Water Resources Monitoring Plan, Ochoa Mine Project

Lea County, New Mexico

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EXECUTIVE SUMMARY

Intercontinental Potash Corp. USA (ICP) is proposing to construct and operate the Ochoa Mine Project (Project), which would comprise an underground polyhalite mine, a processing facility, a groundwater well field, and a loading facility. The Project would be located about 60 miles east of Carlsbad and less than 20 miles northwest of Jal, New Mexico (Figure 1). Polyhalite ore from the underground mine will be used to produce sulfate of potash (SOP) and sulfate of potash magnesia (SOPM), potassium fertilizers used throughout the world for food production. Project water requirements for ore processing and for use at the plant facilities building are 6,452 acre-feet per year (4,000 gallons per minute) for 50 years. The source for the Project's water supply is the Capitan aquifer, which is a confined aquifer known to contain significant quantities of saline groundwater in New Mexico and Texas (Hiss, 1975). Up to eight water supply wells will produce saline water from the Capitan aquifer from an area to the east of the processing facility. This Water Resources Monitoring Plan (Plan) for shallow groundwater aquifers in the vicinity of the mine and plant facilities, as well as for the pumping well field aquifer (the Capitan aquifer), was developed to support the permitting process and to complete the Environmental Impact Statement. The data and information used to develop this Plan is based on existing information. An adaptive management framework will be adopted to update this Water Resources Monitoring Plan as additional information and data are collected through ongoing monitoring.

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ACRONYMS AND ABBREVIATIONS

ac-ft/yr	acre-feet per year
bgs	below ground surface
BLM	Bureau of Land Management
C	centigrade
CAGW	Carlsbad Area Groundwater
CAGWsup	superposition model of the CAGW model
COC	chain of custody
DTW	depth to water
EPA	United States Environmental Protection Agency
F	Fahrenheit
ft	feet
gpm	gallons per minute
GWQB	Ground Water Quality Bureau
ICP	Intercontinental Potash Corp. USA
L/min	liters per minute
LCS	laboratory control sample
mg/L	milligrams per liter
MS	matrix spike
NMAC	New Mexico Administrative Code
NM OSE	New Mexico Office of the State Engineer
NMED	New Mexico Environment Department
ORP	oxygen reduction potential
Plan	Water Resources Monitoring Plan
PQL	practical quantitation limit
Project	Ochoa Mine Project
PRRL	project-required reporting limit
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
SOP	sulfate of potash
SOPM	sulfate of potash magnesia

TD	total depth
US ACE	United States Army Corps of Engineers
USGS	United States Geological Survey
VOA	volatile organic analysis
WIPP	Waste Isolation Pilot Plant

1.0 INTRODUCTION

Intercontinental Potash Corp. USA (ICP) is proposing to construct and operate the Ochoa Mine Project (Project), which would comprise an underground polyhalite mine, a processing facility, a groundwater well field, and a rail load-out facility. The Project would be located about 60 miles east of Carlsbad and less than 20 miles northwest of Jal, New Mexico (Figure 1). Polyhalite from the Project will be used to produce sulfate of potash (SOP) and sulfate of potash magnesia (SOPM). SOP and SOPM are non-chloride-based potassium fertilizers that are used in the fruit, vegetable, and horticultural industries. The Project will require water for processing ore and for use at the plant facilities building. The Capitan aquifer was identified by ICP as a viable non-potable water resource that will not compete with limited fresh water resources in the area. The Capitan aquifer is a confined aquifer known to contain significant quantities of saline groundwater in New Mexico and Texas (Hiss, 1975).

This Water Resources Monitoring Plan (Plan) was developed to support the Ochoa Mine Project permitting process and to complete the Environmental Impact Statement (EIS). The Plan defines groundwater monitoring for the 50-year mine workings and plant facilities area as well as the proposed pumping well field. The Plan incorporates commitments from ICP for groundwater monitoring and fulfills the requirements established by the Bureau of Land Management (BLM), and the New Mexico Office of the State Engineer (NM OSE). It is anticipated that the plan will fulfill the requirements of the New Mexico Environment Department (NMED) Ground Water Quality Bureau that will be established in the future following submission of a groundwater discharge permit application for proposed facilities. Upon submission of the application, a detailed review of the plan will be completed by the NMED and adjustments, where consistent with other agency requirements, may be required. In addition, this Plan may be modified as ongoing monitoring fills in existing data gaps. This adaptive management framework allows for an iterative process in that creates a more flexible groundwater monitoring plan.

The Plan provides a description of the Project, an overview of the regional geology and hydrogeology, and an outline of the monitoring protocols. The monitoring protocols of the Plan address monitoring objectives, the monitoring well network, new well construction and installation, geophysical logging, sampling analytes and frequency, and quality assurance/quality control (QA/QC) procedures.

2.0 PROJECT DESCRIPTION

ICP is proposing to develop a new mine to extract polyhalite ore for the production of SOP and SOPM. Polyhalite ore will be extracted approximately 1,500 feet (ft) below ground surface (bgs) in the Rustler Formation, conveyed to the surface, and processed at a processing facility to produce SOP and SOPM. The final product produced at the processing facility will be moved by truck to a load-out facility near Jal, New Mexico, where it will be loaded on trains and shipped to customers.

2.1 Site Information

The Project is located about 60 miles east-southeast of Carlsbad, New Mexico, and less than 20 miles west of the Texas-New Mexico state line. The mineral leases and prospecting permits total a combined area of 103,000 acres and cover 10 township-range blocks. The Project is located in Lea County, and the plant facilities are accessible from NM Highway 128 (Figure 2). The land surface consists of relatively flat terrain with minor arroyos and low-quality, semi-arid rangeland. The top soil consists of caliche rubble and wind-blown sand with mesquite, shinnery oak, and coarse grasses as the dominant vegetation. Elevation ranges from 3,100 to 3,750 ft above sea level.

2.1.1 Plant Facilities Location

Surface facilities associated with the Project are shown on Figure 3 and consist of roads, processing facilities, shaft facilities, evaporation ponds, waste piles, and product load-out facilities. Temporary and permanent roads will be constructed to support the Ochoa Project.

2.1.2 Pumping Well Field

The pumping well field and pipeline right-of-way are shown on Figure 4 and consist of eight pumping wells, temporary roads, and the pipeline to the plant facilities. Two of the Project's eight pumping wells were installed and used for aquifer testing and bench scale testing. The first well, ICP-WS-01, was completed in February 2012, and the second well, ICP-WS-02, was completed in June 2012 approximately 1,500 ft from ICP-WS-01 (Figure 4; INTERA, 2012). The wells were drilled to approximately 5,400 ft bgs, but the producing interval is from approximately 4,400 to 4,575 ft bgs. The water table in the wells after installation, development, and testing is approximately 700 ft bgs.

2.1 Polyhalite Deposits

ICP's polyhalite target is in the Tamarisk Member of the Rustler Formation, stratigraphically overlying the Salado Formation that produces potash minerals in what is known as the Carlsbad Potash District. The Rustler Formation is predominantly made up of marine anhydrite and dolomite and represents the transition from the predominantly halite-bearing evaporites of the Salado Formation to the continental red beds of the Dewey Lake Formation. Polyhalite occurs in the Tamarisk Member of the Rustler Formation. The Tamarisk Member comprises three sub-units: a lower basal anhydrite, a middle mudstone, and an upper anhydrite. Polyhalite occurs within the upper anhydrite.

The polyhalite in the area of the mine plan is very flat and is located 1,500 to 1,600 ft below the surface. Polyhalite thickness ranges from approximately 4 to 6 ft and averages approximately 5 ft. Polyhalite is an evaporite mineral that is a hydrated potassium-calcium-magnesium-sulfate salt. Polyhalite is generally white, colorless, or light or medium gray, but may be brick red or pink if it contains traces of iron oxide. Potash mineralization is typically a consequence of low temperature chemical processes governed by evaporative concentration of a fluid such as seawater or freshwater.

2.2 Processing Description

The Project requires water for ore processing and for use at the plant facilities building. Project water requirements are 6,452 acre-feet per year (ac-ft/yr) (4,000 gallons per minute [gpm]) for 50 years. Of the total water supply required for the Project, approximately 99 percent is expected to be used for ore processing; less than 1 percent will be treated to drinking water standards and provided to the plant facilities building for drinking water, showers, and other sanitation purposes. Saline water from the Capitan aquifer will be produced from up to eight groundwater wells located east of the Project (Figure 4). The water will be pre-treated at the well field to remove hydrogen sulfide, then piped 11.4 miles to the plant facilities where it will be treated using a reverse osmosis system located on the plant facilities site. Waste from the reverse osmosis system will be disposed of in the evaporation ponds or into injection well(s) (Figure 4).

The polyhalite will be mined from the Rustler Formation using the room and pillar mining technique and transferred to the plant facilities for processing. ICP's ore process involves seven major unit operation steps: (1) primary crushing, (2) wet grinding and salt removal, (3) calcination, (4) leaching, (5) evaporative crystallization of SOP (K_2SO_4), (6) evaporative crystallization of SOPM ($2Mg(SO_4)•K_2SO_4$), and (7) drying/granulation of both products. The final products will be loaded on trucks and driven to load-out facilities near Jal, New Mexico, where it will be loaded onto rail cars. The waste brine from reverse osmosis treatment and from processing the ore will be pumped to a series of 16 evaporation ponds.

The evaporation ponds will have a total pond capacity of approximately 800 million gallons (Figure 3). Surface water run-on will be kept out of the ponds by berms. The disposal ponds will be lined with a geosynthetic liner over a compacted clay layer. Salts crystallizing from the waste brine will form the pond bedding. The clay and pond bedding will protect the liner from damage during harvesting of the salts produced in the disposal ponds. The waste salts will be harvested by rubber tire self-loading scrapers that will dump the waste salts at the dry stack tailings facility.

