b
11	Unknown	Within 0.5-mile of 34.5-kV distribution line	Stick nest on cliff/ledge	Inactive	?	Unknown		Wildlife Consulting Services 2005a
40	Northern harrier	Within 0.5-mile of 34.5-kV distribution line	?	Active	?	Unknown	Assuming ground nest or breeding adults present in riparian or willow habitats.	Wildlife Consulting Services 2005b
15	Unknown	Within 0.5-mile of 34.5-kV distribution line	Stick nest	Inactive	?	Badlands / bank		Wildlife Consulting Services 2005a

Table 3-5 Raptor Nest Locations Documented In and Near Proposed Action

Assigned Nest ID#[1]	Species	Approximate Location[2]	Nest Type and Substrate	Activity Status	Height Above Ground (ft)	Habitat	Comments	Sources
13	Red-tailed hawk/golden eagle	Approximately 150 yards north of substation and power line ROWs	Stick nest on ledge	Active; failed	25	Grassland / sagebrush	Signs of nest tending in February 2005, inferring golden eagle. Occupied by red-tailed hawk May 27; 1 egg observed June 3; nest abandoned.	Wildlife Consulting Services 2005a; BLM observations
14	Unknown	Approximately 150 yards north of substation and power line ROWs	Stick nest on ledge	Tended	20	Grassland / sagebrush	New nesting material observed in May/June 2005; nest site located ~40 feet south of nest #13.	Wildlife Consulting Services 2005a; BLM observations

[1]Assigned identification numbers correlate with Figure 3-2.

[2] Exact nest locations are not provided to protect the nest and its occupants.



SALT CREEK PHASES III/IV EA

RAPTOR NESTS

FIGURE 3-1

SOURCES: ENSR 2005a, 2005b; WILDLIFE CONSULTING SERVICES 2005a, 2005b

Aquatic animals such as muskrat are present in Salt Creek. A diverse benthic community is present, although higher diversity and abundance is found in the lower reaches of the creek (which are shallow, swift, and rocky) than in the reaches in the immediate Phases III/IV Project area, which are slower and deeper, with silty substrate. In summer this upper reach has abundant submerged macrophyte growth. Elevated temperatures in the reach near the discharge points result in ice-free conditions for much of the year.

The Salt Creek tributaries are ephemeral or intermittent water bodies, and generally lack permanent aquatic life. During flow periods, opportunistic species may use these streams, including fish such as the flathead chub (*Platygobio gracilis*), which specializes in spawning in small, ephemeral headwaters. In streams and draws receiving produced water discharges (such as lower Castle Creek) permanent aquatic life may be present, including aquatic insects and some benthic invertebrates.

In summary, current aquatic life in Salt Creek appears to be unimpaired and fairly diverse as noted in the Phase I EA and in the UAA. Continued existence of most if not all of this aquatic community is generally dependent on the perennial water provided by the produced water discharges.

3.10 Special Status Species

3.10.1 Plants

A total of eight plant species are considered to be of special interest within the proposed Phases III/IV Project area. These species include one endangered, two threatened, and five BLM sensitive species. Table 3-6, presents selected habitat characteristics for each of these species.

Colorado butterfly plant and Ute ladies'-tresses orchid are federally listed as threatened. These species are known to occur in extreme southeastern Wyoming. Blowout penstemon, federally listed as endangered, has been found in south-central Wyoming. None of these species is known to occur within Salt Creek Oil Field or surrounding areas, nor are they known to occur in Natrona County. No habitat suitable for these plant species was observed onsite during a July 2005 field reconnaissance survey. Wetland and adjacent upland transitional areas within the project area did not exhibit the suitable soil moisture regimes and appeared too saline to support the Colorado butterfly plant or the Ute ladies'-tresses orchid. Similarly, no sand dunes or blowout depressions were observed in the project area that could support blowout penstemon.

In addition to these federally threatened and endangered species, the BLM also maintains lists of sensitive plant species that are of particular interest because of their rarity. Of these listed species, five are known to occur in the Casper and Buffalo Field Office districts. These species include: Porter's sagebrush, Nelson's milkvetch, many-stemmed spider-flower, William's waferparsnip, and Laramie false sagebrush.

Nelson's milkvetch is the only species that may occur within the Phases III/IV Project area given its habitat requirements. It is known from several populations in Natrona County both east and west of Casper. However, none of the known populations occurs in the northeastern part of the county in the vicinity of Midwest and Edgerton. Appropriate habitat for this species includes

Table 3-6 Special Status Plant Species Summary

Species Name	Agency Listing[1]	Status[2]	Elevation Range (feet)	Habitat Characteristics/Comments	Habitat Observed in Project Area
Colorado butterfly plant *Guara neomexicana* ssp. *coloradensis*	USFWS	T	5,700 - 6,400	Subirrigated alluvial soils of drainage bottoms surrounded by mixed prairie, not known to occur in Natrona County	No
Blowout penstemon *Penstemon haydenii*	USFWS	E	NI[3]	Actively shifting sand dunes, blowout depressions; known from Ferris/Seminoe Mountains region; not known to occur in Natrona County.	No
Ute ladies'-tresses orchid *Spiranthes diluvialis*	USFWS	T	5,100 - 5,200	Moist streambanks, wet meadows, and abandoned stream channels; not known to occur in Natrona County.	No
Porter's sagebrush *Artemisia porteri*	BLM	S	5,300 - 6,500	Sparsely vegetated badlands of ashy or tufaceous mudstones and clay slopes; endemic to Wind River Basin, Fremont County.	No
Nelson's milkvetch *Astragalus nelsonianus*	BLM	S	5,200 – 7,600	Alkaline clay flats, shale bluffs and gullies, pebbly slopes, volcanic cinders in sparse vegetation.	Possible
Many-stemmed spider-flower *Cleome multicaulis*	BLM	S	5,900	Semi-moist, open, saline banks of shallow ponds and lakes with Baltic rush and bulrush.	No
William's waferparsnip *Cymopteris williamsii*	BLM	S	6,000-8,300	Open ridgetops and upper slopes with exposed limestone outcrops or rockslides; endemic to Bighorn Mountains.	No
Laramie false sagebrush *Sphaeromeria simplex*	BLM	S	7,500 – 8,600	Cushion plant communities on rocky limestone ridges and gentle slopes.	No

[1] USFWS = federally listed; BLM = sensitive species
[2] T = Federally listed as Threatened; E = federally listed as Endangered; S = BLM Sensitive species
[3] NI – No Information

Adapted from: Fertig 1994

alkaline clay flats, shale bluffs and gullies, pebbly slopes, volcanic cinders in sparse vegetation, and shadscale communities developing on marine shales. Marginal habitat occurs to a very limited extent within the Phases III/IV project area proper, but this species was not observed during the field reconnaissance. Habitat also may exist for this species across the shale bluffs located within or adjacent to the proposed power line ROWs and CO_2 trunk line, occurring outside the Phases III/IV boundaries.

No shallow ponds or lakes that would support the many-stemmed spider-flower are located within the project area. Porter's sagebrush and William's waferparsnip are both endemic to other areas in Wyoming, and no suitable habitat for these species was observed on site during the field reconnaissance. Laramie false sagebrush occurs at elevations higher than those within the project area. Further, no rocky limestone ridges suitable for supporting this species were observed within the project area boundaries.

3.10.2 Terrestrial Animals

The Phase I EA (BLM 2003a) outlined a number of special status species for the overall Salt Creek Basin. Subsequent site-specific field surveys were conducted in 2005 for both the Phases III and IV areas (ENSR 2005a, 2005b) and throughout Salt Creek Oil Field (Wildlife Consulting Services 2005a, 2005b, 2005c). Based on these data, the BLM initially identified 18 special status animal species for the proposed Phases III/IV EOR expansion project, encompassing 2 federally listed, 1 federal candidate, and 15 BLM sensitive species. Table 3-7 summaries these species, their associated status, habitats, potential to occur in the project area, and which species are analyzed in greater detail.

Of the two federally listed animal species identified for the project area, the bald eagle and black-footed ferret neither would likely occur in the proposed Phases III/IV Project area. The closest documented bald eagle winter roost is located along Pine Ridge, approximately 6 miles to the east of the project area. No suitable nesting, communal roost, or winter foraging areas for bald eagles occur in or near Phases III/IV or its ancillary facilities. Incidental bald eagle use of the Salt Creek corridor or nearby prairie dog colonies for foraging by individual eagles would be

expected to be sporadic and rare. The black-footed ferret is closely associated with active prairiedog colonies, their primary prey species. Although black-tailed prairie dogs have been documented in the project area, as discussed below, this area of Wyoming falls under the USFWS' black-footed ferret block clearance where no documentation of ferret presence or absence is currently required. Therefore, the black-footed ferret is not expected to occur in or near the project area.

Of the remaining 16 federal candidate or BLM sensitive animal species initially identified for the project area, 11 BLM sensitive species are analyzed in detail as part of this EA. Five species (boreal toad, northern leopard frog, American peregrine falcon, greater sage-grouse, and swift fox) were eliminated from detailed analysis, based on the lack of suitable habitat in the Proposed Action area or associated distribution and range information (see Table 3-7).

The two sensitive raptor species assessed for the Phases III/IV Project include the ferruginous hawk and western burrowing owl. Both species likely occur in and near the project area.

Table 3-7 Special Status Animal Species Examined for the Salt Creek Phases III/IV Project

Common Name	Scientific Name	Status[1]	Habitat Association and Distribution	Addressed in Detail in the EA	Potential to Occur in Project Area
Federally Listed Species					
Bald eagle	*Haliaeetus leucocephalus*	FT[2]	Typically breeds along reservoirs, lakes, and rivers, often using upland habitats for foraging. Winters near open water and in semideserts and grasslands, often associated with prairie dog colonies.	No	Low. No documented nests, communal winter roosts, or foraging areas in or near project area. Occasional individuals may move through the project area along Salt Creek and near active prairie dog colonies, but occurrence would be rare and sporadic.
Black-footed ferret	*Mustela nigripes*	FE	A prairie dog obligate, tied directly to prairie dog colonies. For black-tailed prairie dog, minimum colony size of 80 acres to support ferrets.	No	Low. However, project area falls under USFWS black-footed ferret block clearance; therefore, no presence/absence surveys are required. Additionally, existing prairie dog colonies are of insufficient size to support ferrets. The black-footed ferret is not expected to occur in or near the project area.
Federal Candidate Species					
Boreal toad	*Bufo boreas boreas*	C	Habitats include low elevation beaver ponds, reservoirs, streams, marshes, lake shores, potholes, wet meadows, and marshes, to high elevation ponds, fens, and tarns at or near tree line.	No	Low. Suitable habitat is limited to the Salt Creek drainage and isolated ponds and other open water areas. No drilling activities are proposed in or adjacent to these aquatic habitats.

Table 3-7 Special Status Animal Species Examined for the Salt Creek Phases III/IV Project

Common Name	Scientific Name	Status[1]	Habitat Association and Distribution	Addressed in Detail in the EA	Potential to Occur in Project Area
BLM Sensitive Species					
American peregrine falcon	*Falco peregrinus*	BLM	Typically breeds along high ridges and cliffs in foothills and mountainous areas. Eyries often located 400 feet or greater on cliff faces, overlooking rivers, lakes, wetlands, and wet meadows.	No	Low. No peregrine falcon nest sites have been documented. Habitat in project area and along Salt Creek is marginal for this species' foraging. Cliffs and rock outcrops are of limited height and not suitable for peregrine falcon nesting.
Ferruginous hawk	*Buteo regalis*	BLM	Occurs in open, semi-arid basin-prairies, foothills, badlands, and grasslands. Nest sites include trees, ledges, rock outcrops, and the ground on knolls or hills. Tree nests often occur on the pinyon-juniper woodland interface with sagebrush basins.	Yes	Moderate. Habitat is suitable for this species. Although no active ferruginous hawk nest sites were documented, two inactive nests sites (UNK-06-N and UNK-07-N) appear to be constructed by this species. Potential presence would be rare, but feasible.
Western burrowing owl	*Athene cunicularia hypugea*	BLM	Typically nests in open, grasslands, shrublands, and some woodland communities. Often occupies burrows of prairie dogs, ground squirrels, foxes, and badgers.	Yes	Moderate. Two active nest sites documented approximately 4 miles south of Phase IV area; individuals may breed in portions of the project area.

Table 3-7 Special Status Animal Species Examined for the Salt Creek Phases III/IV Project

Common Name	Scientific Name	Status[1]	Habitat Association and Distribution	Addressed in Detail in the EA	Potential to Occur in Project Area
BLM Sensitive Species					
Greater sage-grouse	*Centrocercus urophasianus*	BLM	A sagebrush obligate with lek sites typically located along ridges, open areas, and plateaus. Nesting habitat includes sagebrush with adequate canopy cover and shrub density. Brooding habitat includes wet meadows and mesic areas adjacent to riparian streams. Winter range requires adequate sagebrush cover and linkage corridors.	No	Low. Although sage-grouse occur in the project region, the sagebrush habitat located in and adjacent to the Phases III/IV area is limited in extent, canopy cover, and density to support breeding adults. Existing habitat fragmentation in the area also restricts grouse use and movement, particularly for breeding and wintering. The greater sage-grouse is not expected to occur in the immediate project area.
Sage thrasher	*Oreoscoptes montanus*	BLM	Breeds in sagebrush shrublands and occasionally in other shrublands or cholla grasslands. During migration and winter, occupies open agricultural areas, pastures, grasslands, shrublands, open riparian areas, and pinyon-juniper woodlands.	Yes	Documented. Species' presence and possible breeding recorded in or near the project area.
Brewer's sparrow	*Spizella breweri*	BLM	Breeds and forages primarily in sagebrush communities, but occasionally in other shrubland types. During migration, occupies woody, brushy, and weedy riparian, agricultural, and urban areas.	Yes	Documented. Species' presence and possible breeding recorded in or near the project area, in conjunction with sage thrasher records.

Table 3-7 Special Status Animal Species Examined for the Salt Creek Phases III/IV Project

Common Name	Scientific Name	Status[1]	Habitat Association and Distribution	Addressed in Detail in the EA	Potential to Occur in Project Area
BLM Sensitive Species					
Sage sparrow	*Amphispiza belli*	BLM	Breeds in sagebrush shrublands; also occupies grasslands and other shrubland communities during migration.	Yes	Documented. Species' presence and possible breeding recorded in or near the project area; observations made in 1987 and 1989.
Loggerhead shrike	*Lanius ludovicianus*	BLM	Typically inhabits grasslands, semi-desert shrublands, agricultural areas, and riparian zones. Nests usually in isolated trees or large shrubs.	Yes	Moderate. This species could breed within suitable shrubland and riparian habitats in the project area.
Mountain plover	*Charadrius montanus*	BLM	Inhabits flat, shortgrass prairie often with surface disturbance, livestock grazing, and prairie dog colonies.	Yes	Moderate. Potentially suitable habitat has been delineated in and near the project area.
Black-tailed prairie dog	*Cynomys ludovicianus*	C	Forms colonies of varying size in shortgrass or mixed-grass prairie, digging complex burrow systems.	Yes	Documented. Colonies occur in and near the project area.
Swift fox	*Vulpes velox*	BLM	Typically occupies short-, mid-, and mixed-grass prairies with flat to gently rolling topography. Den sites provide good visual coverage of surrounding area and may coincide with prairie dog colonies.	No	Low. Project area occurs on the periphery of this species range and habitat is not optimal. Additionally, with the extent of historic activity in Salt Creek Oil Field, potential presence of breeding swift fox would be low.

Table 3-7 Special Status Animal Species Examined for the Salt Creek Phases III/IV Project					
Common Name	**Scientific Name**	**Status[1]**	**Habitat Association and Distribution**	**Addressed in Detail in the EA**	**Potential to Occur in Project Area**
BLM Sensitive Species					
Townsend's big-eared bat	*Corynorhinus townsendii*	BLM	Inhabits dry, coniferous forests, juniper woodlands, deciduous forests, basins, desert shrublands, and grasslands. Roosts are critical to this species, typically requiring underground caverns (e.g., caves and abandoned mines) with stable temperatures and air supply. Roosting in rock outcrops and buildings would be individually dispersed.	Yes	Low. Unlike the myotis, this bat species requires very specific underground features and temperature regimes, particularly for hibernacula and maternity colonies. No communal roosts have been documented in project area, and occurrence would be expected to be low or sporadic.
Fringed myotis	*Myotis thysanodes*	BLM	Primarily inhabits coniferous forests, woodland-chaparral, and basin-prairie shrublands. Roosts include caves, abandoned mines, rock crevices, and buildings.	Yes	Low. This species could potentially occur in the project area; however, no known hibernacula, maternity colonies, or bachelor roosts. Potentially roost sites in rocky outcrops or structures would likely be dispersed.
Long-eared myotis	*Myotis evotis*	BLM	Inhabits basin-prairie and riparian shrublands, grasslands, barren areas, cliffs, and rock outcrops. Roosts primarily include structures (buildings and bridges) and occasionally in mines and caves.	Yes	Low. This species could potentially occur in the project area; however, no known hibernacula, maternity colonies, or bachelor roosts. Potentially roost sites in structures would be dispersed or sporadic.

Table 3-7 Special Status Animal Species Examined for the Salt Creek Phases III/IV Project

Common Name	Scientific Name	Status[1]	Habitat Association and Distribution	Addressed in Detail in the EA	Potential to Occur in Project Area
BLM Sensitive Species					
Northern leopard frog	*Rana pipiens*	BLM	Inhabits ponds, lakes, reservoirs, streams, irrigation ditches, and marshes.	No	Low. Suitable habitat is limited to the Salt Creek drainage and isolated ponds and other open water areas. No drilling activities are proposed in or adjacent to these aquatic habitats.

Sources: Fitzgerald et al. 1994; WGFD 2004; WyGISC 2002; Terres 1991; Andrews and Righter 1992; ENSR 2005a, 2005b; Wildlife Consulting Services 2005a, 2005b, 2005c; BLM 2005.

[1]Status:

FE = Federally listed as endangered
FT = Federally listed as threatened
FC = Federal candidate species
BLM = BLM Sensitive Species

[2]The bald eagle is proposed for delisting; the final decision is pending.

Although no active ferruginous hawk nests were documented during the 2005 field surveys in Phases III/IV (ENSR 2005a, 2005b) and Salt Creek Oil Field (Wildlife Consulting Services 2005a, 2005b), habitat in the area is suitable to support breeding and foraging birds. The appearance of two inactive nests sites (#48 and #49) documented June 2005 (Figure 3-1, Table 3-5, and Table 3-7) infer they may have been previously constructed by ferruginous hawks. Both were composed of large diameter sticks placed on the ground on the edge of a rock outcrop or cliff edge overlooking the basin below, which is classic nest construction for ferruginous hawks. The similarity of appearance and the close proximity of these two nests to each other also infer they could have been constructed by the same breeding pair as alternate nest sites within the same territory. However, both nest sites were not intact and age of initial construction could not be determined.

The burrowing owl has been documented nesting in the project region (Wildlife Consulting Services 2005a, 2005b). Three active burrowing owl nests were documented during these two field survey periods. One occurs approximately 2 miles north of the Phase III area; the other two nest sites are located in the Southern Unit, approximately 4 miles south of Phase IV (see Figure 3-1). No breeding burrowing owls were documented in or adjacent to the proposed Phases III/IV area or near the proposed Claim Jumper Switchyard, 230-kV transmission line ROWs, or 34.5-kV distribution line alignment.

Four BLM sensitive passerines or songbirds were identified for the proposed project, including the sage thrasher, Brewer's sparrow, sage sparrow, and loggerhead shrike. The sage thrasher, Brewer's sparrow, and sage sparrow are closely associated with sagebrush communities, particularly during the breeding season. All three of these bird species have been documented in the project region (BLM 2005) and may occur within suitable habitats in and near the Phases III/IV area. The loggerhead shrike typically occurs in more open grasslands and sagebrush steppe with scattered shrubs and small trees. It has been documented in the project region, specifically in greasewood communities (BLM 2005).

The mountain plover is closely associated with shortgrass prairie, disturbed areas, and prairie dog colonies. This bird species returns to Wyoming to breed between March and August. Surveys for potentially suitable habitat were conducted in and adjacent to the Phases III/IV Project area in 2005 (ENSR 2005a, 2005b; Wildlife Consulting Services 2005c). Suitable plover habitat relative to the Proposed Action and recorded during these surveys is shown on Figure 3-2.

Active black-tailed prairie dog colonies also were delineated during the 2005 field surveys in Phases III/IV and the surrounding areas (ENSR 2005a, 2005b; Wildlife Consulting Services 2005c). Table 3-8 lists the colonies recorded within 0.5 mile of the Proposed Action project components, which also are shown on Figure 3-3. No white-tailed prairie dogs occur in the area. A range of estimated colony size is provided in Table 3-8, based on the results from the two separate field programs completed for the project area (ENSR 2005a, 2005b; Wildlife Consulting Services 2005c).

Three bat species were identified for the proposed project area, including the Townsend's big-eared bat, fringed myotis, and long eared myotis. As summarized in Table 3-7, these bats can

occupy a variety of habitat types. However, particularly for the Townsend's big eared bat, underground features (e.g., mines, caves) and stable temperature regimes are critical for this bat species. No known winter hibernacula, maternity colonies, or bachelor roosts for either of these three bat species have been documented in or near the project area, and the potential for a feature of this nature would be low. Individual bats may day-roost under appropriate vegetative cover, in rocky crevices, and in buildings, but roosting would be anticipated to be sporadic and dispersed through the area.

Table 3-8 Black-tailed Prairie Dog Colonies Located In and Near Phases III/IV Area

Acres (Ranges[1])	Location	Density
205.8	Within 0.5 mile southeast of Phase IV	Unknown
43-53	Intersects corners of Phase III and Phase IV	High
36-53	Phase IV area	Moderate
22-28	Phase IV area	Moderate
15.89	Within 0.5 mile south of Phase IV	Moderate to High
2-3	Within 0.5 mile south of Phase IV	Moderate
1.4	Within 0.5 mile south of Phase IV	Unknown
1.1	Within 0.5 mile south of Phase IV	Unknown
1.09	Within 0.5 mile south of Phase IV	Low

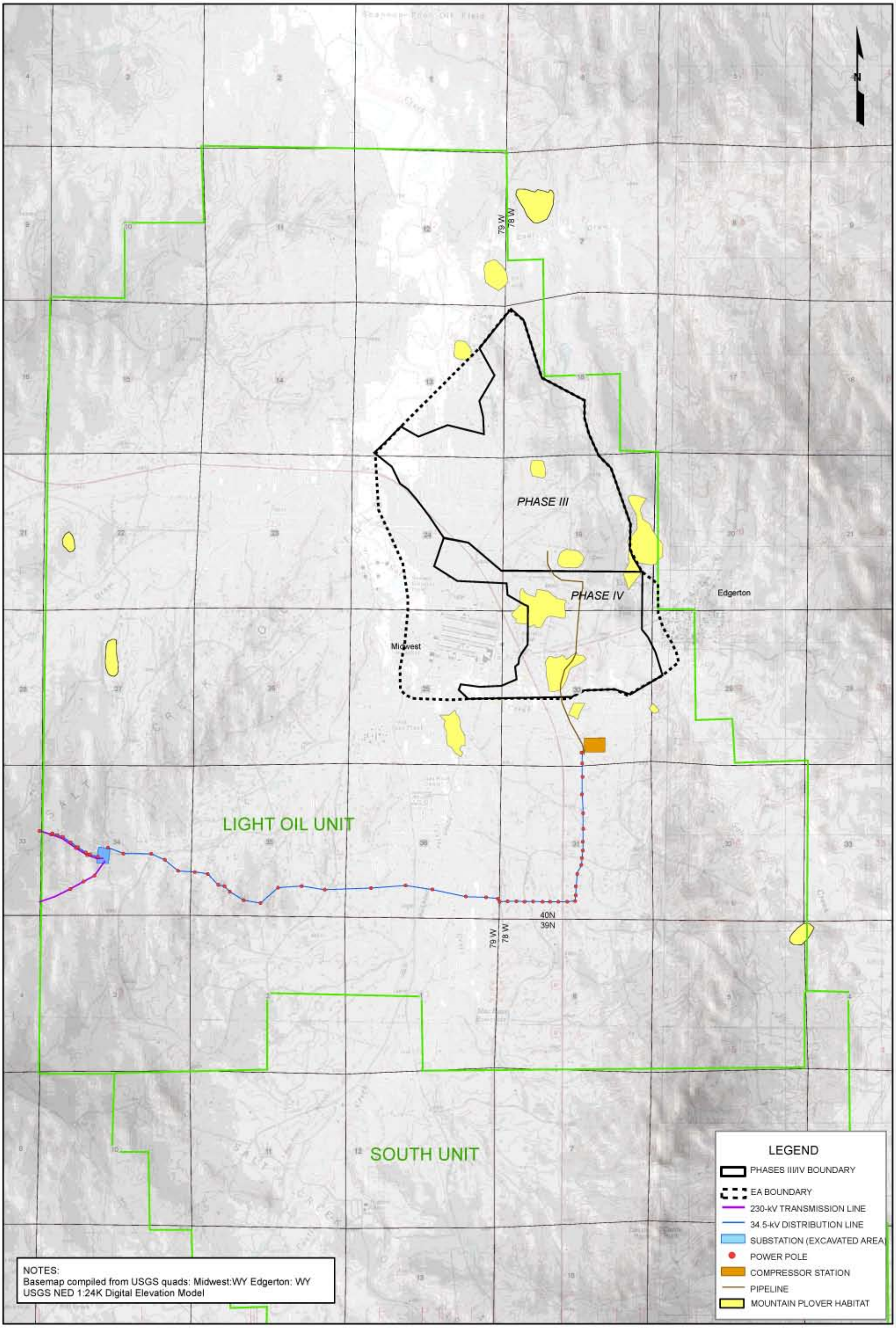
[1]Ranges provided from two study sources; exact acreage recording from one source.
Sources: ENSR 2005a, 2005b; Wildlife Consulting Services 2005c.

3.10.3 Aquatic Species

A review of federal and state documentation conducted for the Salt Creek UAA (RETEC 2004) did not identify any special status aquatic species likely to be specifically present in Salt Creek or its tributaries. However, two species of fish are listed for the Powder River downstream of the confluence with Salt Creek. These species include the sturgeon chub, (*Macrhybopsis gelida*) listed as Native Species Status (NSS) Class 1 by the WGFD, although USFWS has issued a Resolved Taxon decision on April 12, 2001 denying a petition for to federally list this species (USFWS 2004). Class 1 species are of the highest conservation priority on the state sensitive species list due to possibility of extirpation from habitat loss. The second species is the shovelnose sturgeon (*Scapirhynchus platorhynchus*), also NSS Class 1, a big-river fish present in the Mississippi-Missouri drainage, which may inhabit the northernmost portion of Powder River. Neither of these species is present or expected to occur in the project area.

3.11 Cultural Resources

The Salt Creek Phase I EA (BLM 2003a) outlined a number of cultural resource inventories conducted in Salt Creek Oil Field that also have been confirmed by a recent Class I file search of the databases of the Wyoming Cultural Records Office and BLM Casper Field Office. In the project area, the earliest of these occurred in 1978 and included Class I, II, and III studies that do not meet current state and federal standards. Other studies conducted more recently were primarily related to oil field development and are mostly Class III (100% ground

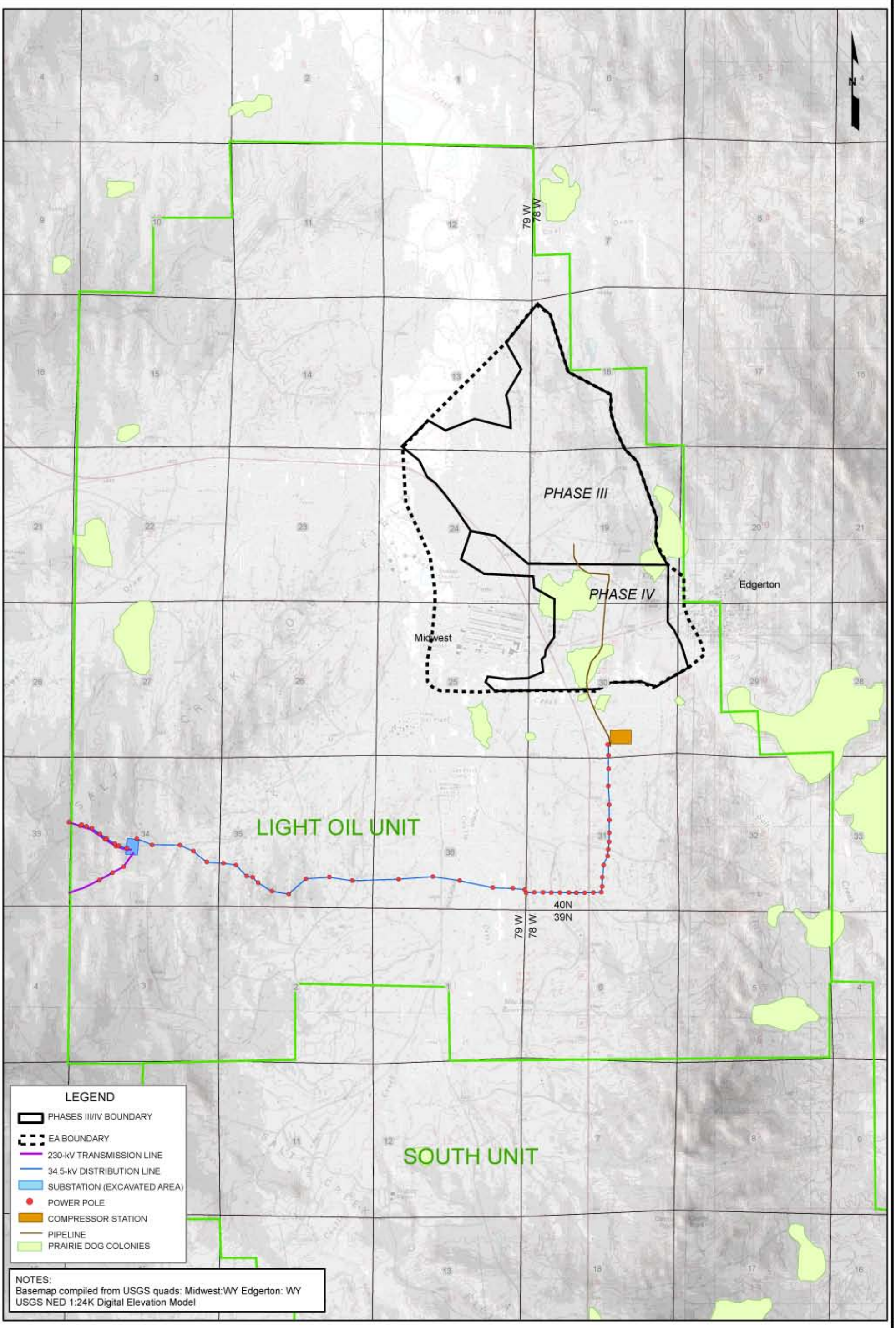


SALT CREEK PHASES III/IV EA

SUITABLE MOUNTAIN PLOVER HABITAT

FIGURE 3-2

SOURCES: ENSR 2005a, 2005b; WILDLIFE CONSULTING SERVICES 2005c



SALT CREEK PHASES III/IV EA

PRAIRIE DOG COLONIES

FIGURE 3-3

SOURCES: ENSR 2005a, 2005b; WILDLIFE CONSULTING SERVICES 2005c

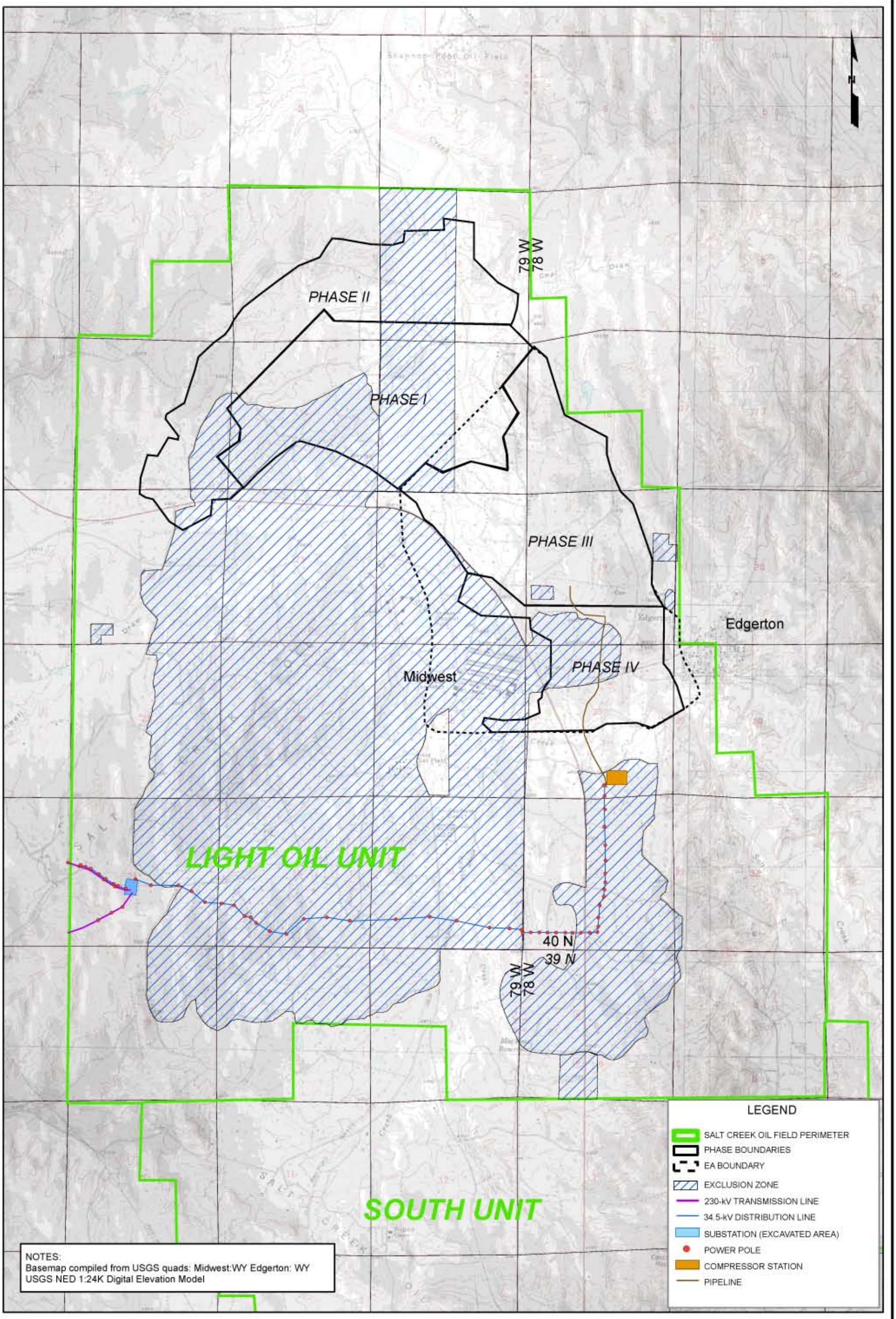
coverage) surveys for pipelines, access roads, and well pads. The most comprehensive was a reinventory study of Salt Creek Oil Field that focused on prehistoric archaeological resources

(Berrigan 1990). In conjunction with the foregoing, Rosenberg (1988) wrote a detailed historical overview of the proposed Salt Creek Oil Field District where oil has been in relatively continuous production since the 1880s. In June of 2005, a Class III archaeological survey also was conducted within the north half of Salt Creek Oil Field for a 3D vibroseis geophysical project (Kail 2005). No new cultural resource sites were found. The study encompassed the entire Proposed Action, including the project's ancillary facilities. An environmental assessment for the project was completed prior to the Class III inventory (BLM 2005).

For over 100 years much of Salt Creek Oil Field has sustained surface disturbance that has removed the contextual integrity of existing cultural resources on or near the ground surface and, thus, future archaeological surveys in these areas were deemed unnecessary. This decision became official in 1988 when the BLM and State Historic Preservation Office (SHPO) entered into an agreement that delineated the boundaries of a Salt Creek Oil Field cultural resources exclusion zone (Figure 3-4). The Salt Creek Phase I EA references Berrigan (1990) for the exclusion boundaries and notes that Berrigan refers to the exclusion zone as "not inventoried" areas (BLM 2003a).

The Class I investigations for those portions of the study area associated with the proposed Phases III/IV project and located outside the exclusion zone have resulted in the identification of 13 prehistoric and 5 historic known cultural resource sites (Table 3-9). The Salt Creek Oil Field itself (48NA296) is officially eligible to the National Register of Historic Places

(NRHP) and has been nominated for consideration as a historic district. Rosenberg (1988) reports four former oil field camps associated with the development of Salt Creek Oil Field in the 1910s and 1920s are located within the current project study area. These camps were named Kittleson, Riverside Auxiliary 30, Skinnerville, and Sunnyside; however, apparently little material evidence of these camps remain (Rosenberg 1988). They appear not to have been evaluated separately from the proposed district and were not assigned individual Smithsonian site numbers. There is limited evidence in the SHPO records suggesting they may be part of the non-contiguous Teapot-Salt Creek District (48NA273). They are included on a map of the district that appears with a partial undated NRHP nomination form; however, SHPO records indicate that the NRHP status of this district is unknown. Of further note is the Edgerton Cemetery, also associated with oil field history, which is located in the Phase III area (Rosenberg 1988). Although cemeteries are not generally considered eligible to the NRHP, because the Edgerton Cemetery is within the nominated Salt Creek Oil Field District, Rosenberg (1988) recommended it be viewed as a contributing element. It also is noted that the route of the Salt Creek variant of the Bozeman Trail (48NA3024) traverses the study area, but no physical evidence of the trail has been identified and documented (Kail 2005). Lastly, it should be noted that 11 of the prehistoric sites remain unevaluated. Most have experienced severe levels of surface disturbance, but the recorders report that there is potential for subsurface remains at some of these sites.



SALT CREEK PHASES III/IV EA

CULTURAL RESOURCES EXCLUSION ZONE BOUNDARIES

FIGURE 3-4

Table 3-9 Previously Recorded Cultural Resource Sites in the Phases III/IV Project Area

Site Number	Description	NRHP Status[1]	Comments
48NA231	Prehistoric; Hearth	-	Destroyed
48NA273	Historic Teapot-Salt Creek District	U	Non-contiguous boundaries, portions of which may or may not fall within the present project area.
48NA296	Historic; Salt Creek Oil Field	OE	Nominated to the NRHP as a historic district.
48NA1736	Prehistoric; Lithic Scatter and Features	U	Part of the Midwest Site Complex. Recorded and subjected to limited testing in 1988. Stratigraphic profiles suggest potential for subsurface archaeological remains.
48NA1737	Prehistoric; Lithic Scatter	U	Part of the Midwest Site Complex. In 1988 it was recorded and subjected to limited testing that produced negative results for subsurface materials.
48NA1739	Prehistoric; Lithic Scatter	U	Recorded in 1988, the site form notes that the surface assemblage is sparse and heavily disturbed. However, positive shovel tests suggest potential for subsurface cultural remains.
48NA1740	Prehistoric; Lithic Scatter	U	Part of the Edgerton Site Complex. Recorded in 1988, the surface assemblage is reported to be sparse and heavily disturbed. However, its proximity to other Edgerton sites suggests potential for subsurface cultural remains.
48NA1744	Prehistoric; Lithic Scatter	U	Part of the Edgerton Site Complex. Recorded in 1988, the surface assemblage is reported to be sparse and heavily disturbed. However, its proximity to other Edgerton sites suggests potential for subsurface cultural remains.
48NA1745	Prehistoric; Lithic Scatter	U	Part of the Edgerton Site Complex. Recorded in 1988, the surface assemblage is reported to be sparse and heavily disturbed. However, its proximity to other Edgerton sites suggests potential for subsurface cultural remains.

Table 3-9 Previously Recorded Cultural Resource Sites in the Phases III/IV Project Area

Site Number	Description	NRHP Status[1]	Comments
48NA1746	Prehistoric; Lithic Scatter	U	Part of the Midwest Site Complex. Recorded in 1988, the site form states that the surface assemblage is heavily disturbed, but suggests that undisturbed subsurface cultural remains may be present.
48NA1747	Prehistoric; Lithic Scatter	FNE	Recorded in 1988, the site appears to have been briefly occupied and thus there is minimal potential for subsurface remains.
48NA1748	Prehistoric; Lithic Scatter	U	Recorded in 1988, the site form reports that it has been adversely affected at the surface by oil field activities, but has the potential to yield subsurface cultural materials.
48NA1749	Prehistoric; Lithic Scatter	U	Recorded and subjected to limited testing in 1988, the site surface is heavily disturbed, but potential exists for the presence of subsurface cultural remains.
48NA1759	Prehistoric; Artifacts and Features	U	The site surface is heavily disturbed due to oil field activities. However, a partially buried stone feature suggests subsurface potential.
48NA3024	Historic; Bozeman Trail	U	The portion of the trail that traverses the project area is the westernmost Salt Creek route that is the first of several variants. The route is reported in the literature, but no physical evidence of the trail has been identified on the ground in this area by previous investigators.
48NA3072	Historic; Highway Bridge	-	Destroyed and replaced.
48NA3377	Historic; Building	ONE	Located in Edgerton.

[1]FNE=Field Not Eligible; OE=Officially Eligible; ONE=Officially Not Eligible; U=Unevaluated/Unknown

3.12 Range Management and Grazing Resources

The Proposed Action falls in portions of one BLM grazing allotment, the Davis Allotment (#10039). Although much of the surface in the Phases III/IV Project area is public, portions are leased by one lessee for livestock grazing. The total Davis Allotment has an estimated capacity of 5,160 animal unit months (AUMs), 3,044 of which are on public (BLM) lands. The 3,044 public AUMs on the Davis Allotment represent approximately two-thirds of the lessee's public AUMs on four allotments, and approximately one-third of the lessee's total public and private AUMs associated with the four allotments.

The number of acres required per AUM varies across the Phases III/IV area, depending on the forage productivity, which is largely a function of soil type and precipitation. The productivity was estimated based primarily on Ecological Site Description (ESD) and NRCS Soil Map Unit Description information. The Phases III/IV area is generally in transition between the 10- to 14-inch Northern Plains precipitation zone and the 10- to 14-inch High Plains SE precipitation zone (Jelden 2005; Bainter 2005).

Based on the soil series that comprise the NRCS map units and the carrying capacity values in the ESD for each respective soil series, the "high" and "low" values for acres per AUM were determined based on the anticipated mid-range production plant community. It was assumed that no site was in the Historic Climax Plant Community, which had the highest carrying capacity listed in each ESD, based on the level of historical disturbances in this area. In addition, no map unit was considered to be on the lowest end of the carrying capacity scale. A range was approximated based on the extent of acreage within a given soil map unit. A simple arithmetic average of the range was used to calculate the "Approximate Average Acres per AUM." The soil map unit acreage was divided by this approximate average to get the number of AUMs per Soil Map Unit. Carrying capacity (AUM/acre) was converted to acres per AUM for purposes of presentation in this section.

Table 3-10 lists the number of acres/AUM by soils series within soil map units found in the Phases III/IV area.

Table 3-10 Acres per AUM by Soil Series for the Phases III/IV Project Area

Map Unit #	Soil Series	Map Unit %	ESD	Acres/AUM	Average Acres/AUM	Weighted Acres/AUM by % of Map Unit
112	Arvada	35	Clayey	3.33-5.00	4.17	1.46
	Absted	30	Loamy	3.33-10.00	6.67	2.00
	Slickspots	15	N/A	N/A	0.00	0.00
	Inclusions:	20				
	Keyner		Loamy	3.33-10.00	6.67	
	Silhouette		Clayey	3.33-5.00	4.17	
	Cadoma		Clayey	3.33-5.00	4.17	
	Orella		Clayey	3.33-5.00	4.17	
	Inclusion Avg.				4.80	0.96
	Map Unit Total					**4.42**

Table 3-10 Acres per AUM by Soil Series for the Phases III/IV Project Area

Map Unit #	Soil Series	Map Unit %	ESD	Acres/AUM	Average Acres/AUM	Weighted Acres/AUM by % of Map Unit
125	Blackdraw	45	Saline Upland	6.67-20.00	14.01	6.30
	Lolite	20	Shale	8.33-20.00	14.17	2.83
	Gullied Land	20	N/A	N/A	0.00	0.00
	Inclusions:					
	Amodac		Loamy	3.33-10.00	6.67	
	Razsun		Clayey	3.33-5.00	4.17	
	Samday		Shale	8.33-20.00	14.17	
	Silhouette		Clayey	3.33-5.00	4.17	
	Inclusion Avg.				7.30	1.46
	Map Unit Total					**10.59**
134	Bowbac	40	Loamy	3.33-10.00	6.67	2.67
	Taluce	25	Shallow Sandy	5.88-10.00	7.94	2.65
	Terro	15	Sandy	3.03-5.00	4.02	0.60
	Inclusions:	20				
	Hiland		Loamy	3.33-10.00	6.67	
	Shallow Sodic		Clayey	3.33-5.00	4.17	
	Shallow Gravelly		Shallow Loamy	5.88-10.00	7.94	
	Rock Outcrop		N/A	N/A	0.00	
	Inclusion Avg.				4.70	0.94
	Map Unit Total					**6.86**
140	Cadoma	40	Clayey	3.33-5.00	4.17	1.67
	Renohill	25	Clayey	3.33-5.00	4.17	1.04
	Samday	25	Shale	8.33-20.00	14.17	3.54
	Inclusions:	10				
	Silhouette		Clayey	3.33-5.00	4.17	
	Gullied Land		N/A	N/A	0.00	
	Inclusion Avg.				2.09	0.21
	Map Unit Total					**6.46**
195	Haverdad	45	Saline Lowland	2.50-6.67	4.59	2.07
	Clarkelen	35	Saline Lowland	2.50-6.67	4.59	1.61
	Inclusions:	20				
	Draknab		Lowland	2.00-4.00	3.00	
	Petrie		Saline Upland	6.67-20.00	14.01	
	Aquic Ustifluvents		N/A	N/A	0.00	
	Inclusion Avg.				5.67	1.13
	Map Unit Total					**4.81**
275	Shingle	30	Shallow	5.88-10.00	7.94	2.38

Table 3-10 Acres per AUM by Soil Series for the Phases III/IV Project Area

Map Unit #	Soil Series	Map Unit %	ESD	Acres/AUM	Average Acres/AUM	Weighted Acres/AUM by % of Map Unit
			Loamy			
	Taluce	25	Shallow Sandy	5.88-10.00	7.94	1.99
	Rock Outcrop	25	N/A	N/A	0.00	0.00
	Inclusions:	25				
	Kishona		Loamy	3.33-10.00	6.67	
	Orella		Clayey	3.33-5.00	4.17	
	Theedle		Loamy	3.33-10.00	6.67	
	Worf		Shallow Sandy	5.88-10.00	7.94	
	Gateridge		Shallow Loamy	5.88-10.00	7.94	
	Taluce Variant		Shallow Sandy	5.88-10.00	7.94	
	Inclusion Avg.				6.89	1.72
	Map Unit Total					**6.09**

In the Phases III/IV project area, the number of acres required per AUM varies from 4.4 to 10.6, but averages approximately 5.4 acres per AUM (Table 3-11). At this stocking rate, previous disturbance of approximately 356 acres of the project area, due to more then 100 years of oil field development, has reduced the stocking capacity of the Davis Allotment by approximately 66 AUMs, which will continue until reclamation is accomplished.

Range improvements in the project area include pasture fences and stock reservoirs. Currently, cattle are fenced out of the LACT facilities, but individual wells are not fenced.

Table 3-11 Average Acres per AUM by Soil Map Unit for Phases III/IV Project

Soil Map Unit	Weighted Average (acres/AUM)	Soil Map Unit (acres)	Number of AUMs/Soil Map Unit
112	4.42	753	170
125	10.59	119	11
134	6.86	417	61
140	6.46	153	24
195	4.81	160	33
275	6.09	112	18
Totals		1714	317
Average	5.4		

3.13 Land Use

Most of the surface and the minerals in Salt Creek Oil Field are publicly owned and administered by the BLM. There are a few exceptions, including a section where the state owns both surface and mineral rights (T40N, R79W, S36) and several smaller areas where either the surface or both

the surface and minerals are privately owned. Midwest is privately owned and was developed as a company town, but subsequently sold to the residents. Surface rights in Edgerton are private, but the oil and gas rights are owned by the federal government and administered by the BLM. Within the Phases III/IV boundaries, there are two small areas with both surface and minerals privately owned (T40N, R79W, SW¼ S13 and T40N, R79W, E½ S25), and two with private surface ownership but federal mineral ownership (T40N, R79W, SE¼ S24 and T40N, R78W, SE¼ S19).

The current land use in the project area includes oil and gas production, wildlife habitat, domestic livestock grazing, and some recreation. Midwest and Edgerton are primarily residential with some supporting commercial activities.

Section 3.12, Range Management and Grazing Resources, details the BLM grazing allotment and livestock use for the Phases III/IV area. One party leases portions of Phases III/IV Project area for livestock grazing, with the 3,044 public AUMs on the Davis Allotment representing approximately two-thirds of the lessee's public AUMs on four allotments, and approximately one-third of his total public and private AUMs associated with the four allotments.

3.14 Socioeconomics

The Social Environment section addresses social and economic values in the vicinity of the project area, including population, employment, economic effects, and community resources such as housing, and community facilities and services. These topics have been described in greater detail in Section 3.4 of the Phase I EA (BLM 2003a). Factors that are particularly relevant to the Proposed Action (Phases III/IV EOR expansion) or that have changed notably since publication of the Phase I EA are discussed accordingly.

3.14.1 Population

The nearest communities to the Phases III/IV Project area are Midwest and Edgerton (see Figure 2-1). Both communities are now significantly smaller than they were when the Salt Creek Oil Field was at its peak in the first half of the 20th century. Both communities lost population from 1990 to 2000. Midwest, including the Gas Plant Camp, dropped from 636 people to 408 in that decade; Edgerton declined from 510 to just 169 residents (U.S. Census 1990 and 2000). Together they have lost half their combined populations; however, since 2000, they have experienced modest growth and the 2004 combined population was estimated at 600 people (U.S. Bureau of the Census 2005). Casper, the nearest city to the project area, had an estimated 2004 population of 51,240, which was almost exactly the same as its 1990 population after a slight drop in 2000 (U.S. Bureau of the Census 2005). Casper is located approximately 40 miles south of the project area. Casper, with its suburbs, and Midwest and Edgerton make up nearly 83 percent of the total Natrona County population, which was estimated at 69,010 for 2004 (U.S. Bureau of the Census 2005).

Demographically, Natrona County is generally similar to the state as a whole. The county's age profile is virtually the same as the state's with very slightly higher percentages of persons under 20 and over 65. Racially and ethnically, Natrona County is 96.1 percent white compared with 94.7 percent white for Wyoming. Both the county and the state have 0.9 percent blacks; Natrona

County has lower percentages of every other census tabulated race or ethnic category (WES 2005).

3.14.2 Employment and Income

Natrona County's non-agricultural employment increased to approximately 35,900 jobs in 2004 (Wyoming Department of Employment [WDOE] 2005a), an increase of 7.2 percent from the 33,500 jobs reported for 2002 (BLM 2003a). Natrona County has higher percentages of employment than the state in several sectors, including natural resources and mining (which includes oil and gas development), and manufacturing. Statewide, the percentages of government employment and leisure and hospitality services employment, in particular, are higher than the county's.

The labor force in Natrona County was estimated at 41,185 for April 2005, which would represent a 16.9 percent increase over the 2002 annual figure reported in the Phase I EA (BLM 2003a). Although the April 2005 figure is not directly comparable to the 2002 annual figure, it gives an indication of the growth that has occurred. The April 2005 unemployment rate was estimated at just 3.3 percent for Natrona County, compared with 3.8 percent for Wyoming and 4.9 percent for the U.S. (not seasonally adjusted) (WDOE 2005b). Updated labor force and unemployment estimates for Midwest and Edgerton are not available.

There are currently 69 Howell employees at the Salt Creek Oil Field, plus approximately 22 contractor personnel on long-term contracts. Operations at the oil field also utilize the services of 22 local contract companies for various purposes on an as-needed basis. Howell also employs 12 people at its Casper office. Nearly all of these workers reside in Midwest, Edgerton, or the Casper area.

The Department of Housing and Urban Development (HUD) estimated the 2005 median family income was higher for Natrona County ($55,900) than for Wyoming as a whole ($55,250) (WES 2005). These numbers aren't directly comparable to the "household" income cited in the Phase I EA (BLM 2003a), but they do indicate that incomes in the county are rising. Although data aren't available separately for Midwest and Edgerton, it is assumed, based on the disparity reported in the Phase I EA that the localized average income levels remain below the county level by as much as 15 to 20 percent.