The dry stack tailings facility will consist of a tailings pile and two collection ponds immediately adjacent to the tailings pile. After SOP (K_2SO_4) is processed, the gypsum and salts from the evaporation ponds will be placed in the dry stack tailings facility (Figure 3). The tailings pile will be bermed to prevent run-on and runoff. Grading at the base of the tailings pile and the benches will direct runoff to the collection ponds.

2.3 Soil

Native surface conditions within the Project area consist of relatively flat terrain with minor arroyos and low-quality, semi-arid rangeland. Windblown sand dunes and limited bedrock exposures, a petrocalcic horizon (caliche), and poorly developed soil horizons are the predominant soil features found on the Project site. The soils in the Project area consist predominately of fine sands and loamy fine sands. The top soil is caliche rubble and wind-blown sand. The northern portion of the project is situated in sandy dune country. The soils are predominately well drained, not very susceptible to water erosion, and highly susceptible to wind erosion. Most soils have a “moderate restoration” potential; the lack of precipitation limits restoration potential. Precipitation and soil depth are the most frequent limiting factors to restoration.

2.4 Surface Water

The surface facilities proposed for the Project are located in areas that are drained by ephemeral streams (arroyos) within the Landreth-Monument Draws watershed, an area that comprises 4,270 square miles of land in southeastern New Mexico and western Texas. Several arroyos exist south of the processing facility area. Flows in these arroyos are ephemeral, as they only occur in direct response to heavy precipitation. Surface water monitoring has not been included in this water resources monitoring plan due to the limited presence on the Project area. The U.S. of Army Corps of Engineers (US ACE) has determined that there are no Waters of the United States within the Project area in a letter dated May 28, 2013 (US ACE, 2013). ICP will, if required, prepare a storm water pollution prevention plan (SWPPP) if required to comply with the National Pollution Discharge Elimination System (NPDES). Following the EPA guidance for developing such plans, the SWPPP will be prepared as a standalone document and will address surface water concerns.

2.5 Climate

The climate in the Project area is semi-arid with generally mild temperatures and low precipitation and humidity. The prevailing winds are from the southeast in summer; during the winter, strong winds come from the west. Winter temperatures generally range from lows of -6°centigrade (C) (-20° Fahrenheit [F]) to highs of 10°C (50°F). Summer daytime high temperatures are typically above 32°C (90°F) with nighttime lows of 21°C (70°F). The average precipitation is 11.75 inches per year, about half of which comes from thunderstorms occurring from June through September (WRCC, 2012).

3.0 GEOLOGY

The Project is located along the northeastern margin of the Delaware Basin (Figure 5), a structural sub-basin of the large Permian Basin that dominated the region now including southeastern New Mexico, western Texas, and northern Mexico from 265 to 230 million years ago. The Permian Basin is an asymmetrical depression formed on top of Precambrian basement rocks. Marine sediments accumulated in the basin throughout the Paleozoic Era. The slow collision of the North American and South American crustal plates resulted in tectonic subdivision of the Permian Basin into numerous sub-basins, of which the Delaware and Midland basins are the largest (Ward et al., 1986).

The Delaware Basin was an area of subsidence, resulting in deposition of a thick sequence of marine rocks. The Project area is underlain by almost 12,000 ft of Permian-age deposits (Figures 5 and 6). The basin is bounded on the west by the Diablo Platform, on the north by the Northwest Shelf, and on the east by the Central Basin Platform (Figure 5). The Capitan aquifer was formed by the youngest of the Permian shelf-margin complexes developed around the Delaware Basin (Harris and Saller, 1999).

The Capitan Reef Complex is a horseshoe-shaped limestone, dolomite, and sandstone deposit surrounding the Delaware Basin (Figure 5). The complex extends over approximately 200 miles in southeastern New Mexico and western Texas. Geologic formation names vary somewhat from west to east, but the overall structure of the reef complex (i.e., the basin, slope, reef, back-reef, and shelf facies) is consistent throughout.

Older Permian deposits (San Andres, Yeso, Abo, and Hueco formations) consist of approximately 4,000 ft of mostly fine-grained sandstones, siltstones, shales, and various types of limestone deposited before the Capitan Reef Complex was deposited and the Delaware Basin was formed (Hill, 1996) (Figures 6 and 7). The Permian-age Delaware Basin deposits in southeastern New Mexico are divided into the Guadalupian and the Ochoan series. The Guadalupian series consists primarily of sandstones that comprise the Delaware Mountain Group (Ward et al., 1986; Hill, 1996). The Ochoan series comprises, from oldest to youngest, the Castile Formation, the Salado Formation, the Rustler Formation, and the Dewey Lake red beds (Bachman, 1983).

Oil and gas reserves exist within the Guadalupian series formations primarily concentrated at the boundary between up-dip evaporites and shelf dolomites and siltstones and fine-grained sandstones (Ward et al. 1986). The following subsections describe the stratigraphy of the Project area, beginning with the youngest formations.

3.1 Quaternary Alluvium

Alluvial gravel, sand, and silt deposited by the Pecos River and its tributaries underlie much of the Carlsbad area (Barroll et al., 2004). In addition, wind-deposited Quaternary alluvial deposits exist throughout Lea County. Below the alluvium, deposits of gypsum, red silt, and clay are interbedded in places with thin lenses of gravel. The red silt and clay are not alluvium, but rather a residue of Ochoan series soluble salts and gypsum that were removed by solution (Bjorklund and Motts, 1959; Mercer, 1983).

3.2 Ogallala Formation

The Ogallala Formation of the Miocene epoch is composed of clay, silt, sand, and gravel sediments and is locally cemented with a calcium carbonate (caliche) layer (Hendrickson and Jones, 1952). Braided streams flowing eastward from the ancestral Rocky Mountains deposited this sequence of heterogeneous sediments. The Ogallala Formation is one of several formations that compose the High Plains aquifer. In the Project area, the presence of the Ogallala is discontinuous and thin or it is non-existent (Leedshill-Herkenhoff et al., 2000).

3.3 Upper Triassic Rocks

3.3.1 Dockum Group Undivided

The Dockum Group of the Delaware Basin is of Late Triassic age and, in the Project area, exists as an erosional wedge that pinches out westward along a north-south line through the middle of the Waste Isolation Pilot Plant (WIPP) site (Beauheim and Holt, 1990). The Dockum Group sediments represent a terrestrial floodplain, alluvial-fan deposit composed of deltaic, fluvial sandstone and mudstone irregularly distributed over much of the Project area (Hill, 1996). The uppermost unit of the Dockum Group is a dominantly shaly mudstone interspersed with greenish-grey mudstone and lenses of sandstone as conglomerate (Mercer, 1983). The lower unit consists of a medium- to coarse-grained sandstone and conglomerate with interbedded siltstone and silty claystone (Mercer, 1983; Hill, 1996). The sandstones are generally poorly sorted, vary from fine to very coarse grained, and are not well cemented (Adams, 1929; Hill, 1996). The formation thickness varies from 10 to 26 ft at the WIPP site (Hill, 1996) to 230 ft approximately 10 miles east of WIPP (Anderson, 1981). Although many group the Santa Rosa Formation with the Dockum Group, some separate the older Santa Rosa Formation from the younger Dockum Formation (Mercer, 1983).

3.4 Ochoan Series

3.4.1 Dewey Lake Red Beds

The Dewey Lake Formation is unconformably overlain by the Dockum Group (Mercer, 1983). The deposits consist of red siltstone, sandstone, and shale (Bjorklund and Motts, 1959). The Dewey Lake Formation ranges in thickness from 345 to 541 ft at the WIPP site and thin and disappear to the east and the west on the margins of the Delaware Basin (Mercer, 1983 and Bachman, 1983). The Dewey Lake beds are presumed to have very low permeability and would yield very little water, if any, though very little data are available about the hydraulic properties of the beds (Summers, 1972). The Dewey Lake red beds conformably overlie the Rustler Formation and mark the transition from the marine environments of the Rustler Formation and other older deposits to continental environments left by the retreating sea (Mercer, 1983).

3.4.2 Rustler Formation

The Rustler Formation, which lies beneath a conformable contact with the Dewey Lake Formation, is the youngest unit in the Ochoan evaporite sequence (Mercer, 1983). The Rustler Formation has a varying lithology, consisting of interbedded sulfates, carbonates, clastics, and halite (Beauheim and Holt, 1990). The Rustler has been divided into five formal members, which are, from oldest to youngest, the Los Medaños, the Culebra, the Tamarisk, the Magenta, and the Forty-Niner members. Los Medaños consists of siliciclastics, halitic mudstones, muddy halite, and sulfate minerals, principally anhydrite (Powers and Holt, 1999). The Culebra consists of a microcrystalline dolomite that contains spherical cavities that range from 2 to 20 millimeters in diameter (Mercer, 1983). The Tamarisk comprises three units: a lower basal anhydrite that contains polyhalite, a middle halite-rich mudstone, and an upper anhydrite. The polyhalite targeted by ICP for mining is in the Tamarisk Member. The Magenta Member is predominantly a silty dolomite and anhydrite, altered in places to gypsum (Mercer, 1983). The Forty-Niner Member comprises a lower and an upper anhydrite with a middle siltstone. The middle siltstone shows lateral facies changes between mudflat deposits and halite-pan deposits (Holt and Powers, 2010).

The Rustler thickness is highly variable due to solution of anhydrite by groundwater, which has resulted in residues of gypsum and brick-red silt interbedded with dolomite (Bjorklund and Motts, 1959; Hill, 1996). In the Malaga Bend area of the Pecos River (Figure 5) south of Carlsbad and in some areas of Nash Draw, extensive dissolution and erosion of the halite and anhydrite beds has occurred. The Rustler is more than 390 ft thick in eastern Eddy County and thickens to 650 ft in the southern part of the basin (Hill, 1996). Farther west, the Rustler Formation is missing due to erosion by the Pecos River (Hiss, 1975).

3.4.3 Salado Formation

The Salado Formation is part of the Late Permian Ochoan series of west Texas and southeastern New Mexico and consists of generally flat-lying beds composed of halite, muddy halite, anhydrite, polyhalite, dolostone, and mudstone (Lowenstein, 1988). Although it can be as much as 2,300 ft thick (Figure 8) (Lowenstein, 1988), the Salado has disappeared along the western margin of the basin where the reef has been uplifted and the Pecos River has cut down to the reef complex. Potassium minerals in the Salado Formation are interbedded within the anhydrite and halite stratigraphic units. The Salado Formation interfingers laterally with the underlying Castile Formation (Lowenstein, 1988).

A red silt and clay layer occurs at the contact of the Salado and the overlying Rustler Formation (Bjorklund and Motts, 1959; Bachman, 1983). Composed of clay with interlayered seams of gypsum and sandstone, this layer exists between the Salado and the Rustler in Nash Draw and represents residuum from the dissolution of clayey halite and other evaporites in the upper Salado (Mercer, 1983). The thickness of the residuum is variable.

Dissolution of the Salado adjacent to the Capitan aquifer has led to formation of sinks and collapsed breccias (Figure 9) (Hill, 1996). In these areas, the Salado has been reduced in thickness resulting in solution and slumping of the overlying Rustler (Hill, 1996). The deeper depressions are filled with more than 1,180 ft of Cenozoic sediments.

3.4.4 Castile Formation

The Castile Formation represents the oldest evaporite cycle of the Ochoan series in the Delaware Basin. Bachman (1983) describes the Castile Formation as primarily anhydrite with interlaminated beds of halite and to a lesser extent limestone and dolomite. The Castile Formation interfingers with the Capitan Formation (Bjorklund and Motts, 1959), with the slope carbonates thinning and basinal siliciclastics thickening towards the basin (Harris and Saller, 1999). The Castile Formation rests unconformably on the upper member of the Bell Canyon Formation, the youngest sequence of the Delaware Mountain Group (Hill, 1996).

The thickness of the Castile Formation ranges from about 1,500 to 1,700 ft, reaching 2,100 ft locally in north-central Loving County, Texas (Figure 10). Thicknesses of approximately 1,700 ft have been reported in Winkler County, Texas (Garza and Wesselman, 1959), and of approximately 900 ft in the region overlying the Capitan Reef Complex in Pecos County, Texas (Armstrong and McMillion, 1961). The Castile Formation marks the beginning of conditions favorable for evaporite deposition.

3.5 Guadalupian Series

The rock units of the Guadalupian series of Permian age are characterized by four major facies: (l) basin facies consisting of quartzose sandstone interbedded with limestone, deposited seaward from the Guadalupe reef complex; (2) reef facies of massive limestone; (3) carbonate shelf facies of carbonate rocks interbedded with sandstone, deposited landward from the Guadalupe reef complex; and (4) evaporite shelf facies of gypsum in back-reef waters, and anhydrite and other evaporite rocks interbedded with red sandstone and shale, all of which were laid down in back-reef waters (Bjorklund and Motts, 1959) (Figure 7).

3.5.1 Basin Facies

The Delaware Mountain Group represents the Guadalupian basin facies, described by Hiss (1975) as a thick sequence of terrigenous sandstones, siltstones, and mudstones. Carbonate debris was likely transported into the basin through submarine canyons, mudflows, and forereef avalanches while the fine silt and clay carbonate were carried into the basin in suspension (Hiss, 1975). The submarine canyon channel deposits, built up in time over the basin, were meandering and braided, but were oriented in a roughly linear, northeast-southwest direction (Hill, 1996). Submarine fans developed in the deep seas at the mouths of the submarine canyons and gradually coalesced to form a compound submarine apron or bajada. The thickness of the deep-sea fans and component sediment grain size both decrease seaward (Hiss, 1975).

In the Guadalupe Mountains, the Delaware Mountain Group is 2,700 to 3,475 ft thick, and is divided into approximately equal thirds by the Bell Canyon, Cherry Canyon, and Brushy Canyon formations (Figures 6 and 7). The Bell Canyon is equivalent to the Capitan Formation and the Tansill, Yates, and Seven Rivers formations of the Artesia Group; the Cherry Canyon and Brushy Canyon are equivalent to the Goat Seep Limestone and the Queen and Grayburg formations of the Artesia Group (Hill, 1996).

The Bell Canyon Formation is the upper formation of the Delaware Mountain Group and varies in thickness from about 650 to 980 ft (Hill, 1996). It consists of very thick sandstones, alternating with thinner limestone layers and rather hard shales. The sandstone beds of the Bell Canyon Formation are extremely fine grained. Aside from the occasional, persistent limestone members, the sandstones contain few or no calcareous beds or lenses, and there are no interbedded black, shaly layers of the sort found in the Cherry Canyon Formation beneath (King, 1948). The carbonate members of the Bell Canyon interfinger with unnamed sandstone units along the margin of the basin. The sandstone units thin basinward (Hill, 1996).

3.5.2 Shelf Carbonate and Evaporite Facies

The shelf facies include the Artesia Group and the San Andres Formation. The Artesia Group underlies the Salado Formation (Ochoan series) and consists of the Tansill, Yates, Seven Rivers, Queen, and Grayburg formations (Figure 7). Ward et al. (1986) describe the shelf dolomites as burrowed dolomites capped by algal-laminated anhydritic dolomites. Interbedded quartz siltstones and sandstones are more common landward; also, the shelf facies may locally contain pelletal packstones and grapestone grainstones, suggesting a high-energy shoreline. The carbonate facies consists of interbedded limestone, dolomite, and sandstone, with a predominance of carbonate rocks (Bjorklund and Motts, 1959). Laterally, these change in a landward direction from lagoonal dolomites to a mixture of carbonates, evaporites, and quartz siltstones (Ward et al., 1986).

3.5.2.1 Artesia Group

The carbonate facies changes abruptly, within about 500 to 650 ft, into an evaporite facies at different stratigraphic intervals, depending on the age of the rocks (Bjorklund and Motts, 1959; Ward et al., 1986). The evaporite facies consists predominately of interbedded gypsum and anhydrite with beds of siltstone and sandstone (Bjorklund and Motts, 1959). The carbonate-evaporite facies contact is found farther up dip with deeper formations. For instance, along the western edge of the Central Basin Plateau, evaporites of the Queen Formation occur 12 to 16 miles shelfward from the Capitan Formation, while evaporites of the Yates Formation occur approximately 8 miles behind the Capitan Formation (Figure 7) (Ward et al., 1986; Hiss, 1975). Hill (1996) shows the thickness of the carbonate facies ranging in width from 6 to 12 miles. Hiss (1975) reports the average thickness of the Artesia Group within the northern part of the project area is approximately 1,500 ft and thins to a thickness of about 1,000 ft on the southern end of the Central Basin Platform.

Shelf dolomites and siltstones contain higher average porosities than shelf-marginal or basin strata and account for most of the hydrocarbon production from the Permian Basin. Most of the subsurface porosity occurs as intercrystalline and moldic pores in the dolomites and as preserved primary pores in the siltstones (Ward et al., 1986).

3.5.2.2 San Andres Formation

The San Andres Limestone west of Carlsbad, New Mexico, has a thickness of 1,370 ft and consists of two lithologies (Bjorklund and Motts, 1959; Hiss, 1975). The thickly bedded upper 350 ft is composed of tan-white, dense to very fine crystalline dolomite, and the lower 1,020 ft is composed of tan-brown, dense to fine crystalline dolomite limestone with numerous gray-brown cherty stringers (Miller, 1969). In the northern portion of the structure, the carbonate facies of the San Andres Limestone is exposed west of Carlsbad and grades into the evaporite facies southwest and northeast of Roswell, New Mexico (Bjorklund and Motts, 1959). Sandstone tongues of the Cherry Canyon Formation (Delaware Mountain Group) extend into the upper part of the San Andres Limestone in many localities (Hiss, 1975).

Miller (1969) further describes the reef portion of the San Andres, noting that it is not comparable in extent to the Goat Seep-Capitan barrier reef in that the San Andres reef environment represents reef growth with interspersed clean, massive, dolomitic "bank type" deposition. The San Andres reef facies is separated by a nonporous, non-permeable envelope of porcelaneous dolomite, formed from dolomitic muds that help to hydraulically seal off the San Andres reef from other formations. However, this type of seal may not be extensive (G. Lamb, personal communication).

3.5.3 Capitan Formation

In the Project area, the Capitan Reef Complex extends from the Guadalupe Mountains and Glass Mountains down to a depth of more than 5,000 ft bgs (Hiss, 1975). Logs from oil, gas, and water wells were used to define the stratigraphy of the reef and associated formations (Hiss, 1975; Harris and Saller, 1999). These cross sections form the basis for our understanding of the Capitan Reef Complex, adjacent formations, and the Capitan aquifer (Figures 11-14).