3.14.3 Economy

As indicated in the Phase I EA (BLM 2003a), Natrona County's economy exhibits a significant degree of diversity. Oil and gas development and production are important to the county's economy, and are especially so in the Midwest-Edgerton area, which effectively originated because of Salt Creek Oil Field. The communities continue to rely on the oil field for their economic existence today. Salt Creek Oil Field is the largest producing field in Natrona County, producing 1,762,994 barrels of oil and 790,523 mcf of gas in 2004 (WOGCC 2005). Oil production from the field represented 55 percent of Natrona County's total and was 10 times the production of the second largest field in the county (WOGCC 2005; Hoffman 2004).

In addition to the jobs provided by oil and gas, the communities receive tax revenues from oil and gas severance taxes and from sales and use taxes generated by purchases in the oil fields and

spending by workers for goods. Oil and gas producers pay ad valorem taxes on equipment and production. They also pay royalties on production from state and federal leases at 16.67 percent and 12.5 percent, respectively. Half of the federal lease payments are passed on to the state.

The severance tax rate for oil and gas is 6.0 percent, of which 0.25 percent is distributed to counties and 0.75 percent is distributed to cities and towns, based on population. The remaining 5.0 percent is committed to various state funds and accounts. Tertiary projects are taxed at 4.0 percent rather than 6.0 percent. The Oil and Gas Conservation mill levy is now 0.02 percent, down from the 0.06 percent reported in the Phase I EA (WOGCC 2005). The average property tax rate in Natrona County is 7.95 percent; the assessment rate is 9.5 percent of fair market value, so the average tax is 0.76 percent of actual value per year (Wyoming Department of Revenue [WDOR] 2005).

Howell, as owner and operator of Salt Creek Oil Field, paid approximately $424,000 in 2004 severance taxes and $712,000 in ad valorem property taxes plus an unquantified amount of sales taxes on in-state purchases and use taxes on materials purchased elsewhere for use in Wyoming.

3.14.4 Infrastructure

The Phase I EA (BLM 2003a), quoting the 2000 census, reported 29,882 housing units in Natrona County in 2000, including 229 in Midwest and 122 in Edgerton. An additional 898 units received building permits from 2000 through 2004, 814 of which were single-family units and 84 of which were multi-family units (WES 2005). The number of new units, if any, in Midwest and Edgerton is not known, although 13 homes were reported to have been built in the 2 communities between 1990 and 2003 (BLM 2003a). At the time of the 2000 census, the rental vacancy rate in Natrona County was reported as 8.4 percent, which is fairly high. The rental vacancy rate in December 2004 had dropped to 2.8 percent, which would indicate a tight rental market (WES 2005). There are at least 29 motels in the Casper area, however, with approximately 2,000 rooms; several of these have weekly rates for longer stays (Casper, Wyoming Convention and Visitors Bureau [CCVB] 2005). There also are a half-dozen commercial campgrounds with approximately 200 spaces plus BLM and county park campgrounds (CCVB 2005).

The project area is served by the Natrona County School District, which has 5 senior high schools, 8 junior high and middle schools, 27 elementary schools, and 4 rural schools. Midwest Elementary School, with an enrollment of approximately 66 students, and Midwest Junior/Senior High School, enrolling 130 students, are both located in Midwest (Natrona County School District [NCSD] 2005).

The nearest full service medical facility to the project site is the Wyoming Medical Center, a 282-bed acute care regional medical center in Casper, 40 miles south of the project area. The center is a non-profit corporation. Physicians and midlevel practitioners in 45 different specialties provide care (3R Net 2005). First response emergency services are provided in the immediate project area by the all-volunteer (SCES). Several Howell personnel are qualified Emergency Medical Technicians and are volunteers with the organization.

SCES also provides fire protection in the Midwest-Edgerton area, with support from the professionally staffed Natrona County Fire Protection District. The Natrona County Sheriff's Department and one local officer in Midwest provide police protection to the area. Howell has an emergency response plan in place to provide guidance in the event of an emergency related to its operations. For additional information on emergency services, see the Phase I EA (BLM 2003a) and Section 2.1.1.1 of this EA.

Utility services for the project vicinity are provided by a combination of public and private entities. The Town of Midwest provides water service, obtaining water from the Central Wyoming Regional Water System, and sewer service. The water distribution system has a capacity of approximately 250 taps, 192 of which are currently in use. The sewage treatment system has two lagoon cells, but only one is in use and it operates below capacity. Natural gas, electricity, and communications services are provided by private entities. See the Phase I EA (BLM 2003a) for additional information.

3.14.5 Environmental Justice

Executive Order No. 12898, "Federal Action to Address Environmental Justice in Minority Populations and Low-Income Populations" (59 FR 7629), is "intended to promote nondiscrimination in Federal programs substantially affecting human health and the environment, and to provide minority communities and low-income communities access to public information on, and an opportunity for participation in, matters relating to human health and the environment." It requires each federal agency to achieve environmental justice as part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects, including social and economic effects, of its programs, policies, and activities on minority and low-income populations.

Environmental justice concerns are usually directly associated with impacts on the natural and physical environment, but these impacts are likely to be interrelated with social and economic impacts as well. EPA guidelines (CEQ 1997) for evaluating potential adverse environmental effects of projects require specific identification of minority populations when either: 1) a minority population exceeds 50 percent of the population of the affected area or 2) a minority population represents a meaningfully greater increment of the affected population than of the population of some other appropriate geographic unit, such as the State of Wyoming, as a whole. Neither of these situations was found to exist in either the project vicinity or Natrona County. Income levels in the Midwest-Edgerton area are lower on average than in other parts of Natrona County and Wyoming. It is not known, however, whether people living at or below the poverty level make up "meaningfully greater increment(s)" of the county or state populations.

3.15 Recreation

Recreation opportunities in the vicinity of Salt Creek Oil Field are discussed in greater detail in the Phase I EA (BLM 2003a). The oil field itself receives minor use for dispersed recreation such as wildlife viewing, hunting, and OHV travel. Two new (2001) reservoirs, Water Tank Reservoir and Petro Reservoir, are located about 5 miles south of Midwest. Initially fed by Salt Creek Oil Field discharge water, they are now fed by higher quality groundwater from the Madison formation. They are stocked with rainbow trout by the WGFD and have been attracting fishing activities, especially in drought years when other water features have been low or dry

(Conder 2005). There are no designated Wilderness Areas, Wild and Scenic Rivers, or Wilderness Study Areas in or near the project area.

3.16 Visual Resources

Initial oil production at Salt Creek Oil Field began in 1889 and, currently, the active wells in the SCLOU number approximately 754 production wells and 568 injection wells. The SCSU contains an additional 76 production wells and 75 injection wells. Salt Creek Oil Field, together with other fields in the vicinity, has been one of the most prominent visual features in northeast Natrona County for over 100 years. The oil field landscape is peppered with production well sites, pump jacks, production facilities, equipment storage areas, working rigs, power lines, unimproved roadways, and oil field traffic, all of which are part of the past, present, and foreseeable future visual environment of the area.

Many of the nearly 1,500 active wells and remnants of some inactive wells in Salt Creek Oil Field are visible in the foreground from highways State Route (SR) 259 and SR 387, and in the background from I-25/U.S. 87. They also are prominently visible from the residential and recreational areas in Midwest, Edgerton, and Gas Plant Camp. These highways and communities represent the visual observation points from which the landscape effects of the Proposed Action were evaluated.

Under the BLM's Visual Resource Management (VRM) System, public lands are normally evaluated for visual quality and sensitivity and, based on the results of the inventory, designated as one of four VRM classes with associated objectives for management of the visual environment under the umbrella of the RMP for the area (BLM 1986). The project area was excluded from this process because it is part of an ACEC with a separate management plan (BLM 1980) (Bennett 2005). Under the ACEC management plan, the visual resource objective for the project area is simply "to improve visual resources."

Upon final field closure in 30 to 40 years or more and full-field reclamation is ultimately achieved, the landscape of the former Salt Creek Oil Field will once again be primarily characterized by the dissected, rolling upland plains punctuated by badlands, broad valleys, deep eroded gullies, and isolated hills that characterized the landscape before oil was discovered in the late 1800s.

3.17 Noise

Noise levels in the vicinity of the Proposed Action have not been measured. Based on studies from other areas, it is expected that noise levels away from the industrial activity immediate to Salt Creek Oil Field would be quite low, influenced mainly by wind, insects, birds, and animals. The background noise in the area without these influences is likely in the range of 40 to 45 dBA (decibels, A-weighted) (EPA 1971). When the wind is blowing, the noise levels may be substantially higher. Noises from operations in the oil field include large diesel engines, compressors, heavy equipment operations, pipes clanking, and other industrial type noises. The nearest noise sensitive receptors are residences in Midwest and Edgerton and, perhaps, the schools in Midwest. At times, depending on the particular activity occurring in the oil field, the oil field noise sources may be within 200 to 300 feet of a sensitive receptor. These activities have been ongoing for over 100 years in Salt Creek Oil Field and many of the residents of Midwest

and Edgerton are employed in the oil field. Under these circumstances, it can be assumed that most residents are acclimated to the oil field noises and don't find them objectionable under most circumstances.

3.18 Transportation

Transportation access to the project area is almost exclusively highway oriented. The primary route is I-25/U.S.87, which runs north and south approximately 5 miles east of the project site. SR 387 connects to I-25 at exit 227 and passes through the project site before heading northeasterly toward Wright and Gillette. SR 259 runs south from Midwest, intersecting I-25 at exit 210. The three highways are paved and in generally good to excellent condition. There also is a network of county and BLM roads serving rural areas in the vicinity, none of which is paved. These roads are typically in poor to fair condition and are irregularly maintained, at best (BLM 2003a). Traffic counts for the state and federal highways are presented in the Phase I EA (BLM 2003a). The counts indicate levels of service (LOS) on the highways are currently at an "A" level, which means traffic flows freely with few restrictions, even at peak traffic periods.

4.0 Environmental Consequences

The Proposed Action to expand the existing EOR for Phases III/IV conforms with the plans and policies of the BLM's Casper Field Office Platte River Resource Management Plan (RMP). Specifically, the Proposed Action is in accordance with the planning decisions outlined in the Salt Creek Resource Management Unit (RMU) (BLM 1985). The Salt Creek RMU comprises approximately 347,000 acres of both BLM-administered surface lands (91,000 acres) and federal mineral estate (206,000 acres). Pertaining to the project area and Proposed Action elements, the Salt Creek RMU states that the management focus would encompass mineral development, special management emphasis for the Salt Creek ACEC based on soil conditions, protection of cultural resources in connection with historic significance of oil field development, and realty support associated with energy and non-energy linear ROWs.

4.1 Air Quality

4.1.1 Proposed Action

Additional surface disturbance and activity levels associated with the Proposed Action may temporarily result in an increase in the wind-blown dust generated from increased traffic on the existing and newly constructed access roads, well sites, pipelines, facility and storage sites, and electric line ROWs in the project area. Increased activities associated with vehicles and equipment engaged in construction, drilling, workover, and other installation activities associated with the Phases III/IV project may result in a temporary increase in combustion emissions. As flow lines, wellhead equipment, and production facilities are upgraded, however, the potential for degrading air quality resulting from line or equipment failure would decrease. Gas plant operations would remain unchanged.

The Proposed Action would use to the greatest extent possible existing wells, facilities, access roads, and power lines to minimize areas of disturbance. Fugitive dust control measures and prompt reclamation of disturbed areas also would minimize air quality impacts. The potential localized impacts from short-term increase in dust and combustion emissions from additional drilling and well workover activities and drilling/workover rigs, construction equipment, and worker vehicles would, therefore, be expected to be negligible.

The subsurface pressure "water curtain" discussed in Chapter 2 and illustrated in Figure 2-3 is designed to eliminate the potential for CO_2 seeps in and around the populated areas within Salt Creek Oil Field and specifically for implementation of Phases III/IV. The monitoring "fence" also discussed in Chapter 2 provides further assurance that no CO_2 would enter the isolated subsurface area of high pressure. In the unlikely event that the monitoring wells indicated migration of CO_2 into the isolated subsurface area, Howell's proposed "CO_2 Seep Containment Plan" summarized in Chapter 2 would be implemented to eliminate the potential for a surface seep event. Potential air quality impacts from Phases III/IV due to CO_2 seeps would, therefore, be expected to range from no impacts, particularly in populated areas, to negligible or minimal impacts in remote areas.

The Phase I EA discussed potential ambient impacts of a CO_2 pipeline rupture for the proposed Phase I operations at Salt Creek (BLM 2003a). The initial modeling study (BLM 2003a) was

limited to vertical "jet" plume releases of CO_2 from hypothetical pipeline rupture scenarios. Howell subsequently retained Cameron-Cole to perform further air dispersion modeling studies to estimate downwind CO_2 and H_2S concentrations resulting from various well blowout and pipeline rupture scenarios, including vertical and horizontal plume releases (Cameron-Cole 2005b). The modeling results were reported relative to the 10-minute time-weighted averages (TWA) and the immediately dangerous to life or health (IDLH) thresholds for H_2S and CO_2. It should be noted that the potential occurrence of a catastrophic pipeline rupture or well blowout event is extremely unlikely. Pipeline systems, drilling and completion equipment and work practices are conservatively designed to maximize reliability and avoid such events. In the unlikely event of a short-duration catastrophic well blowout event, CO_2 and H_2S concentrations in the breathing zone (approximately 5 feet in elevation) would not be expected to exceed the 10-minute TWA thresholds (Cameron-Cole 2005b). Depending on ambient temperatures, wind, and plume rise conditions, modeling predicted that a pipeline leak could potentially result in short-term H_2S concentrations that would exceed the TWA and IDLH levels once the plume settled to the ground. No CO_2 impacts, based on TWA thresholds, were predicted for a pipeline rupture (vertical or horizontal). No long-term ambient air quality impacts would be expected.

4.1.2 No Action

Under the No Action Alternative, activities associated with the existing waterflood operations within the Phases III/IV area would continue. Under the No Action Alternative scenario, the ambient air quality in and around the project area would be expected to remain unchanged. Currently, there are no ambient air quality exceedances or other issues with respect to Wyoming Air Quality Standards and Regulations (WAQS&R).

4.1.3 Mitigation and Monitoring

No additional mitigation or monitoring measures applicable to air quality have been developed for the Proposed Action.

4.2 Geology

4.2.1 Proposed Action

The project region has been under similar development for over a century, most of the proposed operations would be located at existing facility sites, and overall the proposed Phases III/IV development activity would avoid steep or unstable slopes. Hence, no impact associated with reduced slope stability would be anticipated. Some minor changes I topography from cut and fill operations would be anticipated during construction of new roads and drill pads. However, the impacts from this activity would be minimal.

No impacts to surface geological structure would be anticipated from continued removal of petroleum hydrocarbons under the Proposed Action. There is no record of detectable earthquakes induced by water injection in the project region, and no record of subsidence as a result of oil production.

4.2.2 No Action

No impacts to topography and geology would be expected under the No Action Alternative. A certain amount of underground geological resources (i.e., oil and gas) would not be recovered, as the No Action Alternative would continue with the waterflood operations and EOR in the Phases I/II areas.

4.2.3 Mitigation and Monitoring

No additional mitigation or monitoring measures applicable to geology have been developed for the Proposed Action.

4.3 Water Resources

4.3.1 Surface Water

4.3.1.1 Proposed Action

Changes in surface water resources, as a result of the Proposed Action, have been collectively evaluated on the basis of the anticipated whole-field buildout of the enhanced oil recovery program. The partial contributions from each phase have not been disaggregated, as all discharges would be routed through the existing discharge points. The Phase I EA concluded that the primary anticipated effect would be a temporary increase in the total volume of produced water discharged to Salt Creek (and affected tributaries). However, recent (2005) operating data gathered during Phases I and II implementation indicate that CO_2 injection also may affect the composition of produced water discharges from the field.

As is detailed in the Phase I EA, prior to CO_2 EOR, approximately 168,000 barrels of water per day (BWPD) were discharged from Salt Creek Oil Field via the permitted outfalls to Salt Creek and its tributaries. The maximum average discharge rate into Salt Creek as a result of the EOR program was projected to reach a high of 196,250 BWPD in 2004 and 2005 after Phase II startup, which equates to an increase of about 17% over the waterflood only baseline discharge. In 2006, volumes are anticipated to drop to approximately 122,000 BWPD. By the time final phase expansion would be completed (when the additional contribution from the EOR program ceases) volumes are projected to be 132,000 BWPD, a 32% decline over current baseline waterflood discharges (Phase I EA, Table 37).

The effects of the Proposed Action on Salt Creek hydrology would be considered small in the context of historical flows and in the context of the total increase in flow anticipated when the final phases of the EOR program would be completed. Additional water volumes released for downstream use may result in an overall positive effect on water budgets.

No adverse impacts (e.g., sedimentation, siltation) to Salt Creek water quality from Phases III/IV construction activities would be anticipated, based on Howell's committed soil erosion control and reclamation measures. The Phase I EA details these committed protection measures that also would apply to the Phases III/IV Project.

The existing WYPDES permit and monitoring program establishes concentration limits on water discharges to protect Salt Creek (and the Powder River) beneficial uses. The primary constituents of concern found in produced waters include salinity-related parameters (e.g., TDS, conductivity and chlorides) and oil and grease, which are indicators of petroleum product spills. All of these constituents of concern are regulated. Chloride and TDS are currently the regulated constituents of greatest concern – chloride due to its presence in excess of the current water quality criterion, and TDS because recent data indicate several discharges exceed the permit effluent limit. The chloride concern is being addressed by WDEQ implementation of a site-specific WQC for chloride, based on the UAA completed in 2004. The specific manner in which the TDS issue will be resolved has not yet been determined, although several options have been identified (see Section 3.3.1.2). Howell is actively working with WDEQ to assure compliance with established discharge limits to protect beneficial water uses including aquatic life.

If a WYPDES noncompliance event occurs during future EOR operations Howell would be required to submit to WDEQ a written explanation for the noncompliance and steps taken or planned to reduce or eliminate the noncompliance event, and prevent a recurrence. Further, the WYPDES permits would require Howell to take reasonable steps to minimize or prevent any discharge in violation of their permits that has a reasonable likelihood to adversely affect human health or the environment. Howell must comply with all permit conditions, as permit noncompliance represents possible grounds for an enforcement action or permit modification, revocation,, reissuance, or termination. Through the WYPDES program, WDEQ's continued monitoring and enforcement of the existing discharge permits would protect water quality in Salt Creek as Howell's EOR program expands.

4.3.1.2 No Action

Under the No Action Alternative, Phases III/IV of the EOR would not be implemented and the Phases III/IV area program would continue under waterflooding only. No additional water quantity issues or changed water quality would be anticipated for Phases III/IV of the EOR program. The additional water provided for the Powder River basin water budgets would not occur, reducing downstream beneficial water use. No changes in water quality would occur, positive or negative, in relation to the waterflood baseline.

4.3.1.3 Mitigation and Monitoring

No additional mitigation or monitoring measures applicable to surface water resources have been developed for the Proposed Action beyond those described in Phase I EA (BLM 2003a). Howell would continue monitoring water volumes and water quality of produced water discharged from LACTs to Salt Creek, as part of the established WYPDES monitoring program.

4.3.2 Groundwater

4.3.2.1 Proposed Action

The maximum reservoir pressure under current waterflood operations is approximately 1,200 psi. An estimated maximum reservoir pressure during CO_2 injection operations would be around

1,500 psi. Howell conducted petrophysical analysis and matched the results of this analysis with the results from step-rate injection tests in the WC2 horizon. It was determined that the maximum injection pressure for the reservoir would be 1,550 psi, which is higher than the maximum reservoir pressure anticipated during the CO_2 injection operations. Maintaining the pressure difference between maximum injection pressure and maximum reservoir pressure would allow the project operators to maintain reservoir integrity during WAG injection operations.

Three pathways for CO_2 migration that could potentially impact groundwater include leakage through faulty cement grout along used and abandoned well casings, at points of failure in the cap rock aquitard, and across geologic units through naturally occurring fractures and faults. Potential impacts to groundwater could arise from the water solubility of CO_2 leaking into the upper aquifer system. CO_2 dissolves in groundwater to form the weak acid, H_2CO_3. The acid can dissolve aquifer minerals such as calcium carbonate (calcite) and mobilize associated trace metals under higher CO_2 pressures. However, Howell's efforts to eliminate or minimize leakage of CO_2 from the WC2 through improved well integrity work (e.g., re-plugging of abandoned wells, re-cementing of existing wells) would be expected to eliminate or minimize the potential for groundwater impacts from the project. Furthermore, the public water supplies for the towns of Midwest, Edgerton, and Gas Plant Camp are obtained from the Casper Regional Water System, which would not be impacted by the Proposed Action.

In summary, the Proposed Action is not expected to impact the groundwater resources. No changes in the hydraulic head in the upper and lower hydraulic units of the Powder River sedimentary basin and/or no leakage from the Wall Creek horizons into the upper and lower hydraulic units would be expected as a result of proposed operations in the WC2.

4.3.2.2 No Action

No additional development activities and/or operations that would affect groundwater resources in the project area would occur under the No Action Alternative. The current waterflood and EOR in the Phases I/II areas would continue.

4.3.2.3 Mitigation and Monitoring

No additional mitigation measures applicable to groundwater have been developed for the Proposed Action. Currently, there are no regulatory groundwater monitoring requirements for the project operations; however, Howell personnel conduct groundwater monitoring from selected wells for operational purposes under the Routine Oilfield Water Analysis (ROWA) and annual groundwater monitoring program for Salt Creek Oil Field Sewage Lagoon, as required by Permit Number 94-372 issued by WDEQ. Howell would continue the sewage lagoon and the ROWA groundwater monitoring programs, but no additional monitoring measures were identified for the proposed Phases III/IV EOR project.

4.4 Human Health & Safety and Ecological Risks

4.4.1 Proposed Action

The potential for localized occurrence of CO_2 seeps in the project area would be considered a potential risk to human health and the environment. Sections 2.1.1.1 and 2.1.3 of this EA summarize the measures, approach, and actions Howell has implemented to understand, predict, and minimize or prevent the occurrence of CO_2 seeps for future EOR phases.

The evaluation of adverse impacts to human health, safety, and the environment from the occurrence of CO_2 seeps depends on three factors: 1) the probability of significant surface seeps occurring during Phases III/IV implementation, 2) the probability of such an event occurring in a location where significant exposure is likely, and 3) the magnitude of exposure to CO_2 or other components in excess of toxic or adverse levels.

As discussed in Chapter 2.0, in-depth resources and technologies have been used to identify, asses, and control the source and pathways of surface seeps noted during the Phase I development. These data will aid in establishing measures to predict, prevent, and contain current CO_2 seeps and minimize future seeps from occurring. Containment measures have been proposed to eliminate potential seeps, as well as to minimize the effects of these seeps. Assuming the measures discussed above are sufficient in preventing surface seeps, there would be no adverse impacts to human health and ecological communities beyond the baseline risks associated with industrial activities in an active oil field. The following analysis provides information to better understand these relative risks and focuses on evaluating the effect of a rare event or scenario where CO_2 seeps would nonetheless occur in spite of containment and prevention measures.

4.4.1.1 CO_2 Toxicity

The primary constituent of the seeps occurring from the Phase I operations is CO_2. Cameron-Cole (2005) measured CO_2 concentrations ranging from 18% to 90% in the seeps found in the NE ¼ of Section 14 (see Figure 2-6). H_2S also was present at concentrations ranging from 18 to 196 ppmv. Cameron-Cole (2005) reported that H_2S content when CO_2 concentrations are equal to 5,000 ppmv (the regulatory standard for CO_2) are expected to be less than 10 ppmv (measured H_2S ranged from 17 to 188 ppmv). The regulatory standards for H_2S are 20 ppmv (maximum exposure ceiling), 50 ppmv (10 minute maximum peak exposure), and 100 ppmv (IDLH). In relation to the CO_2 content of the seeps, the potential contribution to human health risk from H_2S would be minor, given the potential CO_2 levels would be the dominant factor.

Appendix C of this EA presents a review of CO_2 toxicity. Briefly summarized, CO_2 may be considered harmless (from a toxicological viewpoint) below 5,000 ppmv (0.5% by volume in air). Compare to the normal atmospheric concentration of 0.035% by volume. Above 5,000 ppmv toxic effects may occur, as seen in Table 4-1. CO_2 is primarily an asphyxiant, that is it exerts its toxic action by displacing oxygen in breathed air. At higher concentrations it also acts as a systemic central nervous system toxicant.

Table 4-1 CO_2 Symptoms and Regulatory Standards

% CO_2	Symptoms / Effects	Regulatory Limits
0.5		Occupational threshold (8-hour): - OSHA PEL - ACGIH TLV - NIOSH Workday TWA
2 to 3	Shortness of breath, deep breathing.	
3		- OSHA STEL - ACGIH 10-minute Ceiling Exposure Limit - NIOSH 15-minute STEL
4		- OSHA IDLH level
5	Heavy breathing, sweating, quickened pulse	
7.5	Headaches, dizziness, restlessness, increased heart rate and blood pressure, visual distortion	
10	Impaired hearing, nausea, vomiting, loss of consciousness	
30	Coma, convulsions, death	

Sources: Table 1 in Appendix C and sources cited therein.

The Occupational Safety and Health Administration (OSHA) has an occupational Permissible Exposure Limit (PEL) for an 8-hour day of 0.5% CO_2. ACGIH (American Conference of Industrial Hygienists) has the same value as an 8-hour Threshold Limit Value (TLV) as does NIOSH (National Institute for Occupational Health and Safety). Little specific information is available on ecological exposures, except to note that data underlying the human health values often is based on animal studies. Although 24-hour exposure is not contemplated in these limits, it is reasonable to use 0.5% as the key indicator of adverse impacts over long-term exposure, and 3% as the indicator of adverse impacts over a short exposure (10 minutes).

The effects of sublethal CO_2 exposure is rapidly reversible once the affected person or animal is removed from the elevated CO_2 atmosphere. If a person reacts to incipient symptoms by leaving the area no long-term health effects are likely to occur.

4.4.1.2 Potential Magnitude of Exposure

Cameron–Cole (2005) evaluated the CO_2 seeps observed to date with the Phase I development. Seeps were present in open areas as well as in drainages. While the seeps themselves ranged from 18% to 90% CO_2, concentrations measured at the perimeter of a major seep (diameter 4.5 feet) measured at 6 inches from the ground and 10 feet away from the edge of the seep varied from background values to over 2.4% CO_2, depending on wind and temperature conditions. Modeling was conducted to define the dispersion of CO_2 under varying seepage and weather conditions. Concentrations at ground level exceeding 0.5% would generally be limited by the normal variance in weather conditions to less than 21 feet distance from the seep. At human breathing altitude, approximately 5 feet (1.5 meters), the concentration would not exceed 0.5%.

Under a worst-case scenario, with no wind or other dispersion, CO_2 concentrations exceeding the 10-minute criterion of 3% may be present at ground level (but not at breathing height) up to 45 feet from the seep. The highest measured CO_2 concentrations exceeded 2.4% (the maximum for the gauge) at 10 feet. Therefore, a potentially toxic condition (i.e., a CO_2 concentration exceeding 0.5%) may exist in the seep itself and extend near the ground but would not be present at the human breathing altitude of 5 feet. Toxic levels could extend at ground level for up to 45 feet from the seep perimeter, but more typically would occur 10 feet or less from the seep. A walking human, therefore, would not be expected to be exposed to a risk from CO_2 in open areas.

In drainages, depressions, and other protected areas concentrations may be higher. Measured concentrations (near ground level) in a gully with active seeps were typically well below the 0.5% long-term exposure criterion during the day, but would exceed 2.4% (gauge maximum) during night-time periods of no wind. It is possible that concentrations of CO_2 in sheltered depressions and gullies could rapidly reach potentially hazardous conditions in still conditions. However, as CO_2 is heavy, concentrations in the breathing zone would be expected to be much lower.

In summary, it is recognized that when CO_2 is allowed to accumulate in enclosed spaces it poses a threat to human health (Holloway 1997). If exposed, potential risks to human health and the environment could occur in enclosed spaces, sheltered drainages, and low spots during wind-free conditions and near ground level in the immediate vicinity of a seep during low-wind conditions, if a CO_2 seep were to occur. Evaluation of whether this constitutes a significant adverse impact depends on the probability of such an exposure occurring, which is defined and discussed in the following section.

4.4.1.3 Probability of Exposure

Human Health and Safety

The CO_2 seeps recorded following Phases I and II implementation occur in a small portion of the Phase I area. Seeps were noted in open land as well as in drainages, and all seeps presently occur in remote areas relative to habitation or travel routes (see Figure 2-6). Oil field workers would be the only anticipated sensitive receptors at these seep locations.

The Phases III/IV Project area is located closer to the towns of Midwest and Edgerton (see Figure 2-1). Public roads and highways also are present in the project area. Therefore, the potential for human exposure if a seep were to occur is greater for the Phases III/IV area than in the Phases I/II area.

Because of the potential risk if CO_2 were to accumulate in enclosed spaces or low spots, Howell's CO_2 Seep Containment Plan was structured to prevent CO_2 seepage from occurring both in rural areas and in or near the towns of Midwest or Edgerton. As detailed in Section 2.1.1.1, a series of water injection wells would be located to provide a barrier to lateral subsurface CO_2 migration in the vicinity of the towns and would be intended to promote movement of subsurface fluids (i.e., hydrocarbons, CO_2, and water) toward production wells and away from the town perimeters. Based on the CO_2 Seep Containment Plan (Section 2.1.3), the probability of CO_2 seeps occurring in the towns of Midwest or Edgerton would be very low.

Seeps in open country present a much lower potential for health hazards. The Cameron-Cole (2005) report documented rapid dispersion of CO_2 in open country. In drainages and ravines Cameron Cole (2005) showed CO_2 concentrations may increase during periods of little or no wind. However, such times tend not to be of long duration, and the presence of people over extended periods in drainages located in the Phases III/IV Project area is not likely.

Two areas located outside of the towns of Midwest and Edgerton may support more extensive human use than the surrounding unoccupied areas. These two areas include the Edgerton Rodeo Grounds and the Midwest Golf Club. The Edgerton Rodeo Grounds are located northeast of Edgerton and consists of a fenced area without bleachers or inhabited buildings except for a small ticket booth. The grounds are used a few times a year for local outdoor events (Farrell 2005.). The probability of occurrence of CO_2 seeps and health hazards are very low for these rodeo grounds, as occupancy would be short-term and no confined spaces are present. The Midwest Golf Course is located between Edgerton and Midwest and is within the Phases III/IV project area. It is a nine-hole golf course used a few days a week during the summer season (May through September) primarily by the local population. A small clubhouse, lacking running water, is located on the premises (in addition to a storage shed) and is used exclusively for golfers. The clubhouse lacks a basement or confined spaces, and is typically used after games with doors and windows open (Chapman 2005). Therefore, the potential for health hazards would be very low, as well, if a CO_2 seep were to occur in the area, and comparable to open country conditions.

Health hazards could occur only if individuals seek out, enter, and remain indefinitely in the immediate vicinity under the worst-case scenario outlined by Cameron-Cole (2005) (i.e., 1% of the time up to 31.9 feet downwind at ground level for a large seep and 6.7 feet for a medium-sized seep) . This scenario applies only close to ground level. At breathing height for a person (5 feet), no health hazard would be anticipated (Cameron-Cole 2005a). Further, such an individual would have to deliberately ignore the early symptoms of exposure to elevated CO_2 and remain in the seep area. Finally, Howell has initiated measures to eliminate such contact (e.g., seep fencing), as outlined in Section 2.1.3.

Ecological Exposure

Potential ecological exposure of animals to a CO_2 seep also could occur; however, the areas affected by elevated CO_2 concentrations around an open-land seep are typically small (Cameron-Cole 2005a) and significant exposure is unlikely. Small animals such as rodents, rabbits, snakes, and ground-dwelling birds occupying drainages could be affected by increased CO_2 concentrations, although the number of animals present in specific ravines or drainages is likely to be small. CO_2 exposure in burrows is a potential pathway for burrowing animals in the immediate vicinity of a seep; however, because CO_2 seeps are typically accompanied by surface water, any burrow in the path of a seep would likely be rendered uninhabitable.

A final ecological exposure pathway examined included individual animals accessing available surface water at a seep location for drinking or bathing, particularly in the seeps located in the more arid, upland habitats. High concentrations of CO_2 (70% to 80%) could be present in these depressions caused by the seeps (Cameron-Cole 2005). Animals may become overwhelmed from CO_2 inhalation near seeps. While most animals are expected to avoid the seeps due to the

noise and vibration, access for purposes of drinking is possible. Therefore, Howell developed the ongoing seep containment fencing and netting to prevent animal and bird access, minimizing potential impacts to area wildlife species, as discussed in Section 4.8.

4.4.1.4 Summary of Impacts

Potential impacts to human health from exposure to CO_2 would primarily apply to confined or protected spaces, if a CO_2 seep were to occur in that specific area. However, the probability of a seep surfacing in a confined space is low to none, based on a series of ongoing well improvements, future drilling scenarios, and project monitoring in the towns under the Proposed Action to prevent any CO_2 buildup and provide early detection, if warranted (see Sections 2.1.1.1 and 2.1.3). CO_2 seeps occurring outside of town would be expected to be rare occurrences. If present, the likelihood of unacceptable human exposure in such locations is low due to the small footprint of toxic conditions, infrequent occurrence of windless conditions, low intensity of use of land in most of the project area, and application of containment and monitoring measures currently implemented for Phase I and proposed by Howell for Phases III/IV.

The potential for ecological risks also is low. This assessment is based on the low probability of seeps occurring; the small footprint of the seeps, if present; likely avoidance of active seeps by some wildlife; and containment measures implemented by Howell to minimize access to seep areas.

4.4.2 No Action

Under the No Action Alternative, the Phases III/IV EOR would not occur, and continued oil production using waterflooding would continue in the Phases III/IV areas while economically practicable. No adverse impacts to human health and ecological communities would be anticipated beyond the risks inherent in an active oil field, and Howell would continue to monitor and minimize existing CO_2 seeps associated with Phase I, anticipating full control (as discussed in Chapter 2.0).

4.4.3 Mitigation and Monitoring

Howell has developed a detailed approach to prevent CO_2 seeps and to contain them if they were to occur as part of the Proposed Action for Phases III/IV. This CO_2 Seep Containment Plan is summarized in Section 2.1.3 of this EA. The containment measures are designed to prevent the surface expression of CO_2 seeps, thus eliminating or minimizing potential adverse impacts. Application of these containment measures reduces the probability of occurrence of a seep and minimizes exposure pathways, if it were to occur, thereby, reducing the risk to human health, safety, and the environment.

4.5 Soils and Reclamation

4.5.1 Proposed Action

Based on the inherent nature of the soil resources in the project region (i.e., steep topography and erodible soil material), loss from erosion is likely. Soil loss is expected on disturbed surface areas during dry and windy conditions from increased road travel. During wet conditions, soil

loss due to wheel rutting, compaction, and associated water erosion also would be expected from increased vehicle traffic. The potential for soil loss would be greatest during the short-term construction phase of the Proposed Action. Soil erosion, whether from wind or water, would likely continue to occur on disturbed areas until they were successfully reclaimed.

Direct impacts to soils would include vegetation removal resulting in soil exposure to wind and water erosion; mixing of soil horizons; loss of topsoil productivity by removal of organic matter; as well as modification of texture, particle size distribution, chemical properties, and biological content due to erosion, deposition, compaction, and stockpiling. Soils would be compacted by vehicles during construction activities reducing infiltration and water storage capacity, increasing runoff, thereby increasing soil loss due to water erosion. Equipment handling during stockpiling would break down the soil structure and dilute soil organic matter resulting in a reduction of soil viability over time. No impacts to the Salt Creek drainage ACEC, based in part on erosion severity in portions of the watershed, would occur since no areas or soil map units coincide with the Phases III/IV project area. Therefore, no potential effects to soils would violate the Salt Creek RMU's planning directives.

Soil contamination could result if spills or leaks of petroleum products, drilling muds, or other contaminants occur. Previously, soil contamination from reserve pit leakage has been a concern in the project region. Other possible contamination sources include leakage or spills from production and storage facilities. If soil contamination occurs, constituents could then be transported and potentially affect water and soil quality downgradient of the source.

Topsoil quality in the project area varies considerably but is generally fair, with clay content and increased salinity and sodicity being the primary limitations to reclamation success in specific areas. In addition to these limitations, relatively low effective annual precipitation and wind and water erosion make successful reclamation more difficult to attain. Past experience in this area, however, has shown that successful reclamation can be attained with aggressive reclamation measures and follow-up monitoring and remediation.

The ACEPMs described in Section 2.1.6.4 of the Phase I EA (BLM 2003a) would aid in reducing potential impacts to soils from the Proposed Action. A Storm Water Pollution Prevention Plan (SWPPP) and Spill Prevention, Control, and Countermeasure Plan (SPCCP) are currently in place and would continue to be implemented for the proposed Phases III/IV expansion project to minimize impacts to soils, in addition to associated resources, such as vegetation, wildlife, and surface water resources. Post-construction monitoring on a regular basis would be undertaken to ensure: 1) surface reclamation is undertaken in a timely manner and 2) applicable erosion control measures are effective, including revegetation. Point 10 of the Master Surface Use Plan (MSUP) (Appendix D) outlines surface reclamation practices designed to reduce the environmental impact of project activities on the soil and vegetation resources within the project area. Table 4-2 summarizes the reclamation seed mixture agreed upon between Howell and the BLM. This seed mix is part of the MSUP and would be applied as part of the Proposed Action reclamation plan to enhance revegetation and minimize noxious weeds.

Table 4-2 Reclamation Seed Mix

Species	Pounds per Acre (PLS)[1]
Gardner saltbush	2.31
Slender wheatgrass revenue	3.24
Western wheatgrass	4.68
Sandberg bluegrass	0.70
Bottlebrush squirreltail	2.68
Alkalai sacaton	0.15
TOTAL	**13.76**

[1]PLS = pure live seed

In summary, approximately 167 acres of surface soils, representing approximately 8% of the Phases III/IV Project area (2,182 acres), would be newly disturbed from implementation of the Proposed Action, of which 145 acres would be short-term disturbance (i.e., reclaimed after construction) and 22 acres would be long-term disturbance (i.e., reclaimed at the end of the project). Redisturbance of existing disturbed area within the Phases III/IV project area would be approximately 356 acres.

4.5.2 No Action

Under the No Action Alternative, no additional surface-disturbing activities associated with CO_2 injection from Phases III/IV would occur, with the exception of those associated with the existing waterflood operations. Therefore, the potential for additional soil loss due to wind and water erosion, and the potential for soil and water contamination, attributable to Phases III/IV Project area activities, would not occur. Without the implementation of the Phases III/IV EOR Project, the additional potential disturbances to soil resources from these project phases would not occur, and, the economic life of Salt Creek Oil Field would likely be shortened. The indirect effect of this alternative on the soil resource would be that reclamation of the entire project area would begin sooner.

4.5.3 Mitigation and Monitoring

No additional mitigation measures applicable to soils or reclamation have been developed for the Proposed Action.

4.6 Wetlands

4.6.1 Proposed Action

Based on the development scenarios presented for the Proposed Action, the avoidance of wetland areas (e.g., bridging Salt Creek for the proposed CO_2 trunk line), and the ACEMPs described in Section 2.1.6.5 of the Phase I EA for vegetation and wetland resources, no adverse impacts to wetlands would be anticipated.

4.6.2 No Action

The No Action Alternative would result in the same type and level of impacts that have occurred over the past several years in Salt Creek Oil Field, although a lower level of well drilling, workover activity, and field maintenance would occur if the Proposed Action is not implemented. Activity in the well field would continue at a decreasing level until the field becomes uneconomical. Field abandonment and project closure would be followed with the appropriate decommissioning, reclamation, and revegetation activities, as described in Howell's existing Reclamation Plan (see Item #10 in Appendix D).

Wetlands that have developed along the WYPDES discharge channel into Salt Creek would likely be reduced or eliminated as discharge flows decline and are eventually terminated. Continuing the existing waterflood operations would not produce any adverse impacts compared to current conditions, unless regulatory pressure results in more reinjection and/or reduction in Salt Creek flow, which could reduce wetland/riparian values. If the amount of water in Salt Creek is reduced as a result of decreased or eliminated WYPDES discharge, it is possible that wetland changes could occur as the floodplain and riparian areas become drier. In this situation, wetland communities along the creek would likely return to conditions similar to those present prior to oil field development.

4.6.3 Mitigation and Monitoring

No additional mitigation measures applicable to wetlands have been developed for the Proposed Action.

4.7 Vegetation and Weeds

4.7.1 Proposed Action

The Proposed Action would result in additional short-term and long-term losses of vegetation in the areas of new construction. However, much of the new disturbance would occur in areas that have already been disturbed by previous oil field activities. The Proposed Action would maximize the use of existing well pads and roads that have been previously disturbed. Riparian vegetation would likely not be impacted within the project area, since no construction activity would disturb riparian communities along Salt Creek. Eventually, as the amount of produced water discharge to Salt Creek declines, it is possible that some riparian habitat could be lost as inundated or saturated streamside zones are reduced. Since the economic life of Salt Creek Oil Field would be prolonged with implementation of the Proposed Action, riparian habitat supported by the produced water discharge in the project area would be maintained for a longer period of time under the Phases III/IV Project.

Development of new well sites, access roads, substation, electric power lines, and associated facilities would result in disturbance of approximately 167 acres of vegetation in the short-term, and following reclamation and revegetation 22 acres in the long-term. Although total disturbance of vegetation communities is estimated, the majority of new disturbance would be in the upland grassland and upland shrubland communities with relatively little disturbance in saltbush badlands for which revegetation efforts can be somewhat problematic. There would be no or very little impact in riparian communities. As discussed in Section 2.1.1.3, Gas System,

Howell would "bridge" Salt Creek with the CO_2 trunk line, avoiding surface disturbance to the stream or its associated riparian vegetation. Areas of short-term disturbance would be revegetated as soon as feasible after construction is complete. Long-term losses of vegetation would remain until field abandonment and the appropriate decommissioning, reclamation, and revegetation activities are completed (see Item #10 in Appendix D).

The ACEPMs described in Section 2.1.6.5 of the Phase I EA should be adequate to protect and minimize impacts to vegetation resources in the project area, including construction site management (e.g., using previously disturbed areas and existing easements, limiting equipment/materials storage yard and staging area sizes). New well locations and associated roads and pipelines would be located to avoid or minimize impacts in areas of high value, such as wetland/riparian areas. The reclamation seed mix listed in Table 4-2 in Section 4.5 would be used to enhance revegetation and minimize noxious weeds. Point 10 of the MSUP (Exhibit 5.3.2 of the Phase II EA [BLM 2004a]) outlines surface reclamation plans that should be effective in reducing the environmental impact to the soil and vegetation resources in the project area.

Construction involved with proposed project area activities has the potential to increase the spread of weeds across disturbed sites. The NWMP would be revised, as necessary, for these project phases to include the information and tools needed to mitigate the potential spread of noxious weeds associated with past and future development activities (see Appendix B). The objectives of the plan would be to reduce existing weed infestations and prevent the establishment of new infestations. An updated copy of the NWMP would be prepared as a part of the POD for these phases. If weeds were successfully controlled and the reclamation guidelines in the ACEPMs strictly followed, there should be no residual impact to the vegetation resource from proposed development activities with regard to noxious weed species.

Section 2.1.6.5 of the Phase I EA (BLM 2003a) states that Howell would monitor for noxious weeds and would apply BLM-approved weed control techniques, as necessary, on sites affected by oil field operations. The NWMP (see Appendix B) prepared for previous project phases in Salt Creek Oil Field provides a comprehensive plan to control the spread of noxious weeds and other invasive species that would be applied for the Proposed Action.

4.7.2 No Action

The No Action Alternative would result in the same degree of impacts to vegetation that has occurred over the past several years. Activity in the well field would continue at a declining level until field abandonment and project closure occurs. The applicable decommissioning, reclamation, and revegetation activities would be completed earlier than under the Proposed Action.

No new disturbances that could enhance the spread of weedy plant species would occur. The NWMP would be instituted with the existing weed population decreasing as weed control activities are applied and become effective.

4.7.3 Mitigation and Monitoring

Considering that the NWMP (see Appendix B) would be updated to meet the conditions of the Phases III/IV Project, no additional mitigation or monitoring measures applicable to vegetation and weeds have been developed for the Proposed Action.

4.8 Terrestrial Wildlife

4.8.1 Proposed Action

Potential impacts to terrestrial wildlife species were assessed based on potential species' presence, overall habitat quality, and relative degree of historical and ongoing oil extraction activities in and near the Phases III/IV area and in Salt Creek Oil Field. The incremental surface disturbance and oil field activities over the last 116 years has modified the landscape, associated vegetation types, wildlife habitats, and relative carrying capacities in this immediate area. The specific project components of the Proposed Action were examined relative to the temporal and spatial patterns of both resident and migratory wildlife species and the current wildlife population trends apparent in the project area.

The incremental loss and disturbance of native habitats, habitat fragmentation, animal displacement, and direct loss of wildlife species from project construction and operation would be expected to be low. The reworking of existing wells, the use of existing roads and some power lines, and the use of existing ancillary facilities would minimize the degree of new surface disturbance. The Proposed Action would result in 167 acres of new disturbance, as compared to the use of 356 acres of previously disturbed areas. The vegetation types that would be impacted by new surface disturbance associated with the Phases III/IV Project primarily encompass upland grassland and upland shrubland communities, with little disturbance occurring in saltbush badlands, as detailed in Section 4.7.1. No impacts to riparian habitats would be anticipated from the Proposed Action, since no direct drilling or associated activities are proposed within the riparian community located along the Salt Creek drainage. Additionally, Howell's proposed CO_2 trunk line construction techniques for the Salt Creek crossing would entail bridging the channel with the pipe, similar to the existing Phase I CO_2 pipe crossing of Salt Creek (see Section 2.1.1.3, Gas System).

Of new disturbance, Howell's Reclamation Plan (see Section 4.5 and Appendix D), would reclaim an estimated 145 acres in the short term, following well drilling activities. The estimated 22 acres of habitat lost in the long term would be an incremental impact, given the degree of existing disturbance within Salt Creek Oil Field and the level of commitment to utilize existing infrastructure to the extent possible. Additionally, the ACEPMs presented in Section 2.1.6.6 of the Phase I EA (BLM 2003a) delineate committed protection measures to minimize impacts to terrestrial wildlife that also would apply to the Phases III/IV expansion. Specifically, logical site selection for wells, new access roads, flow lines, and ancillary facilities would aid in minimizing the potential effects to terrestrial wildlife habitats.

Parallel to the anticipated effects of habitat lost from the Proposed Action, the increased drill sites, access roads, substation, power line rights-of-way (ROWs), and ancillary facilities associated with Phases III/IV would incrementally increase habitat fragmentation and animals

displacement. It is assumed that surface disturbance and increased human-related activities (e.g., noise, human presence) would result in the loss or displacement of some terrestrial animals from the project area with a direct correlation to a reduced carrying capacity. Typically, animals will either avoid noise sources or become accustomed to the increased noise levels. The level of this impact depends on the type of noise source, individuals or species present, buffering capacity of the area (e.g., topography), and duration of the noise. As discussed, the degree of existing disturbance in Salt Creek Oil Field surrounding Phases III/IV, the minimal acreage with new surface disturbance, the relative existing habitat quality in these areas, and the observation that several species appear to habituate to these activities to a certain degree (e.g., pronghorn) helps to minimize direct and indirect effects to terrestrial wildlife species.

Potential impacts to the two big game species that occur in the area, pronghorn and mule deer, would reflect the discussion regarding potential short- and long-term effects to native habitats. Implementation of Phases III/IV would result in an incremental increase in habitat loss and fragmentation for pronghorn and deer use; however, the level of expected effects would be low, based on the degree of existing disturbance, the historic development of this oil field, and the focus on reworking existing wells and using existing infrastructure in and near the Phases III/IV area. No designated big game seasonal ranges or movement corridors would be affected by the Proposed Action.

These incremental habitat changes and increased human presence in the Phases III/IV area would likely reduce presence and use by certain more sensitive predators, such as bobcat, golden eagle, and ferruginous hawk; however, other predator species, including coyote, red fox, common raccoon, and red-tailed hawk, would more readily adapt to these changes in habitat configurations and human presence. It is assumed that the relative prey density and distribution (i.e., prey base of rodents and other small- or medium-sized mammals) would not change dramatically from the EOR expansion into the Phases III/IV area.

As discussed in Section 3.8, five active and eight inactive raptor nests were recorded in or within 0.5 mile of the Proposed Action. An increase in human-related activities (e.g., presence, noise, pedestrian or vehicle traffic) could directly impact nesting raptors, if they occur in close proximity to the nest site. Loss of eggs or young would be in violation of the Migratory Bird Treaty Act, and if the nest were occupied by a golden eagle, potential loss of eggs or individual birds in addition to disturbance to adult birds would be in violation of the Bald and Golden Eagle Protection Act.

Two raptor nest sites are of particular concern, given their location. The active red-tailed hawk nest (see Table 3-5, #8, 46) located approximately 0.25 mile east of the proposed pipeline corridor in Section 30 and the golden eagle nest that may have been originally “tended” by an eagle in February 2005 and ultimately occupied by a red-tailed hawk (see Table 3-5, #13). This nest was initially active in 2005 (i.e., containing one egg, but subsequently abandoned) and is located approximately 750 feet from the proposed Claim Jumper Switchyard and associated transmission and distribution power lines (Figure 3-2). Given that this golden eagle nest site exhibited signs of eagle use in early 2005, it is feasible that eagles could return in spring of 2006. The golden eagle nesting period extends from February 1 through July 31.

In accordance with the BLM's permitting stipulations outlined in the Platte River Resource Area Resource Management Plan (PRRA RMP) (BLM 1985), active raptor nests (i.e., containing eggs or young) are protected during the breeding season to minimize the potential for nest abandonment or loss of eggs or young. Therefore, project-related activities typically would be restricted within 0.5 mile of the nest for a specified period between February 1 and July 31 to protect breeding raptors and their nest sites. The applicable size of the buffer zone and extent of the seasonal restriction would be determined on a case-by-case basis by the BLM biologist. Since so many variables exist, the buffer and seasonal restriction can vary and would be determined, taking into account the species affected, topography, habitat suitability, degree of existing disturbance, associated prey base, breeding phenology, and degree or extent of proposed disturbance (BLM 1985). Therefore, based on the implementation of this BLM stipulation, no impacts to nesting raptors would be anticipated from construction of the Phases III/IV Project. However, there is a potential that the golden eagle nest located approximately 750 feet north of the substation in direct line-of-site would not be occupied in the future during project operation, resulting in a long-term loss of use by eagles. It is feasible, red-tailed hawks could re-occupy the nest site, since they are typically more tolerant of human-related influences.

This EA analysis also examined the potential for avian electrocution risk for birds that may perch on the proposed power lines associated with the Phases III/IV expansion project. As part of the Proposed Action, Howell has committed to construct and operate the 34.5-kV distribution lines in accordance with the standard raptor protection measures outlined in APLIC (1996) (see Section 2.1.1.4). Although larger birds (e.g., raptors) are generally of primary concern for electrocution hazards, applying the line design specifications outlined in APLIC (1996) and committed to by Howell for the Phases III/IV Project would aid in protecting birds of all sizes (including smaller birds perched on distribution equipment poles). Since these measures generally apply to lines below 69 kV voltage, these measures would specifically be implemented for the 34.5-kV distribution lines from the Claim Jumper Switchyard into Salt Creek Oil Field and to the Phases III/IV area. No impacts to birds from the operation of the two, 0.5-mile, 230-kV transmission lines from PP&L's existing main line to the Claim Jumper Switchyard would be anticipated. According to the National Electric Safety Code (NESC) specifications for electric conductor clearances, the larger 230-kV electrical line configuration increases the distance between phase-to-phase and phase-to-ground clearances, thereby preventing bird contacts or electrocutions on these larger structures.

No impacts to terrestrial species generally associated with open water or the riparian community (e.g., waterfowl, riparian obligate songbirds, amphibians) would be expected. As stated above, no direct impacts to the riparian corridor of the Salt Creek drainage or its inhabitants would be anticipated, based on Howell's commitment to avoid siting project facilities in this area. Potential impacts to reptiles would be expected to be minor and dispersed, based on the limited amount of new surface disturbance.