The Capitan and Goat Seep formations constitute the Guadalupian reef facies. The origin of the Capitan Formation "reef" has been interpreted in different ways, including as a barrier reef, a deep-water skeletal wackestone mound, a cement boundstone mound, and a linear complex of buildups (Hill, 1996). The depositional structure and texture within the reef varies depending on position within the complex. The reef facies may be divided into the "massive member" and "breccia member," and these members may be divided further into lower, middle, and upper parts, each corresponding to a different facies (and formation) within the back-reef or inner shelf. The breccia member is volumetrically much larger and is about three times as thick (1,250 ft) as the massive member (400 ft), based on outcrop measurements near Carlsbad. Some references conclude that the massive portions of the Capitan formed as a barrier reef based on the presence of low-energy, restricted facies on the outer shelf leeward of the reef, while other studies suggest that the outer shelf was open to marine-current energy and thus the reef did not act as a shelf-margin barrier. Together these interpretations indicate that the water depth and shelf margin position of the reef varied through time. During deposition or growth, the front of the massive reef wall was nearly vertical (80- to 90-degree slope). Below this wall was a talus pile composed of reef blocks and sediments created as the reef front prograded basinward, continually over steepened (by the growth of organisms), fractured, and fell into the basin (Hill, 1996).

The shelf marginal sediments of the Capitan consist of an upper massive unit and an underlying, thick-bedded, foreslope facies. This margin can be divided into three informal chronostratigraphic units: (1) the lowermost unit is known as the lower Capitan, and is equivalent to the Seven Rivers shelf sediments; (2) a middle Capitan unit is equivalent to the Yates Formation; and (3) an upper Capitan unit is equivalent to the Tansill Formation

(Figures 15 and 16). Underlying the Capitan is the Goat Seep reef margin and its shelf equivalents of the uppermost San Andres, Grayburg, and Queen formations (Ward et al., 1986).

In outcrop near Carlsbad, the Capitan Formation consists of cream-colored to very light gray massive limestone. This limestone grades into re-cemented, in part dolomitized, breccia consisting of reef fragments, calcarenite, and rounded fossils in the reef-talus deposit (Bjorklund and Motts, 1959). Outcrops are absent in the vicinity of the ICP wells, but a geological core and geophysical logs of the PDB-04 research core hole (Harris and Saller, 1999), 40 miles west of the ICP wells, document that the Capitan consists primarily of dolomite with minor amounts of limestone and siltstone; "the entire reef interval (massive and slope facies) in the core is pervasively dolomitized, unlike in the Guadalupe Mountains where the Capitan Formation is predominantly limestone" and "anhydrite and gypsum fill pore spaces throughout the Capitan Formation and slope facies" (Harris, 2011).

The Capitan reef was incised locally by submarine canyons that extended into the back shelf (Figure 17). Hiss (1975) states:

> The margins of the Delaware basin were incised by numerous submarine canyons, contemporary in age to the shelf, shelf-margin, and basin facies. Much of the sediment in the Delaware basin was transported through canyons that extended (several miles) back onto the shelf. No one has located a completely exposed submarine canyon in the field. The exact nature of the material filling the canyons on the shelf margin remains unknown. The geometry and lithology interpreted from studies of electrical logs suggest that the submarine canyons are almost completely filled with a mixture of carbonate debris, sandstones, and siltstones resembling the basin facies near the shelf margin but may be partly filled with Ochoan evaporites.

Hiss's map of submarine canyons shows limited data that can be used to accurately characterize the canyons. Additional well logs were obtained to more carefully evaluate the West Laguna Submarine canyon, one of the deeper canyons observed by Hiss (Figure 18). The West Laguna Canyon as proposed by Hiss (1975) was corroborated using the additional well logs.

Dissolution features exist on the north and east sides of the Delaware Basin (Hill, 1996) and caves and karst features are known to exist within the Capitan Formation. Cavernous porosity has been documented in drill holes into the Capitan aquifer (Hill, 1996). A 690-ft section of the reef was reported as very vuggy and cavernous (Hill, 1996). Larger dissolution features exist within or above the Capitan Formation on both the north and east sides of the basin forming dissolution troughs, sinks, and domes/breccia pipes (Anderson, 1981; Figure 9). Two theories have been proposed to account for the formation of these features: (1) the collapse of large voids, such as caves that had formed in the reef, and (2) the dissolution of overlying salt (Anderson, 1981; Hill, 1996). No wells have penetrated these structures to the depth of the Capitan

Formation, thus a definitive explanation for the cause of these features is currently lacking. However, if collapse of caves in the reef were the cause, the overall reef thickness in that location would be reduced and replaced with breccia pipe debris from the overlying strata.

A linear zone of basalt dikes approximately 1.24 miles wide and 42.25 miles long intersects the Capitan Formation at the north end near the Laguna Submarine canyons (Figure 17, top) (Calzia and Hiss, 1978). Where observed in potash mines, the dikes are parallel, nearly vertical, and range from 0.39 ft to 13.8 ft wide. The dike material is very fine grained and vesicular (based on hand samples). Dikes observed in a potash mine east of the Pecos River are badly fractured and altered (Calzia and Hiss, 1978).

3.5.3.1 Goat Seep Formation

The Goat Seep Formation limestone underlies the Capitan Formation and is time equivalent with the Cherry Canyon Formation of the Delaware Mountain Group and also with the San Andres Limestone. The Goat Seep is a reef that formed during rapid subsidence of the Delaware Basin resulting in predominantly upward growth of the reef, as contrasted with the outward and upward growth of the Capitan Formation reef (Bjorklund and Motts, 1959). The stratigraphic relationships depicted in the geologic literature suggest there is no lithologic or hydrogeologic separation between the top of the Goat Seep and the base of the Capitan (Hill, 1996).

4.0 HYDROGEOLOGY

Based on the geology described in Section 3, the aquifers that could be impacted by evaporation ponds and tailings piles at the plant facilities are the discontinuous shallow alluvial aquifer, the Ogallala Aquifer, and potentially the Santa Rosa Formation. The aquifers that could be potentially impacted by pumping from the proposed Project wells are the Capitan aquifer and the alluvial aquifer that is in contact with the Capitan aquifer in the vicinity of Carlsbad, New Mexico. Those aquifers are discussed in the following sections.

4.1 Plant Facilities Aquifers

4.1.1 Alluvial Aquifers

Quaternary alluvial deposits exist throughout Eddy and Lea County, though the saturated thickness of the alluvium is sufficient only in a few places to provide a significant water source (Leedshill-Herkenhoff Inc. et al., 2000). Most of the wells accessing the alluvial aquifer in the Capitan Basin are completed near Monument Draw on the Mescalero Ridge and less are located on the Querecho Plains and the northeast San Simon Swale (Leedshill-Herkenhoff Inc. et al., 2000). The amount and characteristics of the water stored in the alluvial aquifer are difficult to determine because the aquifer is not continuous, and in most areas, the extent of saturated alluvium is quite small (Hill, 1996; Barroll et al., 2004).

4.1.2 Ogallala Aquifer

The Ogallala Formation is one of several formations that compose the High Plains aquifer. The lateral extent of the Ogallala Formation in southeastern New Mexico is approximately 10 to 15 miles east of the plant facilities (Nicholson and Clebsch, 1961). Though the Ogallala Formation is the principal source of water for much of northern and central Lea County where it underlies approximately 2,800 square miles, it provides only a limited amount of water in the area of the Project because its saturated thickness is small or it is non-existent (Leedshill-Herkenhoff et al., 2000). Water quality of the Ogallala Formation is highly variable. Near the Project area in the southern portion of the High Plains aquifer, total dissolved solids (TDS) concentrations in the Ogallala Formation range from about 500 to 2,550 milligrams per liter (mg/L) (McMahon et al., 2007).

4.1.3 Santa Rosa Aquifer

The principal aquifer of the Dockum Group is the Santa Rosa Formation. The Santa Rosa sandstones are estimated to have large amounts of stored groundwater; however, low permeability affects flow and has limited well completion (Leedshill-Herkenhoff Inc. et al., 2000; Summers, 1972). The Santa Rosa aquifer has well yields that average 25 to 30 gpm in southern Lea County (Summers, 1972). Depth to water (DTW) in the Santa Rosa aquifer ranges from 120 to 700 ft (Leedshill-Herkenhoff Inc. et al., 2000). Testing of mineral exploration borehole ICP-092 confirmed the presence of water bearing sandstone units from 458 to 699 ft bgs and estimated steady-state inflow rates ranging from 4.4 to 27 gpm (INTERA, 2013).

4.2 Pumping Well Field Aquifers

4.2.1 Alluvial Aquifer

The majority of the alluvial deposits throughout Eddy and Lea County do not have adequate saturated thicknesses to provide significant amounts of water for potable or non-potable uses (Leedshill-Herkenhoff Inc. et al., 2000). The alluvial aquifer in the vicinity of Carlsbad consists of surficial deposits associated with the Pecos River and its tributaries. In the vicinity of Carlsbad, the alluvial aquifer directly overlies the Capitan aquifer and is in hydraulic connection with the Capitan aquifer (Barroll et al., 2004). The Pecos River is generally considered the eastern limit of the Pecos Valley alluvium. Deposits of older alluvium exist to the east of the river, but they yield little or no water. The total thickness of the alluvium ranges from 100 to 300 ft, and the saturated thickness varies between 50 and 150 ft (Barroll et al., 2004).

4.2.2 Capitan Aquifer

The Capitan aquifer is a confined aquifer in the vicinity of the pumping well field where it is overlain by the Salado and Castile formations. The Salado Formation is characterized by extremely low hydraulic conductivity (Mercer, 1983). Rocks of this type are considered to be essentially impermeable (Bear, 1972), which was one of the main reasons for constructing WIPP in the Salado Formation. Other studies, based on water levels from many existing wells, revealed no hydraulic connection between rocks overlying and underlying the Salado Formation (Hunter, 1985). Thus, no vertical communication is expected between the Capitan aquifer and any overlying aquifers that may occur within the Rustler Formation, Dewey Lake Formation, and Dockum Group. Alluvial aquifers within the basin that lie above the Salado are also not in communication with the Capitan aquifer, except where the Salado has been eroded by the Pecos River in the vicinity of Carlsbad and the alluvial aquifers are in contact with the Capitan aquifer (Figure 11). As a result, groundwater flow within the Capitan aquifer over nearly its entire extent between Carlsbad and the Glass Mountains is constrained to the associated Capitan Reef Complex formations and, to a limited extent, adjacent formations such as the San Andres.

A further constraint to flow on the basin side of the Capitan aquifer is the Castile Formation, which acts as a barrier to groundwater flow. In the halite zones of the Castile, the presence of water is restricted because the halite does not maintain primary porosity, solution channels, or open fractures (Mercer, 1983 and Bachman, 1983). The Delaware Mountain Group underlies the Castile Formation. Mercer (1983) states that water movement in the sandstone of the Delaware Mountain Group is probably very slow, as it is restricted by negligible hydraulic conductivity of the intervening siltstones. With the hydraulic conductivity several orders of magnitude lower than that of the Capitan aquifer, along with very low, naturally occurring hydraulic gradients, a relatively small quantity of water would be expected to flow from the Delaware Mountain Group into the Capitan aquifer under natural-gradient conditions (Mercer, 1983). Vertical movement across the base of the Capitan aquifer is limited by the Cherry Canyon sandstone tongue (Hill, 1996). Along the back-reef side of the aquifer, the shelf carbonates and sandstones of the Artesia Group grade into evaporites farther back reef, as previously discussed by Ward et al. (1986) (Figure 7). The aquifer is largely constrained by these evaporites, although in places such as the San Simon Channel and the Sheffield Channel, the hydraulic conductivity and porosity are not known to be plugged by the evaporites, and there may be other areas where there is enhanced hydraulic connectivity such as near Kermit, Texas (Brackbill and Gaines, 1964).

4.2.2.1 Flow Parameters

The Capitan aquifer exhibits variable hydraulic conductivity. Barroll et al. (2004) used an estimated hydraulic conductivity of 750 ft/day for the Capitan Formation to the west of the Pecos River in their numeric model. Hydraulic conductivity is higher in the Guadalupe Mountains and Glass Mountains due to a higher percentage of limestone resulting in formation of extensive dissolution features (Hill, 1996; Barroll et al., 2004). Within the subterranean portions of the Capitan aquifer between the upland areas, the aquifer exhibits moderate porosity and high hydraulic conductivity. In the PDB-04 well, the upper 402 ft of the reef have 5 to 25 percent porosity (average 10 percent), and hydraulic conductivity of up to 4.86 ft/day, averaging 0.622 ft/day (Harris and Saller, 1999). In comparison, the lower Capitan Formation has porosities of less than 5 percent and hydraulic conductivities of less than 0.00243 ft/day (Harris and Saller, 1999). Ward et al. (1986) note that matrix porosities in the reef facies and the upper forereef are low on outcrop, but localized fracturing and solution hydraulic conductivity can be significant. Original porosities were reduced during deposition by marine cementation and internal sediment.

Hiss (1975) documents “breaks” encountered during drilling oil and gas wells in the northern and eastern margins of the Delaware Basin that reflect cavernous zones of high porosity and increased hydraulic conductivity resulting from dissolution of limestone and dolomite along joints and fractures. The hydraulic conductivity of the Capitan aquifer southwest of Carlsbad is extremely high due to the formation of caves and caverns resulting from groundwater dissolution of carbonate rocks (Hiss, 1975). Hydraulic conductivity measured for the Capitan aquifer ranges from 1 to 25 ft/day (Figure 19) and averages 5 ft/day (Hiss, 1975). Hydraulic conductivities of 1 to 5 ft/day are more representative for the eastern part of the Capitan aquifer (Hiss, 1975).

Transmissivity for the Capitan aquifer in the area extending east of the Pecos River at Carlsbad (around the northern and eastern margins of the Delaware Basin) to the Pecos-Brewster County boundary in Texas ranges from approximately 10,000 ft^2/day in the thicker inter-canyon sections to less than 500 ft^2/day in the vicinity of the more deeply incised submarine canyons (Hiss, 1975). According to Hiss (1975):

> The transmissivity of the Capitan aquifer in a small area near the boundary between Eddy and Lea Counties, New Mexico, in the vicinity of the deeply incised Laguna submarine canyons appears to be the lowest encountered anywhere within the project area. A representative transmissivity for this major restriction has not yet been determined. However, the general response to stresses placed on the aquifer by (1) withdrawal of water in the water fields to the east, (2) recharge by floods in the Pecos River valley, and (3) precipitation in the Guadalupe Mountains to the west, suggest that the transmissivity must be at least one and perhaps two orders of magnitude lower than the average transmissivity of the Capitan aquifer.

Relying on analysis of the response in the observation well (ICP-WS-01) during the seven-day pumping test of ICP-WS-02 (INTERA, 2012), transmissivity of the Capitan aquifer was estimated at 7,000 ft^2/day, which is comparable to the 10,000 ft^2/day of Hiss (1975) for a similar aquifer setting. The open-hole portion of well ICP-WS-01, within the aquifer, was approximately 1,000 ft, resulting in a hydraulic conductivity of 7 ft/day. The specific storage coefficient of the Capitan aquifer ranged from 4.8×10^{-8} to 1.5×10^{-7} 1/ft based on analysis of the seven-day pumping test (INTERA, 2012).

Shelf sandstones and some shelf carbonates have good porosity and moderate hydraulic conductivity adjacent to the reef, but porosity and hydraulic conductivity of those units generally decrease with distance lagoon-ward (Harris and Saller, 1999). The hydraulic conductivity of the shelf aquifers is generally one to two orders of magnitude smaller than for the Capitan aquifer (Hiss, 1975). Limited data for the San Andres at the north end of the Central Basin Platform, in the vicinity of the San Simon Channel, indicate higher hydraulic conductivity ranges than for the San Andres at other locations around the Delaware Basin and higher than the Artesia Group (Hiss, 1975). The zone of higher hydraulic conductivity for the San Andres coincides with groundwater exhibiting lower chloride-ion concentrations (Hiss, 1975). Together, these data indicate significantly higher hydraulic conductivity at the northern end of the Central Basin Platform compared to the hydraulic conductivities of either the Artesia Group or San Andres along the north end of the Delaware Basin or along the west side of the Central Basin Platform (Hiss, 1975). Furthermore, Hiss suggests that the higher hydraulic conductivities could also be expected at the southern end of the Central Basin Platform, in the vicinity of the Sheffield Channel (Figure 5).

4.2.2.2 Movement of Groundwater

Hiss (1975) delineates three different historical flow regimes in the Capitan aquifer (Figure 20). Initially, prior to the Pecos River down-cutting into the aquifer, recharge in the Guadalupe

Mountains flowed to the east and recharge from the Glass Mountains flowed north. Flow out of the Capitan aquifer and into the San Andres occurred at the San Simon channel (a.k.a. Hobbs channel) and the Sheffield channel at the northern and southern ends of the Central Basin Platform, respectively.

After the Pecos River incised into the aquifer, recharge in the Guadalupe Mountains discharged at the Pecos River, while recharge in the Glass Mountains continued to flow north. Hiss (1975) writes:

> Movement of water eastward into the Capitan aquifer from the Guadalupe Mountains toward Hobbs was decreased by the lowering of the hydraulic head along the Pecos River. At the same time, a trough in the potentiometric surface of the shelf and basin aquifers began to develop east of Carlsbad, and water began to drain into the Capitan from the surrounding sedimentary rocks.

Groundwater flowed westward to the Pecos River on the western side of the trough, and groundwater flowed eastward on the eastern side of the trough (Figure 20).

This flow regime continued until oil production began in the first half of the twentieth century. Groundwater pumping in the Capitan aquifer is conceptualized to induce flow from the adjacent back-reef aquifer (mainly the San Andres formation) and Delaware Basin to the Capitan aquifer. Pumping centers near Kermit, Texas, resulted in excess of 700 ft of drawdown in the Capitan aquifer and reversed flow in the aquifer between Kermit and the northern end of the aquifer from a northerly to a southerly direction (Figure 20c). Following peak oil production in the mid-1970s, water levels began to rebound in many of the monitoring wells established by the United States Geological Survey (USGS) (e.g., South Wilson Deep Unit 1, North Custer Mountain Unit 1, Southwest Jal Unit 1) within the Capitan aquifer along the eastern side of the basin (Figures 21 and 22) (Hiss, 1975). Water levels in two USGS wells, South Wilson Deep and North Custer Mountain, show an increase of 350 ft and 412 ft, respectively, between the peak oil-production period and measurements made in late 2011. Based on the water levels for these two wells, the hydraulic gradient is 1.8×10^{-4} in a southerly direction in 2011. This compares to a hydraulic gradient of 1.0×10^{-3} to the south in late 1975. The larger hydraulic gradient of 1975 reflects the intense oil-related pumping in Texas.

The Capitan aquifer water levels also show the separation of the flow system from east to west along the northern portion of the aquifer (Figure 21). The City of Carlsbad wells show no response to the large drawdowns in the aquifer near Kermit, Texas, in the mid-1970s. The USGS well, North Cedar Hills Unit 1, located to the west near the Pecos River, shows no discernible response to the Texas drawdown and tracks very closely to the hydrograph for City of Carlsbad well 13, which is in close proximity to the Pecos River. These results demonstrate the east-west hydraulic separation of the northern portion of the aquifer.

4.2.2.3 Groundwater Recharge and Discharge

Recharge to the Capitan aquifer includes natural recharge from precipitation, leakage from canals, surface water, and irrigation return flow. Recharge from precipitation largely occurs in the Guadalupe Mountains near Carlsbad and in the Glass Mountains in Texas. Discharge from the Capitan aquifer includes pumping for municipal, irrigation, mining (including oil and gas industry), and stock watering. Areas where the Capitan aquifer is close to the surface are also areas where recharge from precipitation occurs. Evapotranspiration has been taken into account when estimating recharge and is not considered further.