Potential impacts to terrestrial wildlife from potential CO_2 seeps in the future would likely be low overall. Individual animals that occupy the low-lying drainages could be lost if a CO_2 seep were to occur in this type of area. However, it would likely be limited to small- and medium-sized animals that use below-surface burrows. Two of the more important burrowing species include the burrowing owl and black-tailed prairie dog. Both of these species are addressed in Section 4.10.2.1. Potential impacts to other ground species would likely be

sporadic and dispersed. Howell's CO_2 Seep Containment Plan and existing seep containment fencing and netting reduces the potential exposure of animals to CO_2 effects.

4.8.2 No Action

Under the No Action Alternative, potential short- and long-term habitat loss and fragmentation would be the same as under the current EOR regime. No incremental increase in impacts to terrestrial wildlife species would occur beyond that already permitted within Salt Creek Oil Field. No potential increase in incidental mortalities of small- to medium-sized animals would occur from CO_2 seeps in low-lying draws or gullies beyond those anticipated for implementation of Phases I/II, albeit this number would be expected to be low.

4.8.3 Mitigation and Monitoring

Existing mitigation and monitoring measures have been developed for terrestrial wildlife species that are committed to by Howell and presented in Section 2.1.6 of the Phase I EA (BLM 2003a), Section 2.1.1.4 of this EA, and the BLM's stipulations contained in the PRRA RMP (BLM 1985). An additional mitigation measure has been developed to improve off-site avian protection and habitat enhancement in order to mitigate the potential long-term loss during project operation of golden eagle use of the existing eagle nest site located approximately 750 feet from the proposed Claim Jumper Switchyard and associated electric power lines. Three elements comprise this off-site protection program for area birds, specifically resident and migratory raptors. These elements include: 1) Howell would build new electric distribution lines to service Salt Creek Oil Field in accordance with the Avian Power Line Interaction Committee's *Suggested Practices for Raptor Protection on Power Lines: The State of the Art in 1996* (APLIC 1996) and forthcoming updates, 2) existing structures where future bird fatalities may be recorded would be retrofitted according to these same guidelines, and 3) existing de-energized electric distribution lines that are re-energized in the future would be made bird-friendly, as well. In accordance with APLIC's 1996 guidelines currently being updated and scheduled to be available for review in early 2006, these measures would either make the power poles safer for perching birds or implement perch management tools to control where birds perch on at-risk structures. This mitigation approach would not only aid in protecting raptor species that may occur in the project area, it also would improve habitat value for area birds.

4.9 Aquatic biology

4.9.1 Proposed Action

The EOR program (including the Proposed Action for Phases III/IV) is projected to increase water volumes on a temporary basis (see Section 4.3.1). As Salt Creek has an established perennial aquatic life community adapted to the existing conditions, the effect of increased water flows in the Salt Creek system overall would be positive. In the arid conditions of the region, increased water availability has a positive effect on aquatic resources limited by water availability.

There are indications that changes in discharge water quality have occurred in LACT 4 and LACT 5, the LACTs associated with Phases I and II EOR. At this time it is not known if the water quality changes are associated with EOR. Produced water from the Proposed Action also

would be routed to the LACT 5 discharge. If the cause of the changes observed previously following Phases I and II implementation are related to EOR, it is possible that the Phases III/IV produced water may contribute further to changes in discharge water quality. However, as LACTs 4 and 5 together account for only 9.7% of Howell´s total discharge volumes to Salt Creek (prior to EOR), these discharges, even considering the increase in discharge volumes, would not be expected to significantly alter the overall water quality in Salt Creek. The ongoing WYPDES monitoring program provides constraints to decreased water quality for the regulated constituents and procedures to address exceedances of the effluent limits and protect designated uses are in place per permit requirements. As proposed in the Salt Creek UAA (RETEC 2004), as long as cumulative discharges to Salt Creek do not increase over current (waterflood only) levels aquatic life should be protected and remain unimpaired.

4.9.2 No Action Alternative

Under the No Action Alternative, no additional water discharge would occur to Salt Creek. Any beneficial effects of the additional water supply to resident aquatic life would not occur. Water quality in Salt Creek would not change over the baseline water quality conditions in the creek based on waterflooding only and the Phases I and II EOR development.

4.9.3 Mitigation and Monitoring

The measures to minimize erosion described in Section 2.1.6 of the Phase I EA and the ongoing WYPDES monitoring would adequately reduce the chance of adverse impacts to aquatic life in Salt Creek. No additional mitigation or monitoring measures applicable to aquatic biological resources have been developed for the Proposed Action.

4.10 Special Status Species

4.10.1 Plants

4.10.1.1 Proposed Action

The Proposed Action occurs in an area that has been disturbed for over 100 years in the search for, and development of, petroleum resources. The threatened, endangered, and other special status plant species evaluated by this analysis are not known to occur in project area region, and no habitat for these species was observed within the project area boundaries, with one exception. Habitat for Nelson’s milkvetch is present to a limited extent on site consisting of shale ridge outcrops associated with various project component elements. This species has not been observed in the project area. Based on the historical use of Salt Creek Oil Field, lack of plant species’ observations, and the committed environmental protection measures to avoid steep slopes during construction, it can be assumed that no impacts to threatened, endangered, or other special status plant species would occur as a result of the proposed project.

4.10.1.2 No Action

Activity in the well field would continue at a decreasing level until the field becomes uneconomical. Field abandonment and project closure with the appropriate reclamation,

revegetation, and weed control activities would be completed. No impacts to special status plant species would be associated with the No Action Alternative.

4.10.1.3 Mitigation and Monitoring

No additional mitigation or monitoring measures applicable to special status plant species have been developed for the Proposed Action.

4.10.2 Terrestrial Animals

4.10.2.1 Proposed Action

The following impact analyses focus on the special status terrestrial wildlife species that may occur in or near the proposed Phases III/IV Project. As summarized in Table 3-7, of the 18 animal species examined for this project, 11 are analyzed in detail for potential direct, indirect, or cumulative impacts from construction and operation of the Proposed Action. A "no effect" impact determination has been made for the federally listed bald eagle and black-footed ferret, based on the lack of suitable habitat for bald eagle use and the USFWS block clearance for black-footed ferrets.

If present in the project area, potential impacts to the BLM-sensitive ferruginous hawk and western burrowing owl from project implementation would parallel those discussed for nesting raptors and predator species in Section 4.8.1. An increase in human-related activities (e.g., presence, noise, pedestrian, or vehicle traffic) could directly impact nesting raptors, if the activities were to occur in close proximity to the nest site. Species such as the ferruginous hawk are highly susceptible to nest abandonment, if disturbed during the breeding season. If abandoned, loss of eggs or young could occur, which would be in violation of the Migratory Bird Treaty Act. Since burrowing owls use underground burrows for nest sites, potential impacts to this raptor species could occur from ground-disturbing activities in proximity to nest burrows. However during the 2005 nest surveys, no active ferruginous hawk or burrowing owl nests were documented in or within 0.5 mile of the Phases III/IV boundaries, near the proposed substation site, along the proposed power line ROWs, or near other ancillary facilities (e.g., new compressor station) (ENSR 2005a, 2005b; Wildlife Consulting Services 2005a, 2005b). Therefore, it is assumed that no impacts to these two sensitive raptor species would occur from implementation of the Phases III/IV Project, if project construction began the winter of 2005/2006 prior to the 2006 breeding season. In the event that construction activities were delayed into the spring of 2006, the BLM's permitting stipulations outlined in the PRRA RMP (BLM 1985) are structured to protect raptor nests to minimize the potential for nest abandonment or loss of eggs or young.

In the event that construction were delayed and breeding ferruginous hawks or burrowing owls were to documented in 2006 within 0.5 mile of the Phases III/IV area, project-related activities would likely be restricted within 0.5 mile of an active nest site during a specified period between February 1 and July 31. As stated for other raptor species in Section 4.8.1, the extent of an applicable buffer area and seasonal restrictions can vary and would be determined by the BLM biologist, based on a number of factors (e.g., topography, existing disturbance, prey base, breeding phenology, proposed disturbance). In summary, no direct impacts to breeding

ferruginous hawks or western burrowing owls would be anticipated, based on survey data collected in 2005 and the implementation of the applicable BLM stipulations to protect active nest sites in the future, if they are warranted.

Other potential impacts to special status species, such as the ferruginous hawk and burrowing owl, from the incremental surface disturbance and oil field activities associated with the Proposed Action would parallel the discussion for general terrestrial wildlife species discussed in Section 4.8.1. Historic oil field development over the last 116 years has resulted in the incremental loss and disturbance of native habitats, increased habitat fragmentation, and animal displacement. The reworking of existing wells, the use of existing roads and some power lines, and the use of existing ancillary facilities would minimize the degree of new surface disturbance. Approximately 167 acres of new disturbance would occur under the Proposed Action, as compared to the use of 356 acres of previously disturbed areas, with an estimated 145 acres of new disturbance reclaimed in the short term, following well drilling activities, and an estimated 22 acres of habitat lost in the long term. Howell's commitment to build new electric distribution lines in accordance with APHLC (1996)to minimize the risk of bird electrocution for birds perching on these structures would aid in protecting ferruginous hawks attempting to perch on these new power lines (see Section 2.1.1.4), which is discussed in detail for general raptor species in Section 4.8.1. Additionally, the ACEPMs presented in Section 2.1.6.6 of the Phase I EA (BLM 2003a) delineate committed protection measures to minimize impacts to terrestrial wildlife applicable to the Phases III/IV expansion.

Potential impacts to the four sensitive songbirds identified as potentially occurring in the project area, i.e., sage thrasher, Brewer's sparrow, sage sparrow, and loggerhead shrike, would primarily include incremental habitat loss and fragmentation and potential displacement of adult breeding birds, if present. Displacement of breeding birds could result from project construction and increased human presence in native shrubland steppe habitats. Assuming an incremental reduction in habitat carrying capacities, some of these breeding birds could be displaced in the short term (i.e., during construction and site reclamation) and in the long term (e.g., until shrubs become re-established). Displacement or nest abandonment during the breeding season could result in the loss of productivity for that breeding season. Potential impacts to nesting birds would depend on the nest location relative to the proposed project components, the species' breeding phenology, the duration of the potential impacts, and the individual species' tolerance to disturbances.

In September 2003, the USFWS determined federal listing of the mountain plover as federally threatened was not warranted; however, the species remains a BLM sensitive species. Plover nest sites are protected on BLM lands with applied seasonal restrictions for surface use and human-related activities from April 10 to July 10. As shown on Figure 3-2, potentially suitable habitat for the mountain plover occurs in and adjacent to the Phases III/IV Project area. If development activities were to occur during the breeding season, increased human presence and noise could result in displacing breeding adult plovers (if present) from their respective territories resulting in the potential loss of productivity for that season. It is assumed that breeding birds would likely return to these areas the following year, particularly since this species' habitat association encompasses open, disturbed areas. Therefore, surface disturbance for the Phases III/IV development would not likely degrade habitat quality or availability for this species.

If project development were to occur within suitable plover habitat delineated for the Phases III/IV area during the breeding season, the BLM would require specific mountain plover surveys, and if present, applicable restrictions would be required near active nest sites. These procedures are outlined in the BLM Instructional Memorandum No. WY-2004-035, dated April 16, 2004. Restrictions include mountain plover surveys conducted in potentially suitable habitat, if project-related activities were to occur between April 10 and July 10. Two surveys (14 days apart) would be required prior to the initiation of project actions to minimize impacting breeding or nesting birds. The BLM has developed additional protection measures, in the event a nest site were recorded in the vicinity of project activities.

No impacts to active prairie dog colonies would be anticipated from the development and expansion of Phases III/IV involving existing infrastructure. It is not likely that project-related activities with existing wells, roads, and ancillary facilities would impact prairie dogs or their burrows. Potential impacts to prairie dogs from the construction and development of new wells, access roads, power lines, and associated facilities could result in crushing of burrows and direct mortality of individual animals if present in these development areas (see Figure 3-3). As stated in Section 2.1.6.6 of the Phase I EA, Howell has committed to avoiding active prairie dog colonies whenever possible. Howell and the BLM maintain communications on this avoidance measure when siting would unavoidably impact prairie dog burrows.

No impacts to the three bat sensitive bat species identified for the proposed project, Townsend's big-eared bat, fringed myotis, and long-eared myotis, would likely occur. No communal bat roosts (e.g., hibernacula, maternity colonies, or bachelor roosts) are known to occur in the project area, and if present, bats would likely occupy individual day roosts only.

Potential impacts to special status species from potential future CO_2 seeps would parallel the impacts discussed for Terrestrial Wildlife (Section 4.8.1). Individual prairie dogs, ground-nesting birds, or burrowing owls that may occupy low-lying areas in the vicinity of a CO_2 seep could be lost. However, the anticipated incidence of these potential mortalities would be expected to be low, based on the low incidence of CO_2 seeps recorded for Phase I, the sporadic occurrences of these special status species, the CO_2 Seep Containment Plan developed by Howell for the Proposed Action (see Section 2.1.3), and Howell's existing seep containment fencing and netting to prevent or minimize wildlife access to these areas.

4.10.2.2 No Action

Under the No Action Alternative, current levels of EOR activities would continue until field closure and reclamation. Potential impacts to special status animal species examined for the Proposed Action would be the same as under the current EOR regime. If species are present, the anticipated incremental increase in surface disturbance, habitat fragmentation, or animal displacement would continue under the current levels already permitted within Salt Creek Oil Field. However, the ACEPMs outlined in the Phase I EA (BLM 2003a) would help in mitigating potential habitat effects and impacts to special status species. The potential increase in incidental mortalities of special status songbirds, black-tailed prairie dogs, or burrowing owls from CO_2 seeps in low-lying draws or gullies would be expected to be low, based on typical habitat associations, animal mobility, isolated occurrences of the CO_2 seeps from the Phase I EOR

activity, and the CO_2 Seep Containment Plan developed by Howell to minimize or prevent CO_2 seeps.

4.10.2.3 Mitigation and Monitoring

No additional mitigation or monitoring measures applicable to special status animal species have been developed for the Proposed Action beyond those already committed to by Howell in Section 2.1.6.6 of the Phase I EA (BLM 2003a), Section 2.1.1.4 of this EA, and as part of the Proposed Action.

4.10.3 Aquatic Species

4.10.3.1 Proposed Action

The Proposed Action would not affect any federally listed, state-listed, or BLM sensitive aquatic species, since no sensitive aquatic species have been documented in Salt Creek or its tributaries. Any changes in water discharge quality or quantity from the Proposed Action would not be of such magnitude that water quality or quantity conditions would change significantly in the receiving waters in the Powder River where sensitive fish species (e.g., sturgeon chub, shovelnose sturgeon) may occur. Additionally, Howell proposes to cross the Salt Creek drainage by bridging the new CO_2 pipe, thereby avoiding dried or indirect effects to this creek.

4.10.3.2 No Action

No effect on sensitive aquatic species would be expected under the No Action Alternative and current waterflood conditions continue in that area.

4.10.3.3 Mitigation and Monitoring

No additional mitigation or monitoring measures applicable to special status aquatic species have been developed for the Proposed Action.

4.11 Cultural Resources

Cultural resources are regarded as significant if they are enrolled in or meet the eligibility criteria of the NRHP. NRHP eligibility criteria are enumerated in 36 CFR 60 and are described as follows:

> The quality of *significance* in American history, architecture, archaeology, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, *and*:
>
> (a) That are associated with events that have made a significant contribution to the broad patterns of our history.
>
> (b) That are associated with the lives of persons significant in our past.

(c) That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction.

(d) That have yielded, or may be likely to yield, information important in prehistory or history.

To qualify for NRHP eligibility, a property must meet two separate types of requirement. It must exhibit integrity of location, design, materials, etc. and it must meet one or more of the four additional criteria. The National Historic Preservation Act (NHPA) of 1966, as amended, makes clear that a site need not be of national historic significance to be considered eligible; sites of local, state, and regional importance also may be listed, and thus are significant in the legal sense. The phrasing of NHPA is critical with respect to actual management of cultural resources. A site does not have to be included on the NRHP to receive protection under the law, but must simply meet the requirements of eligibility.

Impacts to cultural resources may be direct or indirect. Direct impacts are those that occur as a primary result of project designs and might be associated with actual gas field development (e.g., well pad construction activities, equipment staging areas, building of temporary access roads) and subsequent gas field maintenance operations. The greatest direct impacts can be expected to occur early in the course of any undertaking when surface disturbance takes place. Indirect impacts are those that occur as a secondary consequence of a project and are generally associated with increased human activity in previously inaccessible areas. Illicit surface collection of sites is a common form of indirect impact. Indirect impacts can occur at any time during or after construction; however, their effects must be anticipated at the outset.

4.11.1 Proposed Action

Applying these guidelines and NRHP eligibility criteria, a number of protection measures currently exist to protect known and undiscovered archaeological or cultural sites located outside of the existing cultural resources exclusion zone. ACEPMs for archaeological and cultural resources presented in Section 2.1.6.7 of the Phase I EA (BLM 2003a) remain applicable for the Phases III/IV Project, but do not include the Class III cultural resources exclusion zone (see Figure 3-4).

Based on these committed measures, existing sites (see Table 3-9) and new (unknown), significant prehistoric and historic sites would either be protected or a data recovery program would be implemented, as deemed appropriate by the BLM in consultation with the SHPO, the Advisory Council on Historic Preservation (ACHP), and Howell (BLM 2003a). Therefore, no significant impacts to archaeological or cultural sites would be anticipated from implementation of the Proposed Action, and the project would conform to the Salt Creek RMU planning decisions and direction for cultural resources.

4.11.2 No Action

Under the No Action Alternative, no additional impacts would occur to cultural resources.

4.11.3 Mitigation and Monitoring

No additional mitigation or monitoring measures applicable to cultural resources have been developed for the Proposed Action beyond the ACEPMs detailed in Section 2.1.6.7 of the Phase I EA (BLM 2003a).

4.12 Range Management and Grazing Resources

4.12.1 Proposed Action

Under the Proposed Action, AUMs would be lost in the short term during the Phases III/IV construction until new road ROWs, new pipeline routes, and non-work areas around wells and facilities could be reclaimed. Within the Phases III/IV areas, approximately 167 acres of new disturbance would occur from project implementation, with 145 acres being short-term disturbance and 22 acres would be long-term disturbance. A precise estimate of the AUMs lost from this disturbance is difficult to obtain. However, a simple average productivity estimate for the Phases III/IV project, based on ESD and NRCS soils information (see Table 3-11), yields an estimate of 5.4 acres per AUM. Applying this estimate to the projected short- and long-term surface disturbance in the Phases III/IV Project area would yield an estimated short-term loss of 27 AUMs and a long-term loss of 4 AUMs during Phases III/IV. These numbers represent less than 0.9% of the public land AUMs and less than 0.6% of the total AUMs in the Davis Allotment from the short-term disturbance. Losses from long-term disturbance would be 0.1% of public AUMs and less than 0.1% of total Davis Allotment AUMs. They would, however, be in addition to the reduced AUM capacity in the allotment from previous disturbance.

The total surface disturbance would be projected to be 8% of the total Phases III/IV area (2,182 acres) and the long-term surface disturbance would be 1% of the total Phases III/IV area (see Table 2-2). Following full-field production, the field would be closed in an estimated 30 to 40 years and the Phases III/IV area would be reclaimed.

The ACEPMs described in Sections 2.1.6.4 and 2.1.6.5 of the Phase I EA (BLM 2003a) would reduce potential impacts to range resource in the Phases III/IV area. In accordance with Howell's Reclamation Plan (see Item #10 in Appendix D), new surface disturbance for pipelines, wells, power lines, and other ancillary facilities would be reclaimed as soon as practicable with the proper seed mixture (see Table 4-2).

Although the project-related reduction in grazing capacity in the project area would be small, the operations associated with construction of the Proposed Action also could potentially disrupt efficient management of the allotment for grazing. Construction and drilling related activities would be dangerous to cattle, and cattle could cause problems for oilfield workers, especially during the construction period, as discussed below.

Range improvements in the project area include pasture fences, stock reservoirs, and one stock water surface pipeline. However, few existing range improvement projects would be impacted by the Proposed Action. Leaving fences down or gates open when livestock are present could result in livestock moving into unauthorized areas or mixing in adjacent pastures. If this were to occur, livestock entering the production area could either be injured or cause damage to the facilities. If fenced, no impacts to livestock from the Proposed Action would be anticipated.

Increased heavy vehicle traffic could cause damage to existing cattle guards, especially during construction, depending on the size of the equipment.

After construction is completed, the short-term disturbed areas would be reclaimed and revegetated. The BLM typically requires a 2-year period without grazing on reclaimed areas to facilitate the success of the reclamation effort. The short-term loss of grazing capacity on the Davis Allotment would continue through this period. Howell also has committed to a protection measure to coordinate directly with the grazing lessee to review applicable options to minimize potential grazing impacts in the short term. Once reclamation is successfully completed, it is expected that the reclaimed areas would be more productive for grazing than the native pasture.

4.12.2 No Action

Under the No Action Alternative, development would continue under the existing EOR and waterflood operations. No additional AUMs would be lost from EOR activities beyond those already permitted within Salt Creek Oil Field.

4.12.3 Mitigation and Monitoring

ACEPMs developed to minimize potential impacts to range resources and livestock grazing are presented in Sections 2.1.6.4 and 2.1.6.5 of the Phase I EA, and an additional measure was developed for the Phases III/IV Project in Section 2.1.4.2 of this EA. The new measure for the Proposed Action would increase communication and coordination with the Davis Allotment operator to minimize adverse effects on grazing management. Although the number of AUMs expected to be lost from the Proposed Action would be small, this measure would aid in compensating the allotment operator for the anticipated loss by providing 1) temporary fencing of reclaimed areas, 2) alternative pastures, or 3) supplement livestock feed. Howell and the grazing lessee would develop a mutual agreement as to the specific option or options to be implemented. It is recommended that BLM serve as an arbitrator, if warranted.

Additionally, whenever possible, construction activities should be conducted when the construction area is not actively in use for grazing. Fencing should be erected to prevent conflict between grazing operations and oil field development activities, including reclamation activities. Fences should be constructed around production facility areas that present a risk to cattle to prevent injury to the animal or damage to the facility. No residual impact from the Proposed Action would be anticipated if the disturbed areas are properly reclaimed and returned to productive use for grazing purposes. Increased forage production from reclaimed areas also would help mitigate some AUM loss due to native area disturbance

Finally, gates should be closed immediately after passing through them, whenever possible. Gates adjacent to roadways should be used as an alternative to crossing cattle guards, wherever possible.

4.13 Land Use

4.13.1 Proposed Action

The Proposed Action would have essentially no effect on surface ownership or existing land use outside the project area. Within the project area, the Proposed Action would result in short-term disturbance of an estimated 167 surface acres and a long-term disturbance of approximately 22 surface acres. The potential effects to livestock grazing, the primary land use, is discussed in Section 4.12.

4.13.2 No Action

The No Action alternative would have essentially no effect on surface ownership or land use, except that reclamation would begin earlier on previously disturbed areas. Additionally, field closure, with its attendant reclamation requirements, would occur in 5 to 15 years rather than 30 to 40 years.

4.13.3 Mitigation and Monitoring

Mitigation or monitoring measures applicable to land use for the Proposed Action are discussed in Section 4.12.3.

4.14 Socioeconomics

4.14.1 Proposed Action

4.14.1.1 Population

The Proposed Action would result in a 6- to 10-month increase in workforce at Salt Creek Oil Field of approximately 250 to 300 construction workers (see Section 4.14.1.2). It is expected that 80 to 90 percent of the workers would come from the existing labor pool in the local surrounding areas of Midwest, Edgerton, Casper, Mills, Evansville, and Kaycee. Most of these workers would be expected to commute from their current residences, which are all within 45 miles of the project area. Assuming a maximum of 20 percent of the new workers would be non-local, there would be 50 to 60 potential new families, or 120 to 144 additional people at an average of 2.4 people per household. Assuming acceptable housing were available, perhaps half of the new people would choose to live in the Midwest-Edgerton area, which would represent a 10 to 12 percent increase in the population for the area. While not insignificant, the increase would still leave the population well below the 1,148 individuals recorded as recently as the 1990 census. Consequently, the increased population and the economic activity they would bring would likely be viewed as a benefit in Midwest and Edgerton. The population increase would be an insignificant 0.2 percent, or less, of the current estimated Natrona County population.

It is likely that most of the remaining half of the population increase would choose to live in the Casper area because of the greater range of services and housing opportunities available there. An increase of 60 to 72 people in Casper would scarcely be noticed. One concern would be the current low vacancy rate in rental housing, but ample temporary housing would be available in motels and campgrounds to accommodate workers and families, if needed.

Unless the construction employment opportunities were to continue in subsequent phases of the project, the population gain would be temporary and would be absent in 6 to 10 months.

4.14.1.2 Employment and Income.

The Proposed Action would require a temporary increase in construction worker employment of 250 to 300 workers. As the region has a long history of oil and gas activities, it is anticipated that the necessary skills for construction and drilling work would be available locally; consequently, most of the workers would be hired from the local Natrona County area, as noted in Section 4.14.1.1. Approximately 85 percent would be skilled workers, including welders and fitters, heavy equipment operators, and a number of experienced supervisory personnel; the remainder would be unskilled workers. The skilled jobs, in particular, would pay above average wages ranging up to approximately $20 per hour. The result would be an influx of money into the local economy, as workers would spend a portion of their earnings locally for housing, food, and other necessities. Construction activities are anticipated to begin in January-February 2006, pending regulatory approvals. Expenditures by workers would lead to additional business and employment opportunities for provision of various goods and services in local communities. Total new employment created by the project would increase employment opportunities in the Natural Resources and Mining sector of the Natrona County economy by 12 to 15 percent in the short term, which is considered a beneficial effect.

In addition to the construction workers, one or two operating employees would be added to the Howell staff at each phase. These would be long-term positions. The long-term employment increase would be negligible in the context of the county economy. Most of the required operations workforce would be expected to come from Casper, Midwest, Edgerton and surrounding local communities.

4.14.1.3 Economy

The Proposed Action would have mostly beneficial effects on the economy. Oil production is expected to increase by over 50 percent from current levels of 7,000 BOPD to approximately 10,700 BOPD. The total increase in oil production from the Phases III/IV area is estimated at 22 MMBO over the 30- to 40-year life of the project. Increasing the total recoverable oil from Salt Creek Oil Field and extending the life of the field would increase property and severance taxes to the county and the state. Royalty payments to the federal and state governments also would increase and a portion of the tax and royalty increases would accrue back to the local communities. For the Phases III/IV CO_2 flooding in 2007, Howell estimates that $10 million in gross revenue would be generated. The company would pay about $3.8 million in royalties and taxes (not including income taxes) annually for the Phases III/IV expansion. Estimated operating expenses, severance taxes and ad valorem taxes for the Proposed Action are summarized in Table 4-3.

Table 4-3 Phases III/IV Estimated Expenses and Taxes Generated[1]

Description	Operating Expenses	Severance Tax	Ad valorem Tax
First Full Year (2007)	$2,000,000	$424,000	$712,000
Maximum Value	$7,300,000	$1,055,000	$1,800,000
Annual Average (40 years)	$3,091,000	$655,000	$1,109,000

[1]Estimates from Howell.

Increased employment and wages also would increase economic activity in the region and state and would result in an increase in personal income tax revenue.

Wage rates for the skilled and unskilled construction workers range from $12 to $19 per hour plus benefits. Assuming an average pay rate of $15.50 per hour at 60 hours per week and 300 construction workers, the estimated construction payroll during Phases III/IV construction would be approximately $600,000 per month for approximately 11 months. A portion of this income would be spent in the local area for goods and services, resulting in a beneficial effect on local businesses such as restaurants, service stations, and retail stores. Oil field workers also would be contributing to the local and regional economy through expenditures for goods, services, housing, insurance, entertainment, and food. Operating positions at Howell would average about $65,000 per year with benefits and would be ongoing for the life of the project.

A summary of actual and estimated capital expenditures by year, from 2003 through 2006, is presented in Table 4-4. Estimated capital expenditures for the Proposed Action beyond 2006 would average about $35 million per year over the next several years, plus approximately $15 million per year for CO_2.

Table 4-4 Phases III/IV Estimated Capital Expenditures

Year	Wells and Equipment	CO_2 Purchases
2003	$74,300,000	$280,000
2004	$34,900,000	$10,250,000
2005	$17,300,000	$19,300,000
2006	$68,800,000	$15,600,000

A portion of the capital expenditures would be spent in the local area for miscellaneous supplies and repairs. This would benefit the local economy.

The current livestock operation associated with the Phases III/IV area would experience a short-term economic loss from a reduction in AUMs available on the Davis Allotment. This is addressed in greater detail in Section 4.12.

4.14.1.4 Infrastructure

Housing

A short-term increase of 50 to 60 households would be a small increment, approximately 0.2 percent, in Natrona County as a whole. If an assumed 25 to 30 of those households would prefer to live in the Midwest-Edgerton area, they may encourage renovation of currently unused homes and they may put increased pressure on local rental rates. The local communities have accommodated a substantially larger population in the past, although the condition of currently vacant residences is uncertain. If as many as all of the new households located in the Casper area, they would increase pressure on an already tight rental housing market. The effect would be very small, however, and there are a substantial number of motels and camping facilities available to relieve the pressure in the short term until the market could accommodate the demand. Extending the life of Salt Creek Oil Field would tend to support additional investment in the supply of housing by increasing the confidence level of builders, developers, and bankers.

Other Public Facilities and Services

The potential population increase in the Midwest-Edgerton area would include an increase of as many as 35 to 45 school-age children. The Midwest schools have accommodated substantially larger numbers of students in the past, however, and the increase would not be expected to be problematic for the school district. All other public facilities and services are believed to have ample capacity to accommodate the modest, short-term population increase associated with project construction.

4.14.1.5 Environmental Justice

Economic and demographic data indicate that minority populations are a small increment of the population of Natrona County. Although average incomes in the Midwest-Edgerton area are lower than for Natrona County as a whole, the percentage of people living at or below the poverty level is not known. However, no adverse impacts to people living in the area from implementation of the Proposed Action have been identified, so there would be no disproportionate environmental impacts on low income or minority populations. Economic effects of the Proposed Project would be expected to be beneficial to the local population. The Native American population is smaller than for the state as a whole and there are no known Native American scared sites on or near the Phases III/IV project area. Consequently, the Proposed Action would not adversely affect environmental justice considerations in the study area.

4.14.2 No Action

4.14.2.1 Population

The No Action Alternative would mean no additional construction workers would be required. Existing personnel would continue to operate the field at current levels as long as it remained economical to produce oil from the field.

4.14.2.2 Employment and Income

The No Action Alternative would not change the current status of employment in Salt Creek Oil Field.

4.14.2.3 Economy

The No Action Alternative would result in a continuation of current operations; the productive life of the oil field would end within approximately 5 to 15 years. Upon completion of reclamation of the oil field, much of the economic rationale for the communities of Midwest and Edgerton would be gone and it is expected that they would decline, as have other resource-based communities throughout the West.

4.14.2.4 Infrastructure

Housing

The No Action Alternative would have no effect on housing demand compared to the existing situation.

Other Public Facilities and Services

The No Action Alternative would cause no measurable effects on public facilities and services.

4.14.2.5 Environmental Justice

No impacts to environmental justice would occur under the No Action Alternative.

4.14.3 Mitigation and Monitoring

4.14.3.1 Population

Because the population growth would be modest and considered beneficial to the local area, no additional mitigation or monitoring measures applicable to area population have been developed for the Proposed Action.

4.14.3.2 Employment and Income

No additional mitigation or monitoring measures applicable to employment and income, which would be considered beneficial, have been developed for the Proposed Action.

4.14.3.3 Economy

No additional mitigation or monitoring measures applicable to the overall economical effects have been developed, except to mitigate the effects for the grazing allotment, which are addressed in Section 4.12.3.

4.14.3.4 Infrastructure

Housing

No additional mitigation or monitoring measures applicable to the relatively small increase in housing demand have been developed. It may be necessary to informally monitor camping on public lands as construction activities have, in some past energy development scenarios, caused problems. The scale of the Proposed Action suggests any such problems would be minor, however.

Other Public Facilities and Services

In the absence of adverse effects, no additional mitigation or monitoring measures applicable to public facilities or services have been developed for the Proposed Action.

4.14.3.5 Environmental Justice

No additional mitigation or monitoring measures applicable to environmental justice review have been developed for the Proposed Action.

4.15 Recreation

4.15.1 Proposed Action

The Proposed Action would have minimal, if any effect on recreation activities in the area. Access through the Phases III/IV area may be restricted at times, but there are ample alternative recreation opportunities nearby to accommodate local recreation needs, including potential increased demand from project-related population increases.

4.15.2 No Action

The No Action alternative would have no effect on recreation in the project area.

4.15.3 Mitigation and Monitoring

No additional mitigation or monitoring measures applicable to recreation have been developed for the Proposed Action.

4.16 Visual Resources

4.16.1 Proposed Action

The Proposed Action would modestly improve the visual character of the project area in the short term by removing pump jacks that would be made obsolete by the EOR Program. Several proposed project facilities, in addition to the well field activities, would be located outside of the Phases III/IV boundaries and would introduce new visual features to the landscape. These features would include an electrical substation (T39N, R79W, NE¼ SW¼ S34), two short segments of a 230-kV transmission line, approximately 6.7 miles of a 34.5-kV distribution line, an electrically powered compression station (T40N, R78W, NE¼ S31), and a bridged CO_2 trunk

line crossing Salt Creek approximately 0.5 mile north of the compression station (the pipeline itself would be buried underground).

The substation and the electric transmission lines would be approximately 3 miles from the major highways; at this viewing distance features of this type would not dominate the view. The distribution lines located outside the Phases III/IV boundaries would cross SR 259 and would parallel it within 0.25 to 0.5 mile; however, it would be a relatively small electrical line, similar to many others in the area and would not be visually dominant.

The proposed compression station and pipeline bridge also would be located within 0.25 mile of SR 259. As with all new buildings, the compression station would be painted in colors to minimize contrast with the natural environment, to be approved by the BLM. The pipeline bridge would be a low, horizontal structure. It would likely be visible from the highway, but would not dominate the views.

In the short term, these project facilities would be visible from public viewing areas and would add to the industrial character of the Salt Creek Field landscape. They would be offset in this time frame by the reduction in pump jacks and related facilities in the well field and by reclamation of obsolete disturbance areas.

In the longer term, most of the disturbance areas would be reclaimed and facilities would be removed, which would be in keeping with the visual resource objective of the ACEC management plan to improve the visual environment (BLM 1980).

Final rehabilitation of the landscape character of the project area would not be accomplished until after closure and reclamation of Salt Creek Oil Field because of the extensive previous disturbance and development.

4.16.2 No Action

The No Action Alternative would have no effect on the visual environment in the short term. It would result in closure and reclamation of the project area in the 5- to 15-year time frame rather than the 20-to 40-year time frame anticipated under the Proposed Action.

4.16.3 Mitigation and Monitoring

No additional mitigation or monitoring measures applicable to visual resources have been developed for the Proposed Action.

4.17 Noise

4.17.1 Proposed Action

The Proposed Action would increase noise in the project area to some degree because of the construction and drilling activities planned in the short term. Operation of CO_2 compressors also would increase noise in the long term to an unknown degree. The compressors would be electrically driven, which would minimize, but not eliminate, the related noise emissions. It is

expected that the close relationship between the oil field and the nearby communities of Midwest and Edgerton would tend to reduce the sensitivity of residents to project-related noise.

4.17.2 No Action

The No Action Alternative would not change the existing noise environment in the project area.

4.17.3 Mitigation and Monitoring

High noise project activities in close proximity to schools should be conducted when schools are not in session. Compressor stations and other long-term noise sources should be constructed away from potential noise sensitive areas or in areas with natural topographic screening to minimize adverse effects of project noise. Howell should log and investigate any noise complaints related to the project to determine whether any unwelcome noise effects could be minimized.

4.18 Transportation

4.18.1 Proposed Action

The Proposed Action would generate an increase in worker commuting traffic during the construction period and an increase in heavy truck traffic particularly during construction and to a lesser extent during operation of the project. An unlikely worst-case scenario of all construction workers driving separately to the project area would only generate an additional 300 vehicle trips in the peak hour, however, which would not cause the LOS to drop out of the "A" level. Truck traffic would have minimal effect on traffic flows, at worst causing some annoyance to drivers in areas where passing is difficult or prohibited. Effects on traffic safety would be minor with the probability of an accident increasing roughly in proportion to the increase in vehicle trips.

4.18.2 No Action

The No Action Alternative would have no perceptible effect on traffic.

4.18.3 Mitigation and Monitoring

No additional mitigation or monitoring measures applicable to transportation have been developed for the Proposed Action.

4.19 Unavoidable Adverse Impacts

Anticipated impacts from implementation of the Phases III/IV project that cannot be fully mitigated have been identified for the Proposed Action. These unavoidable impacts would remain after application of the ACEPMs listed in Section 2.1.6 of the Phase I EA (BLM 2003a), the committed measures listed in Section 2.1.4 of this EA, and a number of construction and operation procedures that Howell has developed as part of the Proposed Action.

Unavoidable adverse impacts from the Proposed Action are summarized for the applicable resource disciplines:

- Fugitive dust: $PM_{10}/PM_{2.5}$ from construction activities and initial temporary increase in vehicular traffic.

- Combustion emissions from mobile sources (gasoline and diesel vehicles) and non-road engines (e.g., drilling/workover rigs): $PM_{10}/PM_{2.5}$, NO_x, SO_2, CO and VOCs, but levels expected to be negligible.

- Potential negligible to minimal air quality impacts from CO_2 seeps in remote locations.

- Minor changes in topography from cut and fill activities for new pad, road, substation, and compressor station construction.

- Extremely low risk to humans and low risk to animals in rural locations only, if future CO_2 seeps surface.

- Some loss of topsoil productivity from vegetation removal, soil compaction, and removal of organic matter; soil exposure and soil loss from wind and water erosion from construction and operation activities until successful reclamation has been achieved and vegetation has re-established; and potential soil contamination from spills or leaks during project development and operation.

- Removal of 145 acres of vegetation in the short-term and 22 acres in the long-term for new disturbance.

- An increase in weed species until successful implementation of the NWMP and site monitoring, following which weed populations would decline through time.

- Removal of 145 acres of relatively low value wildlife habitat in the short-term and 22 acres in the long-term for new disturbance.

- Incremental long-term increase in minor habitat fragmentation and terrestrial wildlife displacement from surface disturbance and increased noise levels until final reclamation.

- Loss of some small- and medium-sized animals that use below-surface burrows along low-lying drainages, if a CO_2 seep were to occur in this area.

- Potential long-term loss during project operation of golden eagle use of existing eagle nest site located approximately 750 feet from the proposed Claim Jumper Switchyard and associated electric power lines.

- Incremental reduction in habitat carrying capacities, potential displacement during construction activities, and possible short-term loss of productivity for that breeding season for sage thrasher, Brewer's sparrow, sage sparrow, and loggerhead shrike.

- Potential impacts to prairie dogs from construction activities in previously undisturbed areas, if avoidance measures are not feasible.

- Some loss of archaeological or cultural resources from unidentified sites.
- A small amount of potential domestic cattle forage lost.
- A small increase in pressure on the already tight rental housing market to a very small degree.
- A localized, short-term increase in noise due to traffic and construction activities, and some long-term, localized increases in noise due to operation of compressors.
- Minor increase in traffic on area roads.

4.20 Relationship Between Short-Term Use of the Environment and Long-Term Productivity

For the Salt Creek Phases III/IV EA, short-term use of the environment is defined as occurring during project construction and development stages. Long-term productivity refers to the life of the project through final successful project reclamation. Use of the combined waterflood and tertiary EOR could ultimately extend operations for another 30 to 40 years and the economic life of the field. Upon final project completion, facility removal, and successful reclamation, the landscape character would return to the nature of the area prior to regional oil development in the long term.

Examples of short-term use of the environment include increased noise; dust; and surface disturbance from new drilling pad, access road and power line construction. These impacts are temporary in nature and mitigatable with current technology and industry practices. Ongoing actions, such as continual road closures, aid in returning the long-term productivity of the land. If reclamation and revegetation were successful within a few years, some of the surface disturbance associated with the Phases III/IV Project would be considered to be short-term Disturbance to the surface areas that cannot be reclaimed in the short term would result in long-term impacts until final field closure and reclamation.

Some of the positive economic benefits identified for the Proposed Action would increase and extend the benefits of employment, energy production, and public fiscal enhancements in the long term, for up to 40 years.

4.21 Irreversible and Irretrievable Commitment of Resources

Construction and operation of the proposed Salt Creek Phases III/IV Project could result in either the irreversible or irretrievable commitment of specific resources. “Irreversible” loss of resources describes the loss of future options. It applies predominantly to the effects that result from the use of “nonrenewable resources,” such as minerals or cultural resources, or to resources that are only renewable over very long periods of time (e.g., soil productivity). “Irretrievable” is defined as a loss of production, harvest, or use of natural resources. Examples of irretrievable resources would be the loss of livestock forage or wildlife habitat during the life of the project for EOR facilities. The forage production lost for livestock or wildlife would be irretrievable,

but the action is not irreversible. As the Salt Creek Basin is reclaimed and facilities are removed, it is feasible that forage production would resume in the long term.

Specific to the proposed Phases III/IV Project, the oil removed from the Salt Creek Basin would be an irreversible and irretrievable commitment of a mineral resource that would no longer be available for future production. There would be an irreversible loss of some soil productivity from project construction, development, and operation. Construction of new drill pads and production facilities would result in an irretrievable loss of vegetation resources and wildlife habitat for the duration of the project and up to the successful completion of reclamation. Similarly, the potential loss of annual production in areas from displacement of breeding wildlife (e.g., birds) during the life of the project would be irretrievable, but not irreversible. Loss of unknown archaeological or cultural resources would be irreversible and irretrievable, if present. Loss of livestock forage production would be an irretrievable commitment of resources, but reversible over a period of a few years. Finally, the commitment of energy resources, materials, and manpower to the Proposed Action would be irretrievable.

5.0 Cumulative Impacts

CEQ (40 CFR 1508.7) defines cumulative impacts as:

> "…the impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

The Proposed Action incorporates a number of committed environmental protection measures structured to reduce, minimize, or avoid adverse impacts on the environment. These measures are presented in Section 2.1.6 of the Phase I EA (BLM 2003a) and Section 2.1.4 of this Phases III/IV EA. Additionally, components of the Proposed Action described for the project in Chapter 2.0 provide further resource protection, where applicable.

As summarized in Section 4.19, Unavoidable Adverse Impacts, residual effects remain after application of these measures to minimize environmental impacts from implementation of the Proposed Action. Other past, present, and reasonably foreseeable future projects in the region also may have residual impacts, and in conjunction with the residual impacts identified for the Proposed Action would result in cumulative effects to specific resources located in and near the Salt Creek Basin. While much of the following discussion focuses on cumulative adverse impacts, it should be noted that beneficial cumulative impacts also would occur, as described.

5.1 Past, Present, and Reasonably Foreseeable Actions

Chapter 5.0 of the Phase I EA (BLM 2003a) details a number of past, present, and reasonably foreseeable future projects identified for Salt Creek Oil Field and its surrounding region. Those projects or actions most directly related to the proposed Phases III/IV EOR Project would be the past 116-year development of the entire Salt Creek Oil Field, including the recent Phases I and II development within the SCLOU; ongoing waterflood and CO_2 EOR projects; and future phase development (through Phases V-X) extending from the SCLOU into the SCSU. From a regional perspective, the Phase I EA also delineates other oil recovery and development projects. Given the current momentum of the oil and gas industry in the Salt Creek and Powder River Basins, future expansions of oil and gas recovery are only expected to increase.

Two new projects identified for the Salt Creek Oil Field area include the 1) WC1 and Minor Horizon CO_2 Flood Development and 2) Powder River Basin Water Pipeline Project. The following summary information provides an overview of these proposed future projects.

5.1.1 WC1 and Minor Horizon CO_2 Flood Development

The Salt Creek field is a large geological structure with multiple hydrocarbon bearing horizons deposited in the central or crestal area of the anticline. These formations have typically been eliminated from consideration for CO_2 development due to miscibility pressure constraints or insufficient reserve potential. Howell is currently pilot testing the reserve recovery efficiency of immiscible CO_2 flooding in the WC1 formation. If proven economically viable, Howell would

plan for crestal development of the WC1 and WC2 formations subsequent to the miscible CO_2 development, likely occurring after 2013. CO_2 flood facilities for the WC1 and WC2 on the crest would be constructed using a similar 20- or 40-acre, 5-spot design basis as used with the previously installed miscible Phases I and II. Howell would evaluate the feasibility of completing multiple formations within a single wellbore to reduce capital requirements and surface disturbance. Expected surface disturbance would be proportional, based on developed acreage, to previous phase development.

The installation of infrastructure for immiscible CO_2 flooding of the WC1 and WC2 would significantly reduce the capital requirement for the Lakota, Sundance, and Tensleep formations, also known as the Minor Horizons. Pilot testing of the Minor Horizons would most likely not occur until at least 2007. If feasible, these formations would be developed similarly to the WC1 and WC2, as described, and Minor Horizon development would be expected to commence subsequent to the WC1 in approximately 2018.

5.1.2 Powder River Basin Water Pipeline Project

The Powder River Basin Water Pipeline Project would transport produced water from coalbed natural gas (CBNG) production in the Wyoming portion of the Powder River Basin to a WDEQ-approved Class V water injection well facility for injection into the Tensleep and Madison formations. These formations are both DEQ Class III aquifers (for livestock use), and injection would be proposed to occur in the vicinity of Midwest, Wyoming. The pipeline system, as proposed, would encompass up to three water pump station facilities to collect and boost the pressure of the CBNG produced water from various fields for transportation to the injection facilities. The system would commence in the County Line Field in Johnson County, Wyoming (T47N R78W). The water would be delivered into a 24-inch, steel water pipeline for transport to the Midwest Injection Facilities where it would again be boosted in pressure to allow for injection into up to five wells. The initial design capacity of the system would be 400,000 barrels of water per day (BWPD).

The Midwest Injection Station would be located on lands owned by Howell immediately within the boundaries of the SCLOU (T40N, R79W, NW¼ S12) in Natrona County. The station site would encompass 5.74 acres. The facility would have an inlet pig catcher, a 47,500-barrel water storage tank, two pump buildings (each housing four 60,000 BWPD centrifugal pumps), and a series of filters. There also would be an electrical substation and an office/shop building.

It is anticipated that there would be up to five wells drilled in the western half of Section 12 and the western half of Section 13 (T40N, R79W), also on lands owned by Howell. These wells would be drilled to the base of the Madison formation and would be used as injection wells for aquifer recharge in the Madison and Tensleep formations. Each well location would be anticipated to disturb approximately 2 acres, or 10 acres of total well pad disturbance. Approximately 2.5 acres of additional disturbance is estimated for roads, assuming a 40-foot-wide access road. An injection header for well control and fluid measurement also would be included for each location.

The distribution system for the wells would consist of a 24-inch, steel pipeline as a backbone and 12-inch, steel lateral lines to deliver the water to the individual wells. The pipeline would

require a 100-foot ROW for construction that would be reclaimed following project completion. The distribution line would be approximately 1.5 miles long from the plant boundary to approximately the southwest quarter of Section 13. This disturbance would be approximately 18.2 acres. The lateral lines would require a construction ROW of approximately 80 feet and have a combined length of 2,754 feet, or a total of 5.05 acres.

The pipeline into the plant from the north would require the same 100-foot-wide ROW and would be approximately 1,500 feet long in Section 12. This distance would equate to 3.45 acres of additional surface disturbance.

Total surface disturbance would, therefore, be approximately 45 acres, of which 18.2 acres would remain disturbed for plant and well operations. All pipeline ROWs would be reclaimed and re-vegetated upon construction completion.

5.1.3 Other CO_2 Development

Other ROWs projects associated with CO_2 development may include extension of the CO_2 pipeline to the Sussex Field to support potential CO_2 development in the Sussex, West Sussex, and Meadow Creek fields. The proposed route for this extension was approved under a previous environmental assessment conducted for PetroSource Corp. These three fields were discovered by Conoco during the 1950s. They are located approximately 15 miles north of Salt Creek Oil Field in Johnson County, Wyoming. The fields contain multiple producing horizons and have been under secondary recovery waterflood operations for many years. Anadarko/Howell acquired these properties from Westport in 2003. CO_2 pilot testing conducted at West Sussex by Conoco and, more recently, by Anadarko at Sussex suggests that these fields may be candidates for future CO_2 flood development. Anadarko is currently conducting detailed reservoir studies to evaluate the tertiary potential. 3D seismic also was recently acquired over this area to help support this potential development and is currently being processed for evaluation. Long-range plans may include additional extension of the CO_2 pipeline to support EOR flooding further north into the Powder River Basin in, as yet, unidentified fields.

5.2 Cumulative Impacts

As discussed, the project area has experienced intensive oil field development and surface disturbance since 1889, encompassing an extensive network of roads, well pads, pump jacks, pipelines, electric power lines, processing facilities, and ancillary actions. Overall, the Proposed Action would incrementally add to the existing and proposed level of development and disturbance within Salt Creek Oil Field. However, as discussed above, measures have been developed to minimize potential impacts, including ongoing reclamation efforts through field development, closure, and abandonment. Section 5.2 of the Phase I EA (BLM 2003a) details the net or residual cumulative impacts identified for development of Phases I-X by resource. The following information outlines those new, cumulative issues identified during the analyses for the proposed Phases III/IV Project in conjunction with the past, present, and reasonably foreseeable actions, as described.

5.2.1 Air Quality

As discussed in Section 5.2.1.1 of the Phase I EA (BLM 2003a), substantial development and oil recovery actions have been ongoing since the field's inception in 1889. Anticipated cumulative effects to air quality from past, present, and reasonably foreseeable future actions in conjunction with the proposed Phases III/IV Project would be incremental and temporary. A temporary increase in emissions of $PM_{10}/PM_{2.5}$ would be expected to occur from initial land surface disturbance activities. Incremental increases in emissions of NO_x, SO_2, CO, and VOCs would be expected to occur in the short term from mobile combustion sources associated with drilling/workover rig engines ("nonroad engines") and the temporary increase in vehicle traffic. However, cumulative air quality impacts would not be anticipated to exceed state or federal ambient air quality standards (NAAQS/WAAQS). No cumulative effects from potential CO_2 releases from current or future CO_2 seeps would be anticipated based on the analyses completed for the Proposed Action and Howell's existing CO_2 Seep Containment Plan.

5.2.2 Geology

No additional cumulative impacts to area geology or topography would be anticipated beyond the modifications to surface topography and recontouring of construction sites, as described in the Phase I EA (BLM 2003a, Table 42).

5.2.3 Water Resources

5.2.3.1 Surface Water

The overall cumulative effects to surface water resources were essentially described both in the Phase I EA (BLM 2003a, Section 5.2.1.3) and in Section 4.3.1 of this EA, as the effects on surface water resources, and specifically Salt Creek, have been described for the EOR program as a whole and not segregated for each development phase. Because a gradual decline in produced water from waterflooding alone is projected, the cumulative effect of the temporary increases in water volumes from the entire EOR program would be to slow the overall decline in produced water discharge volumes to Salt Creek and thence to the Powder River water budget.

Additional oil and gas development in the Salt Creek Basin by other past, present, and reasonably foreseeable future actions on a scale sufficient to significantly influence water quality is not expected, as APC (including Howell) currently discharges over 75% of the total produced water in the Basin, with another 20% by the Naval Petroleum Reserve #3. No significant industrial or residential development would be expected for the foreseeable future in the area that may further affect water quality.

5.2.4 Groundwater

No additional cumulative impacts to groundwater resources would be anticipated based on the ACEPMs, as described in the Phase I EA (BLM 2003a, Section 5.2.1.3) and in Chapter 2.0 of this EA.

5.2.5 Human Health & Safety and Ecological Risks

No additional cumulative impacts to human health and safety or ecological resources would be anticipated. Section 4.4 describes the relative impact assessment for the ongoing Phases I and II projects, forecasting future potential occurrences and exposure probabilities. The implementation of Howell's CO_2 Seep Containment Plan and approaches for controlling and monitoring CO_2 flooding as part of the Phases III/IV Proposed Action (see Chapter 2.0) would be anticipated to continue to locate, control, and minimize future seep occurrences. No other CO_2 sources would apply to the cumulative impacts analysis for human health and ecological risks. In summary, the likelihood of exposure to CO_2 is very low for humans and low for small burrowing mammals and ground-dwelling birds, and potential cumulative effects would essentially be the same as those discussed in Section 4.4 of this EA.