5.0 POTENTIALLY IMPACTED WATERS

5.1 Plant Facilities Shallow Aquifers

The depth to shallow groundwater in the vicinity of the plant facilities is variable in the Project area, ranging from approximately 50 to 250 ft bgs (Figure 23). In many areas the depth to shallow groundwater is 100 ft bgs or more (Figure 23). The alluvial aquifers in the Project area are discontinuous and contain a limited extent of saturated sediment, producing water in only a few places (Leedshill-Herkenhoff Inc. et al., 2000). The Santa Rosa aquifer is utilized for domestic, stock, and irrigation wells, though the low permeability of the aquifer has limited its use. The depth of the Santa Rosa aquifer in the Project area ranges from 120 to 700 ft bgs (Leedshill-Herkenhoff Inc. et al., 2000).

5.2 Pumping Well Field Aquifers

5.2.1 Shallow Capitan Aquifer near the Pecos River

Due to the confined conditions over most of the Capitan aquifer extent, the depth of the aquifer, and the high salinity associated with much of the water in the aquifer, there are few wells that produce water from the aquifer for municipal or irrigation use. The wells completed in the aquifer are primarily located where the Capitan Reef Complex is shallow, and include wells in the Carlsbad area within both the Capitan aquifer and alluvial aquifer, and in the Glass Mountains (Figure 24). Surface water that is in hydraulic connection with the Capitan aquifer includes the Pecos River in the vicinity of Carlsbad and Carlsbad Springs. Water levels for wells near Carlsbad and farther east and south along the aquifer clearly show that there is a barrier to east-west flow at the northernmost extent of the aquifer (Figure 21). This barrier effectively limits or prevents east-west flow along the aquifer such that pumping from the aquifer farther south in southeastern Eddy County and across the border in Texas has virtually no impact on water levels or groundwater flow in the vicinity of Carlsbad. However, due to the heavy reliance on the Pecos River and the underlying aquifer system near Carlsbad for municipal, irrigation, and mining needs, potential impacts to groundwater and surface water in this area will be monitored.

Potential impacts to groundwater in the vicinity of the Pecos River near Carlsbad, New Mexico, were based on reduced groundwater discharge to the Pecos River. An extensive and detailed evaluation of the groundwater flow system was conducted by the New Mexico Office of the State Engineer (Barroll et. al, 2004). As a result of that work, the numerical model of the flow system in that area, the Carlsbad Area Groundwater (CAGW) model, was developed to assess potential impacts. A superposition model of the CAGW model (CAGWsup) was further developed as a tool for evaluating impacts on river flows due to additional withdrawals from the aquifer in that area (Papadopulos, 2008). The CAGWsup model was used to evaluate impacts due to pumping of ICP wells. The impact evaluated was induced leakage from the Pecos River.

This leakage was compared to the overall groundwater discharge to the river estimated using the CAGW model, which averaged 41,580 ac-ft/yr for the period from 1965 through 2001 (Figure 25).

5.2.2 Capitan Aquifer in Texas

Most groundwater pumped from the Capitan aquifer in Texas is used for oil reservoir flooding in Winkler and Ward counties, though a small amount is used to irrigate salt-tolerant crops in Pecos County (George et al., 2011). In addition, a well in Brewster County in the vicinity of the Glass Mountains produces water with good enough quality to use for domestic purposes (Brown, 1997). However, because the well in Brewster County is in a recharge zone for the aquifer (Brown, 1997), it is expected to show little if any effect from pumping centers farther north.

In both Winkler and Ward counties, groundwater is unregulated where the rule of capture is applied to all uses and the first person to capture groundwater becomes the owner of that resource. In contrast, groundwater conservation districts in Pecos and Brewster counties do regulate groundwater production, but do not have jurisdiction to regulate withdrawals from wells outside the groundwater conservation districts in those counties. As a result of the way groundwater from the Capitan aquifer is managed in Texas, there are no potential impacts that require monitoring or mitigation.

5.2.3 Back-Reef and Basin Aquifers

As discussed above in Section 4.2.2, the back-reef and basin formations have limited porosity and hydraulic conductivity, each decreasing with distance from the Capitan aquifer (Harris and Saller, 1999). In addition, the back-reef and basin aquifers are impacted heavily by extensive oil and gas production as well as injection for oil and gas waste disposal, hydraulic fracturing, and/or pressure stabilization (Figures 26 and 27). Therefore, minimal potential impacts to the back-reef and basin aquifers have been identified and they will not be included in the monitoring of the Capitan aquifer.

6.0 GROUNDWATER MONITORING AND WELL NETWORK

The Ochoa Project Water Resources Monitoring Plan includes a baseline groundwater monitoring and characterization program, an operational groundwater monitoring program, and a closure groundwater monitoring program defined for the monitoring well network for the shallow aquifers at the plant facilities and for the water supply well target aquifer, the Capitan aquifer.

6.1 Groundwater Monitoring

The baseline groundwater monitoring program will commence prior to the operation of the plant facilities or operational pumping of the well field. Baseline groundwater monitoring data will be collected for at least one year prior to and during the construction of the facilities and prior to the operation of the pumping wells. Operational groundwater monitoring will be conducted during mining operations and while groundwater is being pumped from the Capitan aquifer. The closure groundwater monitoring will be conducted after mining operations cease and pumping from the Capitan aquifer is discontinued.

The objectives of the baseline groundwater monitoring and characterization are as follows:

- Obtain the necessary data to evaluate the quantity and quality of the groundwater that may be impacted prior to, during, and after mining activities.
- Address data gaps identified during the evaluation of the Draft Environmental Impact Statement (BLM, 2013).
- Meet the requirement regulated by the NMED Ground Water Quality Bureau (GWQB) to protect first groundwater (Appendix A).
- Meet the requirements set forth by the New Mexico Office of the State Engineer (NM OSE) (Appendix B).

6.2 Hydrologic Monitoring Network

The monitoring well networks for each of the target areas, the shallow aquifers near the plant facilities, and the Capitan aquifer targeted for water supply were selected so that the aquifers could be monitored for potential impacts to both water quality and quantity, as well as the timing of any impacts.

6.2.1 Plant Facilities Well Network

The monitoring well network at the plant facilities was identified based on known groundwater gradient (Figure 23). Six new monitoring wells are proposed for the plant facilities. The six monitoring wells will be installed so that three wells are located upgradient of the plant facilities and three wells are located downgradient of the plant facilities (Figure 28). The proposed shallow groundwater monitoring wells will be drilled so that the groundwater gradient at the plant facilities can be verified as the new monitoring wells are installed. The monitoring wells are positioned to optimize spatial analysis of the groundwater characteristics within and adjacent to the proposed plant facilities (Figure 28). The well locations may be subject to change as more information on site-specific hydrogeology is gathered during the drilling program.

6.2.2 Pumping Well Field Well Network

The monitoring well network for the Capitan aquifer will consist of six existing wells: City of Carlsbad Test Well 3, North Cedar Hills Unit 1, South Wilson Deep Unit 1, North Custer Mountain Unit 1, Federal Davison 1, and Southwest Jal Unit 1 (Figure 29). These wells, with the exception of the City of Carlsbad Test Well 3, were drilled in the 1960s as oil and gas wells. The wells were obtained by the USGS and converted to monitoring wells for the Capitan aquifer (Hiss, 1973). The wells were recently acquired by the BLM, and water levels have been collected by the BLM to record baseline groundwater levels prior to ICP pumping (Figure 21).

As discussed in Section 4.2.2 above, the shallow Capitan aquifer near Carlsbad appears to be hydraulically separated (or restricted) from the deep Capitan aquifer near the ICP supply wells (Figure 17 and 21). Due to this flow restriction, two of the monitoring wells are located west of the restriction and four of the monitoring wells are located in the Capitan aquifer to the east of the restriction (where the pumping wells are located). The four monitoring wells, located in the eastern arm of the Capitan aquifer, will monitor shorter term drawdown in the aquifer (Figure 29). Although the flow restriction should minimize impacts to the Capitan aquifer near the Pecos River, two monitoring wells are located near the river to monitor potential long-term impact to surface water, City of Carlsbad Test Well 3 and North Cedar Hills Unit 1 (Figure 29).

As discussed in Section 4.2.2, there is limited groundwater stored in the Delaware Mountain Group in the Bell Canyon Formation. The Bell Canyon Formation is also used as an injection target for salt water disposal from oil and gas production in the Delaware Basin. Along the back-reef side of the aquifer, the porosity and hydraulic conductivity of the shelf sandstones and carbonates are smaller than that of the Capitan aquifer and these values continue to decrease further back from the Capitan shelf (Harris and Saller, 1999 and Hiss, 1975). The San Simon Channel and Sheffield Channel provide two areas of greater hydraulic conductivity and likely exhibit greater hydraulic connection to the Capitan aquifer (Figure 5, Hiss, 1975). However, due to the extensive oil and gas production and injection (Figures 26 and 27) in the back-reef and basin, it would be difficult to determine the extent of impacts from ICP pumping. As a result, the groundwater levels and water quality in the basin and back-reef aquifers will not be monitored as part of this Plan.

7.0 PROPOSED NEW WELL CONSTRUCTION

7.1 Monitoring Well Design

Six new monitoring wells are proposed for installation to monitor the shallow groundwater aquifer in the plant facilities area. In addition, the water supply well field will be monitored by six existing wells within the Capitan aquifer.

7.1.1 Shallow Well Design

The shallow groundwater monitoring wells in the vicinity of the plant facilities will be installed to monitor potential impacts to shallow groundwater (Figure 28). The wells will be drilled in a sequential pattern to evaluate and characterize the site-specific hydrologic setting, depth to first groundwater, and flow direction as the drilling program is carried out. These data will be used to support the discharge permitting activities. The depth of the monitoring wells in the plant facilities area will vary based on the depth to first groundwater. Nested wells may be considered in locations were groundwater is present in the shallow alluvium as well as in greater depths.

The monitoring wells will be designed, constructed, and developed consistent with regulations from the New Mexico Administrative Code (NMAC) 19.27.4 (Appendix A) and applicable NMED regulations (Appendix B). The monitoring wells will be completed as exploratory wells to determine the depth to the first hydrostratigraphic unit. Based on the depth to groundwater in other wells in the vicinity, groundwater will be encountered at 20 to 200 ft bgs (Figure 23). Monitoring well permits will be submitted to the NM OSE prior to drilling and installation of each new monitoring well. After drilling and installation of each well, well completion report will be submitted to the NM OSE and to BLM.

Water quality samples will be collected after completion of the monitoring wells to determine initial groundwater quality concentrations. The groundwater quality results will assist in determining protectable groundwater versus non-protectable groundwater as classified by NMED 20.6.2 as having a TDS concentration of greater than 10,000 mg/L. Non-protectable groundwater, as classified by NMED, will still be monitored, though the list of required analytical parameters for laboratory analysis may change.

7.1.2 Capitan Aquifer Well Design

The monitoring wells in the Capitan aquifer are existing wells (Figure 29). The Capitan aquifer monitoring wells consist of one well that is monitored by the City of Carlsbad and the USGS (City of Carlsbad Test Well 3) and five wells that were drilled in the 1960s as exploratory oil and gas wells and are monitored by the BLM. These five wells were obtained and converted to monitoring wells by the USGS. These five converted wells are North Cedar Hills Unit 1, South Wilson Deep Unit 1, North Custer Mountain Unit 1, Federal Davison 1, and Southwest Jal Unit 1

(Hiss, 1973). The wells were recently acquired by the BLM and water levels have been collected recently (Figure 21). Table 1 presents the known construction details of the Capitan aquifer monitoring wells.

Table 1
Capitan Aquifer Monitoring Well Information (Hiss, 1973)

Well Name	County	Permit Number	Date Plugged	Depth of Well (ft bgs)	Depth to Water (ft bgs)[1] (2013)	Production Rate (gpm)	Screened Interval (ft bgs)	Screened Formation
City of Carlsbad Test Well 3 (Miller Nix Yates)	Eddy	None	NA	906	91.8	168	640 – 906	Tansill/ Capitan Limestone
North Cedar Hills Unit 1	Eddy	C-1348	1966	2,500	194.45	45	1,007 – 1,170	Capitan Limestone
South Wilson Deep Unit 1	Lea	CP-320	1966	5,390	798.3	50	4,169 – 4,187	Capitan Limestone
North Custer Mountain Unit 1	Lea	CP-385	1966	5,300	529.82	42	4,470 – 4,507	Capitan Limestone
Federal Davison 1	Lea	CP-424	1966	5,713	1,043.25	8*	4,278 – 4,285	Capitan Limestone
Southwest Jal Unit 1	Lea	CP-321	1966	5,300	396.16	28	4,199 – 4,695	Capitan

NA = Not applicable
[1]Not corrected for variable fluid densities.
*Bailer test; did not use swabbing or acid development as with the other wells.

7.2 Borehole Drilling

A geologist must be on-site to oversee drilling activities, log the borehole lithology, oversee geophysical logging, and oversee monitoring well installation and development. The boreholes for the shallow monitoring wells will be drilled using air rotary or another appropriate dry drilling method that would allow for accurate determination of groundwater. The well driller will possess a current and valid drilling license issued by the State of New Mexico. All drilling equipment will be cleaned prior to the start of drilling and between drilling activities at each borehole. Borehole diameter will be approximately 6 to 12 inches, depending on depth. The borehole will be drilled at least 20 ft past the bottom of the target aquifer in order to allow for sufficient room for the geophysical logging. The borehole will be allowed to stabilize a minimum of 12 hours before development.

7.2.1 Borehole Geophysical Logging

Geophysical logging will be utilized to verify and determine the depth of formations and well construction. The following geophysical logging suite is proposed for the new monitoring wells:

- Gamma ray
- Neutron
- Single point, shallow, deep, and micro resistivity
- Temperature

The gamma ray and neutron logs are effective in identifying formation lithology changes and will be used in conjunction with the geologic logs to identify geologic contacts and determine well construction design. The resistivity and neutron logs will help identify the saturated zones of the borehole.

7.3 Monitoring Well Installation

Once the borehole lithologic logging and geophysical logging is complete, the geologist on-site will select the casing depths. The monitoring wells will be completed using schedule 40 (or heavier) polyvinyl chloride (PVC) pipe that has a minimum 2-inch outer diameter. The casing diameter and grout thickness will be determined by the depth of the borehole and compliance with OSE regulations (Appendix B). A deeper well may require a larger diameter well to allow for the installation of pumping equipment that can lift water from greater depths. Figure 30 is a proposed schematic of the monitoring well design following the NM OSE and NMED requirements. The wells will be completed using schedule 40 PVC pipe with a 20-foot-long screened interval.

Casing sections will be welded, threaded, or have mechanically locking joints in accordance with NMED well construction requirements (Appendix A). The wells will be constructed with 20 ft of 0.010-inch slotted PVC screen and a silica sand filter pack to 2 ft above the top of the screen. The filter pack may be #10/20 silica sand and emplaced using a tremmie pipe. The filter pack will be surged or bailed to settle the sand before the bentonite seal is in place. A 3-ft-thick bentonite seal will be placed on top of the filter sand and then the remaining borehole will be filled with a cement grout or a bentonite sealing material to the surface. The cement annular seal may need to be set in lifts to prevent excessive heat against the PVC casing, depending on the depth of the well. The well will be finished with an above-ground surface completion, a cement pad, a locking protective casing, and four protective bollards. The top casing will be surveyed for location and elevation so that groundwater elevation may be calculated. Additional drilling and monitoring well completion information is provided in Appendix A and Appendix B.

7.3.1 Well Development

Well development will be accomplished after the wells have been drilled and completed; the wells must be allowed to stabilize a minimum of 12 hours after completion. The wells will be developed using standard development methods such as pumping and surging techniques until the water is free of sand or silt. Development water will be disposed of on the ground surface unless other water disposal methods are required. The well development may require up to several days.

7.3.2 Aquifer Testing

Following the installation and development of the monitoring wells, a single-well aquifer test may be conducted on the monitoring wells to determine hydraulic parameters and characteristics of the aquifer(s). The monitoring well(s) selected to perform an aquifer test and the design of the test would be selected based on the site-specific conditions and the desired information.

8.0 SAMPLING PROCEDURES

To monitor potential impacts to shallow groundwater in the vicinity of the plant facilities and to monitor the effects of pumping on the Capitan aquifer, this Water Resources Monitoring Plan establishes baseline, operational, and post-operational monitoring. The monitoring design complies with the requirements set forth by the NMED and the NM OSE.

8.1 Monitoring and Sampling Frequency

Baseline water level measurements will be collected on a quarterly basis from the shallow aquifers in the vicinity of the plant facilities and from the Capitan aquifer monitoring well network for at least one year prior to construction of the facilities or pumping of the ICP wells. Table 2 provides the water level measurement frequency for wells in each of the monitoring areas. The water level measurement from some of the Capitan aquifer monitoring wells may be collected by the USGS, this data will be shared with ICP to include in the quarterly monitoring reports described in Section 8.10 below.

Table 2
Monitoring Well Network Water Level Measurement Frequency

Monitoring Area	Pre-Operational Monitoring		Operational Monitoring		Closure Monitoring	
	Duration	Frequency	Duration	Frequency	Duration	Frequency
Plant Facilities – Shallow Aquifers	1 year	Quarterly	Construction and Mine Activity	Quarterly	As Required	Quarterly
Pumping Well Field (ICP wells)	1 year	Opportunistic	Construction and Mine Activity	Quarterly	None (Plugged)	None
Capitan Aquifer Wells (non-pumping wells)	1 year	Quarterly	Construction and Mine Activity	Quarterly	As Required	Quarterly

NMED requires quarterly groundwater quality sampling for the monitoring well network in the vicinity of the plant facilities to protect first groundwater. NM OSE requires quarterly groundwater quality sampling from the Capitan aquifer pumping well field. Sampling frequency for the Capitan aquifer monitoring wells will be developed as needed. Table 3 provides the sampling frequency for the plant facility well network, the pumping well field, and the Capitan aquifer monitoring wells. A representative from the BLM may accompany ICP or ICP's representative on selected sampling trips and may collect split groundwater quality samples as determined necessary by BLM.

Table 3
Monitoring Well Network Sampling Frequency

Monitoring Area	Pre-Operational Monitoring		Operational Monitoring		Closure Monitoring	
	Duration	Frequency	Duration	Frequency	Duration	Frequency
Plant Facilities – Shallow Aquifers	1 year	Quarterly	Construction and Mine Activity	Quarterly	As Required	Quarterly
Pumping Well Field	None	Opportunistic	Well Field Pumping	Quarterly	None (Plugged)	None
Capitan Aquifer Wells (non-pumping wells)	None	Opportunistic	Well Field Pumping	Opportunistic	None	None

8.2 Water Level Measurements

Water level measurements will be collected from all monitoring wells at the plant facilities and in the Capitan aquifer, as wells as from the ICP water supply wells. Water level measurements will be used to create pre-operational, operational, and post-operational (closure) potentiometric surfaces. The pre-operational, or baseline, potentiometric surface will form the basis for future comparisons to determine impacts from mining and pumping of the Capitan aquifer.