5.2.6 Soils and Reclamation

No additional cumulative impacts to soils and reclamation efforts would be anticipated beyond the incremental increase in soil loss, surface compaction, and potential contamination, as described in the Phase I EA (BLM 2003a, Table 42). However, the majority of cumulative impacts to soil resources would be expected to be short-term and associated primarily with initial land disturbances associated with construction activities in the Salt Creek Basin related to upgrading existing infrastructure and adding new wells, roads, and pipelines.

5.2.7 Wetlands

No impacts to wetlands or riparian habitats would be anticipated for the Proposed Action; therefore, no cumulative effects would apply to this analysis.

5.2.8 Vegetation and Weeds

Removal of vegetative cover and disturbance of soils from cumulative projects may result in accelerated wind and water erosion, and an associated increase in sediment yield above natural background levels in the short term. Following successful reclamation measures of the project area, native vegetation would be expected to re-establish. Cumulative disturbances delineated within the entire Salt Creek Oil Field were estimated at 4,900 acres in the Phase I EA (BLM 2003a). Adding the potential future projects, WC1 and Other Minor Horizon Development and the Powder River Basin Water Pipeline Project, would increase anticipated cumulative surface disturbance to be approximately 5,000 to 5,200 acres, assuming similar development scenarios as used for previous and current Salt Creek Oil Field developments.

Noxious weed populations would likely increase to some degree in the short term, as additional well, corridor, and facility sites are disturbed. Implementation of the NWMP (Appendix B, Noxious Weed Management Plan) during operations would serve to decrease to manageable levels or, in some instances, eliminate noxious weed populations in the proposed disturbed areas. The successful application of the NWMP would result in a decrease in such weed populations in the region as compared to projects and developments that do not have a similar plan in place. Therefore, the activities associated with the project would not contribute to the long-term increase in noxious weed populations in the region and no increase in cumulative impacts would be expected.

5.2.9 Terrestrial Wildlife

Potential cumulative impacts to terrestrial wildlife would primarily involve the incremental habitat fragmentation and loss throughout the region, as oil and gas development projects continue to be implemented. The increase in field infrastructure, human presence and activities, and ongoing projects' operations would continue to displace some terrestrial wildlife species more susceptible to disturbances than those species that are more likely to habituate to human activities and increasing surface disturbance. Loss of some animals also would occur. However, given the historic use by the oil and gas industry, relative habitat values, the existing levels of habitat fragmentation, ongoing habitat loss, and direct effects to individual animals occurring over the last 100 years in and near the Salt Creek Basin, the incremental cumulative impacts to wildlife would not be expected to significantly affect these populations.

5.2.10 Aquatic Biology

No adverse impacts to aquatic biological resources would be anticipated for the Proposed Action; therefore, no cumulative effects would apply to this analysis.

5.2.11 Special Status Species

5.2.11.1 Plants

No threatened, endangered, or sensitive plant species are known to occur in the project area. Habitat for these species is lacking for all but the sensitive species, Nelson's milkvetch. Habitat for this species is minimal, and occurs in limited areas. Environmental protection measures limiting development on steep slopes, where such habitat may occur, has been committed to by Howell (BLM 2003a). Therefore, no cumulative impacts to special status plant species would be anticipated.

5.2.11.2 Terrestrial Animals

No federally listed wildlife species are known to occur in the area of the Proposed Action; therefore, no cumulative effects to federally endangered or threatened species would occur. Potential cumulative effects to the federal candidate species (black-tailed prairie dog) and the other BLM sensitive species examined for the Proposed Action would predominantly entail the incremental habitat fragmentation and loss throughout the region, as described for terrestrial wildlife species (Section 5.2.8).

5.2.12 Aquatic Species

No adverse impacts to sensitive aquatic biological resources would be anticipated for the Proposed Action; therefore, no cumulative effects would apply to this analysis.

5.3 Cultural Resources

No additional cumulative impacts to archaeological or cultural resources would be anticipated beyond the potential impacts to known or unknown cultural sites, as described in the Phase I EA (BLM 2003a, Table 42, Section 5.2.1.7). The past use and disturbances associated with Salt

Creek Oil Field do not preclude the possibility of intact archaeological remains existing at depth as is suggested on site forms for some previously recorded sites (see Table 3-9). However, the ACEPMs developed to protect any undiscovered sites would minimize potential cumulative impacts to archaeological or cultural finds.

5.3.1 Range Management and Grazing Resources

Cumulative issues anticipated for range and grazing resources would parallel those discussed for the Proposed Action in Section 4.12. Cumulative grazing impacts would entail the incremental loss of livestock forage and reduction in associated AUMs throughout the project region until successful reclamation mitigation efforts restore or replace loss of livestock forage production.

5.3.2 Land Use

Potential cumulative impacts associated with regional land use would primarily involve cumulative effects to grazing, as discussed in Section 5.2.12. Other cumulative land use impacts would include the incremental increase in oil field infrastructure and use in and near the Salt Creek Basin.

5.3.3 Socioeconomics

No additional cumulative impacts to socioeconomical conditions would be anticipated beyond the beneficial increase in regional employment opportunities and tax base and the incremental increase in housing and other public services demands, as described in the Phase I EA (BLM 2003a, Table 42, Section 5.2.1.8) and in Section 4.14 for the Proposed Action.

5.3.4 Recreation

Minimal, if any, adverse impacts to recreational resources would be anticipated for the Proposed Action; therefore, no cumulative effects would apply to this analysis.

5.3.5 Visual Resources

Cumulative impacts to visual resources would be similar to those discussed for the Proposed Action in Section 4.16. An incremental increase in oil field infrastructure would introduce new visual features to the landscape, adding to the industrial character of the area. Some of the cumulative effects would be offset by the ongoing reduction in pump jacks and related facilities in the well field and by reclamation of obsolete disturbance areas.

5.3.6 Noise

No additional cumulative impacts to sensitive receptors from an incremental increase in noise levels would be anticipated beyond localized short-term increase in construction-related noise levels, as described in the Phase I EA (BLM 2003a, Section 5.2.1.4) and long-term noise sources during project operation (Section 4.17 of this EA).

5.3.7 Transportation

No additional cumulative impacts to transportation would be expected beyond the incremental increase in traffic volumes during project construction and operation, as described in Section 4.18 of this EA. No adverse impacts to traffic safety would be anticipated for the Proposed Action; therefore, no cumulative effects would apply to this resource issue.

6.0 Consultation and Coordination

6.1 Consultation

Bureau of Land Management (BLM), Casper Field Office

- Patrick Moore, Assistant Field Manager, Minerals and Lands
- Jim Bauer, Physical Scientist: EA Project Manager
- Ken McMurrough, Physical Scientist: Technical Reviewer
- Dave Chase, Petroleum Engineer
- Joe Meyer, Soil Scientist: Soils
- Jim Wright, Wildlife Biologist: Terrestrial and Aquatic Biology, Special Status Species
- Chris Arthur, Archaeologist: Cultural Resources
- John Mesrobian, Lead Petroleum Engineer Technician
- Eve Bennett, Recreation Planner: Visual Resources
- Bruce Parker, Range Management Specialist: Range Management and Grazing Resources
- Celia Skillman, Realty Specialist: Reviewer

Project Applicant – Howell/Anadarko Petroleum Corporation

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- Danny Morse, Area Production Superintendent
- Dan Victor, Staff Reservoir Engineer
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- Bjorn Bjorkman, Toxicologist: Surface Water Resources, Human Health & Safety and Ecological Risks, Aquatic Biology; Special Status Aquatic Species, CO_2 Review
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- Christian Zier, Archaeologist: Cultural Resources
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- Mike Phelan, Botanist: Wetlands and Vegetation
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- Brenda Schladweiler, Soil Scientist, Reclamation Specialist, and Vegetation Ecologist: Soils and Reclamation, Range Management and Grazing Resources

Planera

- Bernie Strom, Planner: Land Use, Environmental Justice, Socioeconomics, Recreation, Visual Resources, Noise, Transportation

6.3 Coordination

The following agencies were involved in the document review:

Federal Government Agencies

- Natural Resources Conservation Service, Steve Jelden and Everett Bainter
- U.S. Fish and Wildlife Service

State Government Agencies

- State Historic Preservation Office
- Wyoming Game and Fish Department

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AIR DISPERSION MODELING
OF WELL BLOWOUT AND PIPELINE RUPTURE SCENARIOS
SALT CREEK FIELD

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Appendix A Carbon Dioxide Dispersion Test at 12WC2NE14
Appendix B Carbon Dioxide Dispersion Test – Monitoring Results

1. INTRODUCTION

Howell Petroleum Corporation (Howell) is currently installing a carbon dioxide enhanced oil recovery system, also known as carbon dioxide flooding, at its Salt Creek Field. The flooding technique is used to increase oil production from fields that have been depleted using primary and secondary oil recovery methods. Howell retained Cameron-Cole LLC to perform air dispersion modeling studies to estimate downwind carbon dioxide and hydrogen sulfide concentrations resulting from various well blowout and pipeline rupture scenarios.

The Environmental Protection Agency (EPA) - approved Dense Gas Dispersion (DEGADIS) model was utilized to model vertical releases associated with the scenarios. DEGADIS is a dispersion model that estimates downwind or downgradient concentrations of dense (heavier than air) gases. DEGADIS is primarily used to determine distances of transit resulting in defined gas concentrations. For example, DEGADIS can be used to define the potential extent of migration of concentrations defined to be hazardous based on EPA risk assessment protocols or Occupational Safety and Health Administration (OSHA) exposure thresholds. DEGADIS is capable of modeling finite or continuous release sources either at ground level or as a defined jet. DEGADIS can also model transient scenarios, where flow rates vary with time.

A second EPA-approved model, SLAB, was employed to model horizontal releases resulting from pipeline ruptures. SLAB also simulates the atmospheric dispersion of denser-than-air releases. However, it was developed to model horizontal jet releases in addition to vertical jet releases. SLAB calculates the concentration at downwind locations by solving the conservation equations of mass, momentum, and energy. SLAB handles release scenarios including ground level and elevated jets, liquid pool evaporation, and instantaneous volume sources.

Modeling output was generally compared to the 10 minute Time Weighted Averages (TWA) of hydrogen sulfide (10 parts per million [ppm]) and carbon dioxide (5,000 ppm), the Immediately Dangerous to Life or Health (IDLH) threshold for hydrogen sulfide (100 ppm) and the Short Term Exposure Limit (STEL) for carbon dioxide (30,000 ppm).

2. WELL BLOWOUT SCENARIO

The DEGADIS model is accompanied by a number of various modules that can be executed in series. For the purpose of modeling the release of pressurized gas for a well blowout, the JETPLU module (based on the Ooms model) was used. This module is intended to predict the trajectory and dilution of a denser than air jet plume which has significant upward momentum. For a well blowout, the release rate would be extremely fast, and it was necessary to include the gas' momentum in the dispersion modeling. The JETPLU module outputs concentrations at ground level and at a selected level (five feet or the breathing zone, was used in this case) as well as the point at which the gas cloud impacts the ground. JETPLU in conjunction with a second module (DEGBRIDG) can create an input file to DEGADIS based on concentrations at the point at which the plume first contacts ground level. However, it was found that for all of the conditions modeled, the concentration of the plume after it touched down was well below 5,000 ppm carbon dioxide, and thus it was not necessary to run the DEGADIS model.

2.1. INPUT PARAMETERS

Howell supplied the expected exhaust gas parameters for a well blowout:

- Release Rate: 16 million standard cubic feet per day (MMSCFD)
- Release Temperature: 0°Fahrenheit (F)
- Pipe Diameter: 2.2 inches internal diameter
- Duration of blowout - 36 to 48 hours
- Gas composition -

  96.3% Carbon Dioxide

  0.7 % Nitrogen

  2.7 % Methane

  0.2 % Butane

  0.018% Hydrogen Sulfide

The gases released under these conditions will be moving very quickly, over 8,000 ft/sec, several times the speed of sound. Numerous hazards are associated with this type of release. The only hazard addressed by this report is the risk associated with inhalation of these gases.

For simplicity, it was assumed that the release was 100% carbon dioxide. At these concentrations, assuming that the hydrogen sulfide disperses with the carbon dioxide, the carbon dioxide concentration will be the primary inhalation concern for a well blowout. The modeling runs were made using the most conservative blowout duration, assuming a constant release that lasts 48 hours.

Howell requested that the well blowout be modeled with the weather parameters held constant at worst case conditions. With a high momentum release, such as the one proposed here, the model shows that the plume will lift into the air and then gradually drift downwind based on the influence of gravity.

2.2. SENSITIVITY ANALYSIS

In order to ascertain worst case conditions, a sensitivity analysis was performed. The initial analysis showed that the worst case weather conditions were hot ambient temperatures, low winds and high ambient pressures. The Pasquill Stability Class sensitivity analysis (Table 1) results showed that the worst of the three cases considered was the intermediate Stability Class (D) rather than either the more stable (F) or the less stable (B) Stability Classes considered. This is due to the complex interaction of Stability Class and elevated plumes. Thus it was considered appropriate to determine whether the worst case Stability Class remained Class D, after setting all other parameters to their final worst case settings in the model. The results of this secondary sensitivity analysis which include only the effect of Pasquill Stability Class are shown in Table 2. The results show that at these conditions, Stability Class D again results in the worst case scenario.

2.3. MODEL RESULTS

Despite these conservative assumptions, in all of the runs at all of the weather conditions tested, the maximum concentration of carbon dioxide at ground level and in the breathing zone (five feet) was 192 ppm, well below the lowest regulatory threshold of 5,000 ppm. Hydrogen sulfide concentrations are well below 1 ppm under all conditions, and are also not expected to be of concern.

It should be noted that this model does not evaluate conditions in the immediate vicinity of the blowout (generally a radius of about 100 feet from the center of the source) for these input parameters. However, if there is a blowout, people within the immediate vicinity of the blowout will face considerable hazards in addition to any inhalation hazard, and once the blowout has occurred, it is recommended that access in the immediate vicinity of the site be limited to those with appropriate respiratory apparatus and other appropriate safety gear.

3. HYDROGEN SULFIDE SCENARIOS

DEGADIS was utilized to model four scenarios depicting hydrogen sulfide releases at Howell's Salt Creek Field. The radii of exposure based on the Pasquill – Gifford equation for each of the scenarios was also calculated.

Three of the scenarios (Cases 1, 2 and 3) were based on the worst case conditions as determined by the Monte Carlo analyses contained in the Air Dispersion Modeling in Support of Risk Analysis Report (Cameron-Cole, April, 2005). The Monte Carlo simulations utilized actual weather conditions and varied the input parameters to determine the effects on the output from the DEGADIS model. It was determined that minimum wind speed, a Wind Stability Class of D and high ambient temperatures created the worst case conditions (highest downwind hydrogen sulfide concentrations). The fourth scenario utilized Case 3 input parameters except for the high ambient temperature. A lower ambient temperature was used to evaluate lesser downwind concentrations.

The details of each scenario and the associated output presented below.

3.1. CASE 1 – WELL BLOWOUT

- Wind speed - approximately 1 mile per hour (mph)
- Stability Class - B, D and F
- Ambient temperature - 100°F
- Atmospheric pressure - 0.87 atmosphere (atm)
- Relative humidity - 56%
- Gas flow rate - 16 mmscfd
- Hydrogen sulfide concentration - 180 ppm
- Diameter - 2 7/8 inch tubing

Results - no breathing zone hydrogen sulfide concentrations greater than or equal to 10 ppm.

3.2. CASE 2 – WELL BLOWOUT

- Wind speed - approximately 1 mph
- Stability Class - B, D and F
- Ambient temperature - 100°F
- Atmospheric pressure - 0.87 atm
- Relative humidity - 56%
- Gas flow rate - 16 mmscfd

- Hydrogen sulfide concentration - 450 ppm
- Diameter - 2 7/8 inch tubing, 5 inch casing and 8 5/8 inch casing

Results - no breathing zone hydrogen sulfide concentrations greater than or equal to 10 ppm.

3.3. CASE 3 – PIPELINE LEAK

- Wind speed - approximately 1 mph
- Stability Class - B, D and F
- Ambient temperature - 100°F and 32°F
- Atmospheric pressure - 0.87 atm
- Relative humidity - 56%
- Gas flow rate - 2.5 mmscfd
- Hydrogen sulfide concentration - 22,000 ppm
- Diameter – 4 inch pipe

Results - at 100°F, hydrogen sulfide concentrations in excess of 10 and 100 ppm were predicted (Figure 1). Hydrogen sulfide concentrations in excess of 10 ppm were also predicted with an ambient temperature of 32°F (Figure 2). Because of plume rise due to momentum and temperature, downwind breathing zone concentrations were only predicted to occur once the plume settled to the ground.

3.4. PASQUILL – GIFFORD RADIUS OF EXPOSURE

The more conservative Pasquill – Gifford Radius of Exposure calculation was also utilized to estimate the downwind distance the 100 and 500 ppm hydrogen sulfide plumes would drift before dissipating. Case 1 input parameters produced 100 and 500 ppm radii of exposure of 195 and 89 feet, respectively (Figure 3). Case 2 input parameters yielded 100 and 500 ppm radii of exposure of 347 feet and 158 feet, respectively (Figure 4). Finally, Case 3 calculations determined the 100 and 500 ppm radii of exposure would be 1,237 and 565 feet, respectively (Figure 5). The Pasquill – Gifford calculation does not allow for the input of ambient temperature, therefore, only three scenarios were calculated.

Hydrogen sulfide concentration results from the DEGADIS model and the Pasquill – Gifford Radius of Exposure calculation were plotted on a topographic map of the Salt Creek Field. Rather than plot the data based on specific wind directions, a circular concentration field was used to illustrate the potential hydrogen sulfide concentrations, regardless of wind direction. The DEGADIS model did not predict hydrogen sulfide concentrations greater than or equal to 10 ppm would result from Case 1 or Case 2 input data. Case 3 high temperature input data yielded a narrow band (six to 13 feet) of 10 and 100 ppm concentrations (Figure 6) 270 feet from the source. Case 3 low temperature input data resulted in a 10 ppm concentration band approximately 200 feet wide (Figure 7) 550 feet from the source.

The Pasquill – Gifford Radius of Exposure calculation does not take into account plume rise. So, the 100 and 500 ppm concentration fields are assumed to extend uniformly from the source to the downwind limits of exposure. Cases 1, 2 and 3 radii of exposure are presented on Figures 8, 9 and 10, respectively.

4. COMPARISON OF SLAB RESULTS WITH THE CONTROLLED RELEASE DATA

On May 17, 2005 carbon dioxide was released from a wellhead at the 12WC2NE14 location in order to validate and field test the dispersion modeling. The controlled release commenced at 5:00 a.m. and continued for 30 minutes. The flow rate was held constant at 8.0 MMSCFD, while the release pressure was maintained at 1000 pounds per square inch (psi). Additional details on the experimental procedures and equipment are included in Appendix A.

Weather conditions were estimated based on data from Casper, Wyoming as recorded on the website www.wunderground.com. Casper weather conditions at 4:53 a.m. were as follows:

- Temperature 60.1° F
- Humidity 42%
- Wind Speed 6.9 mph
- Wind Direction SE

Based on the time of day and the wind speed, the Pasquill Stability Class was estimated to be C, or moderately unstable.

Eight carbon dioxide monitors were installed at locations specified with a bearing (degrees off north) and a distance from the source. Four of the monitors were placed one foot off of the ground, and four were placed in the breathing zone, four feet off the ground. The eight locations are presented in Table 3.

Monitoring results are included in Appendix B. Monitoring results prior to the start of the test suggest that background levels at the monitoring locations are about 600 ppm, although measured values range from 556 ppm (Location 5) to 806 ppm (Location 6).

The SLAB model was run using a horizontal release rate of 8 MMSCFD (4.9 kilograms per second [kg/s] of carbon dioxide) exiting through a 2 - inch diameter pipe. The model results are plotted in Figures 11 through 13. The monitoring data recorded 15 minutes after the start of the controlled release are included on the figures.

Generally, the monitoring results from Locations 3, 5 and 8 are close to background levels throughout the controlled release. This is not surprising considering they are west, or north of the source. The pressurized plume was being released directly east. However all three sites have occasional hits of higher carbon dioxide levels, presumably due to shifting winds. The SLAB model predicts that the plume will move due east from the source, and that there will be no impacts to the north, south and west of the source.

Monitoring Location 1 showed carbon dioxide concentrations ranging from about 600 ppm to a high of over 6,000 ppm after the monitoring location is first impacted about 10 minutes into the controlled release. In comparison, the model predicts concentrations would be about 20,000 ppm at this location.

Monitoring Location 2 showed a similar but slightly lower concentration range. Measured carbon dioxide concentrations ranged from background (approximately 600 ppm) to a high near 5,800 ppm. This was in good agreement with the model which predicted a concentration of about 3000 ppm.

Monitoring Locations, 4, 6 and 7 were within one foot of the surface and showed considerably higher concentrations. Location 4 generally showed concentrations that varied between 9,000 and 13,000 ppm. The modeled concentration was about 5,000 ppm. Over the course of the release period, the concentration at Location 6 remained about 8,000 ppm. In comparison, the modeled concentration was about 1,000 ppm. Location 7 concentrations varied widely from about 8,000 ppm up to a maximum of almost 14,000 ppm. In comparison, the modeled concentration was only about 300 ppm.

The modeled concentrations varied above and below, although within an order of magnitude of, the measured concentrations. The only exception was Location 7, for which the monitored concentrations were about 40 times higher than the modeled concentrations. Disparities may be attributable to shifting winds, or more likely, the variable topography of the site. Neither DEGADIS nor SLAB were designed to allow for specific topographical input data. Both models use very basic terrain factors, which can lead to skewed results.

5. PIPELINE RUPTURE - HORIZONTAL AND VERTICAL RELEASES

Thirty-two different scenarios were modeled. These included both a horizontal and a vertical release, four different release rates, carbon dioxide and hydrogen sulfide components, and receptors located at ground level (the worst case for heavier than air gases) and at four feet (generally considered the breathing zone). The results are included in Table 4 and Figures 14 through 21. Horizontal jet releases were modeled using SLAB, and vertical jet releases were modeled using the DEGADIS model.

All runs were made at F stability and a wind speed of 1 meter per second. These are considered extremely stable conditions at which dispersion is minimized. This will result in the highest maximum concentrations for horizontal releases.

Hydrogen sulfide concentrations were assumed to be 322 ppm in the released gas. Since neither the SLAB model nor the DEGADIS model have the capabilities to predict emissions of secondary constituents, it was assumed that hydrogen sulfide dispersed with the carbon dioxide and their relative concentrations remained constant. Thus, the 30,000 ppm carbon dioxide (STEL) contour coincides with the 10 ppm hydrogen sulfide contour (10 minute TWA), and the 300,000 ppm carbon dioxide contour approximates the 100 ppm hydrogen sulfide (IDLH) contour.

5.1. HORIZONTAL RELEASES

The results of the horizontal release modeling show that the scenario release rates could result in carbon dioxide impacts exceeding 30,000 ppm (STEL) 300 feet from the source and 5,000 ppm (10 minute TWA) 4100 feet from the source. Modeled hydrogen sulfide concentrations exceeded 10 ppm (10 minute TWA) approximately 300 feet from the source. Hydrogen sulfide concentrations are not predicted to exceed 100 ppm (IDLH) in the breathing zone. However, hydrogen sulfide concentrations are predicted to exceed 100 ppm (IDLH) at ground level, but only within the first 13 or 14 feet of the source.

5.2. VERTICAL RELEASES

The plumes resulting from vertical jet release scenarios are predicted to dissipate before settling to the ground. Concentrations exceeding 5,000 ppm carbon dioxide (10 minute TWA) and 10 ppm hydrogen sulfide (10 minute TWA) are not predicted to occur in the breathing zone or at ground level.

TABLES

Table 1

Sensitivity Analysis - Well Blowout Modeling

Howell Petroleum
Salt Creek Field, Wyoming

Parameters	Baseline	Tested Values	Change from Baseline					
			Breathing Zone (1.5 m above ground)			Ground Level		
			Max. Concentration	Distance to Max. Concentration	% Increase over Baseline Max. Concentration	Max. Concentration	Distance to Max. Concentration	% Increase over Baseline Max. Concentration
Windspeed (mph)	3	1	71.8	9,000	3.7	66.8	1,022	3.9
		6	4.9	65,790	-0.7	4.1	99,940	-0.7
Elevation at which Windspeed is Measured (meters)	10							
Surface Roughness (meters)	0.2							
Pasquill Stability Class	F	B	30.3	1,602	1.0	24.7	8,551	0.8
		D	62.0	46,520	3.0	50.3	57,130	2.7
Monin-Obukhov	Calculated							
Ambient Temp. (K)	310.8	244.1	5.5	77,980	-0.6	4.9	96,790	-0.6
		280.2	10.4	46,520	-0.3	9.0	57,130	-0.3
Ambient Pressure (atm)	0.83	0.87	16.8	31,130	0.1	14.7	37,920	0.1
		0.79	14.1	37,830	-0.1	12.5	45,520	-0.1
Relative Humidity (%)	56							
Abs. Humidity	Calculated							
Ambient Air Density	Calculated							
Gas Temp. (K)	255							
Flow Rate (kg/s)	11.6							
Source Radius (m)	0.0558							
Source Elevation (m)	0.4 [a]							
Carbon Dioxide Concentration	Baseline		15.4	34,330	0.0	13.6	41,460	0.0

[a] Minimum allowed by model

Table 2

Sensitivity Analysis - Stability Class

Howell Petroleum
Salt Creek Field, Wyoming

Parameters	Baseline	Tested Values	Change from Baseline					
			Breathing Zone (1.5 m above ground)			Ground Level		
			Max. Concentration (ppm)	Distance to Max. Concentration	% Increase over Baseline Max. Concentration	Max. Concentration (ppm)	Distance to Max. Concentration	% Increase over Baseline Max. Concentration
Windspeed (mph)	1							
Elevation at which	10							
Surface Roughness (meters)	0.2							
Pasquill Stability Class	D	B	134.1	1,124	-0.8	112.8	1,330	-0.9
		F	71.8	9,003	-0.6	66.8	9,716	-0.6
Monin-Obukhov	Calculated							
Ambient Temp. (K)	310.8							
Ambient Pressure (atm)	0.87							
Relative Humidity (%)	56							
Abs. Humidity	Calculated							
Ambient Air Density	Calculated							
Gas Temp. (K)	255							
Flow Rate (kg/s)	11.6							
Source Radius (m)	0.0558							
Source Elevation (m)	0.4 [a]							
Baseline Worst Case (Carbon Dioxide)	D	D	192.4	1,370	0.0	181.5	1,454	0.0
Hydrogen Sulfide Concentration			0.035			0.033		

[a] Minimum allowed by model

Table 3

Controlled Release
Monitor Locations

Location	Distance From Ground (feet)	Distance From Source (feet)	Bearing From Source
1	4	53	64°
2	4	110	122°
3	4	59	210°
4	1	206	89°
5	1	146	187°
6	1	450	98°
7	1	400	76°
8	4	103	360°

Notes:

Bearing From Source = degrees off North

Table 4

SLAB Modeling Results
Pipeline Rupture
Horizontal Release

Receptor Height (feet)	Source Release Rate (MMSCFD)	Pipe Diameter (inches)	Maximum Distance From Source at which CO_2 Concentration Exceeds 5,000 ppm (feet)	Maximum Distance From Source at which H_2S Concentration Exceeds 100 ppm (feet)	Maximum Distance From Source at which CO_2 Concentration Exceeds 30,000 ppm and H_2S Exceeds 10 ppm (feet)
4	10	3	905	NA	148
4	30	6	1889	NA	260
4	250	12	4047	NA	268
4	290	16	4049	NA	263
Ground level	10	3	1018	14	192
Ground level	30	6	1982	13	293
Ground level	250	12	4087	13	270
Ground level	290	16	4089	13	266

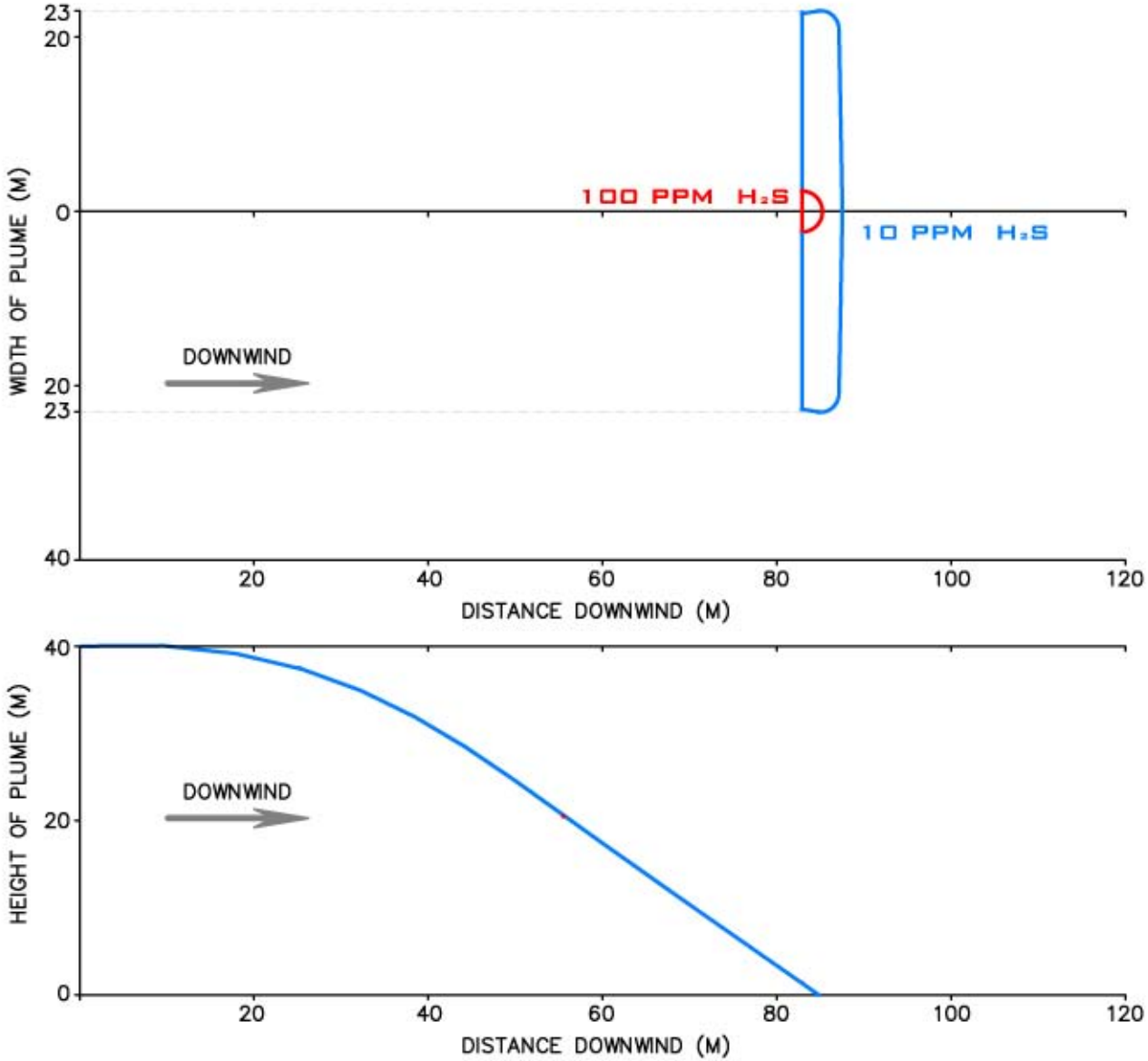
Notes:

Maximum occurs along centerline of plume in the direction of the release.

F Stability

Windspeed = 1 meter/second

FIGURES

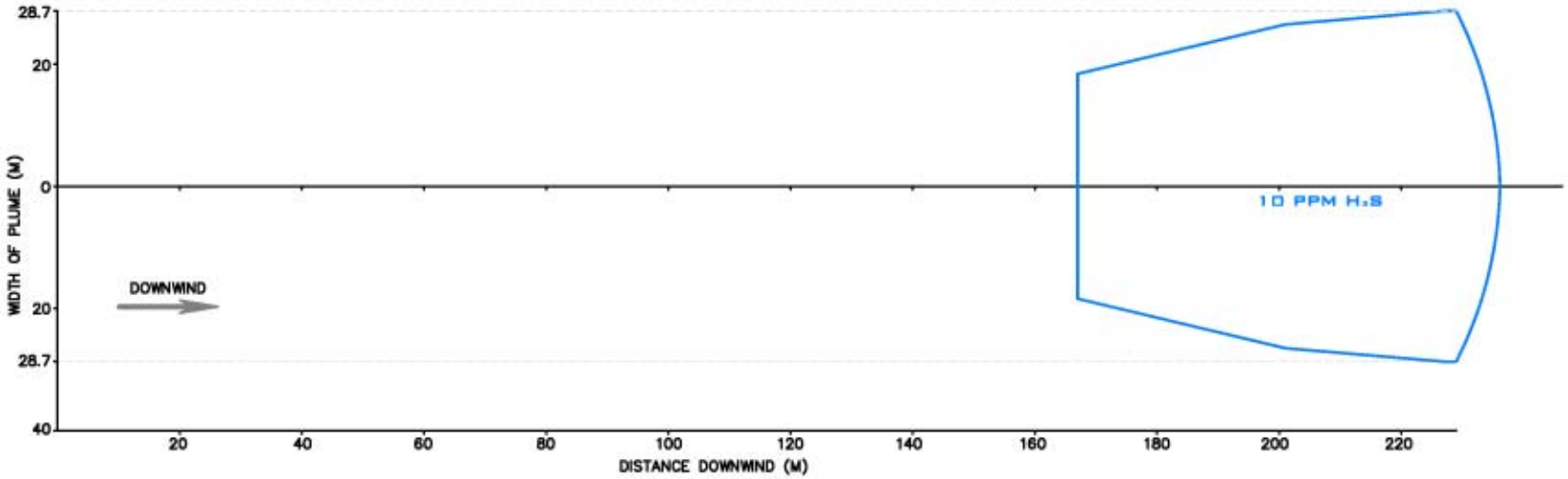


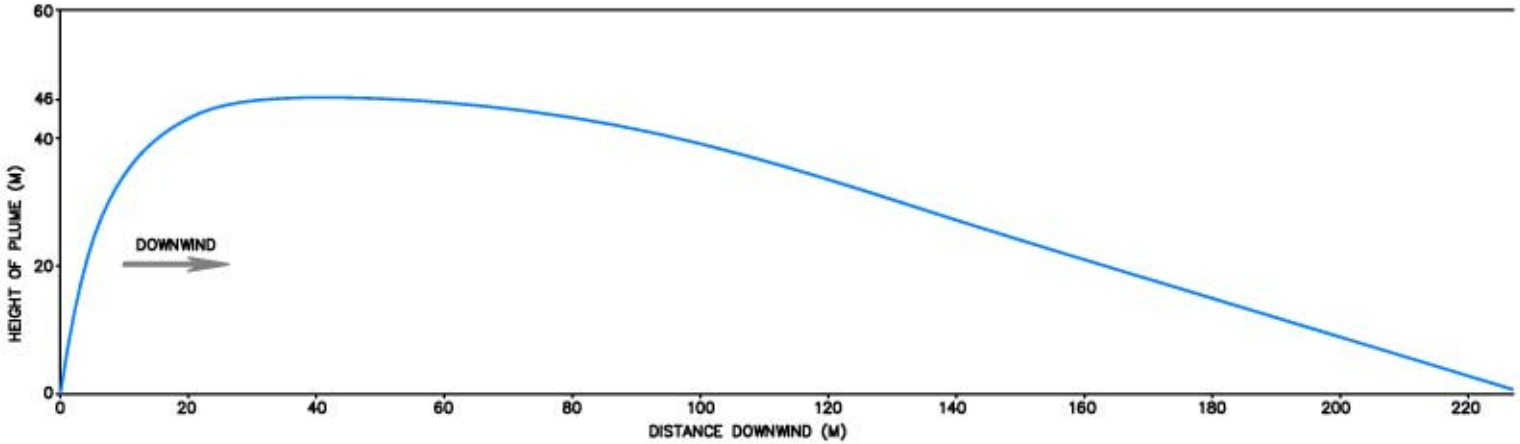
CAMERON-COLE

FIGURE 1

BLOWOUT PLUME DISPERSION
HIGH TEMPERATURE
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
AS NOTED	3/23/05	1065-35



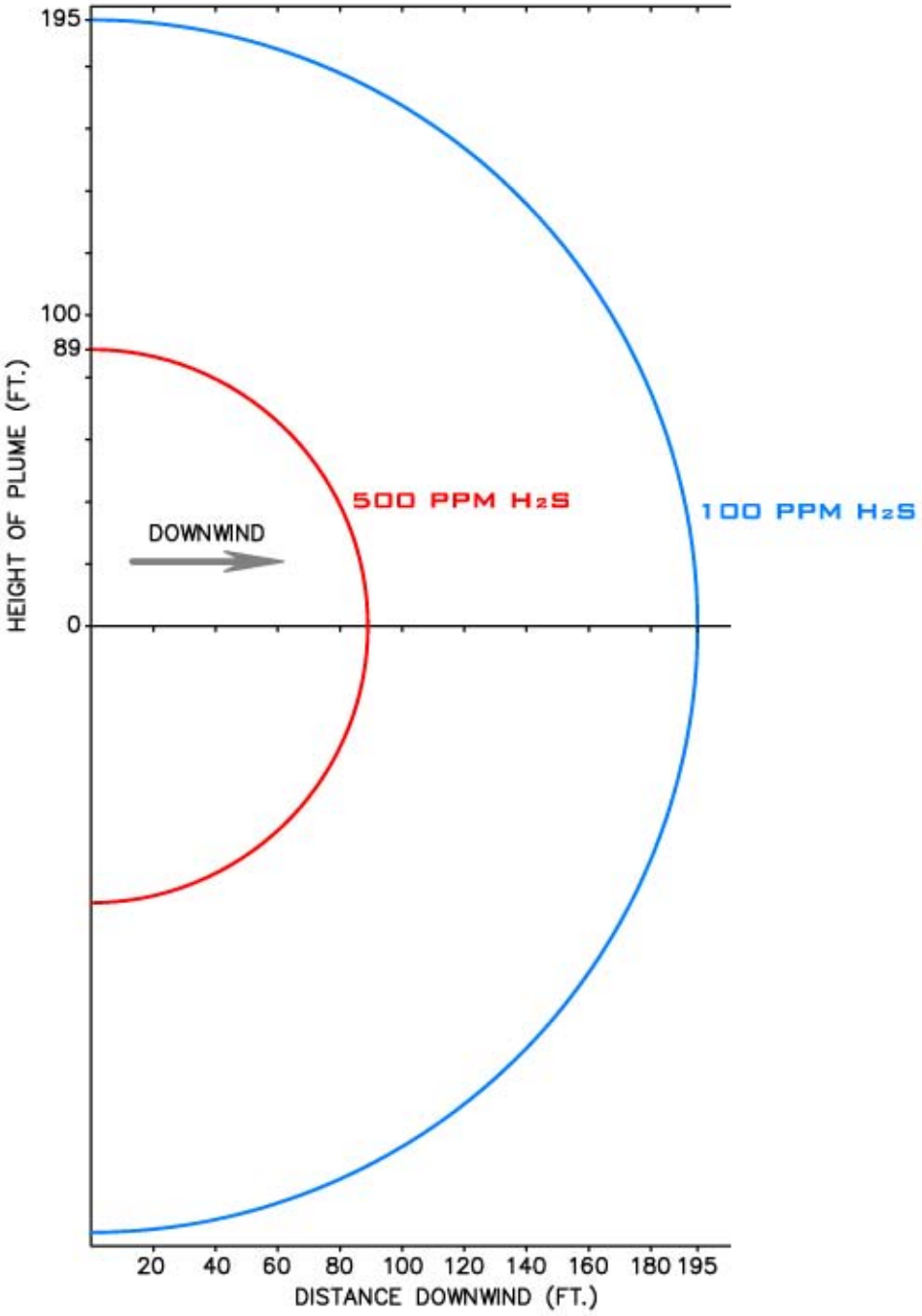


CAMERON-COLE

FIGURE 2

BLOWOUT PLUME DISPERSION
LOW TEMPERATURE
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
AS NOTED	8/5/05	1065-36

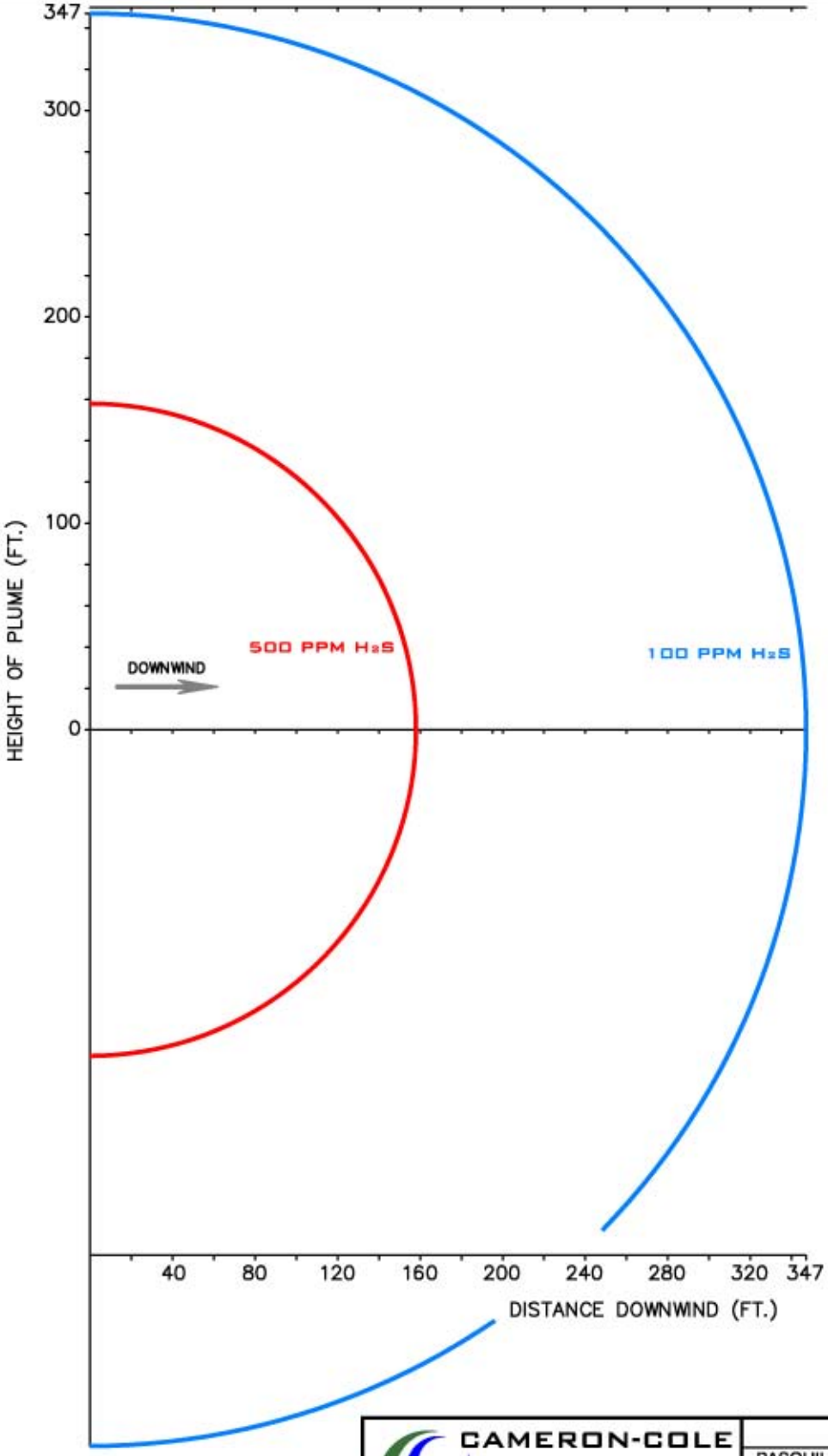


CAMERON-COLE

FIGURE 3

PASQUILL-GIFFORD RADIUS OF EXPOSURE
BLOWOUT-CASE 1
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
AS NOTED	8/5/05	1065-37

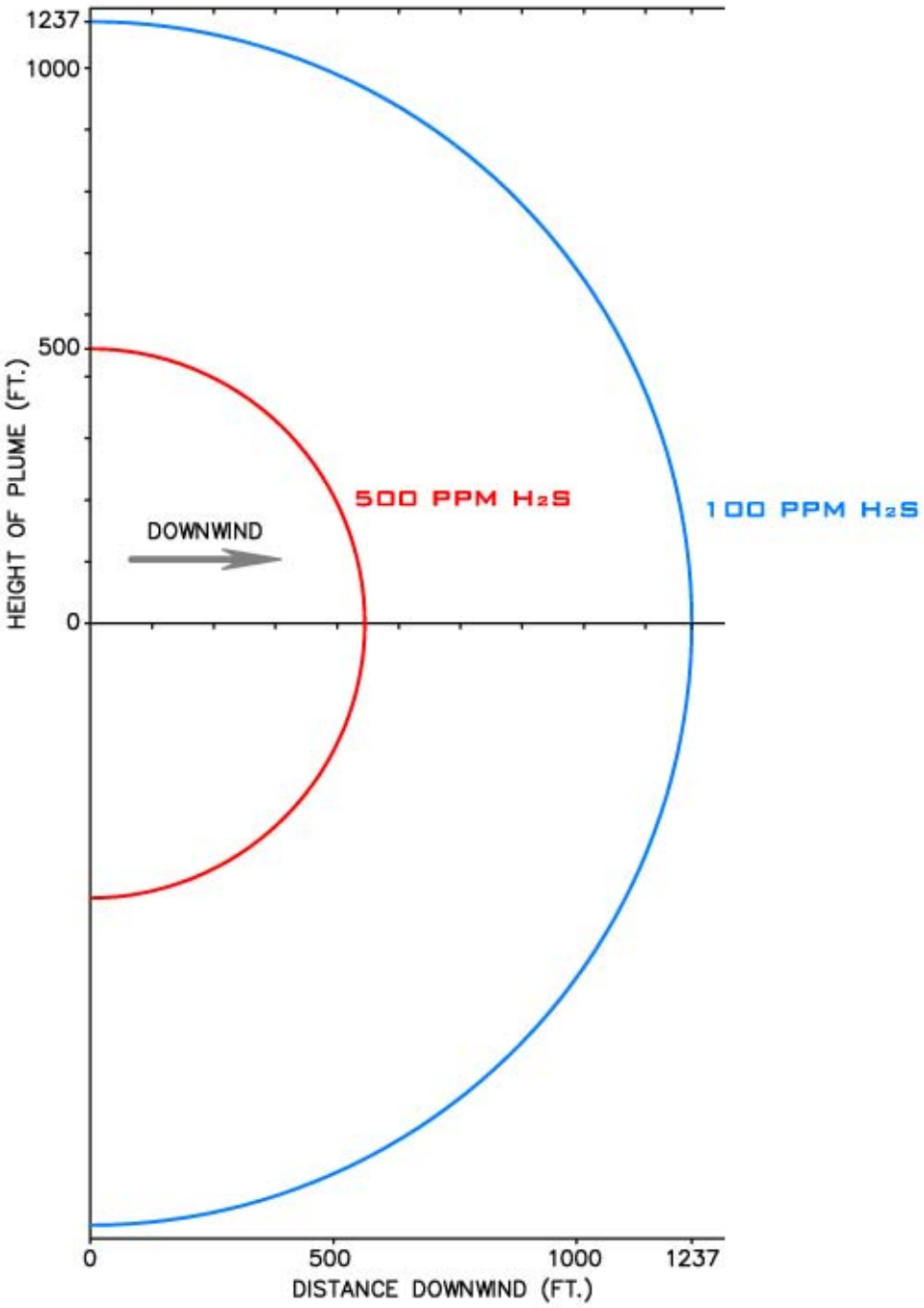


CAMERON-COLE

FIGURE 4

PASQUILL-GIFFORD RADIUS OF EXPOSURE
BLOWOUT-CASE 2
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
AS NOTED	8/5/05	1065-38

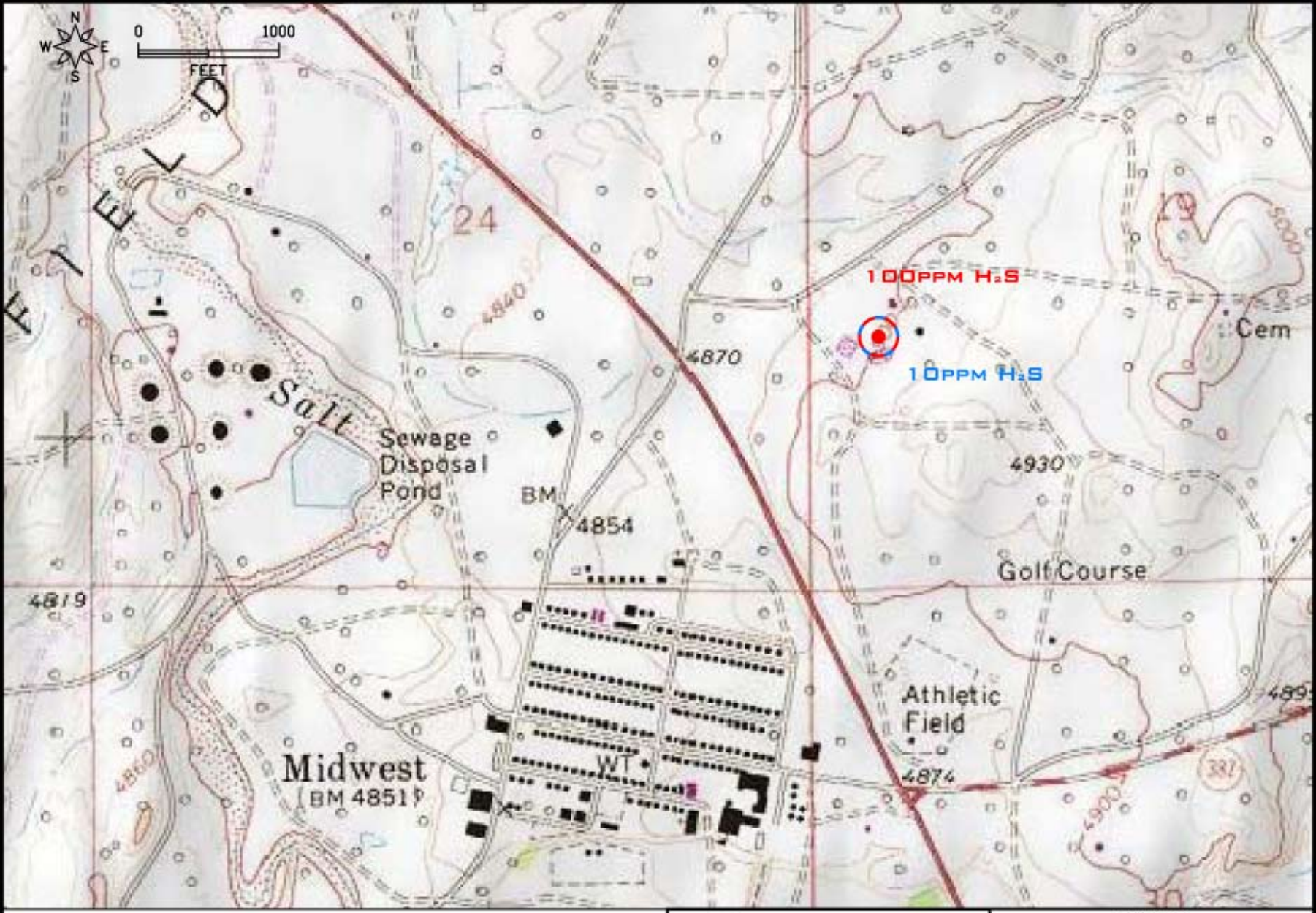


CAMERON-COLE

FIGURE 5

PASQUILL-GIFFORD RADIUS OF EXPOSURE
PIPELINE LEAK-CASE 3
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
AS NOTED	8/5/05	1065-39



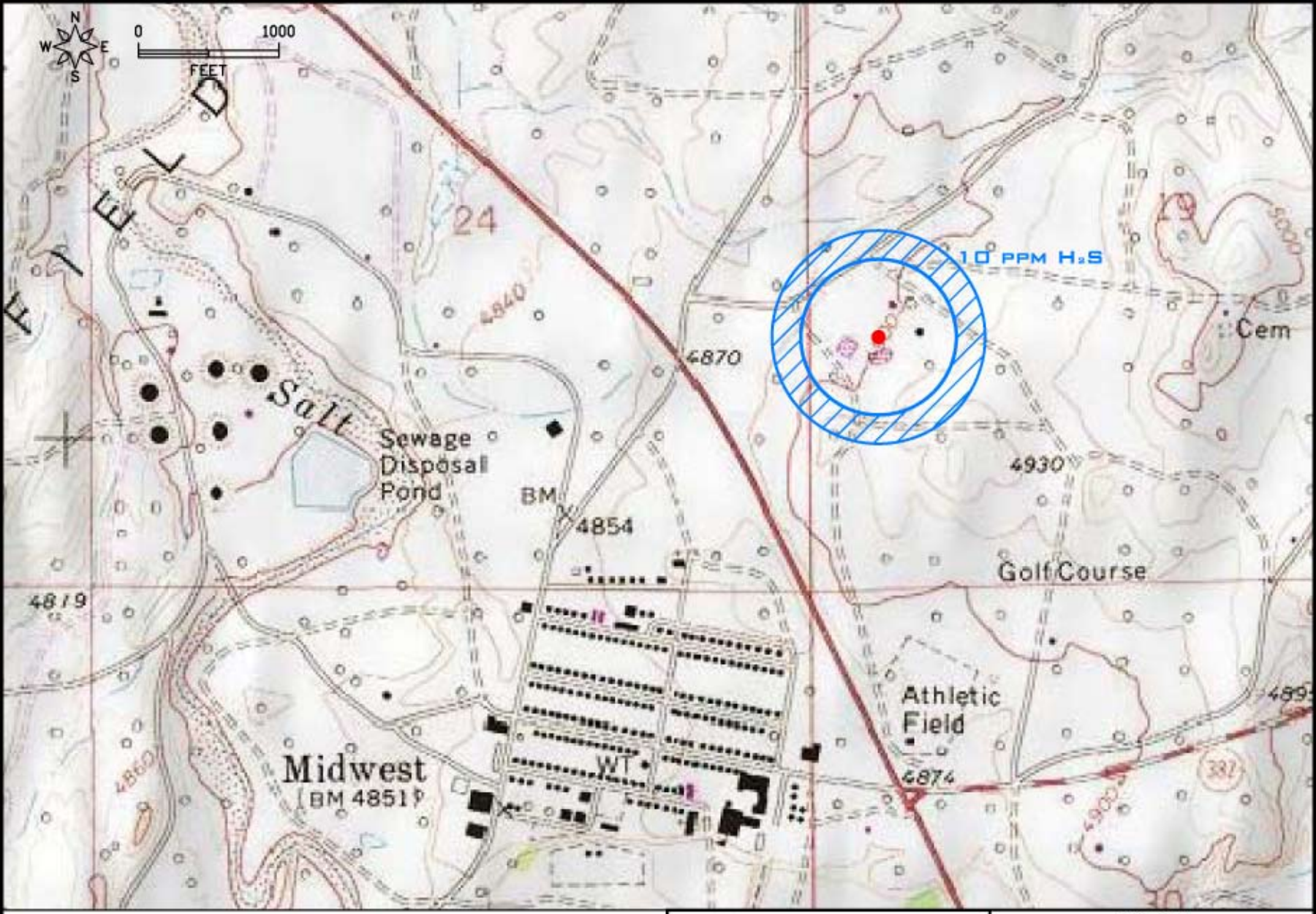
10 PPM H_2S - MAXIMUM DISPERSION 272 TO 285 FT.
100 PPM H_2S - MAXIMUM DISPERSION 272 TO 278 FT.

CAMERON-COLE

FIGURE 6

PIPELINE LEAK PLUME DISPERSION
HIGH TEMPERATURE - CASE 3
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
1" = 1000'	8/5/05	1065-40



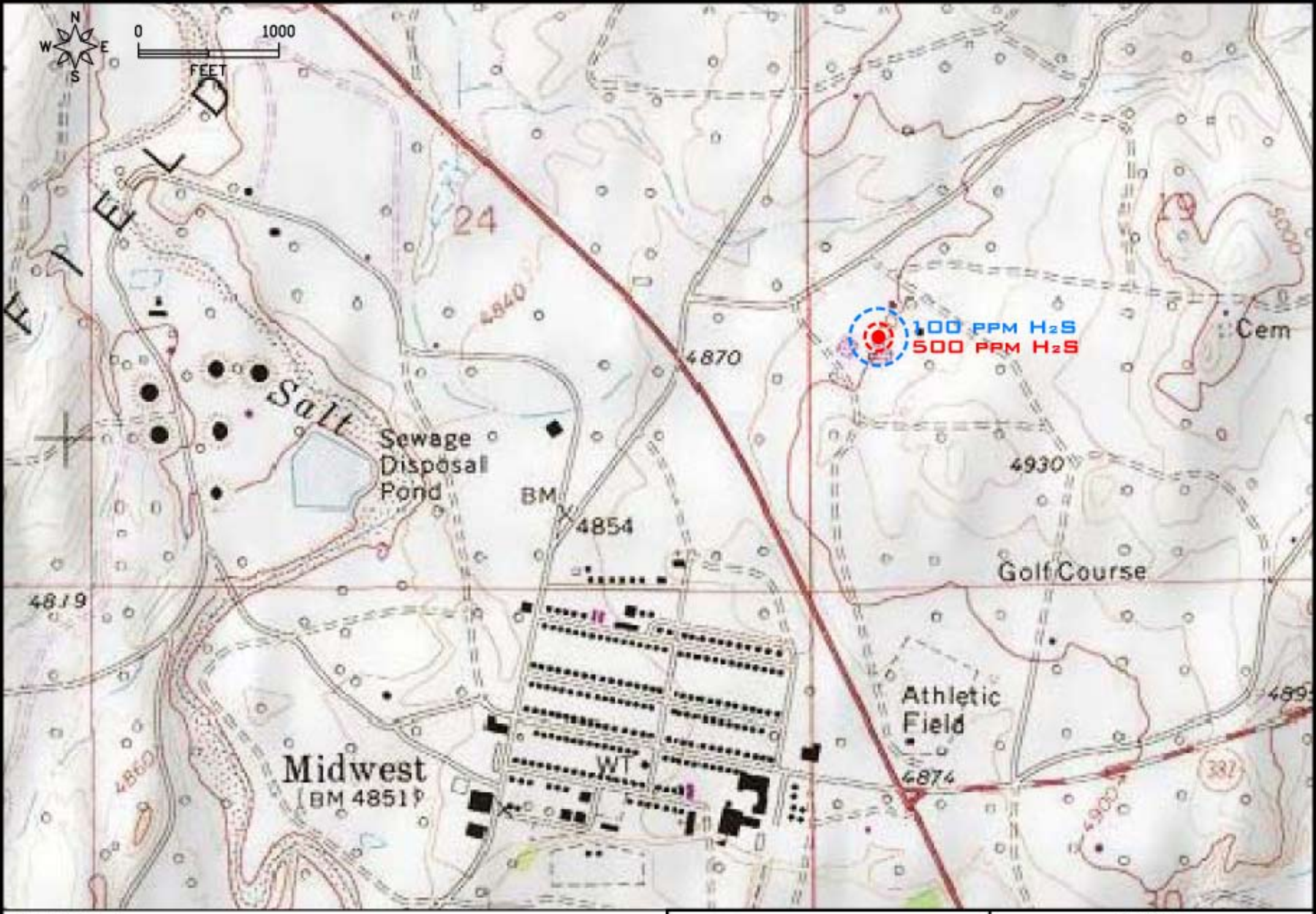
10 PPM H_2S - MAXIMUM DISPERSION 548 TO 751 FT.
100 PPM H_2S - NOT PREDICTED IN BREATHING ZONE

CAMERON-COLE

FIGURE 7

PIPELINE LEAK PLUME DISPERSION
LOW TEMPERATURE - CASE 3
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
1" = 1000'	8/5/05	1065-41



CASE 1

100 PPM H_2S - MAXIMUM DISPERSION 195 FT.

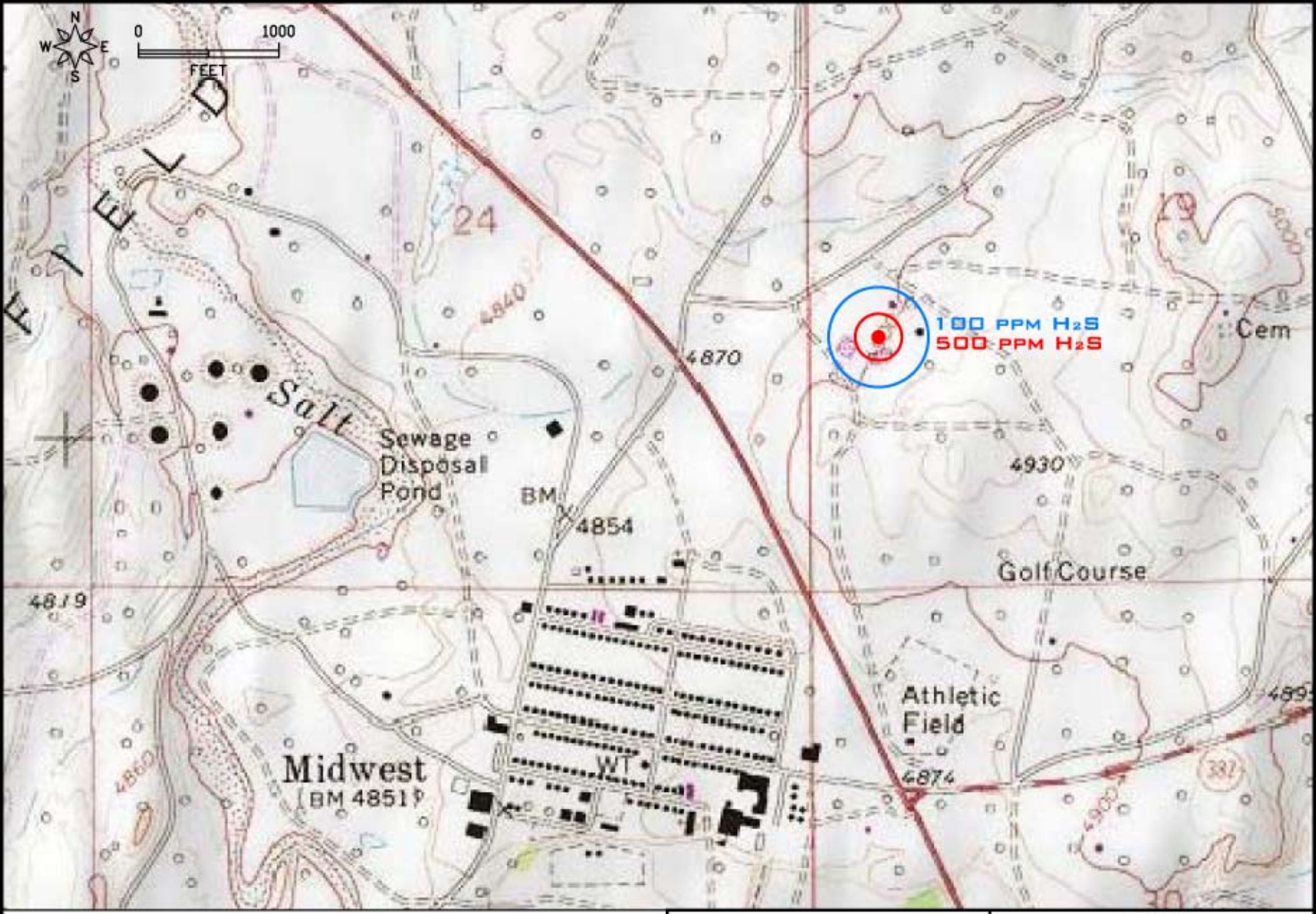
500 PPM H_2S - MAXIMUM DISPERSION 89 FT.

CAMERON-COLE

FIGURE 8

PASQUILL-GIFFORD RADIUS OF EXPOSURE
BLOWOUT-CASE 1
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
1" = 1000'	8/5/05	1065-42



CASE 2

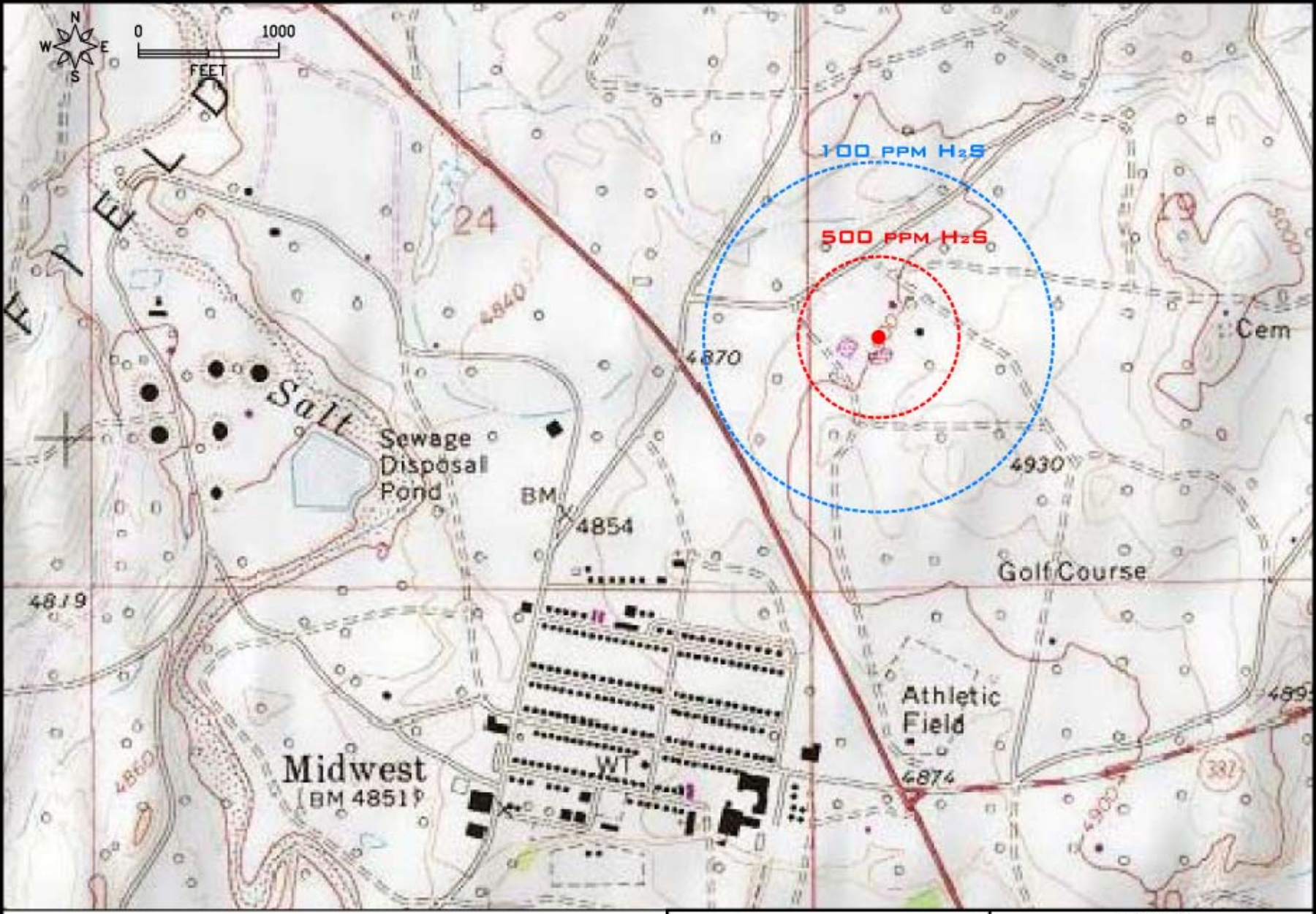
100 PPM H_2S - MAXIMUM DISPERSION 347 FT.
500 PPM H_2S - MAXIMUM DISPERSION 158 FT.

CAMERON-COLE

FIGURE 9

PASQUILL-GIFFORD RADIUS OF EXPOSURE
BLOWOUT-CASE 2
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
1" = 1000'	8/5/05	1065-43



CASE 3

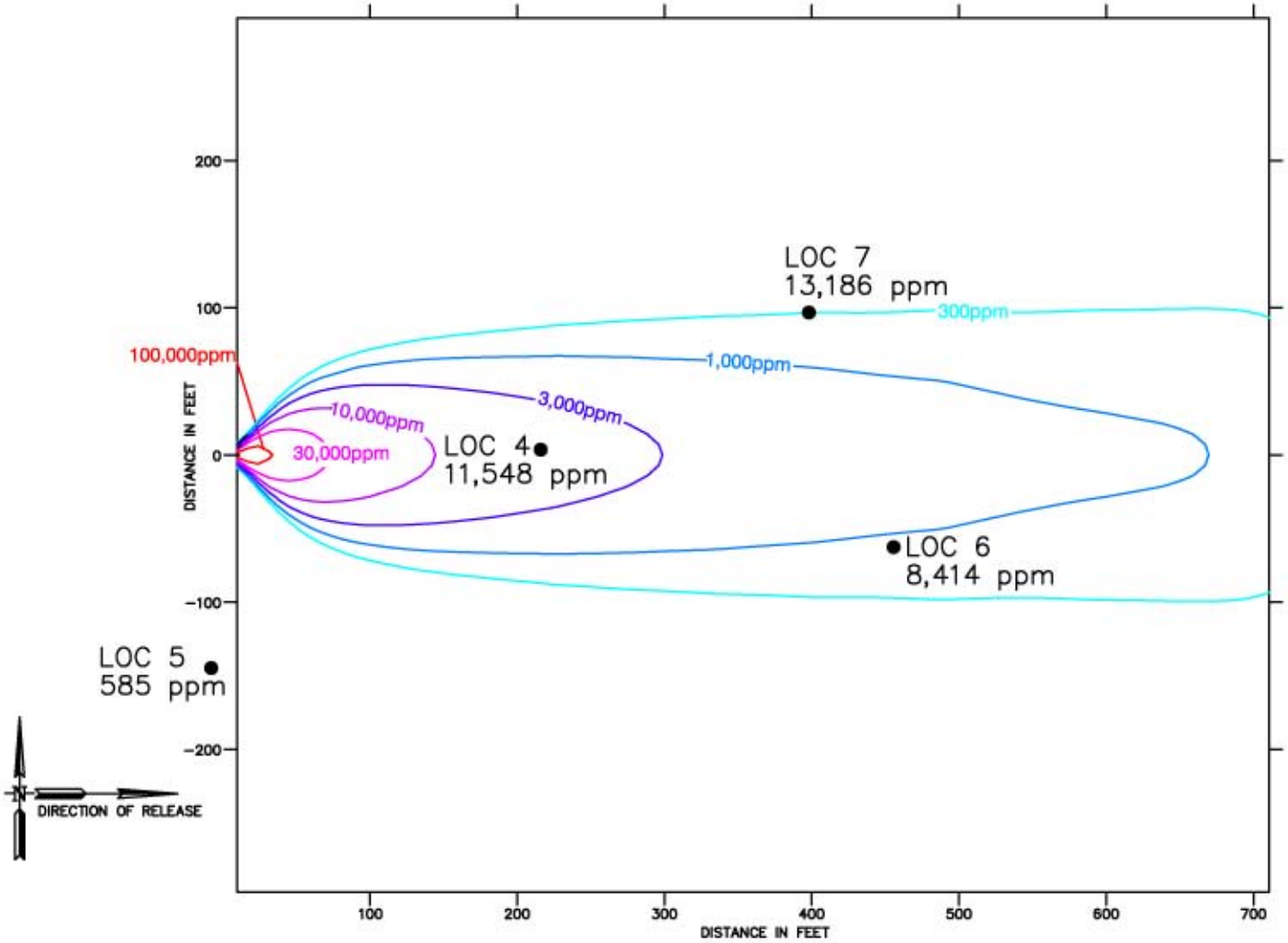
100 PPM H_2S - MAXIMUM DISPERSION 1237 FT.
500 PPM H_2S - MAXIMUM DISPERSION 565 FT.

CAMERON-COLE

FIGURE 10

PASQUILL-GIFFORD RADIUS OF EXPOSURE
PIPELINE LEAK-CASE 3
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
1" = 1000'	8/5/05	1065-44



LEGEND

● MONITORING RESULTS FOR 5/17/05 CO_2 TEST

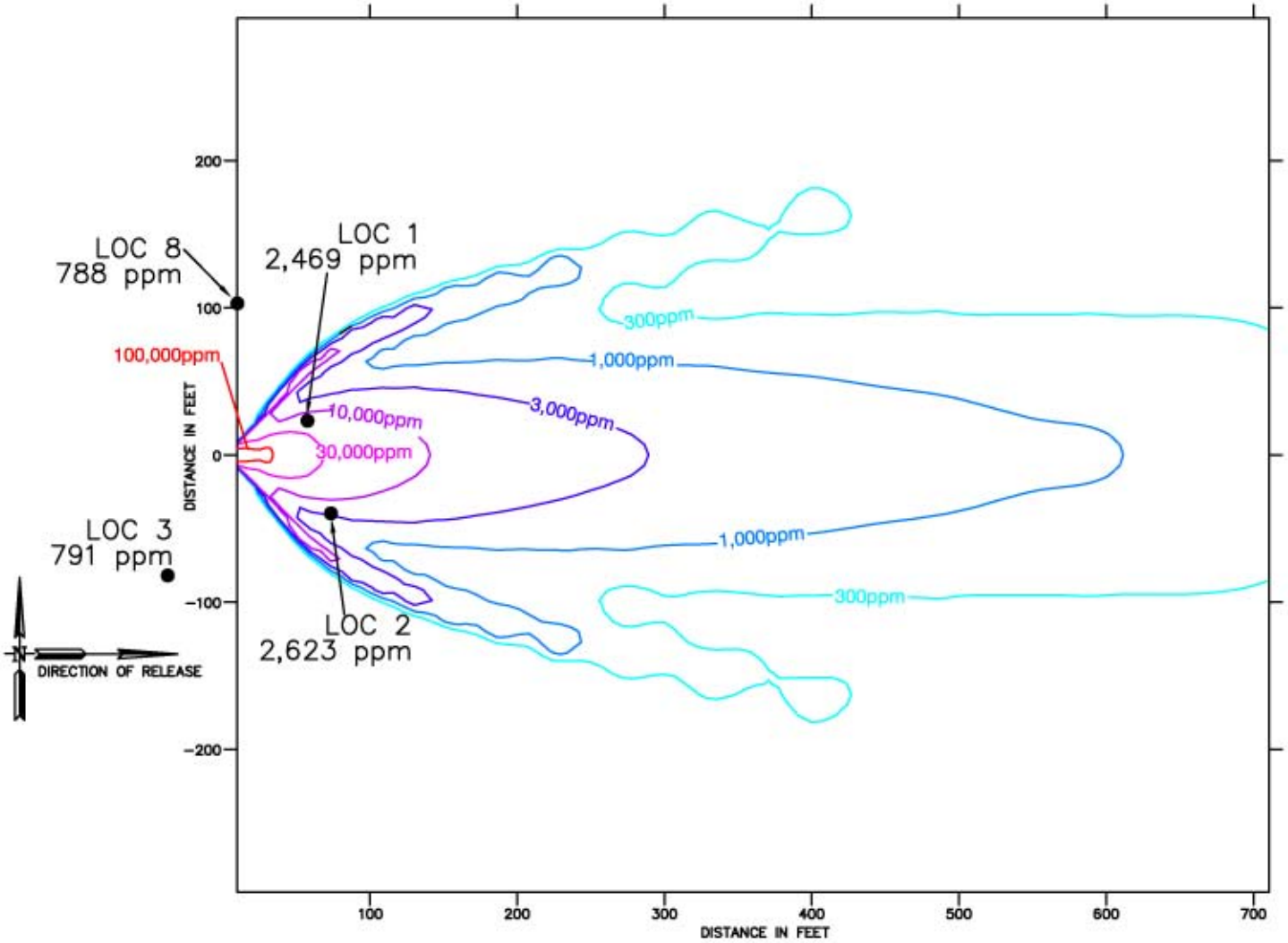
—300— SLAB MODEL OUTPUT ISOCONCENTRATION CONTOUR (CO_2 ppm)

CAMERON-COLE

FIGURE 11

SLAB MODEL RESULTS vs 5/17/05 TEST RELEASE OF CO_2 - RECEPTOR HEIGHT OF 1 FOOT 15 MINUTES AFTER START OF RELEASE HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
AS NOTED	8/5/05	1065-47



LEGEND

● MONITORING RESULTS FOR 5/17/05 CO_2 TEST

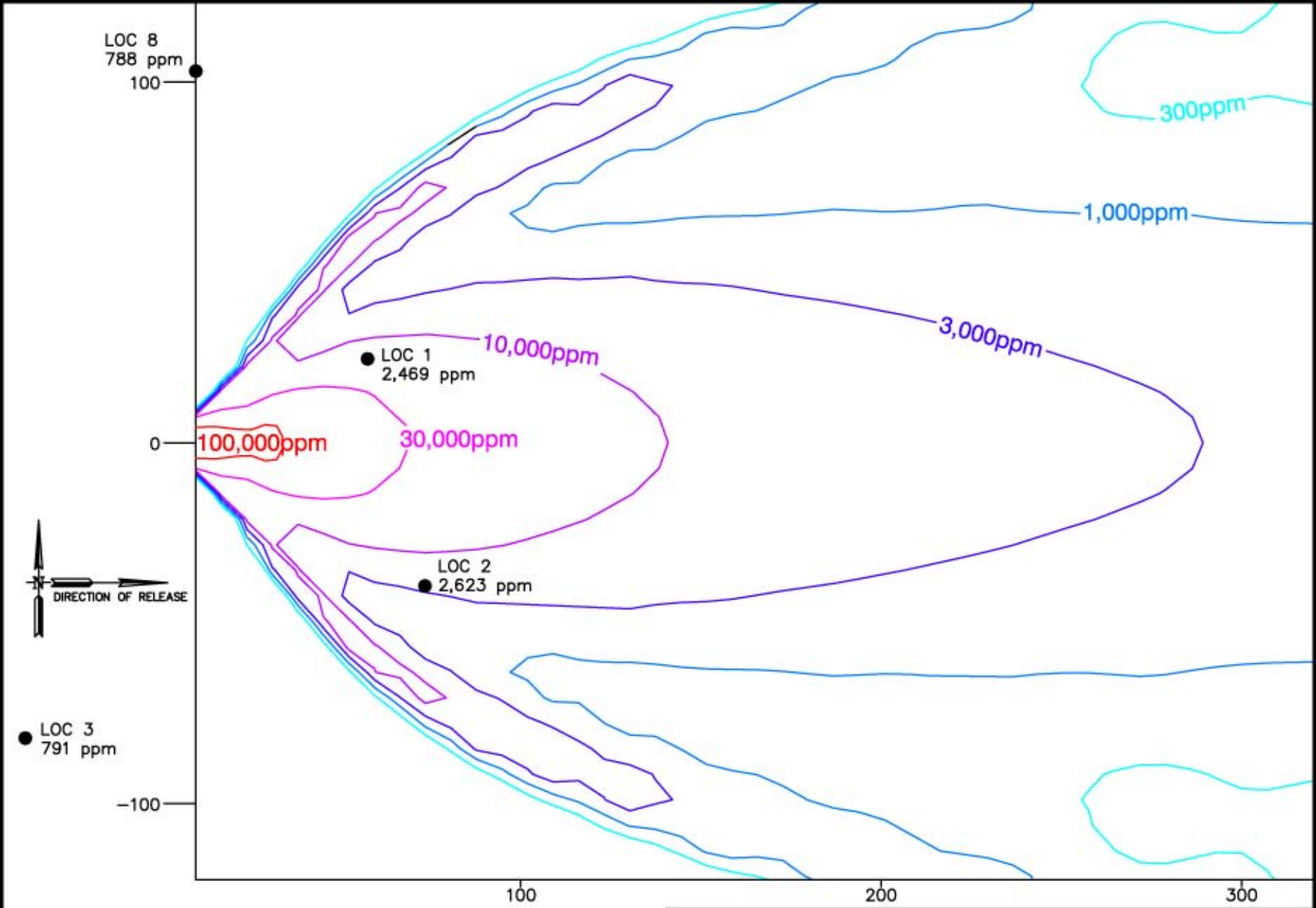
—300— SLAB MODEL OUTPUT ISOCONCENTRATION CONTOUR (CO_2 ppm)

CAMERON-COLE

FIGURE 12

SLAB MODEL RESULTS vs 5/17/05 TEST RELEASE OF CO_2 - RECEPTOR HEIGHT OF 4 FEET 15 MINUTES AFTER START OF RELEASE HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
AS NOTED	8/5/05	1065-45



LEGEND

● MONITORING RESULTS FOR 5/17/05 CO_2 TEST

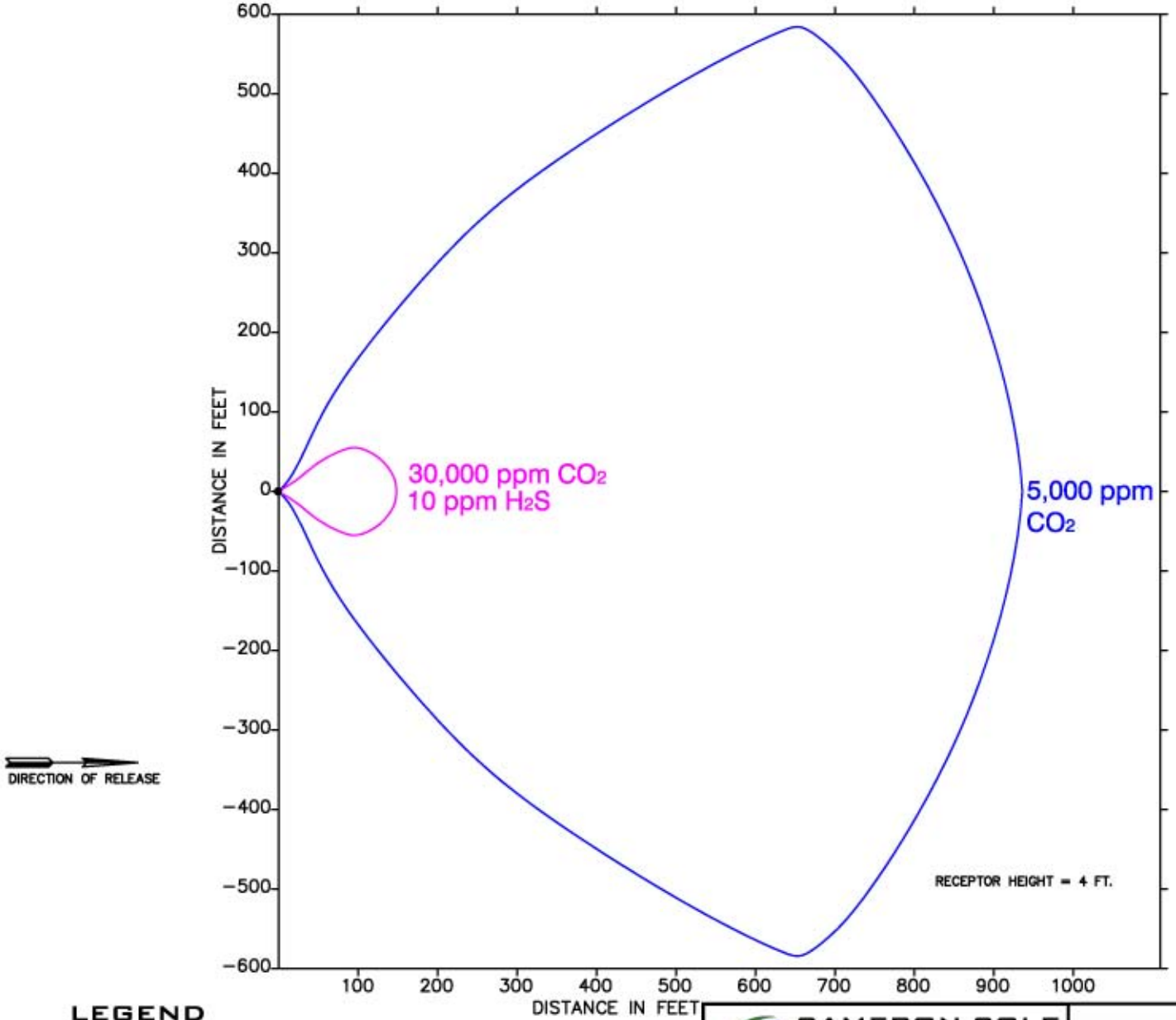
—300— SLAB MODEL OUTPUT ISOCONCENTRATION CONTOUR (CO_2 ppm)

CAMERON-COLE

FIGURE 13

SLAB MODEL RESULTS vs 5/17/06 ZOOM VIEW
TEST RELEASE OF CO_2-RECEPTOR HEIGHT OF 4 FT.
15 MINUTES AFTER START OF RELEASE
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
AS NOTED	8/5/05	1065-46



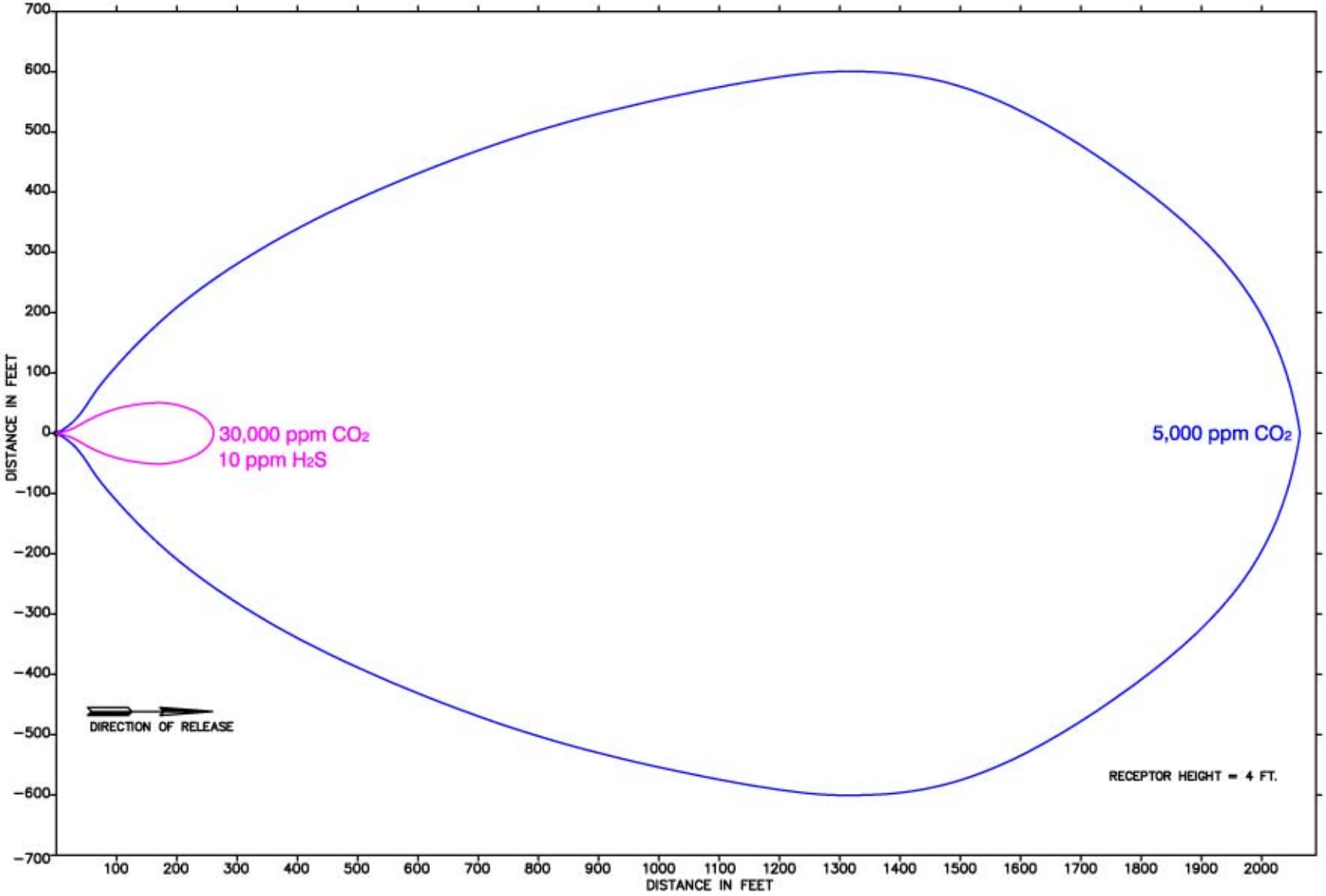
LEGEND

- • SOURCE AREA
- —5,000— 5,000 ppm CO_2 CONTOUR
- —30,000— 30,000 ppm CO_2 AND 10 ppm H_2S CONTOUR

CAMERON-COLE

FIGURE 14
SLAB MODEL OUTPUT
HORIZONTAL JET RELEASE 10 MMSCFD
3 INCH PIPE DIAMETER
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
AS NOTED	8/5/05	1065-48



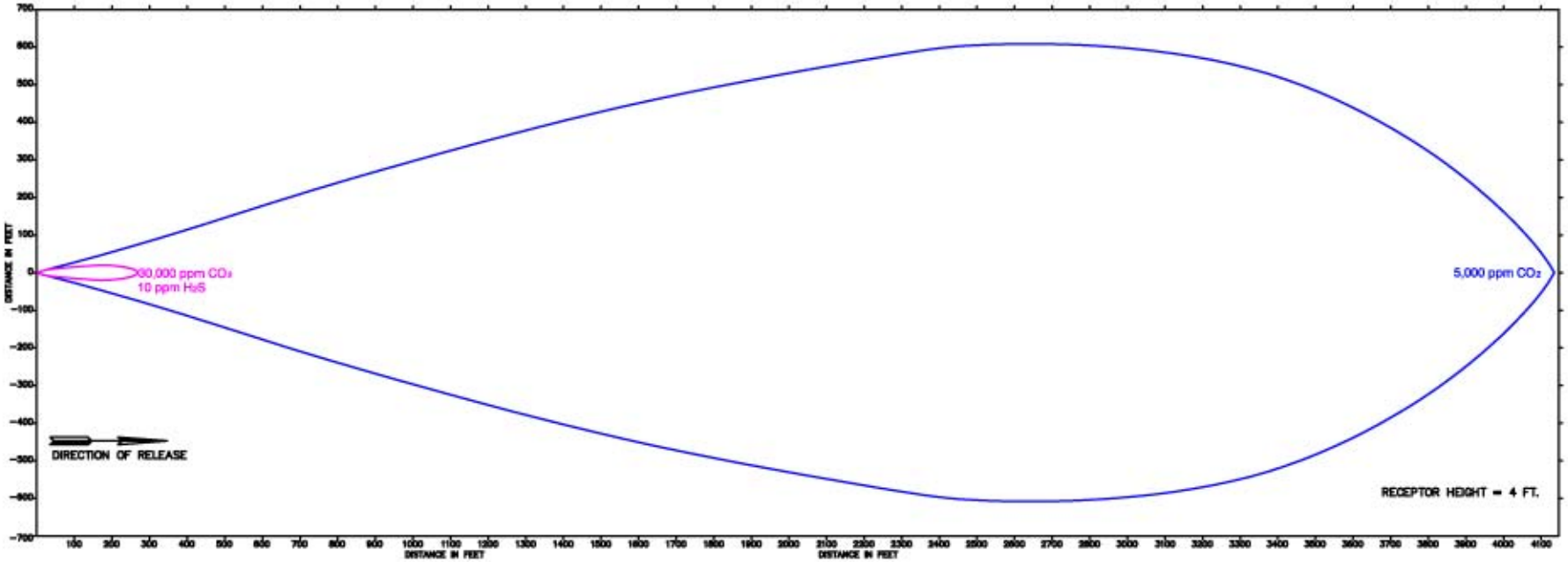
LEGEND

- • SOURCE AREA
- —5,000— 5,000 ppm CO_2 CONTOUR
- —30,000— 30,000 ppm CO_2 AND 10 ppm H_2S CONTOUR

CAMERON-COLE

FIGURE 15
SLAB MODEL OUTPUT
HORIZONTAL JET RELEASE 30 MMSCFD
6 INCH PIPE DIAMETER
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
AS NOTED	8/5/05	1065-49



LEGEND

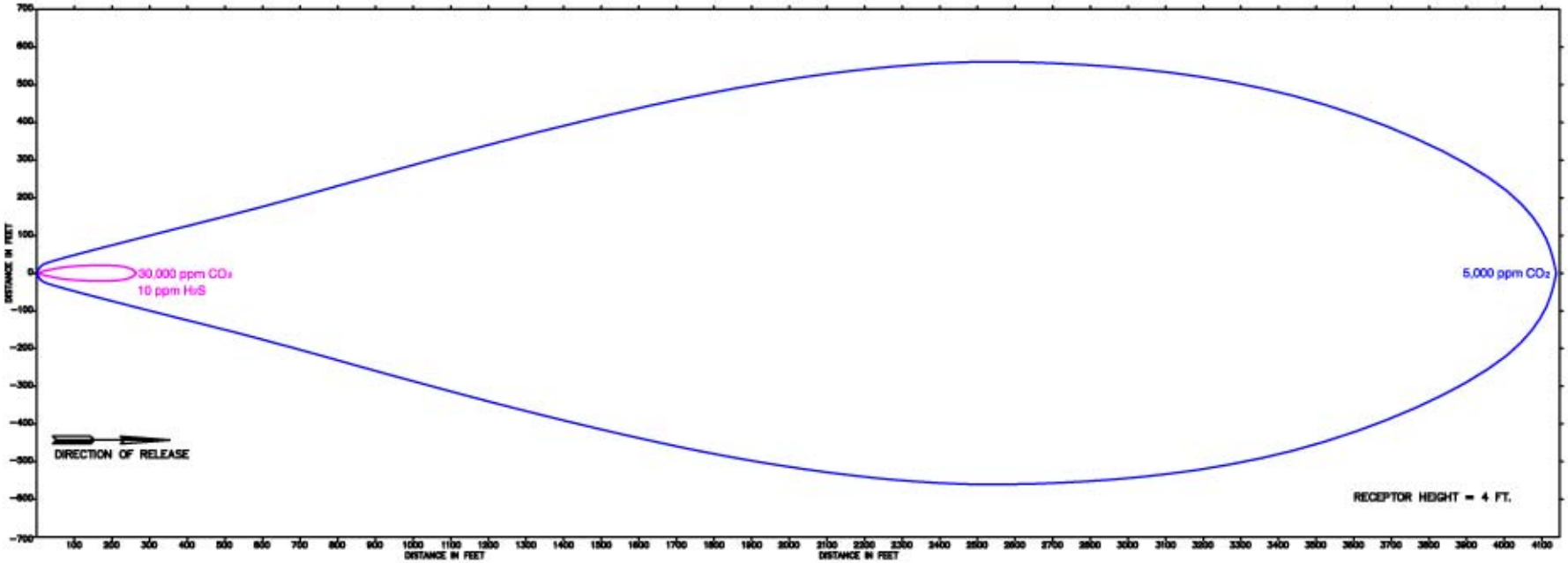
- • SOURCE AREA
- —5,000— 5,000 ppm CO_2 CONTOUR
- —30,000— 30,000 ppm CO_2 AND 10 ppm H_2S CONTOUR

CAMERON-COLE

FIGURE 16

SLAB MODEL OUTPUT
HORIZONTAL JET RELEASE 250 MMSCFD
12 INCH PIPE DIAMETER
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
AS NOTED	8/5/05	1065-50



LEGEND

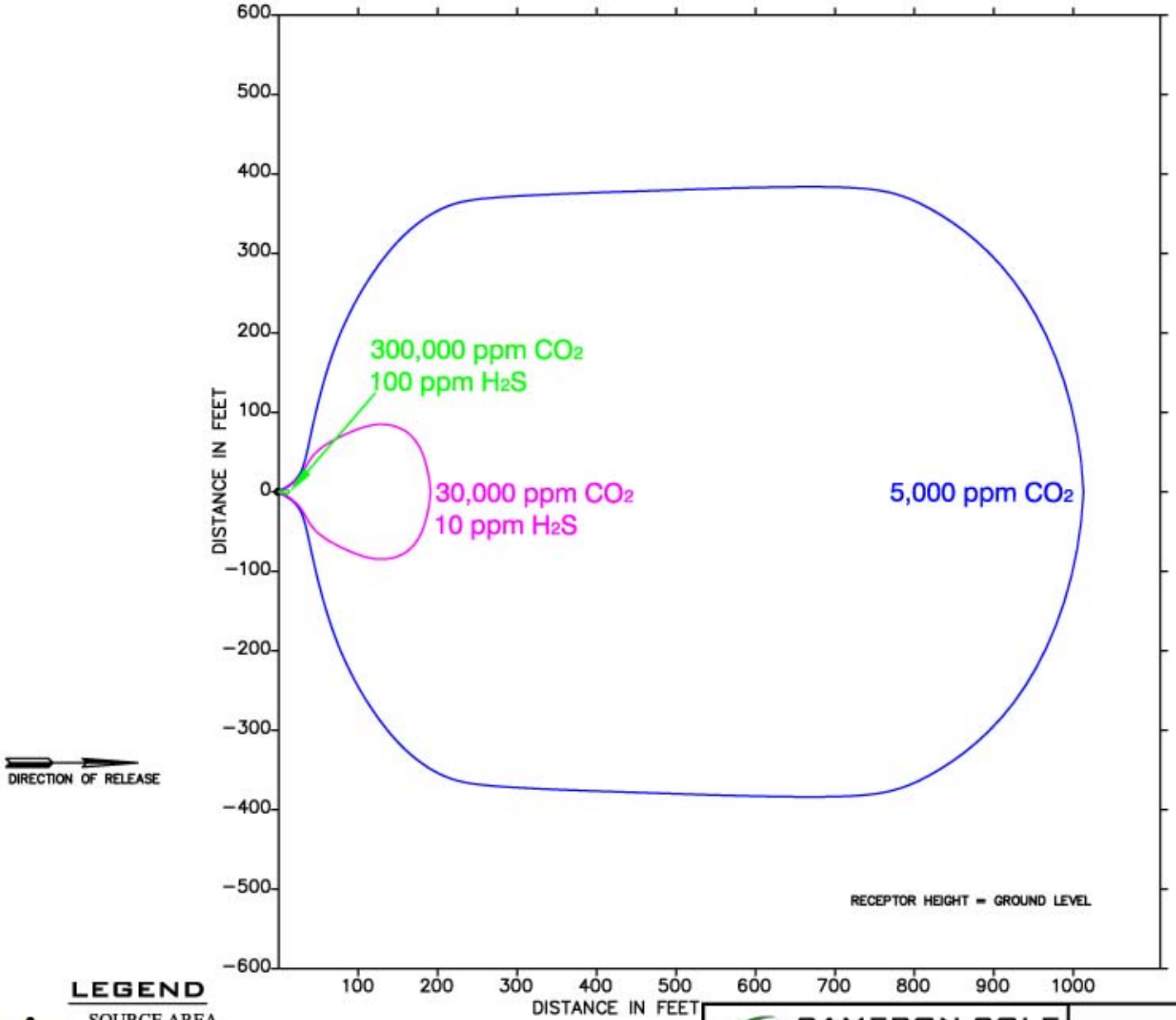
- • SOURCE AREA
- —5,000— 5,000 ppm CO_2 CONTOUR
- —30,000— 30,000 ppm CO_2 AND 10 ppm H_2S CONTOUR

CAMERON-COLE

FIGURE 17

SLAB MODEL OUTPUT
HORIZONTAL JET RELEASE 290 MMSCFD
16 INCH PIPE DIAMETER
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
AS NOTED	8/5/05	1065-51



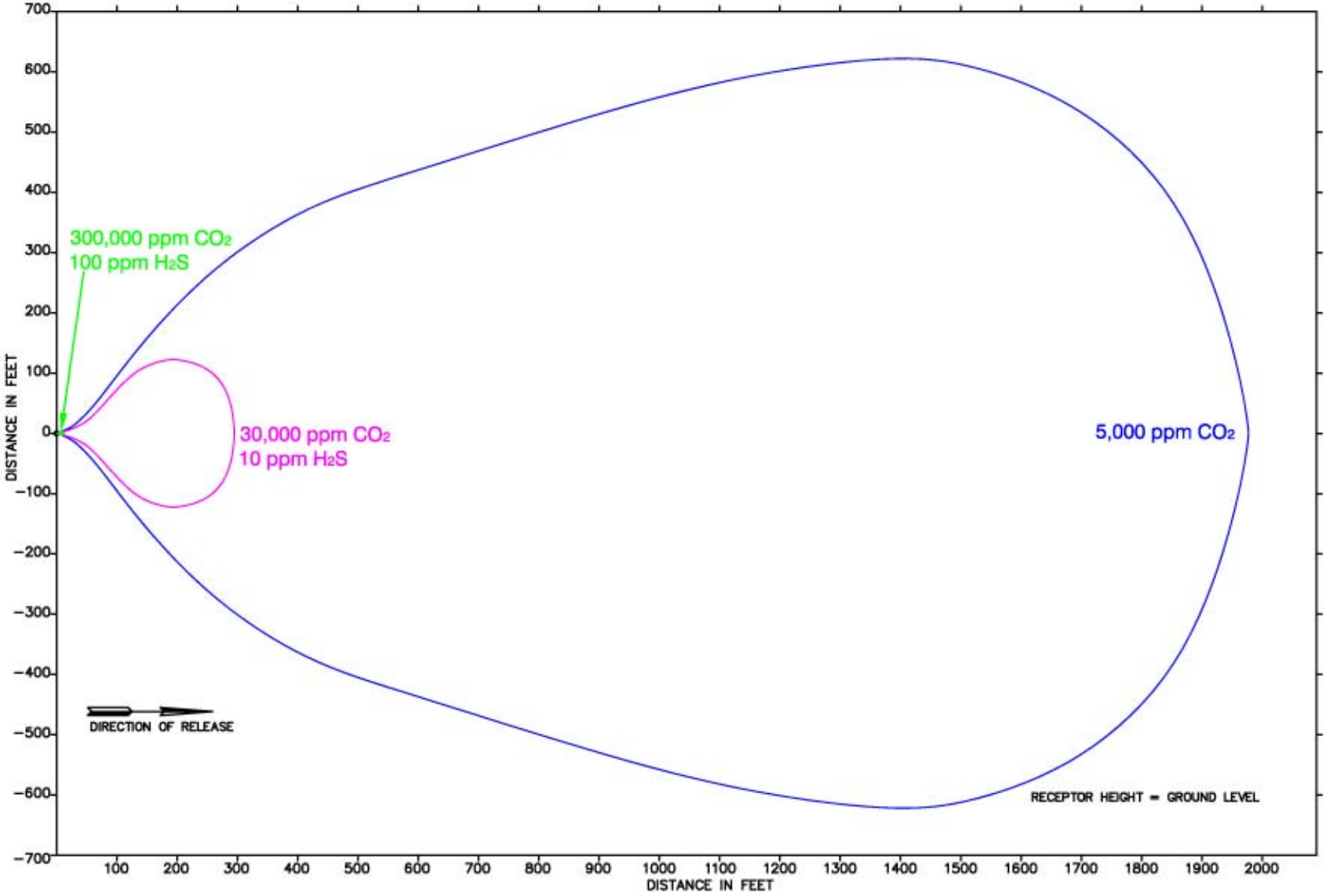
LEGEND

- • SOURCE AREA
- —5,000— 5,000 ppm CO_2 CONTOUR
- —30,000— 30,000 ppm CO_2 AND 10 ppm H_2S CONTOUR
- —300,000— 300,000 ppm CO_2 AND 100 ppm H_2S CONTOUR

CAMERON-COLE

FIGURE 18
SLAB MODEL OUTPUT
HORIZONTAL JET RELEASE 10 MMSCFD
3 INCH PIPE DIAMETER
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
AS NOTED	8/5/05	1065-52



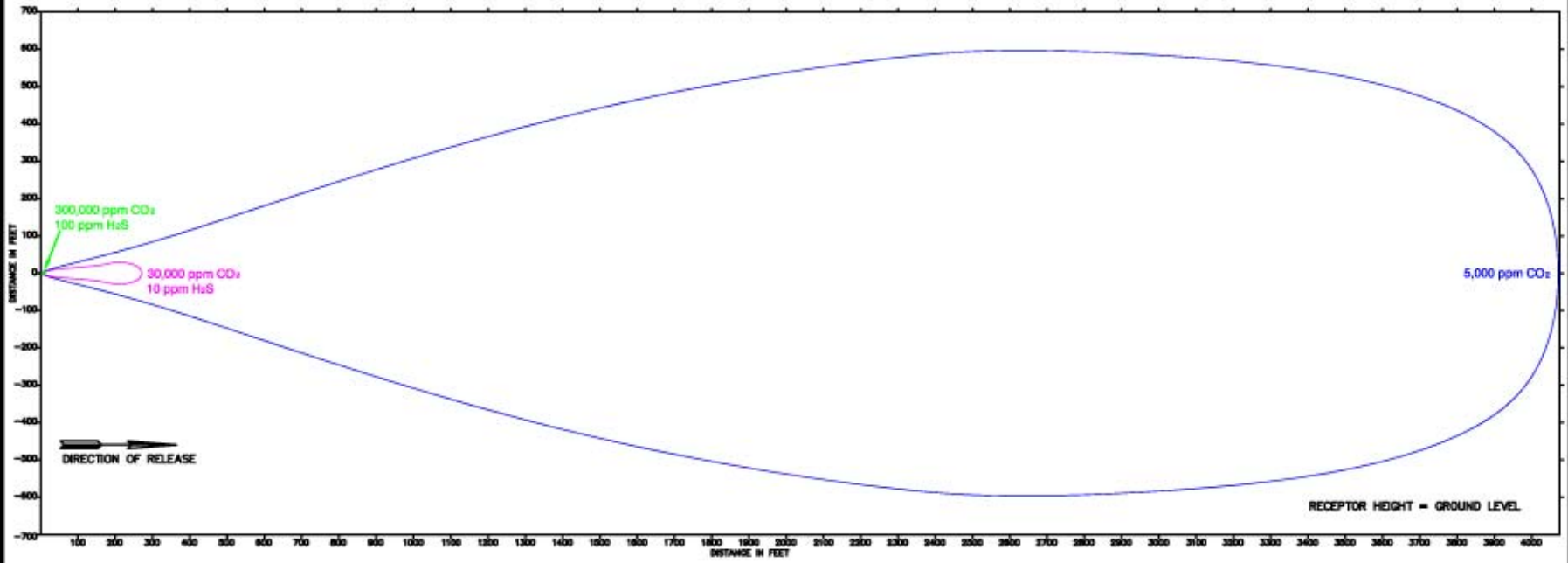
LEGEND

- • SOURCE AREA
- —5,000— 5,000 ppm CO_2 CONTOUR
- —30,000— 30,000 ppm CO_2 AND 10 ppm H_2S CONTOUR
- —300,000— 300,000 ppm CO_2 AND 100 ppm H_2S CONTOUR

CAMERON-COLE

FIGURE 19
SLAB MODEL OUTPUT
HORIZONTAL JET RELEASE 30 MMSCFD
6 INCH PIPE DIAMETER
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
AS NOTED	8/05/05	1065-53



LEGEND

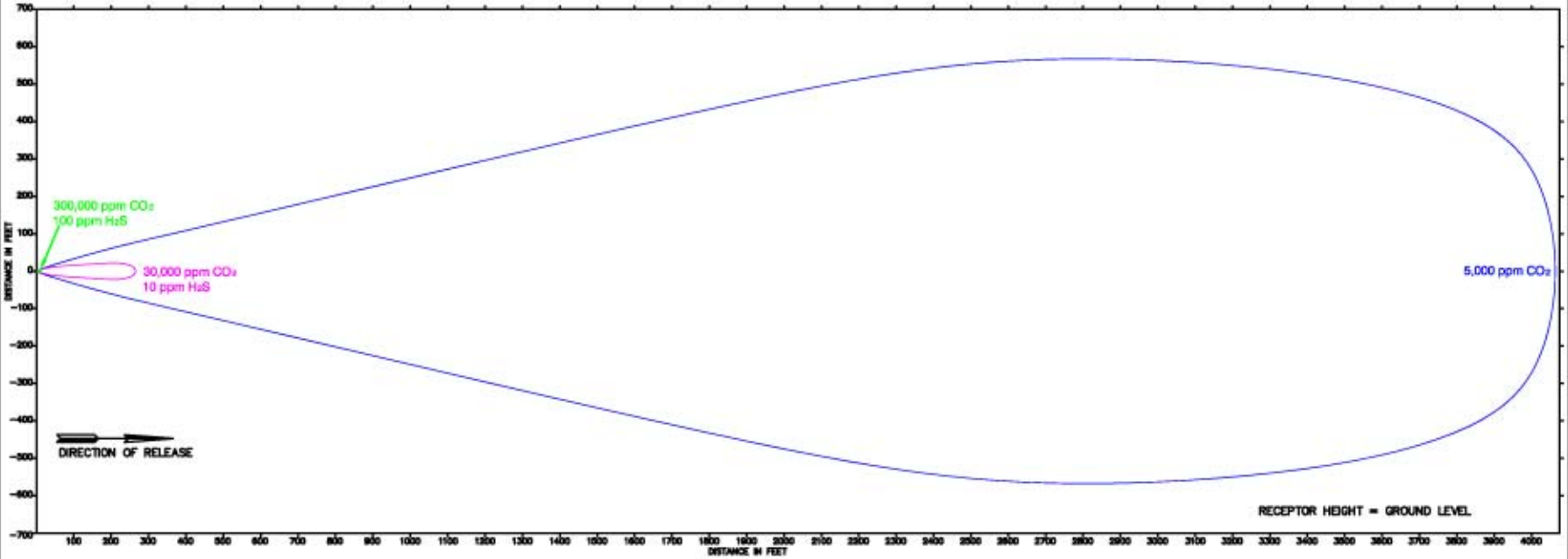
- • SOURCE AREA
- —5,000— 5,000 ppm CO_2 CONTOUR
- —30,000— 30,000 ppm CO_2 AND 10 ppm H_2S CONTOUR
- —300,000— 300,000 ppm CO_2 AND 100 ppm H_2S CONTOUR

CAMERON-COLE

FIGURE 20

SLAB MODEL OUTPUT
HORIZONTAL JET RELEASE 250 MMSCFD
12 INCH PIPE DIAMETER
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
AS NOTED	8/5/05	1065-54



LEGEND

- • SOURCE AREA
- —5,000— 5,000 ppm CO_2 CONTOUR
- —30,000— 30,000 ppm CO_2 AND 10 ppm H_2S CONTOUR
- —300,000— 300,000 ppm CO_2 AND 100 ppm H_2S CONTOUR

CAMERON-COLE

FIGURE 21

SLAB MODEL OUTPUT
HORIZONTAL JET RELEASE 290 MMSCFD
16 INCH PIPE DIAMETER
HOWELL PETROLEUM

SCALE:	DATE:	DWG NO.
AS NOTED	8/5/05	1065-55

APPENDIX A

Carbon Dioxide Dispersion Test at 12WC2NE14

CO_2 dispersion Test at 12WC^{2}NE14

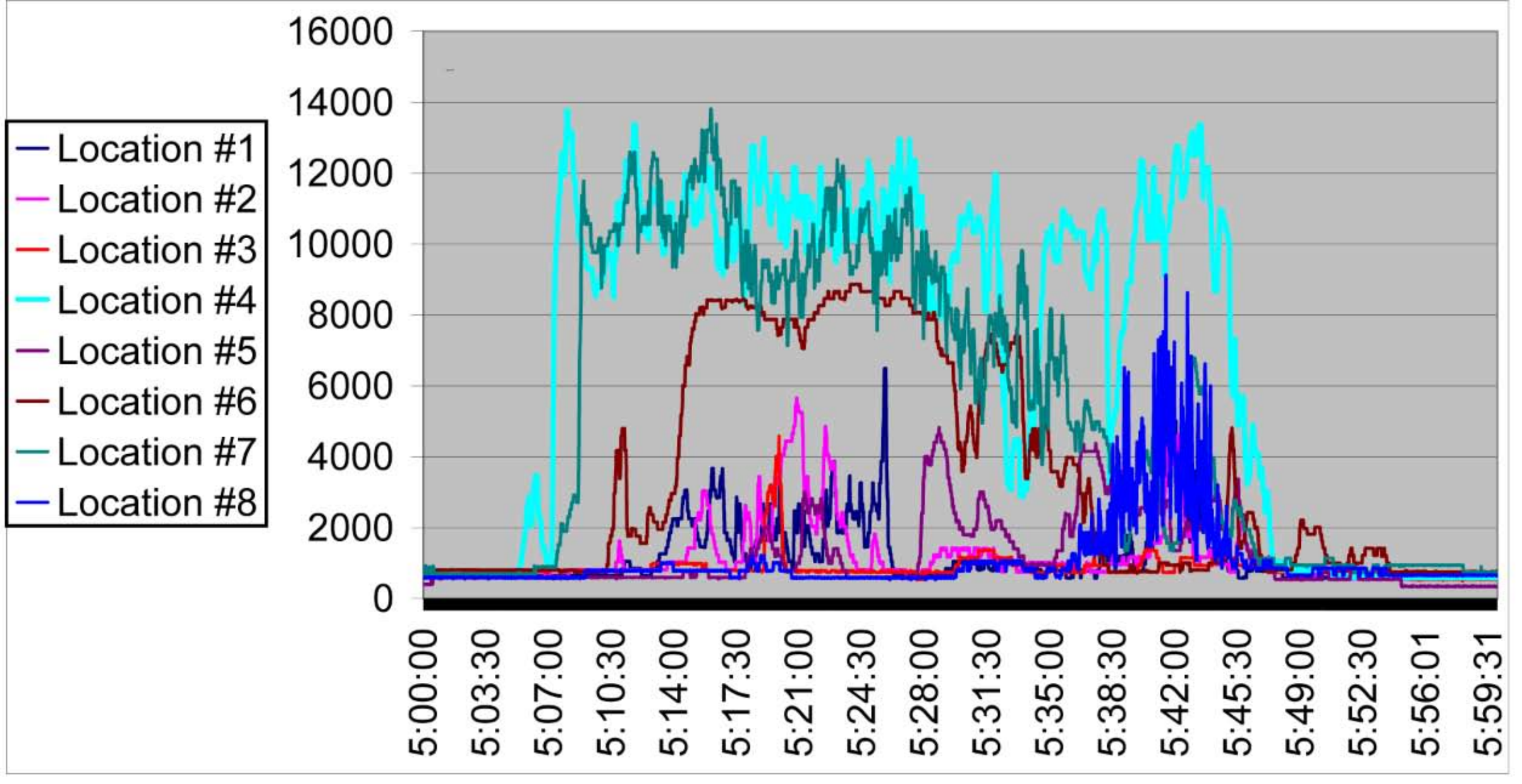
The purpose of this dispersion test is to validate and field test our dispersion modeling. The test conditions need to be worst case scenario, calm day, low lying area (draw), and a high volume release (relatively speaking) (8MM). The test will be performed early morning (between 5 and 6 am) as to not affect field personnel. The well will be WAG'd 24hrs prior to the test to allow any water in the system to be cleared. If water isn't cleared from the system hydrates or ice may form. Below is the procedure for performing the test.

- Set RTU's (8) to record dispersion data (CO_2 concentration in PPM)
    - Calibrate and program RTU's to gather data once per second - Allan
- Stroke 12NE14 choke to the closed position and leave RTU in local
- Shut well head gate valve
    - Using the 1" bleeder located on the flow "T" bleed off the pressure between the choke and the well head gate
- Make up hard line and fittings from well head to ~ 60' from well head running to the east – **SEE HAND SKETCH**
    - Fittings
        - 2 – 90º swivels with 1502 hammer unions
        - 3 – jts of 2" XH hard line with 1502 hammer unions
        - 1- bean choke with 1" bean
        - 1 – 2 3/8" perforated sub
    - Make up
        - On the 2" full port wire line valve thread in a 2" XH nipple with a 1502 wing half
        - Install a 2" 90º swivel
        - Install a short section (~10') of 2" XH hard line
        - Install a 2" 90º swivel
        - Install two (2) twenty (20) foot sections of hard line
            - Hard line will be installed on top of three (3) cement blocks and chain/boomered down
            - There should be one block located on the back side of the ground level 90º swivel
        - Install the bean choke
        - Install a 2" X 2 3/8" HP swage
        - Install a 2 3/8" perforated sub open ended
- Set up well (12NE14) RTU for test
    - Capture rate and pressure every 30 sec – 1 min
    - Set well head set point to 1000 psi
    - Set rate over ride to 8MM
- Start the eight (8) RTU's gathering data
- Open the 2" full port wire line entry valve
- Notify affected personnel that the test is about to commence - DEM

    - BJV will be monitoring the test from the office in case the test needs shut down
- Put RTU in auto and clear the area
    - Monitor from a distance preferably cross wind and up hill
    - Stay in contact with BJV in the office monitoring CASE
        - If for any reason the test needs shut down BJV will do so using the CASE host
            - Reasons can include but are not limited to
                - Hard line plugging from the formation of dry ice
                - The hard line starts to rise off of the ground
                - The hard line starts to move from side to side/ front to back
                - Leaking fittings
                - Completion of the test
- Duration of the test will be twenty (20) to thirty (30) minutes
    - **CAUTION**
        - H_2S and CO_2 gas will be present
        - Extreme cold temperatures will be present
        - Dry Ice may form
        - High pressures will be present
- Notify affected personnel of the completion of the test – DEM
- BJV will change the set points from CASE and notify when the well status indicates the choke is closed
- Once the well is shut in
    - Put RTU in local
    - Close the 2” FP, WL entry valve
    - Break all fittings apart
    - Open the well head gate valve
    - Reset the well RTU to normal injection control set points
    - Put the well RTU in auto
    - Gather all data points from the eight (8) RTU
        - Put in excel format
- Attachments
    - Hand Sketch
    - Map of 12NE14 with approximate RTU locations
    - Map with out 12NE14 but with exact RTU location

APPENDIX B

Carbon Dioxide Dispersion Test – Monitoring Results


Location #1
Location #2
Location #3
Location #4
Location #5
Location #6
Location #7
Location #8
16000
14000
12000
10000
8000
6000
4000
2000
0
5:00:00
5:03:30
5:07:00
5:10:30
5:14:00
5:17:30
5:21:00
5:24:30
5:28:00
5:31:30
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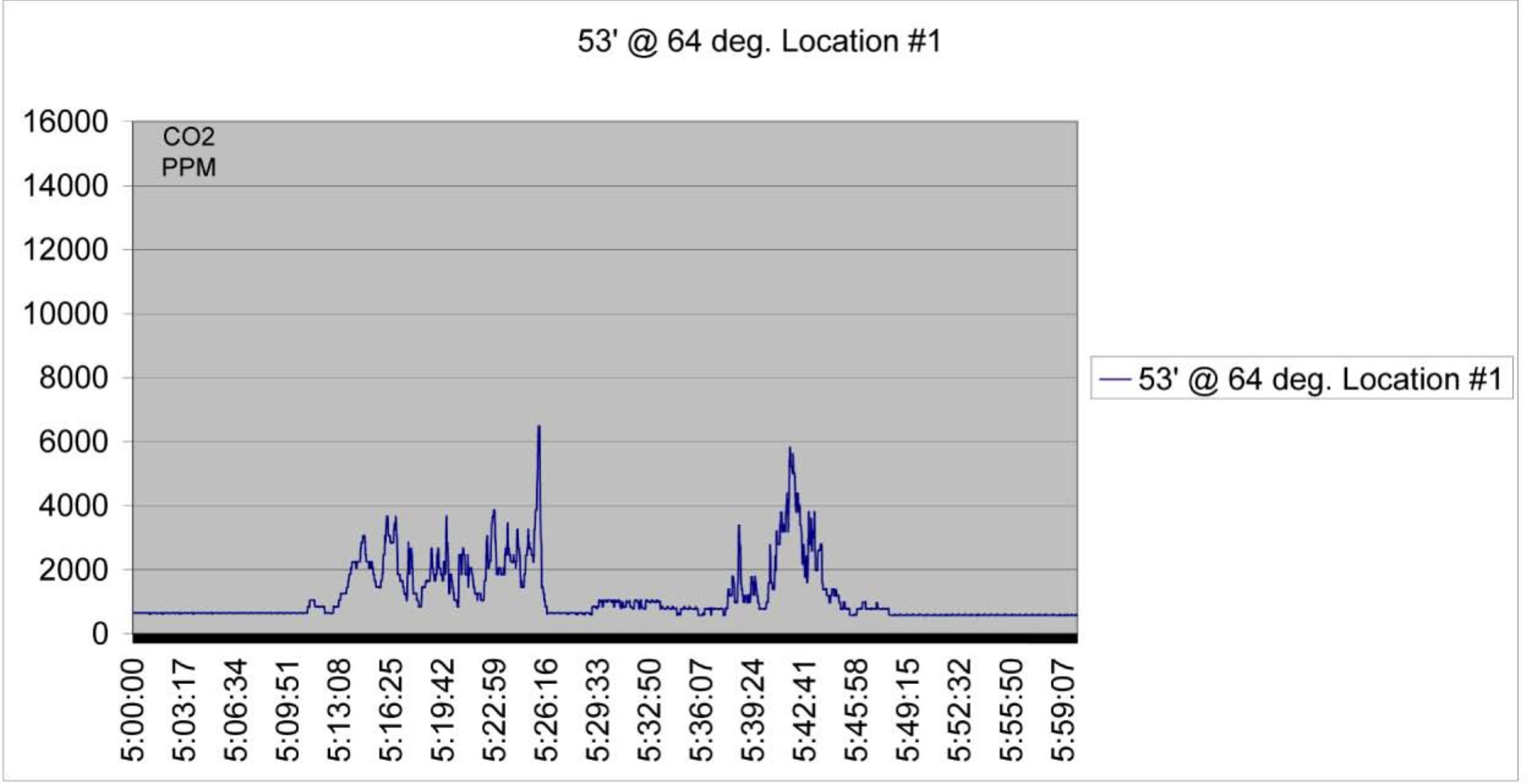
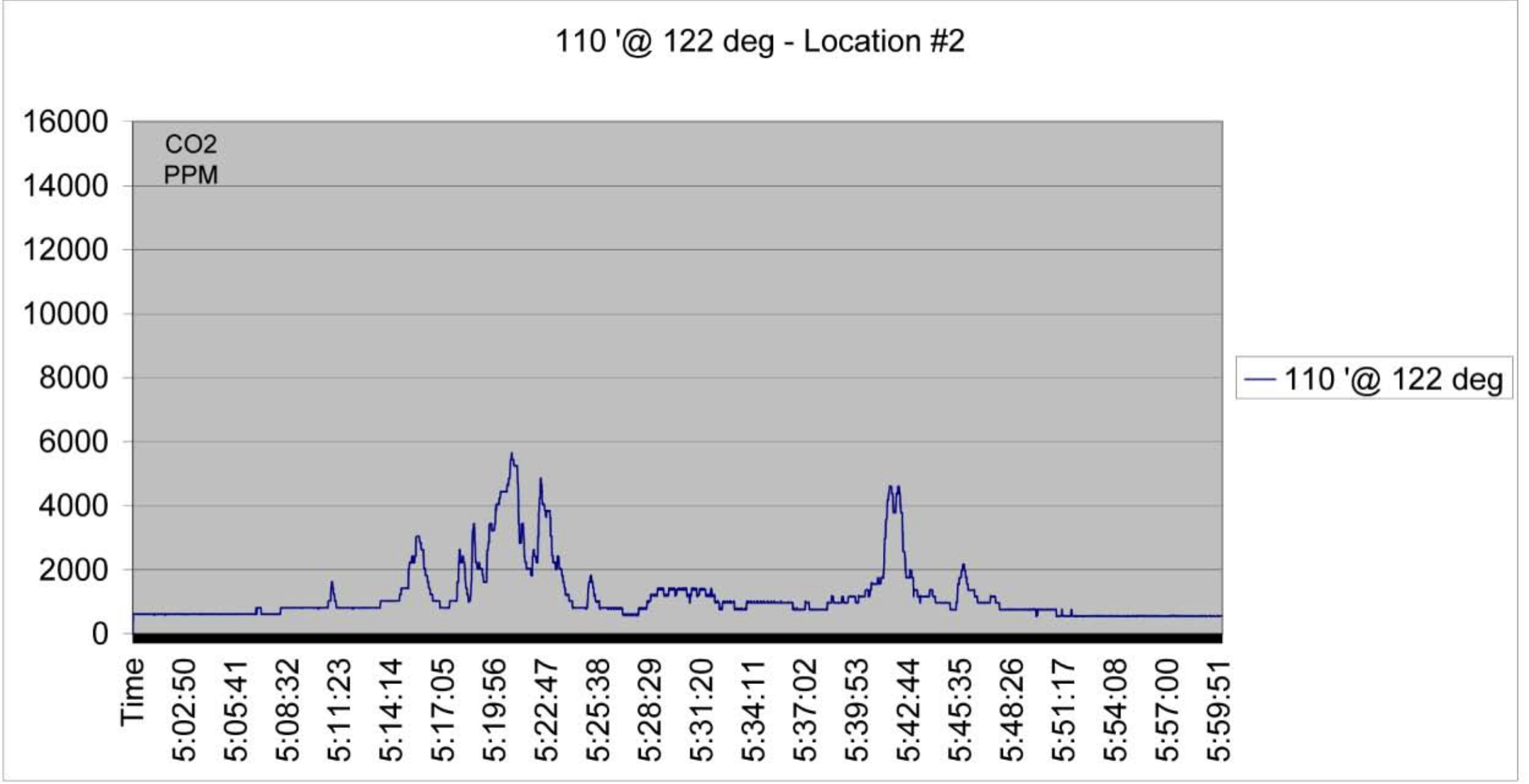
5:56:01
5:59:31


53' @ 64 deg. Location #1
CO2
PPM
16000
14000
12000
10000
8000
6000
4000
2000
0
5:00:00
5:03:17
5:06:34
5:09:51
5:13:08
5:16:25
5:19:42
5:22:59
5:26:16
5:29:33
5:32:50
5:36:07
5:39:24
5:42:41
5:45:58
5:49:15
5:52:32
5:55:50
5:59:07
53' @ 64 deg. Location #1


110 '@ 122 deg - Location #2
CO2
PPM
16000
14000
12000
10000
8000
6000
4000
2000
0
Time
5:02:50
5:05:41
5:08:32
5:11:23
5:14:14
5:17:05
5:19:56
5:22:47
5:25:38
5:28:29
5:31:20
5:34:11
5:37:02
5:39:53
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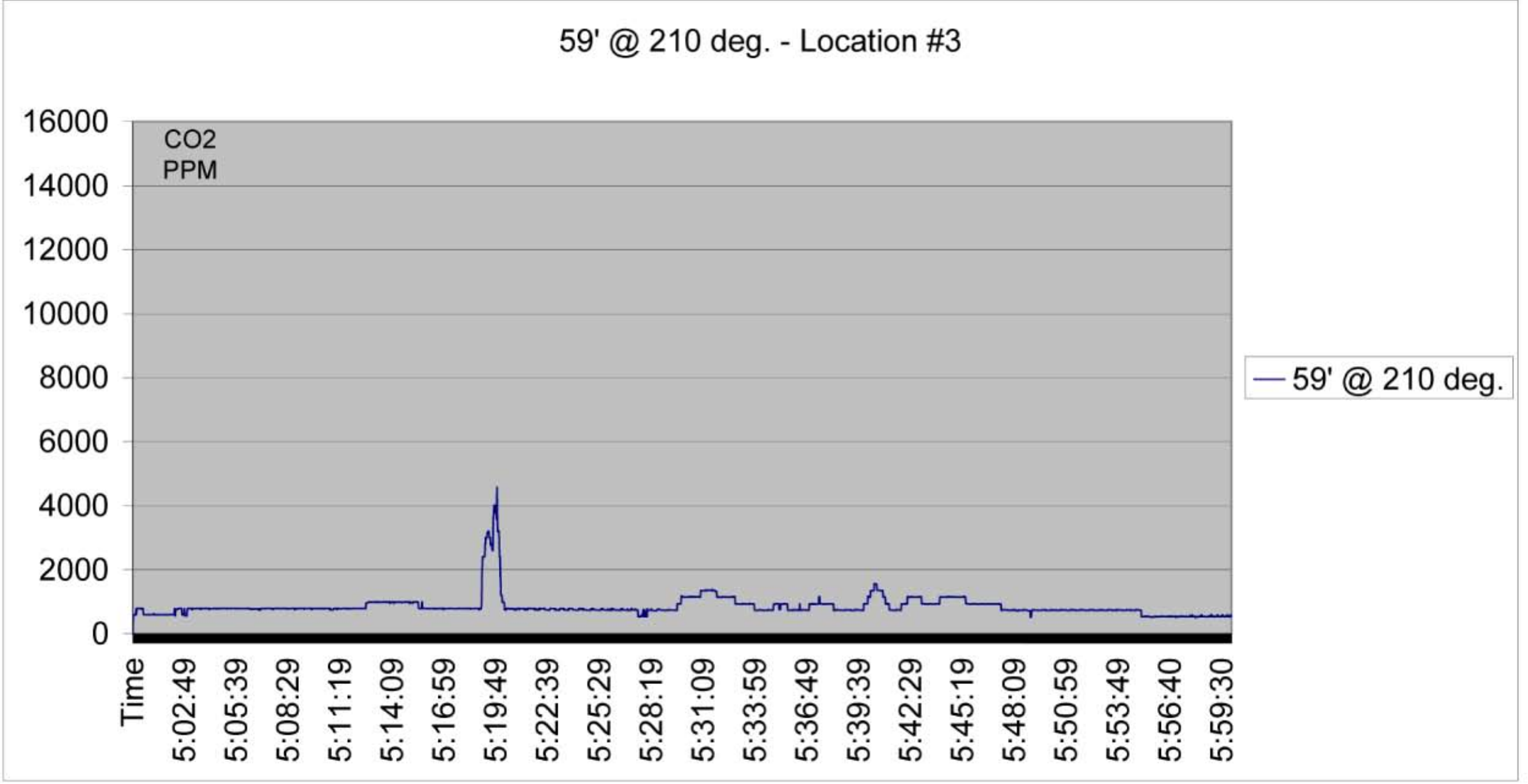
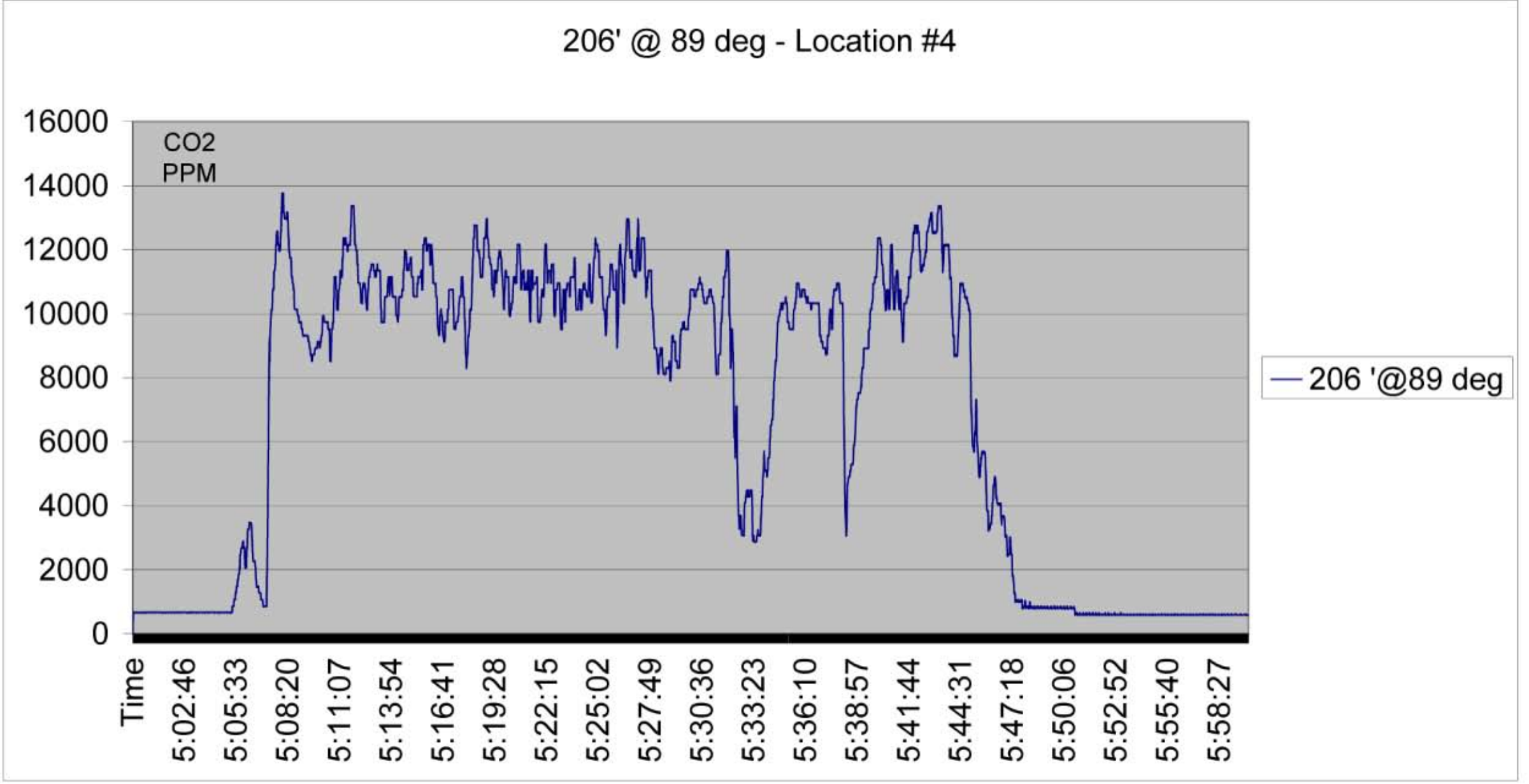
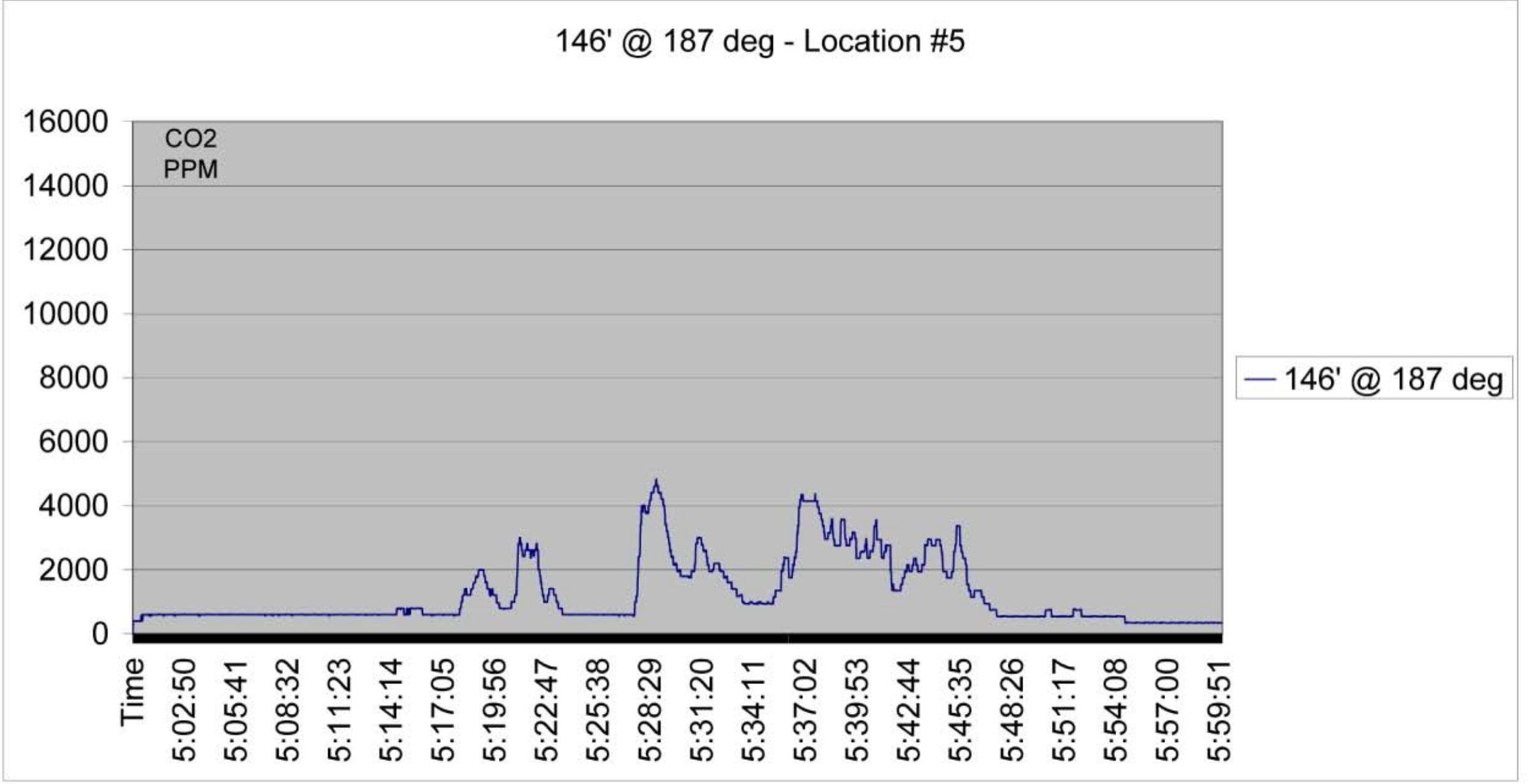
5:51:17
5:54:08
5:57:00
5:59:51
110 '@ 122 deg


59' @ 210 deg. - Location #3
CO2
PPM
16000
14000
12000
10000
8000
6000
4000
2000
0
Time
5:02:49
5:05:39
5:08:29
5:11:19
5:14:09
5:16:59
5:19:49
5:22:39
5:25:29
5:28:19
5:31:09
5:33:59
5:36:49
5:39:39
5:42:29
5:45:19
5:48:09
5:50:59
5:53:49
5:56:40
5:59:30
59' @ 210 deg.


206' @ 89 deg - Location #4
CO2
PPM
16000
14000
12000
10000
8000
6000
4000
2000
0
Time
5:02:46
5:05:33
5:08:20
5:11:07
5:13:54
5:16:41
5:19:28
5:22:15
5:25:02
5:27:49
5:30:36
5:33:23
5:36:10
5:38:57
5:41:44
5:44:31
5:47:18
5:50:06
5:52:52
5:55:40
5:58:27
206 '@89 deg


146' @ 187 deg - Location #5
CO2
PPM
16000
14000
12000
10000
8000
6000
4000
2000
0
Time
5:02:50
5:05:41
5:08:32
5:11:23
5:14:14
5:17:05
5:19:56
5:22:47
5:25:38
5:28:29
5:31:20
5:34:11
5:37:02
5:39:53
5:42:44
5:45:35
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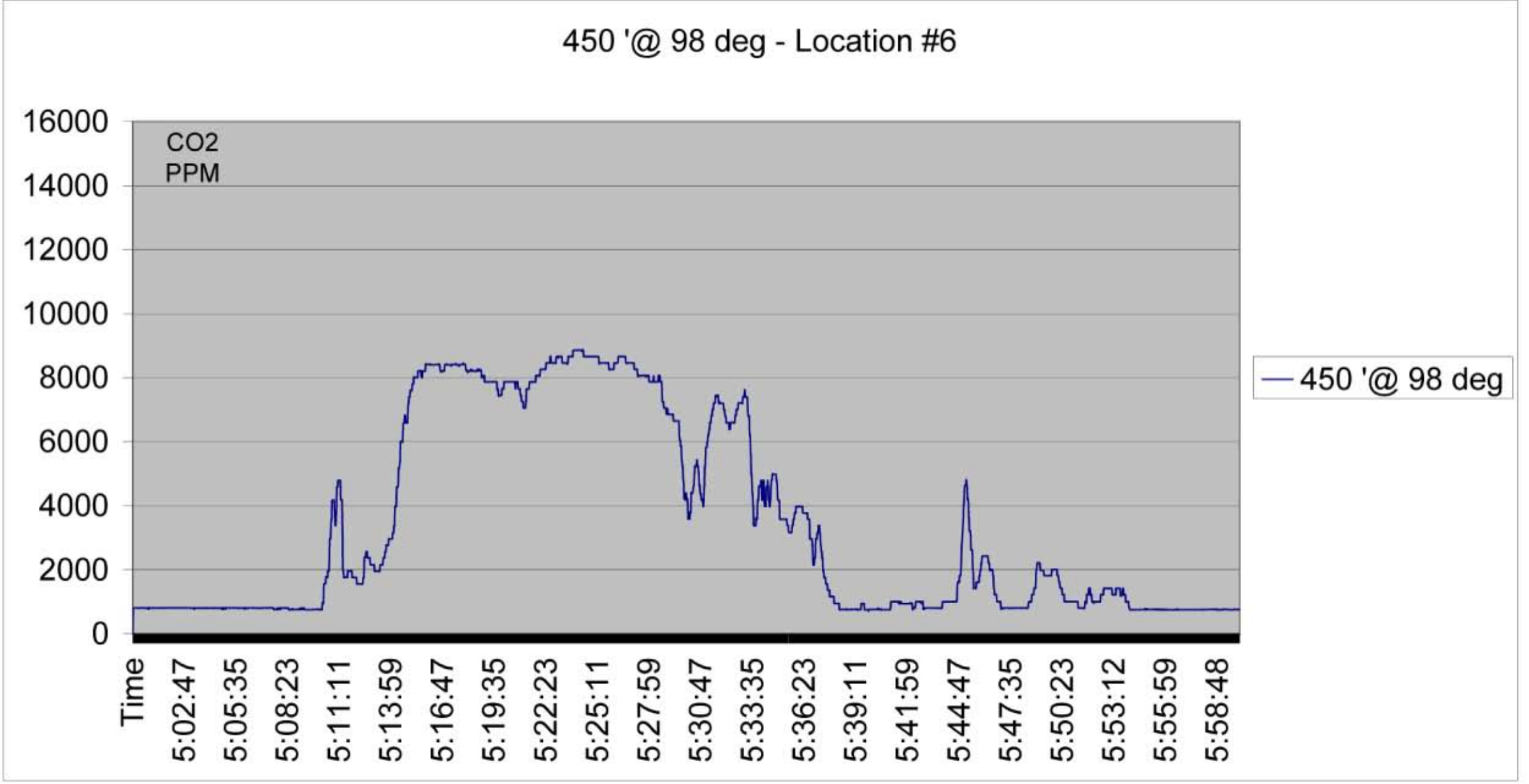
5:51:17
5:54:08
5:57:00
5:59:51
146' @ 187 deg


450 '@ 98 deg - Location #6
CO2
PPM
16000
14000
12000
10000
8000
6000
4000
2000
0
Time
5:02:47
5:05:35
5:08:23
5:11:11
5:13:59
5:16:47
5:19:35
5:22:23
5:25:11
5:27:59
5:30:47
5:33:35
5:36:23
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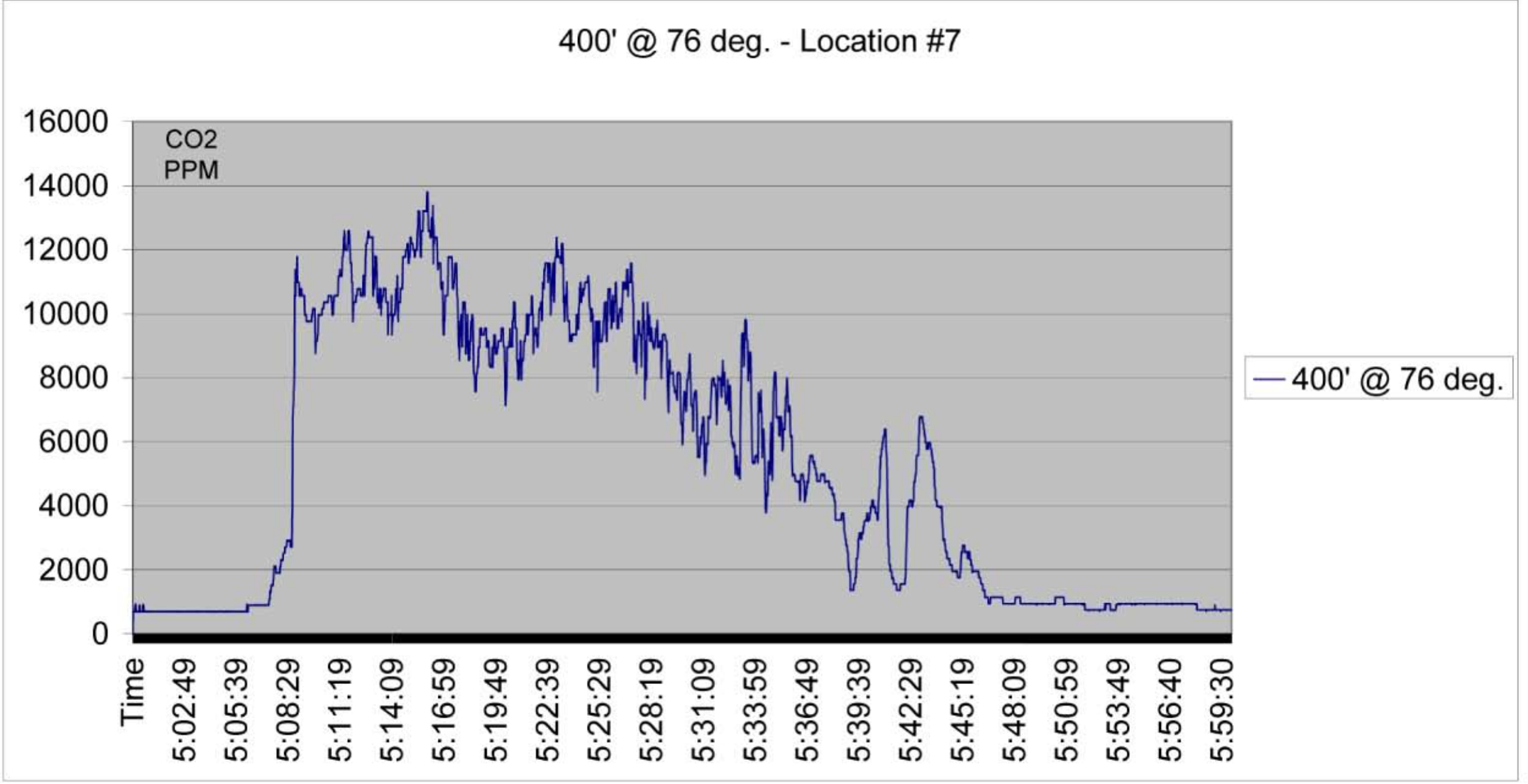
5:55:59
5:58:48
450 '@ 98 deg


400' @ 76 deg. - Location #7
CO2
PPM
16000
14000
12000
10000
8000
6000
4000
2000
0
Time
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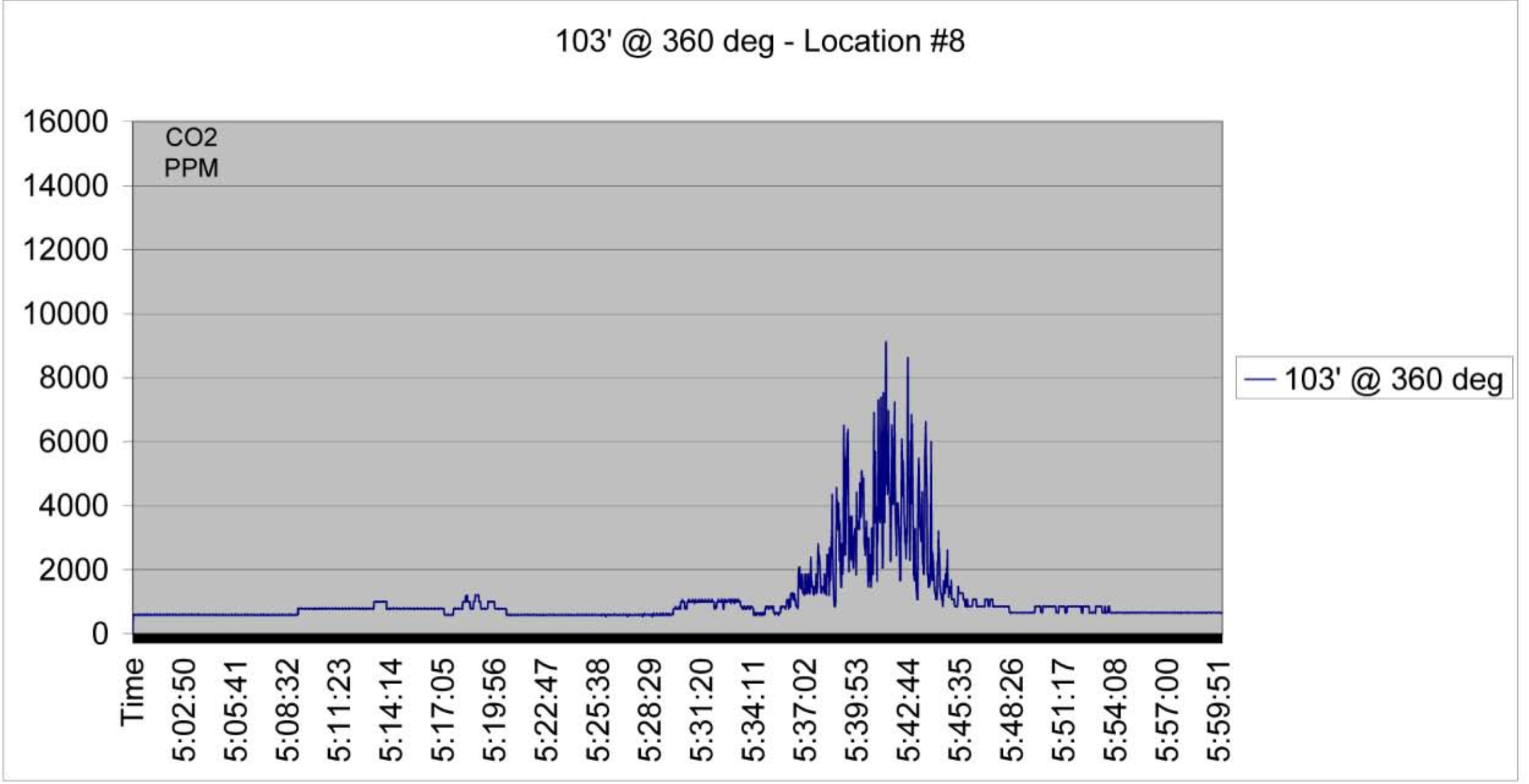
5:11:19
5:14:09
5:16:59
5:19:49
5:22:39
5:25:29
5:28:19
5:31:09
5:33:59
5:36:49
5:39:39
5:42:29
5:45:19
5:48:09
5:50:59
5:53:49
5:56:40
5:59:30
400' @ 76 deg.


103' @ 360 deg - Location #8
CO2
PPM
16000
14000
12000
10000
8000
6000
4000
2000
0
Time
5:02:50
5:05:41
5:08:32
5:11:23
5:14:14
5:17:05
5:19:56
5:22:47
5:25:38
5:28:29
5:31:20
5:34:11
5:37:02
5:39:53
5:42:44
5:45:35
5:48:26
5:51:17
5:54:08
5:57:00
5:59:51
103' @ 360 deg

Noxious Weed Management Plan

A Cooperative and Integrated Weed Management Plan
for
Howell Petroleum Corporation's
CO_2 Enhanced Oil Recovery Project
at
Salt Creek Field, Midwest, Wyoming

A cooperative effort involving:

Howell Petroleum Corporation
Natrona County Weed & Pest
Bureau of Land Management

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Introduction

The Salt Creek oil field has been in existence at Midwest, WY for over a century. The history of noxious weeds and exotic, introduced plants can be assumed to be at least that old. Several species of State designated noxious weeds are found in the area today including; Russian knapweed, salt cedar, scotch thistle, leafy spurge, diffuse and spotted knapweed, Canada thistle, and field bindweed. Because this area is periodically disturbed through operation and maintenance of the oil field, noxious weeds have become an integral part of the plant community of the area. (Can this section also address other land users and their contribution through their operations to the weed problem, for example grazing management).

The impetus for the adoption of this cooperative plan came from the recognition that noxious weeds and their spread are harmful to desirable plant communities and the wildlife and livestock that depend on those plant communities.

Currently Salt Creek oil field is leased and operated by Howell Petroleum Corporation (HPC), a subsidiary of Anadarko Petroleum Corporation. HPC is currently in the preliminary stages of a field-wide recovery project which will use injected Co_2 to enhance oil recovery and extend the life of the field. A part of this process will be a marked increase in "dirt excavation" for pipelines, well pad upgrades, etc. A natural fallout of this increased soil disturbance will be an increase in noxious weed populations. This cooperative document and the integrated plan it describes, is a good faith attempt to mitigate and control future noxious weed spread as it pertains to the Salt creek oil field.

An integrated approach to the noxious weed problem will be adopted. This approach will integrate all available prevention and control methods that are available and feasible to the circumstance(s). These will include planning, prevention, education, monitoring, and mechanical, chemical, biological, and cultural controls. This plan will also establish a framework of communication and cooperation between Howell Petroleum Corporation, the Natrona County Weed and Pest District, the Bureau of Land Management, the town of Midwest, WY, and other interested or affected private landholders. This is designed to be a dynamic document that is conducive to change, revision and upgrade as the "on-the-ground" situation changes. This is also a voluntary and cooperative plan that will rely on good faith effort by all parties. The shared common vision and goal of controlling noxious weeds will the driving force behind the success of this plan. Above all, a culture of intolerance should be adopted by all players in respect to noxious weed infestations. If all entities involved "own" the problem then weed control can be achieved through persistence and "sweat equity".

Goals and Objectives

Primary Goals

The primary goal of this handbook is to provide the interested parties with a comprehensive plan to control the spread of noxious weeds (and other invasive species) in the Salt Creek oil field. The proposed construction involved with the CO_2 Enhanced Oil Recovery Project will potentially escalate the spread of weeds in the area. This plan will give all interested parties the tools to mitigate the potential spread of noxious weeds involved with increased construction, reduce existing weed infestations and prevent the establishment of new infestations. These tools will include mapping and inventory of new and existing weed patches, education in weed ID and management, control of noxious weeds using mechanical, chemical, and cultural control; monitoring existing populations; and communication protocol for keeping everybody "in-the-loop".

Objectives

1) **Education**- An important component of any weed management plan is education. Some of the education objectives of this plan will include:
   a) Weed ID- a list of State Designated noxious weeds of special concern to this project are listed in Appendix I with plant descriptions, illustrations and pictures, natural history, and control options. An additional section in Appendix A will contain Weeds to Watch for. These will include noxious weed species that may come into the project on excavation equipment, trucks, pipes, vehicles, etc.; Copies of "The Weed Handbook" are included with this manual.
   b) Prevention- The prevention Chapter of this manual will describe various techniques for noxious weed prevention. These include roadside management, washing excavation equipment, pre-treatment of future excavation sites, and revegetating disturbed areas.
   c) Chemical Control- In the Control section of this handbook is found a chapter on chemical control. This contains information on herbicide safety and use. It will outline various application techniques and discuss the appropriate use(s) of each. In Appendix II will be an herbicide chart that will illustrate various herbicides, the species they work on, rates of application, application timing and safety equipment required.
   d) Inventory and Mapping protocol- this handbook will establish common inventory and mapping protocol so that all participants can gather data on noxious weed infestations that will be relevant. Appendix X contains blank inventory forms that can be used to report a noxious weed location to the BLM or the Natrona County Weed and Pest District. Weed locations can be entered in PLS (Township/Range ¼, 1/4 Sec) or GPS coordinates.

2. **Treatment priorities and Scheduling**- There are seven species of noxious weeds in the project area. These are Russian knapweed, salt cedar, Canada thistle, spotted and diffuse knapweed, leafy spurge, and field bindweed. Treatment priorities will concentrate on these species with the main focus on Russian knapweed as it represents the largest infestations in the project area. This plan will address these priorities in prevention, education and control. Scheduling recommendations for noxious weed treatment will be suggested and periodic meetings will be recommended for scheduling treatment windows to assure the most efficient results. Treatment recommendations for County weed crews, private contractors and other personnel will be coordinated and scheduled.

3. **Cultural Control-** The most important component in gaining and maintaining long-term weed control lies in good cultural management practices. This handbook will address revegetation practices, encouraging extant native plants to thrive and avoiding soil disturbance where possible.

4. **Communications-** A plan for cooperation between Project personnel, the Natrona County Weed and Pest District, any contract weed treatment personnel and BLM personnel will be addressed in this handbook. This will coordinate efforts of various entities to assure timely and effective weed abatement in the project area. A planning and review meeting should be scheduled each winter to coordinate the upcoming year's efforts and to review and make any needed changes to the plan.

5. **Monitoring and Oversight-** With good preliminary mapping and inventory data, periodic monitoring of project gains and losses will be possible. A revaluation of problem areas will highlight any problems or successes and the plan can be adjusted accordingly.

Summary

The problem of noxious weeds in the Salt Creek oil field is an old one **and** a big one. The extent of the problem is resistant to **any** "one-shot" fixes. The proposed CO_2 Enhanced Oil Recovery Project has the potential to escalate the problem exponentially. The recipe for mitigating potential future weed expansion and to abate existing infestations; is a cooperative, coordinated and integrated plan. The plan must use all available options and resources to be successful. This plan must be realistic and persistent as control will take many years. Above all, this goal is attainable and will be achieved through hard work and the commitment of all parties.

Priorities and Scheduling

There are eight known species of State designated noxious weeds occurring in the project boundaries. These species are listed below:

Russian knapweed

Salt cedar

Spotted knapweed

Diffuse knapweed

Scotch thistle

Canada thistle

Leafy spurge

Field bindweed

(See Appendix I for information/ illustrations on these spp.)

Of these eight target species, **Russian knapweed** occupies the largest area**.** The reasons for Russian knapweed to be a priority are:

1. Russian knapweed occupies more acreage in the project than any other species.
2. Russian knapweed reproduces vegetatively. During cultivation (or excavation!) the small pieces of cut up root will re-establish as another plant. This poses a special problem with proposed CO_2 injection construction work.
3. Russian knapweed is strongly alleleopathic. This means that the plants produce chemicals that prevent other plants from growing in their vicinity. This ability can hamper reseeding efforts.
4. Russian knapweed is very competitive. Without good pre-excavation control, this plant will rapidly out compete and take over any seedling grasses or other reseeded plants in pipeline right-of-ways.

There are currently no biocontrol agents approved for Russian knapweed. Therefore the best control of this plant will involve a combination of prevention, chemical control and cultural control.

Four other weeds found in the project area have a potential to rapidly expand their range if gone untreated or undetected. These are **spotted knapweed, diffuse knapweed**, and **leafy spurge** and **scotch thistle**. Spotted knapweed, diffuse knapweed and scotch thistle are all biennials and must be treated chemical in the spring…before they go to seed!!!. Leafy spurge is a perennial and responds well to both spring and fall herbicide treatments.

The remainder species are of less priority due to several factors that include: specific habitat requirements (salt cedar only grows in "sub irrigated" areas, Canada thistle has similar requirements) and relatively low current densities.

On Table 1 is a prioritized list of noxious weeds in the Project, Area treatment options and ideal treatment timings.

Table 1.

Species	Treatment Options	Timing
Russian knapweed	Chemical and cultural control is effective **No** biocontrol agents available Mechanical control ineffective Herbicides: Tordon™+ surfactant, Redeem™+ surfactant	Fall treatment after plant has flowered but before killing frost Late August and into September
diffuse knapweed, spotted knapweed	Chemical, mechanical, cultural and biocontrol effective. Currently 7 biocontrol agents available in County Herbicides: Tordon™, Redeem™, 2,4-D Amine Addition of surfactant increases control	Spring/ early Summer **Before** seed production Fall treatment ineffective due to seed production w/ the exception of new rosettes
Leafy spurge	Chemical, cultural and biocontrol Currently 2 biocontrol agents available Herbicides: Tordon™ in spring, Plateau™ in fall	Spring/ early summer to mid-bloom Tordon™ Fall before killing frost w/ Plateau™+ MSO

scotch thistle	Chemical, cultural, mechanical controls Herbicides: Tordon™, Redeem™, 2,4-D Amine	Spring/ early summer at rosette stage

Table 2 contains additional weed species and treatment options:

Table 2.

Species	Treatment Options	Timing
Salt cedar	Chemical, possible biocontrol available in 2004? Herbicides: Arsenal™ + surfactant	Foliar application during flower stage requiring 60% coverage Plant must be left undisturbed 2 years after treatment
Canada thistle	Chemical, cultural and biocontrol Biocontrol efficacy is questionable Herbicides: Redeem™, Tordon™, Banvel™, Curtail™	Spring/ early summer from rosette to mid-bolt or fall re-growth before killing frost
Field bindweed	Chemical control possible biocontrol at later date? Herbicides: Plateau™, Paramount™, Banvel™, glyphosate	Fall before killing frost w/Plateau™, Paramount™, glyphosate At full flower w/ Banvel™

Timing and coordination are essential to achieve control and to avoid wasted efforts and money!!

Summary

The first noxious weed priority in the Project Area is **Russian knapweed**. This is due of course to its ubiquitous distribution in the Project Area and its ability to reproduce from the small root fragments resulting from cultivation and/or excavation. The most effective means of controlling this plant is a fall herbicide treatment. This is the time of year that the plant is storing energy in its root system to overwinter. The herbicide applied at this time can achieve good root control. With the scope of proposed excavation in the Project, it is essential to coordinate fall Russian knapweed treatments with winter and/ or next years excavation schedule. Infestations must be inventoried and mapped so that future excavations may be planned to include a previous fall herbicide treatment.

Likewise, excavation and construction should be planned to include an herbicide pretreatment for any of the listed noxious weeds at the appropriate time and w/ the appropriate herbicide.

The Natrona County Weed and Pest District can help coordinate these efforts with periodic planning meetings and timely treatments. Contract weed treatment by outside entities must also be coordinated. It is suggested that at least two meetings/ planning workshops be scheduled annually. They should include one in the late fall to preview upcoming Project construction and excavations and one in the early spring to formulate the season's treatment schedule. These workshops should be attended by all relevant personnel including: BLM Noxious Weed Management personnel, Howell Petroleum Corporation/ Anadarko Petroleum Corporation relevant personnel, Natrona County Weed and Pest District relevant personnel and any contract weed spraying personnel.

Natrona County Weed and Pest District can and will provide technical expertise, inventory and mapping, weed treatments, organizational assistance, and long-term monitoring. Because of limited time (spring, summer and fall only last about 3 months in this country!!), crews, and funding; it will not be possible for the Natrona County Weed and Pest District to inventory, map, and treat the whole project area. For the goal of noxious weed control to be reached in this Project, it will be necessary to apply additional resources to this project. These resources may be in the form of contract weed treatment personnel, company or contract inventory/mapping personnel. The Natrona County Weed and Pest District would be available to assist in training any additional people involved with herbicide treatment or inventory/mapping. Inventory and mapping can be accomplished by any interested parties. The basemap for the Natrona County Weed Survey is already in place with much of the northwest quadrant of the county already surveyed. To add mapping data to that map will only require that certain simple protocol be established and followed.

In the next chapter, Mapping and Inventory, mapping protocol for the project will be detailed. Additionally, there is found in Appendix B, inventory data sheets which can be used to collect data through GPS units or simple map plotting.

Mapping and Inventory

Mapping and inventory of existent noxious weed infestations will be essential for planning, prioritizing and monitoring the Project. This will be an ongoing process and it won't be absolutely necessary to obtain all of this data **before** any treatment starts.
This section of the handbook will establish inventory and mapping protocol to assure that data gathered is useable and relevant. The data gathered in the Project will be stored in the BLM's Natrona County Weed Survey dataset and will be available to all parties in the project.

Overview of Project Mapping and Inventory Data

Mapping and inventory data for this project will follow the BLM's data protocol for their Natrona County Weed Survey. The reasons for this are:

1. Four years worth of weed mapping have already been collected and placed on a basemap of the region.
2. This dataset and accompanying protocol is well established and is currently being used by BLM and Natrona County Weed and Pest District personnel

Mapping and inventory data can be collected in various ways. These methods include:

1. Using a Trimble™ GPS unit with the appropriate Data Dictionary loaded on the unit. The Data Dictionary is the BLM Casper District Office's Data Dictionary labeled "Weed Survey".
2. Using **any** GPS unit. The coordinates gathered and any accompanying data (ex. Weed species, relative density, datum used, coordinate system, etc.,) must follow the protocol listed below and found on the "Noxious Weed Inventory Data Collection" form found in Appendix B.
3. Plotting the data on the PLS (Public Land Survey) grid supplied in the "Noxious Weed Inventory Data Collection" form found in Appendix B (using a 7.5 minute topographical map).

By using various methods of mapping, and by following the below listed protocol, it will be possible for all personnel involved in this Project to collect noxious weed inventory data. The flexibility of the mapping protocol will also make it possible for personnel with varying degrees of map plotting expertise to add to the inventory for the Project.

Mapping and Inventory Data Collection Protocol and Methods

Steps in mapping noxious weed infestation in the Project

1. Positively ID the weed! There are weed ID pictures/ illustrations in Appendix A with descriptions. Other resources include "the little yellow book" (Weed Handbook Series 1-55) and Weeds of the West.

2. If using a **GPS unit**:
   a: Determine the **map datum, coordinate system,** and **date** (these can be found in the "setup menu" of the GPS unit).
   b: After acquiring the satellites, capture a series of points around the perimeter of the weed patch.
   c: Fill out the **Digital Noxious Weed Map Data Form** in Appendix B
   d: Download the GPS points to 3 ½ inch floppy disc or CD ROM and give it and the completed Digital Noxious Weed Data form to the BLM Casper District Office or the Natrona County Weed and Pest District. This data will be entered in the Weed Survey Map for Natrona County.

3. If using a paper 7.5 minute topographical map:
   a: Plot the Township, Range and ¼, ¼ Section of the weed infestation.
   b: Fill out the **PLS Noxious Weed Map Data Form** in Appendix B.
   c: Mail or deliver this form to: BLM Casper District Office
   Attn: Gary Skillman
   2987 Prospector Dr.
   Casper, WY 82609

   OR Natrona County Weed and Pest District
   Attn: Brian Connely
   P.O. Box 1385
   Mills, WY 82644

Prevention

As the old adage says, "an ounce of prevention is worth a pound of cure!". This expression can be directly correlated to pennies and **dollars$$$$**.
Preventing the initial establishment of noxious weeds is as cheap as weed control gets**.**
The excavations planned for the Project have the **potential** to inoculate hundreds of acres in noxious weeds. The Project also has the potential to **prevent** the establishment of hundreds of acres of noxious weeds! To save time and money "down the road", it is essential that prevention be effectively incorporated into the Project plans. Listed below are steps that must be taken in prevention.

Prevention Plan

Step 1- Planning

To the extent feasible, all well pads, pipeline right-o-ways, new road right-o-ways and construction sites must be planned to include a pre-treatment for noxious weeds.(ideally, we can do our preplanning to the degree necessary to achieve pre-treatment. However, there will always be instances where either emergency work is completed or projects are designed and implemented (including siting on the ground) at points after a pre-treatment should have occurred. Ideally, existing stands of Russian knapweed, Canada thistle, and field bindweed will be treated in the fall **preceding excavation**. Existing stands of scotch thistle, spotted and diffuse knapweed and (Leafy spurge should be omitted from this plan as because as I understand it the most effective treatment is on a watershed basis) should ideally be treated in the spring **preceding excavation.** Salt cedar should be treated w/ Arsenal™ in mid summer and left undisturbed for at least one year **or** cut down and the stumps immediately be treated w/ Garlon3A™ with resprouts treated periodically.
To facilitate this prevention plan, biennial "planning workshops" should be incorporated in the fall and early spring of each year. At these workshops, the coming seasons excavations can be reviewed, and a treatment schedule devised to anticipate upcoming work.
These planning workshops should involve relevant personnel from:

Howell Petroleum Corporation
Anadarko Petroleum Corporation
Natrona County Weed and Pest District
BLM Casper District Office
Weed Treatment Contractors

At the successful conclusion of each meeting, a treatment schedule will be assigned to Natrona County Weed and Pest District crews, weed treatment contractors and any other treatment personnel.
Pre-excavation treatments should be scheduled a minimum of 3 weeks prior to excavation to allow for good herbicide translocation and root control.

Step 2 – Dirt Work

To prevent the importation of noxious weed seed onto the construction site, certain measures should be taken.
All excavation equipment should be washed thoroughly at a proscribed location prior to entering the jobsite (how do we define jobsite when we are doing linear facilities that often parallel one another or cross and are all part of the same construction project? Care should be taken to contain equipment and vehicles within the pre-treated construction site while working. This will prevent equipment from becoming re-contaminated with weed seed from adjacent sources.
Proscribed vehicle washing areas should be monitored and treated for germinating noxious weeds on an annual basis.
Haul trucks and other vehicles should avoid driving through weed infestations while traveling to and from the jobsite. Operators should be made aware of noxious weed prevention through education.
Contain weed seed infested overburden on-site.
At the completion of dirt work the area should be revegetated using an appropriate seed mix or maintained as a bareground area (as in the case around buildings or well pads).

Step 3- Post Construction

After all dirt work and construction is completed, the site should be appropriately maintained to discourage weed growth.
In the case of pipeline right-o-ways, roadside borrow ditches and other areas that will not receive heavy vehicle traffic, the following steps should taken.

- ✓ The area should be replanted with an appropriate seed mixture that controls erosion, strongly competitive to weeds, is hardy in these climate/soils and is resistant to broadleaf herbicides that may be used to control future weed problems. Care should be taken to select certified weed-free seed and to plant at the correct time with the right methods. (Pre-treatment may be necessary prior to re-seeding, contact Natrona County Weed and Pest District).

In the case of areas that will receive periodic vehicle traffic and/or disturbance the following option may be considered.

- ✓ Maintain the area as "bareground" using a combination of soil sterilants, non-selective herbicides and mechanical control.

Step 4- Education

It is vital to the success of this Project that all people involved with the Project be educated in noxious weeds, their impacts, prevention and control. A comprehensive and integrated approach to education would be the best. To accomplish this, several ideas are suggested.

- ✓ Provide periodic training of personnel on noxious weeds. Focus on the larger problem of noxious weeds and their impacts on a regional and national scale. Describe the negative impacts noxious weeds have on wildlife, hunting and fishing. Try and get personnel to "own the problem".
- ✓ Post posters, articles and educational materials in employee locker rooms, break areas, etc.,
- ✓ Provide employees with weed ID Handbooks for company vehicles and blank mapping forms found in the appendices of this document.
- ✓ Develop a "zero tolerance" attitude toward noxious weeds at selected sites such as company main offices, compressor station bldgs., etc.,
- ✓ Provide selected personnel with herbicide use and noxious weed control training. Provide basic tools to treat noxious weeds. These would include a Solo™ backpack spray unit, a small "nurse tank" of water, herbicide and safety equipment (gloves, safety glasses, long-sleeved shirt, long pants, shoes that cover the feet are generally all that is needed for safety equipment).

The BLM and the Natrona County Weed and Pest District can provide educational materials and training personnel.

Control

Integrated Weed Management- "Control 101"

The best results for noxious weed control come from an integrated system of weed management. Simply stated this means that you develop a plan that uses all available forms of weed control. An effective Integrated Weed Management (IWM) plan must:

- Manage the land to prevent weeds from establishing and spreading
- Incorporate correct identification and knowledge of noxious weeds
- Inventory, mapping and monitoring weed populations
- Prioritizing weed control based on sound science and land use(s)
- Using all available control methods to maximize effectiveness and reduce cost
- Evaluate the effectiveness of control strategies
- Attend applicable workshops, seminars and training

All IWM plans incorporate prevention, education, and a combination of mechanical, chemical, biological, and cultural control methods. This handbook has previously outlined the Prioritizing, Mapping, Education and Prevention aspects of this IWM plan. This section will detail various, applicable control forms for each target weed species in the Project (refer to Table 1 & 2 of the Priorities and Scheduling section for quick reference). Applicable control methods for each species are **highlighted in bold type** below.

Control of.....

Russian knapweed (*Actipolon repens*)

Control Options:

Mechanical (hand pulling, cultivating, burning, mowing)

Mechanical control of Russian knapweed is not an option due to the plant's ability to reproduce vegetatively and an immense underground root system with massive energy reserves. Cultivating only serves to spread the plants due to the fact that each small portion of the root can become a new viable plant. Hand pulling is equally ineffective because

of the inability to pull up the massive root system. Mowing and burning are also ineffective because Russian knapweed reproduces primarily from vegetative shoots. Reproduction from seed is minimal.

Chemical Control (herbicides)

The proper selection and use of herbicides is an effective way of controlling Russian knapweed. Two effective herbicides on Russian knapweed are; Tordon™ and Redeem. Tordon is used with <u>good</u> effect in the late fall, just before killing frost. Redeem and Tordon both provide acceptable control of Russian knapweed when used in the spring; from rosette stage to mid-bolt. Usage rates are as follows:

Spring (rosette to mid-bolt)

Tordon……. Use 2quarts (Qts) per acre (A)
Redeem…… Use 2Qts/A + .025% non-ionic surfactant (by volume)

Fall (after full flower, before killing frost)

Tordon……. Use 1Qt/A

Fall applications of Tordon provide the best level of control. The addition of a non-ionic surfactant can improve control. Note that Tordon is a restricted use herbicide and a Pesticide Applicators License is required to purchase this product.

Biological Control

There are not currently any biocontrol agents approved for Russian knapweed. Several biocontrol insects are being evaluated at this time and may be available in the future.

Cultural Control

A combination of prevention, initial herbicide control and then a successful reseeding of competitive cool season grasses represent the very best plan for long-term control. The grass species selected should be

> **"cool season, have moderate desirability to wildlife and livestock and establish well on difficult sites. They should be well adapted to an area and be long-lived." (Tom Whitson, 1997, bold type added)**

For Russian knapweed, a treatment of Tordon at a 1Qt/A rate in the fall (after 3rd week in August, before killing frost) followed by reseeding grasses such as Bozoisky Russian wildrye or Luna

pubescent wheatgrass in the spring is a good strategy. Reseeding grasses should be done in a firm bed of topsoil (not "fill dirt"!) down to a depth of ¼". Providing fertilizer and thin, weed free layer of mulch will help the grasses become well established. It is important in a spring seeding operation, to plant early enough that spring moisture will help germinate the seedlings. After grasses become established, broad-leafed weed control can be accomplished with various, appropriate herbicides.

For specific seeding recommendations and methods, contact the NRCS Plant Materials Center for the area and the BLM range management personnel.

Diffuse knapweed (*Centaurea diffusa*), Spotted knapweed (*Centaurea maculosa*), and Scotch thistle (*Onopordum acnathuim*)

Control Options

Mechanical-

These three species are biennials to short-lived perennials so their only source of reproduction is prolific seed production. Because of this fact, hand pulling, mowing and cultivation can be useful tools in helping to control these plants. Mechanical control must be implemented before the plants produce viable seed!

For isolated plants, pulling and burning the pulled plants is effective. For larger stands, a combination of mowing or cultivating before seed production along with herbicide treatment is the best strategy. Repeated mowings throughout the growing season are necessary to prevent seed production. Be aware that this can stimulate a "prostrate growth habit" in spotted and diffuse knapweed.

Chemical-

Because of their massive seed production, these plants need to be treated in the spring/early summer, preferably before flowering. Treatment timing should be after all new seedlings have emerged but before the two-year-old plants bolt and produce seed stalks. The following herbicides provide good control of these species.

Tordon- Use a 1QT/A rate on rosette to mid-bolt plants. The addition of a non-ionic surfactant at the recommended rates (.025% by volume) can improve control of drought stressed plants.

Redeem- Use a 2QT/A rate on rosette to mid-bolt plants. The addition of a non-ionic surfactant at the recommended rates (.025% by volume) can improve control of drought stressed plants.
2,4-D Amine- Use a 2QT/A rate on rosette to mid-bolt plants.

Biological Control-

There are currently seven species of biocontrol insects released on various infestations of diffuse and spotted knapweed in the County. They have provided excellent control when used in conjunction chemical treatment. The Natrona County Weed and Pest District will survey the infestations for the presence of applicable biocontrol insects and make additional releases where necessary and applicable. There are no effective biocontrol agents for scotch thistle.

Cultural control-

These three species are biennials, living two years and reproducing from seed. Seed production is huge, with each plant having the potential to produce up to a thousand seeds per year. Cultural control of these species should involve a spring herbicide treatment prior to exaction activities. After excavation a combination of sod forming and bunch grasses should re-seeded to the site in a firm topsoil seed bed, with a weed free mulch. A dormant fall planting is best with a combination of Sodar streambank wheatgrass, hycrest crested wheatgrass and Luna pubescent wheatgrass. Because of the large seedbank potential for these two knapweeds, spring herbicide treatment of Redeem or Tordon is recommended until grass is well established and the seedbank is worn out.

Leafy spurge (*Euphorbia esula*)

Control Options

Mechanical control-

Leafy spurge has an extremely deep and spreading root system. Some plants have been known to have roots that extent 20' into the ground! This makes any type of mechanical control ineffective.

Chemical control-

Leafy spurge has incredible root reserves of energy. This makes the plant very difficult to control, indeed impossible to control with any "one-shot" application. Two herbicides are effective on this plant. They each have different timings of application.

Spring/early summer- from green-up to bud stage
Tordon- Use 2Qt/A

Fall- from late fall until killing frost
Plateau- Use 8-12 fl. Oz/A with 1QT/A MSO (methylated seed oil)

Biological Control-

Several species of biocontrol insects are approved for leafy spurge. These biocontrol agents have varying habitat requirements. All of these species require an area that has fairly dense leafy spurge stands; that will remain untreated and undisturbed for many years. Because the leafy spurge population is very low on the Project (found in only one area by the old power plant) and will be treated chemically in the future, biocontrol is not an option on this site.

Cultural Control-

Great results of controlling leafy spurge with one initial herbicide application and then reseeding to Bozoisky Russian wildrye and Luna pubescent wheatgrass were achieved in work done by UW at Devil's Tower. It is recommended that any disturbance or excavation in the existent leafy spurge infestation be avoided if possible. Excavation or "dirt work" has the potential to spread this plant "from Hell to breakfast". If disturbance cannot be avoided then the following recommendation is advised:

> **Treat with Tordon in the spring 2QT/A. In Late fall treat with Plateau 8-12 fl. OZ/A. Complete excavation of the area in winter. Reseed a combination of Luna pubescent wheatgrass and Bozoisky Russian wildrye into a firm seed bed of adequate topsoil at a ¼" depth in early spring (prior to good spring moisture). Use a weed- free mulch and fertilize. Spot treat any leafy spurge with a spring application of Tordon, after grasses are well established.**

Fortunately, leafy spurge is contained in a small area of the Project. This is NOT a weed that we would want on a larger scale.

Salt Cedar (*Tamarix chinensis*)

Control Options

Mechanical Control-

As the old Russian farmer would say, "Neyt!" This plant has incredible re-sprouting abilities. Chopping down, bulldozing, chaining are all a waste of time with this plant. There has been some success with chainsawing down the stems followed immediately with an application of herbicides to the cut stems. As one might suspect this is very labor intensive and not an option in most operations with the exception of those operations with access to very cheap labor (the State of Arizona uses convicts for this work!)

Chemical Control-

Two options for chemical control are currently being used with good effect. These are as follows:

Midsummer at full flower stage

Arsenal™- Use a foliar application, covering > 70% of foliage, of a 2.5% solution arsenal in water + .25% percent by volume MSO. Retreat any re-sprouts and leave undisturbed for at least one year after treatment.

Anytime providing there is no snow cover
Garlon 4A™- this is a basal bark treatment where the stems are covered 360° with the herbicide mixture form the ground up to 18". Use 1 part Garlon 4A to 3 parts JLB oil. Re-treat resprouts and leave undisturbed for at least one year after application.

Biological Control-

There is currently work being done with several bicontrol insects for salt cedar in the Bighorn Basin. At least one of these critters (the leaf beetle, *Diorhabda elongata*) should be available for release in 2004. This insect can be incorporated into the salt cedar infestations along Salt creek and should provide good results in the next decade (bicontrol takes a long time!).

Cultural Control-

Each salt cedar plant has the potential to pull from the ground and transpire to the atmosphere up to **200 gallons of water a day**! These plants often grow in very saline environments (like Salt Creek drainage) and have developed mechanisms for dealing with these high saline conditions. They concentrate the salt on their leaf and twig surfaces and then continually shed their leaves/twigs. This creates an extremely salty layer around the plant that excludes other vegetation. Because of this and the fact that they are aggressive resprouters, cultural control of salt cedar is difficult. A healthy and dense carpet of sod forming grasses such as Meadow brome, blue grama, or Sodar streambank wheatgrass may help prevent initial salt cedar seedlings from taking hold.

Canada thistle (*Cirsium arvense*)

Control Options

Mechanical control-

Canada thistle is the number one noxious weed **in the World**! In part this is due to the English and the French spreading it around in the 17th, 18th, and 19th centuries. when they "owned

the world". This is also due to the fact that Canada thistle has a massive system of horizontal and vertical roots. The plant reproduces vegetatively (clones itself). Therefore; one Canada thistle plant may become established from seed in a pasture and consequently spread to 100 acres by cloning from that one plant. When cultivated, each root fragment of Canada thistle can become a new plant. All of these factors contribute to make Canada thistle difficult if not impossible to control with mechanical means.

Chemical Control-

To control Canada thistle with an herbicide, it is necessary to select a product that will translocate and control the rootstock. Several herbicides will do this.

Spring/early summer- from rosette to mid bolt
Redeem- Use a 2QT/A rate with 1QT/A non-ionic surfactant
Tordon- Use a 2QT/A rate.
Dicamba- Use 2LB AI/A

Fall regrowth
Redeem- Use a 2QT/A rate with 1QT/A non-ionic surfactant
Tordon- Use a 2QT/A rate.
Glyphosate (for pre-treatment prior to seeding)- Use 3Qt/A + 15 Lbs ammonium sulphate per 100 gallons solution.

Biological Control

Several species of biocontrol insects are available for Canada thistle. Unfortunately none have been found than provide good control.

Cultural Control-

Canada thistle seedlings are sensitive to shading and will not develop without adequate sunlight. In areas where a multi-storied, dense native plant canopy can be encouraged, Canada thistle will have a tough time establishing. Unfortunately, Salt Creek drainage is not conducive to that type of habitat.

Field Bindweed (*Convolvulus arvense*)

Control Options

Mechanical Control-

Again due to an extensive network of roots, this plant cannot be controlled mechanically.

Chemical Control-

Field bindweed has proven to be difficult to control with herbicides. Two relatively new herbicides have shown some promise.

Fall- after seed production, before killing frost

Paramount™- This BASF product is labeled for, and can be used, on right-o-ways and non-crop areas. Use at 10 OZ(wt.)/ A + 0.25% by volume, MSO.

Plateau™- Another BASF product; labeled for non-crop and native range. Use at 8-12 fl. OZ/A + .25% MSO, by volume.

Glyphosate- Use at 5QT/A rate with ammonium sulphate as recommended on the label.

From full flower stage

Dicamba- 2Qt/A

Cultural Control-

Field bindweed will grow in many different habitats, including tightly occupied plant communities. This fact makes it hard to control by competition. Reseeding protocol for excavated areas that contain field bindweed is as follows:

Treat field bindweed with Glyphosate at 5QT/A + ammonium sulphate in late fall, just before killing frost, but 3 weeks prior to excavation. Reseed in spring, into a firm seedbed of topsoil to ¼"; with seed mixture that is resistant to Plateau™ herbicide. These include blue grama, needle grasses, little bluestem, Prairie sandreed, smooth bromegrass and several of the wheatgrass spp. Control future bindweed in fall with Plateau at recommended rates.

Revegetation

With the proposed amount of excavation and dirt work in the Project Area, reclaiming the disturbed ground will be of primary importance to assure a low maintenance, weed controlled area. To these ends, it is recommended that certain basic reclamation techniques be applied. These are probably standard procedures, but in the interest of weed control, they will be re-visited here. The following steps should be followed to accomplish the weed control objectives on right-o-ways in the Project:

Step 1-
Prior to excavation or dirt work associated with construction, a reclamation plan should be established. This would include pre-construction herbicide treatments and scheduling, construction timing, topsoil conservation plan, re-seeding plan using best information and a post re-seeding plan for maintenance of the seeding.

Step 2-
Pretreat construction areas for noxious weeds found on the site. Pretreatments should be scheduled at the optimum time to get good control. Buffer zones should be treated adjacent construction areas. Pretreatment should be scheduled to allow ample time for herbicides to achieve good control. This is usually a period of 3-4 weeks for most species.

Step 3-
Complete construction/excavation. Take care to wash any equipment before arriving on-site. Keep vehicles and equipment contained in the construction site as much as is feasible. Conserve topsoil and use it as seedbed for reclamation.

Step 4-
Reclaim/reseed area. Select plant species that have good weed competitiveness, are hardy in the climatic and soil conditions, have good soil holding abilities, are long-lived and are moderately palatable to livestock and wildlife. Plant into a firm seed bed (to ¼" for most grass species). Drill in seed. Mulch with certified weed-free mulch. Fertilization will improve seedling vigor. Plant at the correct time to take advantage of natural precipitation.

Step 5-
Perform periodic weed control after the seedlings are established. If reseeding with mainly gasses; it will be possible to control weed with selective herbicides.

For well pads, building sites and other construction areas that will see periodic traffic and disturbance, it is recommended that a bareground maintenance strategy be adopted. Develop a bareground herbicide treatment plan and monitor its efficacy so that periodic adjustments can be made.

Communication and Cooperation

Communication and cooperation will ultimately determine the success of this project. It is important that initially, all parties are in clear agreement of the goals, objectives, and methods for obtaining those objectives. After initial agreement, then the project can be implemented and revised and tailored as necessary.
A spirit of cooperation must exist between all parties to accomplish their common goals. This cooperation will be facilitated through clear channels of communication and design flexibility. Below are some suggestions for methods of comunication and cooperation.

Communication-

Clear lines of communication should exist between Anadarko Petroleum Corporation/ Howell Petroleum Corporation, the Natrona County Weed and Pest District, the District BLM, the town of Midwest, local landowners and involved contractors. These lines of communication should start with an initial meeting(s) to familiarize to cooperators with the management goals and to introduce the relevant personnel to one another. Definite contact personnel and lines of communication can be established at this time.

Implementation and integration of the management plan will be made possible through biannual workshops. These workshops will include relevant personnel from all the cooperators. The workshops will discuss, plan and schedule upcoming goals and objectives for the Project. The plans made must be flexible to accommodate all eventualities. Changes to these biannual schedules will be communicated between the appropriate entities.

Cooperation-

Cooperation will begin with a clear agreement of basic Goals for the Project. The main Goal of the Project might be phrased as, "Develop a Cooperative Weed Management Plan to mitigate the impact of the proposed CO_2 Enhanced Oil Recovery Plan on noxious weed populations in the Salt Creek Oil Field." From that starting agreement to a very general goal; cooperation can begin of the specific objectives agreed on by the cooperators.

Cooperation will also involve a certain level of commitment from the cooperators. Commitment expectations should be agreed on beforehand but flexibility must be built into the infrastructure of the Project.

Through a spirit of cooperation, a commitment to a common goal, some "sweat equity", and some monetary commitment this Project will be successful. Success in

this endeavor will translate into improved land values for wildlife, livestock and people. Success can also be a template for future successes.

Appendix A

Weed Identification

Weed ID Basics

There are eight weed species of special concern in the Project. As mentioned before, these are Russian knapweed, diffuse knapweed, spotted knapweed, Canada thistle, field bindweed, salt cedar, scotch thistle, and leafy spurge.
Identifying these weed species can be very easy when the plant is in full bloom and looks just like the picture in the Weed ID Handbook. Identification of these species is more difficult when they are in different growth stages. Some of the growth stages of these weeds are:

Rosette stage- This is found in the thistles and knapweeds and is characterized by an initial set of leaves that grow from a central point. The rosette stage is seen in the spring and again in the fall, during "fall re-growth.

Mid-bolt stage- After initial appearance in the spring, many of these weeds grow quickly upright before they bud and flower. This stage is characterized by upright stem(s) with plentiful leaves but with no flowers or flower buds. The thistles, knapweeds and leafy spurge all exhibit this growth stage.

Bud stage- This stage is found again in the thistles, knapweeds and leafy spurge. Field bindweed also has a bud stage. This stage is characterized by leafy stems with flower buds formed. There is often a transitional period in which the plant will have flower buds and opened mature flowers appearing on the stalks.

Flowering stage- This is of course self explanatory; a stage where the plant is actively flowering.

Seed production stage- After the flowers have matured and been pollinated, the flowers close or dry up and viable seed is formed in the flower capsule.

Fall re-growth- Both perennial and biennial plants often go through this stage in the fall after seed production. This is characterized by an active greening up and growing of the plant in the fall to replenish and store carbohydrate reserves in the roots. These reserves help the plant survive the winter season. This is often a good time to do chemical

control on perennial weeds, as the herbicide is drawn into the root system, thereby killing the plant.

Identification of these weed species in all of their various growth stages can be best accomplished through simple observation of known infestations over the seasons. There are often plants in different growth stages at one time within large infestations. Close observation and experience are the best methods for learning to ID these weeds in all of their forms.

Weed Species

Russian knapweed

Russian knapweed is a perennial forb with a deep and spreading, black-sheathed root system. This plant reproduces from these roots (vegetatively) and also from seed, although very few seeds are viable. The seeds are not easily wind borne and tend to stay close to the parent plant. Once a Russian knapweed plant becomes established it tends to reproduce from buds off the parent root. This tends to form a dense stand that spreads from the center of the infestation. Russian knapweed is allellopathic, in other words it produces chemicals that exclude other plants from growing nearby. It accomplishes this by concentrating zinc from the soil and depositing a zinc rich layer around each plant. Russian knapweed is toxic to horses in both its fresh and dried forms and prevents the animal from eating and drinking ("chewing disease").

The plant appears as a rosette of leaves in the spring (see picture below) and quickly bolts to form a multi-stemmed plant up to three feet tall. Chemical control of this plant is best achieved in the fall re-growth stage or in early spring in the rosette stage, pictured below.

Russian knapweed infests thousands of acres in Wyoming and a major weed problem in the Salt Creek Oil Field.

Diffuse knapweed

diffuse knapweed, mature plant

Diffuse knapweed is a biennial plant (living 2 years) and reproduces from seed. The flowers are white to light purple in color and appear in early summer. This plant can live in a variety of harsh, dry habitats and with its prolific seed production it has the ability to spread rapidly. The plant appears as a rosette of leaves in the spring (see picture below) and then bolts up to produce multiple flowered stems. The bracts (area below the flower petals) are spiny to the touch.

Diffuse knapweed can rapidly spread to become a dense monoculture than out-competes surrounding vegetation. This plant is a native of Asia and came to N. America as a contaminant in crop seed in the nineteenth century.

This plant is a major invasive weed in many western states.

diffuse knapweed rosette

Diffuse knapweed can be controlled by eliminating the seed production and stressing the parent plant. This can be accomplished by mechanical (mowing) and chemical means. Biocontrol insects are also an effective strategy when used in conjunction with other control measures. There are currently several biocontrol insects approved for diffuse knapweed control.

Diffuse knapweed is not a major problem in the Salt Creek Oilfield yet, but it is found in adjacent locales and has the potential to infest the Project area.

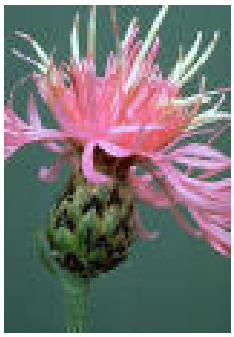
Diffuse knapweed flower

Spotted knapweed

spotted knapweed, mature plant

Spotted knapweed is very similar to diffuse knapweed. Both plants are biennials, both reproduce from prolific seed production, and are similar in appearance. Spotted knapweed comes up in the spring as a rosette of leaves (see picture below) and then quickly bolts to become a tall, rank weed with multiple branches that contain purple flowers. The flower bracts on this plant are not as spiky as the ones on diffuse knapweed and are each tipped with a dark "spot", hence the name "spotted" knapweed(see picture). This plant is the scourge of Montana and has infested tens of thousands of acres of ground in that state.
Control of this plant is identical to diffuse knapweed even including the same biocontrol insect vectors. Currently there are several spotted knapweed infestations in and around the Salt Creek Oilfield. Chemical and biological control methods are being used against this invader from Eurasia.

spotted knapweed rosette



spotted knapweed flower

Leafy spurge

Leafy spurge is an extremely aggressive perennial from Asia. The plant has single, to several straight stalks that contain long, pointed, lance-shaped leaves. The flowers are borne on the branch ends, and are greenish yellow. When any green part of the plant is broken, it oozes a milky white sap. The mature plant grows to 2-3 feet tall

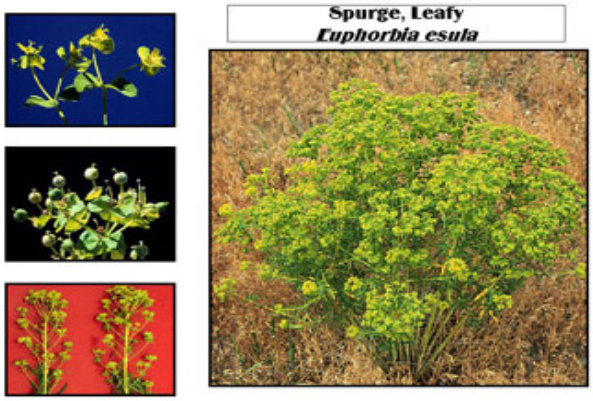
This plant has a root system that needs to be seen to be believed. There have been plants excavated that had roots that extended **17 feet** into the soil!

Leafy spurge reproduces from seed and by vegetative growth. The seeds remain viable in soil for up to 7 years. The seeds are released from the plant by an explosive opening of the seed capsule that will shoot the seed up to 15 feet from the parent plant. Plants can spread by their roots at the rate of several feet per year.

Leafy spurge not only out-competes surrounding vegetation for water and nutrients, but this plant also produces chemicals that exclude other plants. All of these factors combined give this plant the ability to rapidly form dense monoculture stands that exclude all beneficial native plants. These stands can rapidly grow to hundreds and even thousands of acres in just a few years.

Control of this plant is through chemical and biological means.
Currently in the Project area there is a small patch of leafy spurge upstream of the old powerplant. This patch is being treated.

mid-bolt, before flower



Salt cedar

Salt cedar grows as a perennial, deciduous, large woody shrub or small tree. The leaves are long feathery structures and the flowers are small and pink and borne in catkin-like racemes. The twigs are reddish-brown and show white leaf scars. The plant is highly drought and flood resistant. This plant is a native of Asia Minor and central Asia. It was introduced into the southwest for erosion control in riparian areas. This plant is rapidly becoming a real problem in the arid West. The main problem it poses is the fact that each mature tree can draw from the water table, and transpire to the atmosphere, up to **200 gallons of water, per day!** This fact alone can lead to the depletion and even extinction of water sources in the arid western regions. Many important streams and waterholes in the Southwest have literally disappeared due to the effects of this plant. Salt cedar grows in alkaline and salty environments. The way it deals with the excess salt in these environments is to concentrate the

salts in its leaf and twig surfaces, which it then sheds throughout the growing season. This growth habit forms a dense salty layer around each plant that excludes other plants from establishing in the vicinity of the plant.
Salt cedar reproduces from seed and suckers off the parent plant. The seeds are wind borne and can be carried long distances before germinating. Seeds germinate in a few hours after reaching a suitable habitat. Cutting down the plant only serves to make it re-sprout vigorously. Control at this time is only possible through chemical means. Work is being done in the Bighorn Basin area of Wyoming with several biocontrol insects that are showing promise to help control this weedy tree. At least one of these biocontrol insects should be available for release in other areas of Wyoming by summer of 2004.

This plant is highly competitive and if left unchecked can rapidly takeover riparian areas. When present in large stands this plant drastically lowers water tables, thereby drying up rivers, stock ponds and lakes. This has serious consequences for the wildlife and livestock that rely on these water sources. Many rivers in the Southwest have been completely dried up due to this invasive plant.
Currently, salt cedar occupies large tracts along Salt Creek in the Project area.

Scotch thistle

Scotch thistle is a biennial plant reproducing from seed. The plant can grow up to eight feet tall in a large rank, multi stemmed bunch. The flowers are purple and produce numerous seeds in their second year. Each plant can produce up to 40,000 seeds that can remain viable for 20+ years in the soil. The plant comes up as a large rosette of leaves in the spring. The rosettes can be up to three feet in diameter. Large stands of scotch thistle are virtually impenetrable and these stands can exclude any wildlife or livestock from foraging in the area.
The plant is an escaped ornamental and is the national plant of Scotland. It is said that during the Viking invasion of Scotland, the invaders would cry out in pain from trying to move through these plants. This would alert the Scots to their location and helped them defeat the Vikings!

Control of small stands of scotch thistle can be achieved by cutting off the plant at the root so that none of the above ground portion of the plant remains. Mowing the plant at the correct growth stage can be affective, however because the plants

mature at different rates, mowing several times during the season would be required.
Chemical control is effective if applied to the young, small plants and rosettes. There are not currently any biocontrol insects available for scotch thistle control in the US.

Field bindweed

Field bindweed is a vine-like perennial from Europe that infests thousands of acres of land in North America. This plant reproduces from seed and spreading rootstock. This plant has small white, pink, or purplish, morning glory-like flowers that appear along the vines. Due to an extensive root system, and long-lived seeds, this plant can be difficult to control. The plant is a real problem in croplands, lawns, borrow ditches and waste areas. Mechanical control is ineffective as cultivation only spreads the plant and mowing just encourages growth. Chemical control can be effective if applied at the right time and is persistent from year to year. There are not currently any biocontrols for this plant available in Wyoming.

Field bindweed is present in several places, in the Project area and is currently being treated in some of those areas. Current infestations do need to be mapped for comprehensive control.

Appendix B

Mapping Protocol

Mapping noxious weed infestations in the Project area can be accomplished by company, Natrona County Weed and Pest District, contract and BLM personnel. For the mapping to be effective, it is essential that all involved follow standard formatting procedures.

There can be 3 basic ways to map weeds in the Project area.

I. **Plot weed locations from a paper map**. The data will be plotted onto a blank Township grid using PLS format (Township, Range, ¼, ¼ section). These grids can be photocopied from the example in this Appendix B. (see example, page 41)

II. **Obtain coordinates of weed patches with handheld GPS units**. This data can be in the form of a single waypoint or a track log of the perimeter of the weed patch. The data must contain several important pieces of information:

It must have the **datum** the

data was captured in.

It must also contain the **coordinate system** that was used.

A **Weed Location Datasheet** must be filled out (found in this **Appendix B**, example page 39)

The **Weed Location Datasheet** can then be sent to Gary Skillman at the BLM or Brian Connely at the Natrona County Weed and Pest District Office.

III. Obtain weed coordinates using a Trimble GPS Unit. If using a Trimble™, obtain the Data Dictionary from Gary Skillman at the Casper District BLM office.

Step-by-Step Procedures for:

Plotting weeds on a 7.5 minute, USGS, topographic map

1. **Positively ID the weed species** (you can use Appendix A, Weed Handbook, or Weeds of the West).
2. **Plot weed location** from USGS Quad, BLM 1:100,000 surface ownership, or any map showing PLS, Township, Range and Section.
3. **Transfer this plot to a blank Township Grid** and fill in appropriate Township and Range. (see example page 40)
4. Fill out a **Weed Location Datasheet.** (see example, page 41)

Map Weed location with a hand-held GPS unit

1. **Positively ID the weed species** (you can use Appendix A, Weed Handbook, or Weeds of the West).
2. **Capture a "waypoint" from the approximate center of the weed patch.** Look in the setup menu of the machine to determine the **datum** and **coordinate system**.
3. Fill out a **Weed Location Datasheet.**
   (see example, page 39)

Map weed location with a Trimble™ GPS unit

1. **Note: Only use this option if you have uploaded the "Weed Survey Data Dictionary" from the BLM, Casper Office into your machine.**
2. **Positively ID the weed species** (you can use Appendix A, Weed Handbook, or Weeds of the West).
3. **Open a "Rover File" in the "Weed Survey" file.** This will log a series of coordinates as you walk, ride around the weed patch perimeter.

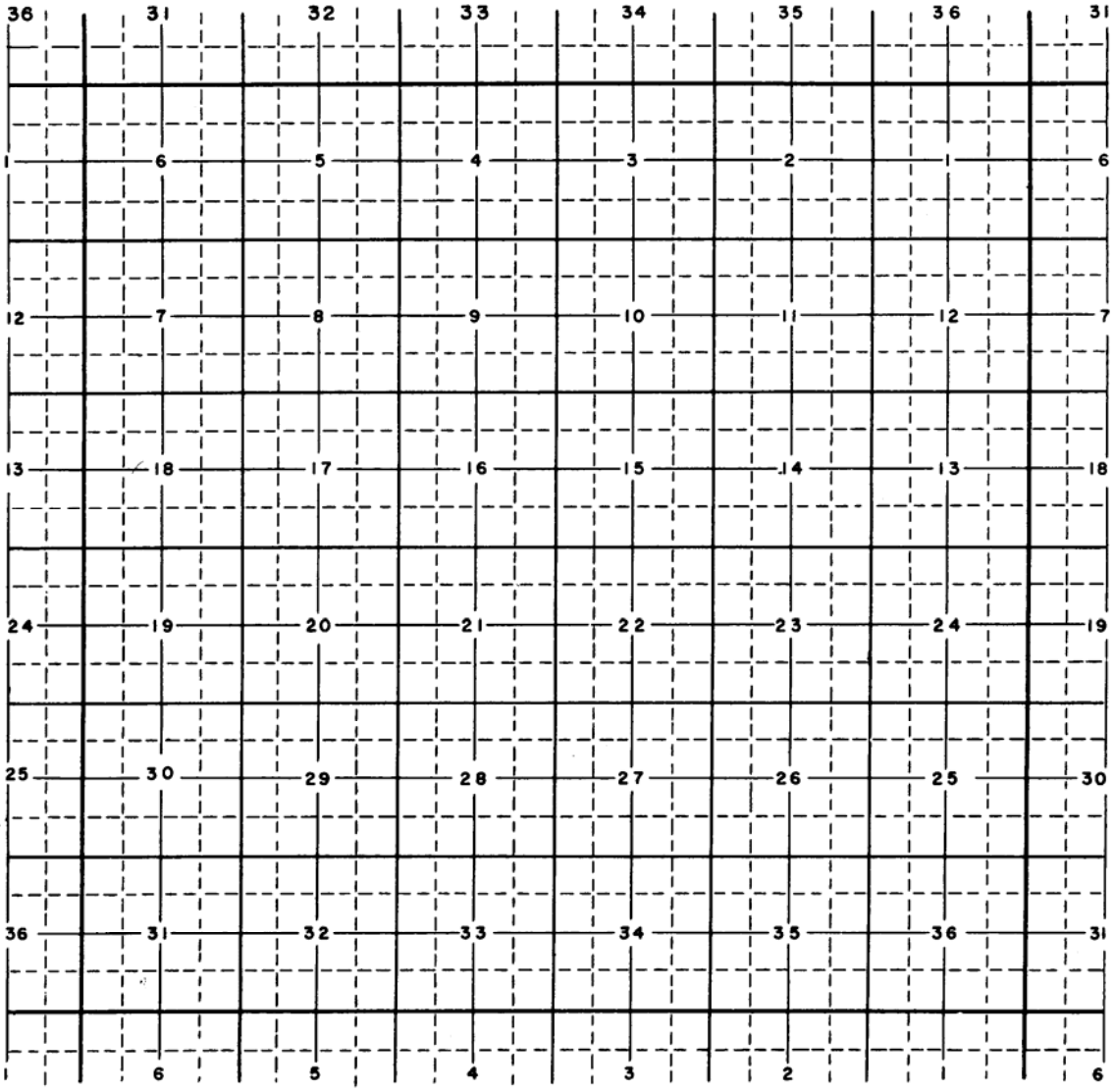
4. **Close the rover file after you have completed the weed patch perimeter.**
5. Download the data in “Pathfinder Office” and save to disc.
6. Turn disc into Gary Skillman at the Casper BLM Office or Brian Connely at the Natrona County Weed and Pest District Office.
7. **Note:** It is **not** necessary to fill out a **Weed Location Datasheet** when using this method.

Form 9600–18
(February 1979)
(formerly 9180–19)

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

TOWNSHIP DIAGRAM*

Township	Range	Meridian	State



*SCALE: 1 INCH = 1 MILE

☆ U.S. Government Printing Office:1984-776-009/4862 R8

Weed Location Datasheet

Species _____

Density * _____

~ Area
(acres, meters²) _____

Location ** _____

_____

Date _____

Datum *** _____

Coordinate System ☐ **UTM Z____ N** ☐ **Lat/Lon** ☐ **PLS**
(Check Box)

*** Relative density:** **T = trace, < 1 plant/meter²** **L = light, < 10 plants/meter²** **M= medium, > 10 plants/meter²** **H = heavy, plants crowded**	**** Location: enter center-point location of weed patch in PLS, UTM, or Lat/Lon**	*****Datum: if using GPS, enter Datum** **NAD27CONUS?** **NAD83?** **WGS84?**

Example Datasheets

Weed Location Datasheet
(Using GPS and UTM coordinates)

EXAMPLE

Weed Location Datasheet

Species Russian knapweed

Density * L

~ Area
(acres, meters²) 1/2 acre

Location ** 395,074 E; 4,806,142 N Z13 N

Date 6/17/04

Datum *** NAD27 CONUS

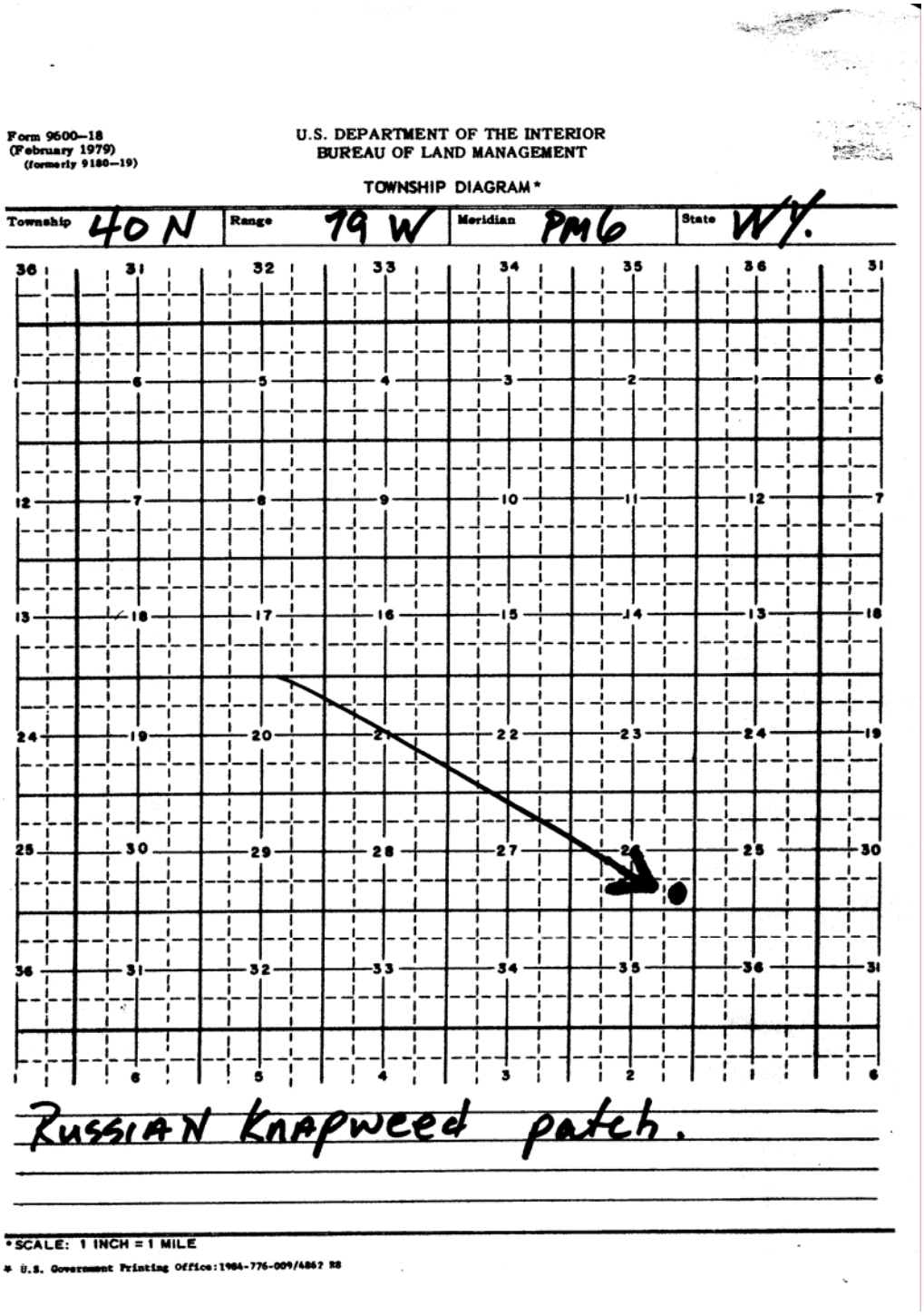
Coordinate System
(Check Box)

☑ **UTM Z** 13 **N** ☐ **Lat/Lon** ☐ **PLS**

*** Relative density:** T = trace, < 1 plant/meter² L = light, < 10 plants/meter² M= medium, > 10 plants/meter² H = heavy, plants crowded	**** Location:** enter center-point location of weed patch in PLS, UTM, or Lat/Lon	*****Datum:** if using GPS, enter Datum NAD27CONUS? NAD83? WGS84?

Example weed location plotted on blank Township Grid:

Example



Form 9600–18
(February 1979)
(formerly 9180–19)

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

TOWNSHIP DIAGRAM*

Township	Range	Meridian	State
40 N	99 W	PM6	WY.

Russian Knapweed patch.

*SCALE: 1 INCH = 1 MILE

U.S. Government Printing Office: 1984-776-009/4862 R8

Example Weed Location Datasheet from previous page:

Example

Weed Location Datasheet

Species Russian knapweed

Density * L

~ Area (acres, meters²) about 1/2 acre

Location ** SE 1/4, SE 1/4, Sec 26, T 40N R 19W

Date 6/17/04

Datum *** N/A

Coordinate System (Check Box) ☐ UTM Z____ N ☐ Lat/Lon ☑ PLS

* Relative density: T = trace, < 1 plant/meter² L = light, < 10 plants/meter² M= medium, > 10 plants/meter² H = heavy, plants crowded	** Location: enter center-point location of weed patch in PLS, UTM, or Lat/Lon	***Datum: If using GPS, enter Datum NAD27CONUS? NAD83? WGS84?

Appendix C
Health Risk Evaluation for Carbon Dioxide (CO_2)

General Information

Carbon dioxide (CO_2) is a colorless, odorless, non-flammable gas that is a product of cellular respiration and burning of fossil fuels. It has a molecular weight of 44.01g/mol (NIOSH 1976). Although it is typically present as a gas, carbon dioxide also can be a solid form as dry ice and liquefied, depending on temperature and pressure (Nelson 2000). This gas is utilized by many types of industry including breweries, mining ore, and manufacturing of carbonated drinks, drugs, disinfectants, pottery, and baking powder (NIOSH 1976). It also is a primary gas associated with volcanic eruptions (Farrar et al. 1999; IVHHN 2005). CO_2 acts to displace oxygen, making compressed CO_2 the main ingredient in fire extinguishers (MDPH 2005). Occupations that are most at risk from CO_2 exposure include miners, brewers, carbonated beverage workers, and grain elevator workers (CCOHS 2005; Nelson 2000).

$CO_2$is present in the atmosphere at 0.035% (Aerias 2005; CCOHS 2005). In terms of worker safety, Occupational Safety and Health Administration (OSHA) has set a permissible exposure limit (PEL) for CO_2 of 5,000 parts per million (ppm) over an 8-hour work day, which is equivalent to 0.5% by volume of air. Similarly, the American Conference of Governmental Industrial Hygienists (ACGIH) TLV (threshold limit value) is 5,000 ppm for an 8-hour workday, with a ceiling exposure limit of 30,000 ppm for a 10-minute period based on acute inhalation data (MDPH 2005; NIOSH 1976). A value of 40,000 ppm is considered immediately dangerous to life and health based on the fact that a 30-minute exposure to 50,000 ppm produces intoxication, and concentrations greater than that (7-10%) produce unconsciousness (NIOSH 1996; Tox. Review 2005). Additionally, acute toxicity data show the lethal concentration low (LC_{Lo}) for CO_2 is 90,000 ppm (9%) over 5 minutes (NIOSH 1996). See Table 1 for a listing of regulatory agency standards for acceptable CO_2 concentrations in the workplace. CO_2 is a good indicator of proper building ventilation and indoor air exchange rates. Consequently, it is measured in buildings to determine if the indoor air is adequate for humans to occupy the building (MDPH 2005).

Table 1 Agency Standards for CO_2 in the Workplace.

Agency	Low end CO_2 Concentration (ppm)[1]	High-end CO_2 Concentration (ppm)[2]
OSHA PEL	5,000 TWA	30,000 STEL
ACGIH TLV	5,000 TWA	30,000 STEL
NIOSH REL	5,000 TWA	30,000 STEL

[1]Applies to CO_2 concentration in the workplace considered safe for a 40-hour week.
[2] Based on a 10-minute period for NIOSH and a 15-minute period for OSHA and ACGIH.
PEL = Permissible Exposure Limit
TLV = Threshold Limit Value
REL= Recommended Exposure Limit
TWA= Time Weighted Average
STEL= Short Term Exposure Limit

Although normal levels of CO_2 are considered harmless, under the right conditions, CO_2 can cause adverse health effects. High concentrations of CO_2 in confined areas can be potentially

dangerous. CO_2 may act as an oxygen displacer in confined spaces and cause a number of reactions. These reactions include, but are not limited to, dizziness, disorientation, suffocation, and under certain circumstances, death. Death occurs when there is a depression of the central nervous system (CNS) with prolonged exposure to high levels of CO_2 and the body's compensatory mechanisms are overwhelmed or fail (Farrar et al. 1999; IVHHN 2005; Nelson 2000; NIOSH 1976; NIOSH 1996).

Toxicology of CO_2

CO_2 is considered to be a potential inhalation toxicant and a simple asphyxiate (Aerias 2005; NIOSH 1976; Priestly 2003). It enters the body from the atmosphere through the lungs, is distributed to the blood, and may cause an acid-base imbalance, or acidosis, with subsequent CNS depression (Nelson 2000; Priestly 2003). Acidosis is caused by an overabundance of CO_2 in the blood. Under normal physiological circumstances, there is a higher concentration of CO_2 in the blood than in the lungs, forming a concentration gradient, where blood CO_2 diffuses into the lungs and then is exhaled. An increase in inhaled CO_2 and subsequent reaction with water in the blood forms carbonic acid (H_2CO_3), which then dissociates into hydrogen ions [H^+] and bicarbonate [HCO_3^-]. The excess CO_2 shifts the equilibrium toward the creation of more hydrogen ions, thus creating an acidic environment (see equation below). During respiratory acidosis, the pH of the blood becomes less than 7.35 (Priestly 2003).

$$CO_2 + H_2O \leftrightarrow H_2\,CO_3 \leftrightarrow H^+ + HCO_3^-$$

Electrolyte imbalance occurs due to decreased blood plasma chloride, potassium, and calcium and increased blood plasma sodium. Furthermore, the oxygen depleted environment does not allow for cells in the body to obtain the oxygen they need to survive. Fortunately, the body compensates for the excess in H^+ ions by binding of the protons to hemoglobin. In addition, the lungs attempt to compensate by removing the excess CO_2, which is the reason rapid breathing is apparent during acute CO_2 exposure. After prolonged exposure, the kidney begins to balance blood pH by retaining bicarbonate and excreting hydrogen ions to correct acidosis (Priestly 2003).

Symptoms related to acute CO_2 exposure are shown in Table 2 (Aerias 2005; IVHHN 2005). Treatment to high exposures of this compound involves removing the victim from the confined space or oxygen inadequate environment, and increasing the oxygen supply to the exposed individual (MSDS for CO_2 2003; Nelson 2000; Priestly 2003). The condition of acidosis is reversible upon removal from a high CO_2 environment.

Table 2 Symptoms from Low to High Concentrations of CO_2

%CO2	Symptoms
2 to 3	Shortness of breath, deep breathing
5	Breathing becomes heavy, sweating, pulse quickens
7.5	Headaches, dizziness, restlessness, breathlessness, increased heart rate and blood pressure, visual distortion
10	Impaired hearing, nausea, vomiting, loss of consciousness
30	Coma, convulsions, death

Animal and Epidemiological Studies

Numerous animal studies have been performed to study CO_2toxicity. Monkeys with implanted electrodes in areas of the brain were exposed to concentrations from 0-30% CO_2, and electrical activity was recorded. This study showed that as CO_2 concentrations increased, the time to obtain electrical stimulation also increased, indicating CNS depression (NIOSH 1976). Rat and guinea pig exposure to higher concentrations of CO_2 indirectly caused a decrease in lung stability. Studies have indicated further that respiratory acidosis was followed by fluid build up and a decrease in lung surface tension in the male guinea pig. Most animal studies concluded adverse effects on the lungs. However, cardiac, kidney, and reproductive effects also have been shown in animals as a result of exposure to high levels of CO_2 (NIOSH 1976).

Epidemiological studies have been performed to observe human toxicity to CO_2, as well. Normal blood concentrations of CO_2 act physiologically to stimulate the CNS, while extremely high concentrations exert CNS depression (CCOHS 2005; NIOSH 1976). Within 1 minute of exposure to 20-30% CO_2, unconsciousness and convulsions occur in humans. Neurologic symptoms including eye and extremity twitching, and convulsions have been observed in humans after CO_2 exposure (CCOHS 2005; NIOSH 1976).

Occupational Exposure

For centuries, miners have been aware of the occupational hazard of "black damp," a condition of low oxygen levels in mine shafts (Cable 2004; NIOSH 1976). It was common for miners to send a candle or mouse into the mine prior to entering and watch for the candle to extinguish or the mouse to lose consciousness, indicating a lack of oxygen, hence, a poor working environment (NIOSH 1976). Brewers also are confronted with the potential of CO_2 poisoning. Yeast releases CO_2 as a byproduct in the process of fermenting alcohol (Nelson 2000; Tox. Review 2005).

Brewers entering enclosed areas, such as cleaning out tanks subsequent to fermentation, could be overcome by high levels of CO_2. A study on brewery workers determined that they are exposed to 1.08% over an 8-hour workday on average (Nelson 2000; NIOSH 1976; Tox. Review 2005). CO_2 is also a byproduct of metabolic activity of organic grains. Therefore, employees working in grain elevators and silos, where stored grain produces 37% CO_2 during oxidation of carbohydrates, are at risk for high levels of CO_2 exposure (Nelson 2000; NIOSH 1976).

From long-term exposure to 3% CO_2, submarine workers have shown symptoms such as flushing of the skin, a fall in blood pressure, and decreased oxygen consumption (CCOHS 2005). However, long-term exposure to low concentrations of CO_2 has not resulted in asphyxiation; adaptive physiological mechanisms to long-term exposure have been reported (CCOHS 2005).

Other Exposures

At CO_2 levels greater than 0.5%, adverse health affects are present in humans, animals, and plants. Plants utilize CO_2 as a primary ingredient in photosynthesis and depend on the gas for survival. However, under concentrated conditions, plant roots can actually be suffocated, which inhibits the uptake of nutrients, and subsequently kills the plants (Farrar et al. 1999; NIOSH 1976). This phenomenon was noted in Mammoth, California, recognized for infrequent, yet recent volcanic activity. Researchers investigating this phenomenon discovered concentrations as high as 95% CO_2 by volume from magmatic emissions (Farrar et al. 1999). These elevated

concentrations were measured in pits in the snow and soil, buildings with poor ventilation, and in belowground valve boxes in the vicinity of Mammoth Mountain. Accumulation in pits and wells occurs due to the fact that CO_2 is denser than air and may slowly accumulate (IVHHN 2005). Specifically, soil gas levels of CO_2 in a snow well in Mammoth were measured at 70% after the death of a skier in the vicinity of the well (Farrar et al. 1999; IVHHN 2005).

Several erupting volcanoes have claimed the lives of people for centuries due to CO_2 exposure. The gas is more dense than that of ambient air (1.8 g/L at 25°C and 1 atm), and therefore, the excess CO_2 flows down the side of the mountain and is trapped near the ground surface (IVHHN 2005). Dieng Plateau, Indonesia released a CO_2 cloud with concentrations of 98-99%, killing approximately 142 villagers (IVHHN 2005). Mount Vesuvius, a volcano in Italy, has claimed the lives of many people due to measured concentrations of up to 100% CO_2.

Several other accounts of excess CO_2 exposure have been recorded. A couple in West Virginia experienced symptoms of CO_2 exposure, including mild confusion, headaches, and blurred vision, from CO_2 levels of 9.5% in their basement crawl space. The West Virginia department of Environmental Protection revealed that their home was receiving high concentrations of CO_2 because it was built above a reclaimed surface and an abandoned deep coal mine (Cable 2004; PGS no date)). Another episode of CO_2 poisoning occurred in a poorly ventilated walk-in refrigerator, where a 50-year-old man was found dead among 15 blocks of dry ice. The off-gassing of the dry ice and non-functional ventilation system was blamed for his death (Nelson 2000).

Conclusions

CO_2 is a naturally occurring atmospheric gas that is considered safe at levels below 0.5% according to OSHA standards (CCOHS 2005). However, occupational hazards related to CO_2 exposure may occur under certain conditions. The American Society of Heating, Refrigerating, and Air Conditioning Engineer, Inc., recommends that indoor air CO_2 levels be less than 700 ppm above the outdoor air concentration of CO_2 (Aerias 2005).

In addition to potential indoor exposure, high concentrations of CO_2 can collect outdoors. Outdoor exposure can occur where CO_2 is venting from below ground sources such as mining operations, natural gas production, and magmatic emissions. Aboveground sources of exposure can occur during volcanic eruptions. External air factors are mostly related to the fact that CO_2 is denser than ambient air and therefore, tends to accumulate near the ground surface (IVHHN 2005).

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MASTER SURFACE USE PLAN

HOWELL PETROLEUM

SALT CREEK
SALT CREEK SOUTH UNITS

DECEMBER 2005

Exhibit 5.3.2

MASTER SURFACE USE PLAN
HOWELL PETROLEUM
SALT CREEK / SALT CREEK SOUTH UNITS

The following explains how the guidelines are used when preparing an Application for Permit to Drill (APDs). APDs will state that all surface use will comply with applicable provisions of the Salt Creek Field Guidelines (WY)/2000 in the 13 point plan. On sundry notices, the statement is placed in Box #13 of Form 3160-5, the sundry notice form.

Project specific information (location and dimensions of roads, well pads, reserve pits etc.) is described in individual 13-point plans. In general, each bit of information is described once - on maps and exhibits rather than in the narrative.

Project Plan

Each project plan will include one or more USGS quadrangles as appropriate to display Howell's planned road construction program for the area(s) where development is occurring.

Plans will show existing and planned roads by functional classification within each quadrangle and will be prepared as needed while Howell's drilling program is being implemented. When an APD, NOS or application for a right-of-way is submitted, a copy of the Project Plan will be included to show other wells and access roads proposed in the area. Road construction plans for one or more roads may be submitted with each project plan as part of the NOS, APD or right-of-way.

Individual APDs and sundry notices include a 7 1/2 minute map from an appropriate USGS Quad Sheet. To facilitate copying, exhibits are placed on 8.5" X 11" pages (scales may be adjusted to 1"=80" if necessary). Below is a description of information included under each point of the "Thirteen Point Surface Use Plan" on individual APDs.

1. Existing Roads - Describes well access in relation to individual well and refer to guidelines for maintenance.

2. Planned Access Roads - States whether or not new road is needed, include information like length, culvert locations, steep pitches that trigger additional engineering, and other information not in the guidelines.

3. Location of Existing Wells - References guidelines.

4. Location of Existing and/or Proposed Facilities - Includes Exhibits and narrative needed to describe specific features of flowlines, power lines, on-site production facilities, etc.

5. Location and Type of Water Supply - Identifies the source and mode of transport.

6. Source of Construction Materials - References guidelines and includes non-standard information.

7. Methods for Handling Waste Disposal - Includes exhibits and narrative needed to describe specific dimensions and other information.

8. Ancillary Facilities - References guidelines and includes non-standard information.

9. Well Site Layout - References guidelines; include specific dimensions, location of center and out side stakes for the pad, topsoil and spoil areas and other pertinent features.

10. Plans for Restoration of Surface - References guidelines and includes non-standard information.

11. Surface Ownership - Describes ownership described where operations and new disturbance occur.

12. Other Information - Includes only information unique to site; other environmental information duplicates BLM's environmental assessment.

13. Lessee's or Operator's Representative and Certification - Includes normal entries required by Onshore Order No. 1 and 43 CFR 3160.

GENERAL INFORMATION

All surface operations will comply with the intent of 43 CFR 3101.1-2; 3101.1-3; 3160, Onshore Oil and Gas Orders No. 1, No. 2, No. 6, No 7, 3-A, and NTL-4A, and the BLM-USGS-USFS brochure, Surface Operating Standards for Oil and Gas Exploration and Development and current State of Wyoming standards.

These standards will guide applicable surface use for Howell's Salt Creek Oil Field in Wyoming and will be incorporated by reference into subsequent Applications for Permit to Drill (APD), Sundry Notices and other permits as the "Salt Creek Guidelines (WY)/2000". To facilitate APD approval Howell may permit pipelines, powerlines and other support facilities under separate Sundry Notices.

Any variances from these standards, employed to solve unusual or unanticipated problems, will comply with all applicable regulations, orders and standards. Safety, erosion or other environmental problems related to existing facilities will be repaired to standards described below when practical and effective under the working conditions at hand.

THIRTEEN POINT SURFACE USE PLAN

Howell will utilize an extensive road network in the Salt Creek Oil Field, some of which is shared with other road users. Planned expansion of their operations, when implemented, will result in the need for additional road construction.

Present Bureau of Land Management requirements for transportation planning and the location, design and construction of roads are intended to provide an adequate road system for development and use of natural resources. Protections of the environment and user safety are also considered in the design of the roads.

The construction of safe and environmentally acceptable roads will be one of Howell's priorities within the Salt Creek Oil Field. Howell will make every effort to provide for the safe and environmentally sound location, survey, design and construction of roads on public lands. Company personnel, the BLM and the affected counties, with the involvement of registered engineers and land surveyors, will ensure all construction meets safety and enviro0nmental requirements.

1. EXISTING ROADS

A road referred to in this Surface Use Plan as an "existing" road is one that has previously been constructed to a standard, which required a crowned traveled way and borrow, and drainage ditches (except for some roads in the fields which were built without ditches, but met BLM requirements at the time they were constructed). "Seismic trails" and existing "two-track trails" are not considered existing roads.

Existing lease roads will be maintained and kept in a good usable condition for safe vehicular traffic free of surface erosion. Culverts, ditches, water turnouts and other features will be fully functional and maintained. All re-entry (work associated with existing well bores) activities will be accessed from existing roads.

Snow will be plowed only when necessary to keep roads open for orderly operation of the field. Generally, unrestricted public access will be allowed on the lease roads, however, Howell may restrict the public and its own employees when essential to protect their safety.

2. ROAD CONSTRUCTION AND RECONSTRUCTION

A) General

Before routes are selected and road plans are prepared, Howell personnel and their surveying/engineering consultants will review the Surface Use plan and any available resource and land use data from BLM or other sources specific to the project area. A joint BLM, operator, and consultant field review will then be scheduled and conducted. Depending upon the number of roads or complexity of a single road, the joint review team will determine the most feasible access route(s) based on the resource conflicts, soils, drainage considerations, terrain and engineering standards for the type of route planned. During the field review, the degree and scope of engineering and construction control required will be specifically defined.

B) Route Location

During the joint field review, routes will be selected that avoid unnecessary resource conflicts whenever possible. The placement of the road relative to migration corridors, ridgelines, and other areas known to be used by big game animals will be considered. Routes should be located to avoid adverse effects to threatened, endangered and other plant and animal species of interest.

During the location of roads, particular attention will be given to meeting or exceeding the minimum vertical and horizontal sight distances required. Reroute locators/surveyors will also select horizontal curves to ensure that the minimum radius requirements for the planned design speed are met or exceeded.

The centerline and locations of structures will be staked, color-coded and clearly marked for all new roads, including those designed and constructed on steep or broken terrain.

C) Road Design Plans

Plans for construction of all roads will be submitted to the BLM for review and acceptance by the Zone Engineer. This review will ensure the design plans meet or exceed BLM minimum standards as presented in the guidebooks, "SURFACE OPERATING STANDARDS FOR OIL AND GAS EXPLORATION AND DEVELOPMENT". Plans for all roads will show the horizontal and vertical alignment of the road and the locations of culverts and other features. Typical sections needed to show the road template, culvert installations and other features will also be attached. Cross-sections of the roadway and other drawings for special design features will be included as needed.

All new roads and appurtenances (such as culverts, Cattleguards, fences, etc.) will be constructed to the dimensions, slopes and details shown on the attached templates, unless agreed otherwise because of conditions or circumstances (see Exhibits).

Surfacing specifications and depths shown on the attached templates may be adjusted because of local soil conditions, or graveling of roads may be waived (with BLM agreement) in instances where gravel is not available or is not considered necessary. Dust abatement mitigation within soil treatment additives will be considered on a case-by-case basis and at the annual review.

Junctions of roads will be located where site distances are adequate for safe entry and exit. All turns, including junctions, will have radii large enough to handle anticipated truck traffic for both drilling and production. Maximum grades will generally not exceed 10% except for pitch grades (i.e. road sections less than 300 feet).

When access roads have sustained maximum grades steeper than 8% on sections longer than 300 feet, or where roads cross side slopes steeper than 25%, Howell will consult with the BLM District Engineer. If he deems necessary, Howell will secure the services of a licensed professional engineer to design a safe, stable road. Vertical alignment diagram, cross sections and other engineering studies may be completed as necessary to assure sound engineering practices and proper road construction. Roads will be abandoned in accordance with Point 10.

Location, design and construction of all new roads in the Salt Creek Oil Field will be to the standards derived from BLM Manual 9113. Howell will use the road standards shown below in the Salt Creek Oil Field unless conditions dictate otherwise.

ROAD STANDARDS FOR THE SALT CREEK OIL FIELD

DESIGN ELEMENT	FUNCTIONAL CLASSIFICATION		
	Resource Rd.	Local Rd.	Collector Rd
Design Speed	20 MPH(max)	30 MPH	40 MPH
Width (traveled way)	14 ft with turn-outs	20 ft.	24 ft.
Width (subgrade)	18 ft.	24 ft.(min)	28 ft. (min)
Min. Horiz. Curve Rad.	220 ft.	460 ft.	820 ft.
Maximum Grade	8%	8%	8%
Minimum Grade	0.5%	0.5%	0.5%
Min. Stopping Sight Distance	135 ft.	225 ft.	325 ft.
Min. Intersection Sight Distance	200 ft.	300 ft.	400 ft.
Min. ROW Width Needed	50 ft.	55 ft.	60 ft.
	(Construction on steep slopes will increase the ROW width needed)		
Design Structural Loading	H-20	H-20	H-20

D) CLEARING AND GRADING

Suitable topsoil will be stripped to an average depth of six inches and stockpiled for subsequent application on the in slopes and back slopes of ditches.

E) ACCESS DURING CONSTRUCTION

Construction-related traffic will be restricted to the disturbed area needed for construction of the roadway.

F) DRAINAGE

1) Culverts, ditches and other drainage features will be designed to handle anticipated runoff events, i.e. 25-year event. Surface cover, slope, length of drainage, return times, channel cross sections and gradients will be considered as appropriate in the hydraulic and engineering analysis of upstream areas to determine the amount of runoff during the life of the access road. To assure proper drainage, the normal standard road will be ditched and crowned and constructed to the following specifications (See also Exhibit A):

WIDTH OF RUNNING SURFACE	16-18 Feet
DISTURBED AREA (DITCH TO DITCH)	33 Feet
DEPTH OF DITCHES	1-Foot Minimum

A lesser standard may be used where little use occurs, but proper drainage dips will be installed as needed. (For instance a safe, stable jeep trail may be used where one trip per day is necessary in stable conditions).

On extremely steep side hills or other difficult terrain where cramped conditions make the road standard costly and create potential hazards to road users, Howell may (in consultation with the BLM) employ a different standard. In most cases a berm would be graded along the

outside edge of the road, and the road be pitched against the high-wall. Drainage will be managed in accordance with other parts of the Guidelines. If this solution results in excessive erosion or sediment loss, Howell may either modify it to fix the problem or build the road to normal standards.

2) Culverts will be used for all minor drainage crossings, unless debris problems, low runoff volume, or traffic volume indicate the use of drainage dips. Drainage dips will be located to provide safe stopping sight distances, constructed such as to be stable and self cleaning, and will not cause serious erosion or sedimentation, especially at the outlets (See Exhibits A&B). Drainage dips will be placed at intervals according to the following formula unless site conditions dictate otherwise:

$$\textbf{SPACING INTERVAL} = \frac{400'}{(\text{SLOPE }\%) + 100'}$$

3) In most cases culverts will be 18 inches in diameter. Backfill will be thoroughly compacted, and minimum cover over culverts will be 12 inches or 2 times culvert diameter, whichever is greater. In steep, broken terrain where the ditch depth, culvert cover and other design standards necessary for 18-inch culvert installation are impractical and often counter productive, Howell may employ smaller pipes (12 inch or greater diameter) in consultation with BLM District Engineer. If casing is used, flanges or other effective anchoring devices will be attached. Cover over casing may be reduced to four inches. If this accepted practice causes plugged pipes, unstable and unsafe roads or unacceptable environmental damage, it will be discontinued.

4) Culverts used as laterals to provide cross drainage between natural drainage will be placed as shown in Exhibit C. They will be skewed to form an entrance angle of 45 to 60 with the side ditch, and have a gradient equal to or slightly greater than the approach ditch gradient (See Exhibit AB). Suitable ditch blocks will be constructed below culvert inlets.

5) Culverts in drainages will be placed on firm, uniform beds, which have been shaped to accept them, aligned with the natural channel and set at a gradient that maintains the natural drainage velocity so sedimentation or erosion is not increased.

6) The inlets and outlets of culverts will be modified as necessary to protect from debris, and limit excessive channel scour and erosion. The modifications may include racks, cribs, raisers, drop inlets, downspout, energy dissipaters, flared ends, headwalls, and rip-rap.

G) SUBGRADE AND SURFACING

The newly constructed sub grade will be bladed and shaped as necessary to prepare a safe, stable road bed, and compacted, necessary for safety, drainage or stability.

H) Road Mixing

a) Road mixing, of waste oil and oily sludge, will be conducted only within the unit boundary or active lease boundary.
b) The Wyoming Oil and Gas Conservation Commission (WOGCC) will analyze Road mix material for criteria as required.
c) Road Mix operations will be subject to WOGCC stipulations as noted in **ATTACHMENT**.

d) An after the fact map, showing areas where road mix was applied, will be submitted after work has been completed.

I) Construction Quality Control

All roads constructed or reconstructed by Howell within the Salt Creek Oil Field Area will be built to the approved plans, and will comply with all other applicable requirements, stipulations and referenced standards. Howell's company representatives, their consultants, will monitor the construction or an independent construction inspector as required.

Any changes which may become necessary during construction will be jointly agreed to by the BLM, the designer, affected private landowners, and Howell representative before construction of the changes commences. The agreed to changes and the reasons they are necessary will be documented in writing with copies distributed to all parties.

Within five days after construction of each road is completed, it will be inspected by company personnel, the contractor who performed the construction and the BLM (at their option). This inspection will be documented on a "post Construction Inspection Record" form) see Attachments) and signed by those performing the inspection. Any work which does not comply with the approve plans will be immediately corrected by the contractor.

3. LOCATION OF EXISTING WELLS

Maps showing the location of existing wells and facilities will be submitted to the BLM.

4. LOCATION OF EXISTING AND/OR PROPOSED FACILITIES

a) Any new permanent production structures, other than wellheads and electrical devices will be painted Carlsbad Canyon - 2.5Y 6/2. The exception to these painting requirements would apply only to those portions of moving parts requiring Safety Colors.

b) Construction activity for flowlines and power lines will be restricted to a route no more than forty feet wide (20' on either side of the centerline). After construction is completed, the route will **NOT** be used as a road.

c) Surface lines may be constructed to transport product. When this occurs, Howell will take necessary measures to avoid problems such as freezing of fluids, rupture of the pipe, or other serious contingencies. Vehicular access will be limited to what is needed for placement, removal and emergency maintenance. Road construction and other dirt work is unnecessary and will not occur.

d) All permanent liquid transfer lines, on the surface for more than one year, will be buried once approval is obtained from the BLM. However, lines crossing difficult or sensitive terrain or serving facilities with expected use of less than 7 years will generally not be buried.

A. PIPELINES

1) Flagging and Staking

The centerline of the pipeline right-of-way will be surveyed and/or pin flagged prior to any surface disturbing activities. On slopes greater than 25% or on rugged terrain, slope grade, and other construction control stakes may be necessary to ensure proper construction. If stakes are disturbed, they will be replaced before proceeding with construction.

2) Construction

a) All underground steel flowlines will be coated or otherwise protected from external corrosion; will be aligned in a straight a line as possible and buried to an adequate depth to prevent freezing.

b) Where possible, clearing along the pipeline route will be limited to the topping of shrubs and grasses up to an inside width of 26 feet. Where surface conditions prohibit the safe use of construction equipment, existing grades will be modified. Where supplemental grading is needed, an average of six inches of topsoil will be windrowed along one side of the modified areas, for storage before construction begins. Topsoil will be kept separate from trench soil.

c) The unbladed portion of the 40' wide right-of-way will be utilized by trucks and other pipeline laying equipment. This portion will **NOT** be flatbladed.

d) When the trench is backfilled, it will be compacted to the approximate bulk densities of the adjacent undisturbed soils and restored to natural ground level. Windrows or crowning using the natural settlement method may be used instead of compaction. All soil windrows will be removed when reclamation is completed (i.e., discing/seeding).

e) Drainage crossings will be constructed to prevent any blocking, diversion, or restriction of the existing channel. The pipelines spanning drainage will provide adequate clearance for anticipated stream flow resulting from a 25-year storm event.

f) In areas of safety concern, no unattended or unprotected open trench will be allowed overnight without warning devices such as signs, flares, warning lights, or inspection personnel. Areas considered hazardous to people, livestock or wildlife will be fenced to reasonably prohibit entry. Warning devices such as flares, signs, flagging, barricades, lights, etc. will normally be used for unattended or unprotected open trench in areas considered hazardous to people, livestock or wildlife. The amount of ditch to be left open is dependent upon the location and circumstances surrounding the situation.

g) Any changes in product metering along the pipeline route will require prior approval from the appropriate BLM Office.

3) Operations and Maintenance

Pipeline trenches will be maintained in order to correct settlement and erosion. Water-bars and other erosion control devices will be maintained. When new construction occurs on an existing right-of-way, reasonable care will be taken protect the pipe from damage or breakage. Adequate soil cover will be retained on buried pipes to prevent freezing and breakage.

B. POWER LINES

To obtain electrical power, minimum disturbance powerlines may be constructed to well sites. A surface or buried cable (of about 100' in length) will conduct power from the last pole to the well head. A service pole may be constructed on the pad when a utility owns the powerline.

1) Construction

Dirt work will be limited to drill holes for poles and anchors, and trenching in the buried cable. Excess soil excavated from the pole and anchor holes will be spread evenly in the immediate vicinity of the pole structure or coned around the pole to allow for settling.

2) Raptor Protection

Unless otherwise agreed to by the authorized officer in writing, powerlines shall be constructed in accordance with standards outlined in "Suggested Practices for Raptor Protection on Power Lines The State of the Art in 1996 (Avian Power Line Interaction Committee)." The holder shall assume the burden and expense of proving that pole designs not shown in the above publication are "eagle safe." Such proof shall be provided by a raptor expert approved by the authorized officer. The BLM reserves the right to require modifications or additions to all powerline structures placed on this right-of-way, should they be necessary to ensure the safety of large perching birds. Such modifications and/or additions shall be made by the holder without liability or expense to the United States.

5. LOCATION AND TYPE OF WATER SUPPLY

Drilling water will be transported by means of a temporary surface line or by truck from the nearest Water Injection well. If water is transported off unit and public land is crossed, a "short term" right-of-way will be requested. Trucking and / or temporary pipelines will follow existing access roads.

6. SOURCE OF CONSTRUCTION MATERIALS

Onsite materials will be used for building locations and roads. Because there are no infield gravel pits operated by Howell, gravel (if needed) will be obtained from sources outside the field.

7. METHODS FOR HANDLING WASTE DISPOSAL

No hazardous substances as defined by CERCLA will be used in the drilling and construction of this well site and access road. Commercial preparations, which may contain hazardous substances, may be used in production operations and will be transported within the project area. These materials, which may contain hazardous substances, will be handled in a appropriate manner to minimize potential for leaks or spill to the environment. No RCRA hazardous wastes will be generated in the well drilling operations. Exempt reserve pit contents will be buried on-site. Cuttings and drilling fluids will be disposed of in the reserve pits. Produced water and oil will be contained in steel tanks then hauled to and treated at the field battery.

A. CONVENTIONAL WELLS - RESERVE PIT CUTTINGS AND FLUIDS -

1) All reserve pits will be constructed to assure that, at reclamation, the cuttings can be covered with at least three feet of fill, and that the filled areas closely resemble natural, pre-existing contours.

2) Pits will be lined where pit failure or release of fluids creates abnormal and unacceptable environmental risk. Determinants include soil porosity, steepness and stability of slopes and potential communication between pit contents and ground water. Fabric liners will meet or exceed all necessary performance parameters (thickness, strength, impermeability, resistance to chemical and ultraviolet deterioration, etc.). They will be properly installed to prevent puncture and wind damage. Bentonite sealers will be chemically non-reactive with pit contents and will be carefully installed in sufficient thickness to prevent release of fluids.

3) Drilling fluids may be transported within the field boundary. Cuttings separated from normal, non-toxic drilling fluids will be contained in a shallow pit or on location until they dry, and then spread on the location. Reclaimed reserve pits will not be re-entered or reused without approval.

4) At least half the depth of the reserve pits will be in native cut. Where the pits are above ground level, the dike will be keyed and constructed in 8-inch lifts. Each lift will be compacted with rubber-tired equipment, a sheep's foot roller or other acceptable equipment. (Tracked vehicles generally exert insufficient pressures for adequate compaction.)

5) Following rig release, reserve pits will be fenced with either A stock tight or four strand barbed wire fence built and braced as shown in Exhibit F. Should there be oil on any pit, the oil will be removed or overhead flagging will be installed until the oil can be removed.

6) Final backfilling will comply with Point 10.

B. RE-ENTRY WELLS - CUTTINGS AND FLUIDS

1) Fluids generated as a result of “re-entry operations” will be placed in steel tanks and disposed of at approved sites.

2) Associated solids will be collected in a small “workover pit” on location and

covered with at least three feet of fill material.

C. WASTE AND SANITATION

1) Howell will comply with all State and Local laws and regulations pertaining to disposal of human and solid waste. The Salt Creek Field will be maintained in a sanitary condition at all times. Sewage from temporary construction sites will be disposed in portable chemical latrines. Garbage and other waste material will be gathered and disposed of in an approved sanitary landfill.

2) Hazardous substances specifically listed as hazardous waste or demonstrating a character of a hazardous waste (see 40 CFR Part 261 - Identification and Listing of Hazardous Wastes; and 40 CFR Part 355 - Emergency Planning Notification) will not be improperly used, produced, stored, transported or disposed of in permitted (lease, unit) operations.

8. ANCILLARY FACILITIES

Ancillary facilities will be temporary, consisting of possibly three to four trailer houses on the location for Howell's contractor personnel. No camps or airstrips will be constructed.

9. WELL SITE LAYOUT

The location of mud tanks, reserve pit, incinerator, pipe racks, living facilities, topsoil and spoil piles will be shown as on Exhibit D. No formation fracturing with volatile fluids are anticipated in normal drilling operations. However, all drill pads will be designed to comply with safety regulations for a frac using volatile fluids.

A) FLAGGING AND STAKING

Staking of the location will include two 250' directional survey reference stakes with the exterior boundaries of the pad marked with corner and centerline stakes. Pits will also be marked with corner stakes. Where drainage or rugged slopes create special problems, additional staking may be necessary to ensure construction in accordance with this Surface Use Plan. If stakes are disturbed, they will be replaced before construction is commenced.

B) CLEARING AND GRADING

1) Topsoil will not be buried under fill material. Prior to any pad or pit construction, four inches of topsoil will be removed from the location and stockpiled. Where little natural vegetation or topsoil is available, more than four inches of topsoil (not subsoil, caliche, etc.) will be removed from pockets of soil and vegetation. If possible, at least 1000 cubic yards of topsoil will be stockpiled.

2) During construction and restoration, surface use and disturbance will not extend more than 40' beyond the cut and fill slopes of the drill pad.

10. PLANS FOR RECLAMATION OF THE SURFACE

All equipment, hardware, waste or debris will be removed prior to any reclamation or stabilization actions. Linear disturbances such as newly constructed pipelines or reclaimed

pipelines or roads, will be cross drained by water bars at intervals shown in Exhibit . On short, steep grades, additional erosion control structures will be located as determined by local conditions. This practice may be altered or modified where field conditions warrant.

A) INTERIM STABILIZATION AND RECONTOURING

1) Unused areas around well pads, unused pits, flowline rights-of-way, cut and fill slopes of roads, and any other surfaces not occupied for field use, will be graded to form stable, rounded slopes, that blend with the natural terrain. Water bars or other erosion control structures will be built as needed, the areas will be ripped, the topsoil replaced, and the areas seeded as per final abandonment practices.

2) A berm at least one foot in height may be constructed around well locations to contain spills during the production phase of the well. Consider constructing a small pit with T siphon to collect any fluid evolving from the pad. Where substantial upslope runoff is anticipated, a diversion will be constructed above the berm to prevent flooding.

B) FINAL RECONTOURING AND ABANDONMENT

1. Pipelines will be purged of all fluids that will be disposed in approved field facilities.

2. Before recontouring takes place, the stockpiled topsoil and vegetative material will be scraped from cut and fill slopes of roads and pads where stable vegetation has occurred. It will be stockpiled for final distribution after the area is recontoured. The point is **NOT** to bury good topsoil that has been previously placed on pad edges or road back slopes.

3. Before well pads and battery areas are recontoured, oily surface material and cuttings (provided they are not regulated under RCRA, CERCLA, or other applicable regulations) should be worked and broken into aggregates of one inch in diameter or smaller, then treated with at least 200 lbs. of ammonium nitrate (33-0-0)/ acre, working it into the material. This should be conducted before available topsoil is spread on the surface for seedbed preparation.

4. All disturbed areas (roads, pads, flowline, etc.) will be graded to the original approximate contour. This practice may be modified in situations where an area would be far more stable in the long term if normal reclamation-recontouring practices were not followed; or where an area is stable and the costs of recontouring would prove excessive. Modifications will be undertaken in consultation with the BLM.

5. Drainage will be reclaimed to approximate the original bank configuration, stream bottom width, and channel gradient. Any pilings, debris, or other obstructions will be removed from drainage channels.

C) PIT RECLAMATION

Produced water pits, blow-down pits, emergency pits, drips, and any other pits which may contain produced fluids, will be reclaimed according to the following standards:

A. Non-sensitive Areas

1) 10,000 mg/kg (1%) total petroleum hydrocarbons/diesel range organics TPH/DRO)
2) Exchangeable sodium percentage (ESP) of 15% or less for remediated soils left on surface. If the native soil ESP is greater than 15%, no salt remediation standards apply. Salt contaminated soil buried under three feet of clean uncontaminated cover cannot exceed an electrical conductivity (EC) of 16, a sodium absorption ratio (SAR) of 61, or an exchangeable sodium percentage of 47. If native soils exhibit characteristics above these criteria, no salt remediation standards apply.
3) No testing for Benzene, Toluene, Ethyl benzene, or Xylene (BTEX) will be required.
4) A subsequent sundry notice will be submitted after work is completed.

B. Sensitive Areas

1) Sensitive area clean-up criteria will be based on depth to aquifers, distance to surface water, residences, water wells, public areas, soil permeability, and other hydro geological factors.
2) A notice of intent sundry and a subsequent sundry will be submitted for pit closures in sensitive areas.

Burn pits, reserve pits and any other pits will be filled, leveled or sloped to resemble adjacent terrain, when no longer needed. Cuttings and drilling muds will be allowed to dry, and then, all contents including liners will be covered with at least three feet of uncontaminated soils.

D) SEEDING AND SOIL AMENDMENTS

1) All disturbed areas (liner disturbances less than 6" in width exempted) will be seeded and fertilized with the following seed mixture or an alternative mixture approved by the Casper Field Office:

Species	**Pounds per Acre (PLS)[1]**
Gardner saltbush	2.31
Slender wheatgrass revenue	3.24
Western wheatgrass	4.68
Sandberg bluegrass	0.70
Bottlebrush squirreltail	2.68
Alkalai sacaton	0.15
TOTAL	**13.76**

[1]PLS = pure live seed

2) Preparation of the seedbed, application of seed and any soil amendment, and coverage of the seed is critical to successful revegetation. Unless otherwise approved, the following cultural methods will be followed:

- The site may be ripped or otherwise scarified up to a maximum depth of 18" on 24" centers to prepare a rough seedbed and eliminate compacted soils. The objective is to leave an extremely rough surface for maximum snow and rainfall retention, as well as ridges to protect the surface from wind erosion.

- Seed will be applied together by mechanical broadcasting to assure even coverage over the entire area to be reclaimed. The seed will be covered by harrowing, discing, or any other mechanical method of scarifying that assures seed coverage after seeding. (Note: Seeding can occur before final scarifying to leave a rough surface and provide seed coverage)
- Soil pitting, imprinting, or similar methods of seeding can be used, but must have prior approval from the AO.
- All seeded areas will be mulched with native hay, grass hay or straw that is sufficiently free of weeds to meet Natrona County noxious weed standards. It will be applied evenly at a rate of 2,000 lbs./A. Where possible, it will be anchored by means of a disc set straight at a depth of 2-3 inches, but on steep slopes, where mechanical spreaders don't work, it will be applied by hand and anchored by other suitable means.

3) Seeding will be take place in fall between the first of September and the fifteenth of October, or in spring from the time the ground is workable to the first of May. It will be repeated if a satisfactory stand is not obtained.

4) Noxious weeds will be controlled on disturbed areas in accordance with guidelines established by the EPA, BLM, State, and local pesticide authorities.

11. SURFACE OWNERSHIP

On individual Applications for Permit to Drill, Howell will identify surface ownership.

12. OTHER INFORMATION

A. FENCES

1) To ensure co-existence between land users, prior notification will be given to grazing lessees when a fence used for livestock control must be cut. The gap will be managed to prevent the passage of livestock by either placing a cattleguard (if frequent, regular passage is necessary) or constructing a wire gate. Fences will be braced and tied off before cutting to prevent slacking of the wire (See exhibit “typical design standards”). At completion of construction, the fence will be repaired to a standard as good as or better than what previously existed. In any case, previously existing management of livestock will be restored.

2) Construction and installation of cattleguards will be conducted in accordance with material and construction standards shown within the exhibit “typical design standards”. They will be as wide as the running surface of the road and at least six feet along the other dimension, and will be set on timber or cast-in-place concrete basses at right angles to the roadway. Backfill around cattleguards will be thoroughly compacted. Bypass gates will be built adjacent to each cattleguard structure.

B) CULTURAL RESOURCES

Any surface disturbing activities off roads, pads, etc. (including installation of surface lines), shall have prior Cultural Resources consideration. Cultural resources will be considered pursuant to applicable law, regulation, and policy guidance existing at time of applications.

The operator is responsible for informing all persons associated with any project that they shall be subject to prosecution for damaging, altering, removing, or excavating any archaeological, historical, or vertebrate fossil objects on site. If archaeological, historical, or vertebrate fossil materials are discovered, the operator is to suspend all operations that may further disturb such materials and immediately contact the Authorized BLM Officer. Operations are not to resume until written authorization to proceed is issued by the Authorized Officer.

Within five (5) working days, the Authorized Officer will evaluate the discovery and inform the operator of actions that will be necessary to prevent loss of significant cultural or scientific values. The operator is responsible for the cost of any mitigation required by the Authorized Officer. The Authorized Officer will provide technical and procedural guidelines for the conduct of mitigation. Upon verification from the Authorized Officer that the required mitigation has been completed, the operator will be allowed to resume operations.

C) GENERAL CONDITIONS OF APPROVAL FOR APDS

1) Approval of APDs does not warrant or certify that the applicant holds legal or equitable title to those rights in the subject lease that would entitle the applicant to conduct operations thereon. In addition, approval of APDs does not imply that the operator has legal access to the drilling location. When crossing private surface 43 CFR 3814 regulations must be complied with and when crossing public surface off-lease the operator must have approved rights-of-way.

2) APDs are valid for a period of one year from the date of approval or until the oil and gas lease expires/terminates, whichever occurs first. If the APD terminates, any surface disturbance created under the application must be reclaimed in accordance with the approved plan.

3) All applicable local, state and/or federal laws, regulations, and/or statutes must be complied with.

4) A complete copy of approved APDs must be at the drill site during the construction of the roads and drill pad, the drilling of the well, and the completion of the well.

5) Individual spud dates will be reported orally to the Authorized Officer 24 HOURS PRIOR TO SPUDDING, unless otherwise required in site specific conditions of approval.

6) Verbal notification shall be given to the Authorized Officer at least 24 hours in advance of formation tests, BOP tests, running and cementing casing (other than conductor casing), and drilling over lease expiration dates. Notice will also be given 24 hours prior to any construction activity approved under an APD or Sundry Notice.

7) A progress report must be filed a minimum of once a month starting with the month the well was spud and continuing until the well is completed. The report must be filed by the 25th of each month on a Sundry Notice (Form 3160-5). The report will include the spud date, casing information such as size, grade, weight, hole size, and setting depth, amount and type of cement used, top of cement, depth of cementing tools, casing test method, intervals tested, perforated, acidized, fractured and results obtained and the dates all work done.

8) The operator shall be responsible for the prevention and suppression of fires on public lands caused by its employees, contractors or subcontractors. During conditions of extreme fire danger, surface use operations may be limited or suspended in specific areas.

9) All survey monuments found within the area of operations shall be protected. Survey monuments include, but are not limited to: General Land Office and Bureau of Land Management Cadastral Survey Corners, reference corners, witness points, U. S. Coast and Geodetic benchmarks and triangulation stations, military control monuments, and recognizable civil (both public and private) survey monuments. In the event of obliteration or disturbance of any survey monuments, the incident shall be reported in writing to the Authorized Officer.

10) If at any time the facilities located on public lands authorized by the terms of the lease are no longer included in the lease (due to a contraction in the unit or other lease or unit boundary change) the BLM will process a change in authorization to the appropriate statue. The authorization will be subject to appropriate rental, or other financial obligation determined by the authorized officer.

11) Gas produced from newly permitted wells may not be vented or flared beyond an initial, authorized test period of 30 days or 50 MMcf following their completion, whichever first occurs, without the prior, written approval of the authorized officer. Should gas be vented or flared without approval beyond the test period authorized above, the operator may be directed to shut-in the well until the gas can be captured or approval to continue venting or flaring as uneconomic is granted, and you shall be required to compensate the lessor for that portion of the gas vented or flared without approval which is determined to have been avoidably lost.

D) <u>CONDITIONS OF APPROVAL FOR WELL ABANDONMENT</u>

1) This BLM Office should be notified sufficiently in advance of actual plugging work so that a representative may have an opportunity to witness the operation.

2) Holes will be plugged by the following acceptable method: balance method, two-plug method, and/or placement by dump bailer on a retainer. Other methods may be acceptable, but require prior approval of the Authorized Officer.

3) Upon completion of approved plugging, erect the regulation marker in accordance with 43CFR3162.6(b) and clean up the location. As directed by the Authorized Officer, the marker shall be below ground. The marker shall be a metal plate at least 3 inch thick and welded in place. A weep hole must be cut in the plate. Pits must be fenced unless approved otherwise by this office.

4) Within 30 days after well bore plugging operations are completed, Form 3160-5 (Subsequent Report of Abandonment) must be filed showing location of plugs, amount of cement in each, amount of casing left in hole, and status of surface restoration.

E) ROUTINE MAINTENANCE CONSIDERATIONS

1) New construction will not take place in wet and unstable soils. Routine maintenance off prepared road and pad surfaces will take place when soils are dry enough to prevent rutting or serious erosion. Unplanned construction to control spills, fires, and other undesirable events will occur at any time. Inadvertent surface damage will be fixed within a reasonable time.

2) Safety pit maintenance

3) Normal day-to-day routine operations shown below do not require written approval from the BLM:

a) Routine maintenance of existing lease roads which does not widen or otherwise extend existing surface disturbance.

b) Repairing or replacing existing culverts which does not require additional surface disturbance, or is limited to active stream channels and does not include terraces or cut-banks.

c) Repair or replacement of existing pipelines which does not require additional surface disturbance outside the original right-of-way.

F) SIGNS

a. Well Signs - New well signs shall have the following information contained on them:

1) Well Name and Number
2) Name of Operator
3) The Lease Serial Number
4) The Surveyed Location
   a) ¼ ¼ Section, Section, Township, Range (Footages are Optional)
   b) Or other authorized survey designation acceptable to the authorized officer.
5) Unit or Communization Name or Number
6) Name of the Indian Allottee Lessor(s) proceeding the Lease Serial Number if applicable

b. Oil Storage Facilities - All facilities which store oil shall be clearly identified with a sign containing the following:

1) Name of the Operator

2) The Lease Serial Number or Communalization or Unit Agreement Identification Number, as appropriate
3) ¼ ¼ Section, Section, Township, Range
4) On Indian Leases, the sign shall also include the name of the appropriate Tribe and whether the Lease is Tribal or Allotted.

c. Well And Battery At The Same Site - For situations of one tank battery servicing one well at the same location, the sign requirements can be met with one sign as long as it includes all of the information required by both A and B above.

13. HOWELL'S REPRESENTATIVE AND CERTIFICATION

Howell's representative will sign individual Applications for Permit to Drill as required by 43 CFR 3160 and Onshore Oil and Gas Orders No. 1.

CONTACTS - BUREAU OF LAND MANAGEMENT

BLM – CASPER FIELD OFFICE
2987 Prospector Dr.
Casper, Wyoming 82604
(307) 261-7500

Patrick Moore, Assistant Field Manager, 307/261-7530

Dave Chase, Petroleum Engineer, 307/261-7685

Ken McMurrough, Physical Scientist, - 307/261-7644

John Mesrobian, Lead Petroleum Engineering Technician, 307/261-7502

Jim Bauer, Physical Scientist, 307/261-7502

SALT CREEK OIL FIELD

POST CONSTRUCTION INSPECTION RECORD
for
Road Construction

Company:_____

Project Name:_____

Date:_____ **Time:**_____ **Weather:**_____

Contractor:_____

Construction Superintendent:_____

CONSTRUCTION CHECKLIST

General	**YES**	**NO**	**N/A**
Does the project look good	___	___	___
Are sight distances to standards shown on plans?	___	___	___
Is it comfortable to drive at design speed?	___	___	___
Will drainage system take all water away from road?	___	___	___
Are curves constructed as shown on plans?	___	___	___
Has topsoil been replaced on slopes?	___	___	___
Have disturbed/work areas been rehabbed/cleaned-up?	___	___	___
Roadway Template			
Cut and fill slopes	___	___	___
Shoulder slopes	___	___	___
Subgrade width	___	___	___
Gravel surface width	___	___	___
Gravel surface depth	___	___	___
Borrow ditch depth	___	___	___

Drainage	**YES**	**NO**	**N/A**
Are culverts damaged or obstructed?	___	___	___
Are these as shown on plans?	___	___	___
Culvert locations	___	___	___
Culvert lengths and diameters	___	___	___
Inlet basins and ditch blocks	___	___	___
Wing and drain ditches	___	___	___
Riprap	___	___	___
Borrow ditch	___	___	___
Other			
Are these built or installed as designed?	___	___	___
Turnouts	___	___	___
Cattleguards	___	___	___
Cattleguard drainage	___	___	___
Fences and gates	___	___	___
Signs	___	___	___
Bridges	___	___	___
Low water crossings	___	___	___
Pipeline or utility crossings	___	___	___
Have shoulder, fill and/or cut slopes been flattened To allow access to sheep wagon or other "2-track" trails?	___	___	___
Permits			
Does construction of the high way approach meet All state highway department permit requirements?	___	___	___
Does construction of the county road intersection			

Meet all county and/or permit requirements? ___ ___ ___

Comments or additional work needed

_____

_____

_____

_____

_____

_____

_____

_____

I have inspected this project and attest that the construction complies with the road plans, all permit requirements, the surface use plan, and the approved APD and/or right-of-way grant stipulations.

COMPANY'S REPRESENATIVE _____

(signature and title)

I have supervised the construction of this project, and attest that all of the construction is in conformance with the plans, specifications and all other permit requirements which apply.

CONTRACTOR'S REPRESENATIVE _____

(signature and title)

[ ] I have inspected this project, and find that it was constructed in conformance with the approved plans and all other BLM requirements and stipulations which apply.

[ ] I waive the requirement for a BLM representative to be present during the post construction inspection of this project.

BLM Representative _____

(signature and title)

Others (Specify) _____

(signature and title)

Copies to:

Company
Contractor **DATE:**_____
BLM
Other_____