The water level measurements will be collected using an electronic water level meter referenced to the surveyed top of casing. At each well, multiple measurements will be collected to verify static water level. The static groundwater elevation will be calculated at each location. All of the water levels for one area, for example all of the plant facility monitoring wells, will be measured on the same day if possible. The water level meter will be decontaminated after use at each well.

Step-by-step procedures for collecting water level measurements are detailed below:

- Unlock and/or open the monitoring well.
- Check for the measuring point at the top of the well. The measuring-point location should be clearly marked on the innermost casing or identified in previous sample-collection records. If no measuring point can be determined, a measuring point should be established. Typically, the top (i.e., the highest point or the north-facing point) of the innermost well casing will be used as the measuring point. The measuring-point location should be described on the monitoring-well gauging data form and should be the same point used for all subsequent sampling efforts.
- Obtain a water level measurement by lowering the probe of the electric water level meter into the monitoring well. Take care that the probe and electric line hang freely in the monitoring well and do not adhere to the wall of the well casing. Lower the probe into the

well until the sound and light (if present) on the meter are activated. At this time, the precise measurement should be determined (to a hundredth of a foot) by repeatedly raising and lowering the tape to converge on the exact measurement. The water level measurement should be entered on an appropriate field form (i.e., monitoring-well gauging data form) (Appendix C).

- Verify that the water level measurement is indicative of a static water level. The initial water level measurement may not be indicative of static conditions if groundwater pumping recently occurred in this vicinity or if the well is screened in a confined aquifer and the well casing does not have a vent hole permitting equilibrium with the atmosphere. A second water level measurement a few minutes after the initial measurement can be used to verify static water level conditions.
- Decontaminate the electric water level meter after use. Generally only the probe and the portion of the tape that enters the well will be cleaned. Ensure that the measuring tape is not placed directly on the ground surface.

8.3 Groundwater Quality Sampling

Groundwater quality samples will be collected from the monitoring wells in the plant facilities area as well as from the Capitan aquifer monitoring wells to characterize pre-operational water quality in the aquifers. Water quality samples will continue to be collected during mining operations to ensure protection of first groundwater as required by NMAC §20.6.2.3103, regulated by NMED GWQB.

8.3.1 Groundwater Quality Parameters

Groundwater quality samples collected from the plant facilities monitoring wells will be analyzed by an accredited laboratory for all parameters in NMAC §20.6.2.3103 as well as general chemistry parameters for the first five years of operation (Table 4). After assessing the data from the first five year of operation, the list of analytes may be reduced.

Table 4
List of Analytes for Plant Facilities Monitoring Well Samples
(expanded from NMAC §20.6.2.3103)

Analytical Parameter	Analysis Method	Practical Quantitation Limit (mg/L unless noted)	Standard in NMAC §20.6.2.3103 (mg/L unless noted)	Sample Holding Times
Aluminum	EPA Method 200.7	0.02	5	6 months
Barium	EPA Method 200.7	0.002	1	6 months
Boron	EPA Method 200.7	0.04	0.75	6 months
Cadmium	EPA Method 200.7	0.002	0.01	6 months

Analytical Parameter	Analysis Method	Practical Quantitation Limit (mg/L unless noted)	Standard in NMAC §20.6.2.3103 (mg/L unless noted)	Sample Holding Times
Calcium	EPA Method 200.7	1.0	No Standard	6 months
Chromium	EPA Method 200.7	0.006	0.05	6 months
Cobalt	EPA Method 200.7	0.006	0.05	6 months
Copper	EPA Method 200.7	0.006	1	6 months
Cyanide	EPA Method 200.7	[-]	0.2	14 days
Iron	EPA Method 200.7	0.02	1	6 months
Magnesium	EPA Method 200.7	1.0	No Standard	6 months
Manganese	EPA Method 200.7	0.002	0.2	6 months
Molybdenum	EPA Method 200.7	0.008	1	6 months
Nickel	EPA Method 200.7	0.01	0.2	6 months
Potassium	EPA Method 200.7	1.0	No Standard	6 months
Silver	EPA Method 200.7	0.005	0.05	6 months
Sodium	EPA Method 200.7	1.0	No Standard	6 months
Uranium	EPA Method 200.7	0.001	0.03	6 months
Zinc	EPA Method 200.7	0.01	10	6 months
Arsenic	EPA Method 200.8	0.001	0.1	6 months
Lead	EPA Method 200.8	0.005	0.05	6 months
Selenium	EPA Method 200.8	0.001	0.05	6 months
Chloride	EPA Method 300.0	4.0	250	28 days
Bromide	EPA Method 300.0	0.1	No Standard	28 days
Fluoride	EPA Method 300.0	0.2	1.6	28 days
Nitrate + Nitrite (as N)	EPA Method 300.0	0.1	No Standard	2 days
Nitrate as N (NO_3)	EPA Method 300.0	0.1	10	2 days
Sulfate	EPA Method 300.0	10	600	28 days
Radioactivity: Combined Radium-226 & Radium-228	EPA Method 900.0	[-] pCi/L	30	6 months
Mercury	EPA Method 7470 CVAA	0.0002	0.002	28 days
Ethylene Dibromide (EDB)	EPA Method 8011/504.1	0.0001	0.0001	14 days
Diesel Range Organics (DRO)***	EPA Method 8015B	1.00	No Standard	14 days
Gasoline Range Organics (GRO)	EPA Method 8015B	1.00	No Standard	14 days
Total Xylenes	EPA Method 8021B	0.001	0.62	14 days
Polychlorinated Biphenyls (PCBs)	EPA Method 8082	0.001	0.001	14 days
1,1-dichloroethane	EPA Method 8260B	0.001	0.025	14 days
1,2-dichloroethane (EDC)	EPA Method 8260B	0.001	0.01	14 days
1,1-dichloroethylene (1,1-	EPA Method 8260B	0.001	0.005	14 days

Analytical Parameter	Analysis Method	Practical Quantitation Limit (mg/L unless noted)	Standard in NMAC §20.6.2.3103 (mg/L unless noted)	Sample Holding Times
DCE)				
1,1,2,2-tetrachloroethane	EPA Method 8260B	0.001	0.01	14 days
1,1,2,2-tetrachloroethylene (PCE)	EPA Method 8260B	0.001	0.02	14 days
1,1,1-trichloroethane	EPA Method 8260B	0.001	0.06	14 days
1,1,2-trichloroethane	EPA Method 8260B	0.001	0.01	14 days
1,1,2-trichloroethylene (TCE)	EPA Method 8260B	0.001	0.1	14 days
Benzene	EPA Method 8260B	0.001	0.01	14 days
Carbon Tetrachloride	EPA Method 8260B	0.001	0.01	14 days
Chloroform	EPA Method 8260B	0.001	0.1	14 days
Ethylbenzene	EPA Method 8260B	0.001	0.75	14 days
Methylene Chloride (dichloromethane)	EPA Method 8260B	0.003	0.1	14 days
Toluene	EPA Method 8260B	0.001	0.75	14 days
Vinyl Chloride	EPA Method 8260B	0.001	0.001	14 days
Naphthalene, total plus monomethylnaphthalenes (PAHs)	EPA Method 8310	0.002	0.03	14 days
Benzo-a-pyrene	EPA Method 8310	0.0002	0.0007	7 days
Phenols	SW-846 9067 or EPA Method 420.3	0.003	0.005	28 days
Bicarbonate (as CaCO3)	SM 2320 B	5.0	No Standard	7 days
Carbonate (as CaCO3)	SM 2320 B	2.0	No Standard	7 days
Total Dissolved Solids (TDS)	SM 2540 C	5.0	1000	7 days
Total Phosphorus (P)	SM 4500PF or EPA Method 365.1	0.01	No Standard	6 months
Conductivity	EPA Method 120.1	0.01 µmhos/cm	No Standard	28 days
pH	SM 4500 H+B	pH units	6 to 9	Upon receipt
Ion Balance	Calculation	12.45	No Standard	NA

Notes:

Practical Quantitation Limit = the minimum levels, concentrations, or quantities of a target variable (e.g., target analyte) that can be reported with a specified degree of confidence
NA = Not Applicable
SM = Standard Method
EPA = United States Environmental Protection Agency
***DRO should be left on the chromatogram long enough to detect motor-oil range organics (MRO)
[-] = Defined by sub-contracted laboratory running radiochemistry analyses

Groundwater quality samples will be collected from the ICP pumping wells in the Capitan aquifer prior to operations as well as throughout operations. Groundwater quality samples will be collected from the Capitan aquifer monitoring wells as needed. Groundwater quality samples collected from the water supply wells in the Capitan aquifer will be analyzed by an accredited laboratory for all parameters required by NM OSE (Appendix D) and as specified below in Table 5.

Table 5
List of Analytes for ICP Water Supply Well Samples

Analytical Parameter	Analysis Method	Practical Quantitation Limit (mg/L unless noted)	Sample Holding Times
Calcium (Ca)	EPA Method 200.7	1.0	6 months
Magnesium (Mg)	EPA Method 200.7	1.0	6 months
Potassium (K)	EPA Method 200.7	1.0	6 months
Sodium (Na)	EPA Method 200.7	1.0	6 months
Chloride	EPA Method 300.0	0.5	28 days
Fluoride	EPA Method 300.0	0.1	28 days
Bromide	EPA Method 300.0	0.1	28 days
Nitrogen, Nitrite (as N)	EPA Method 300.0	0.1	2 days
Nitrogen, Nitrate (as N)	EPA Method 300.0	0.1	2 days
Sulfate	EPA Method 300.0	0.5	28 days
Total Phosphorus (P)	SM 4500PF or EPA Method 365.1	0.01	6 months
Total Dissolved Solids (TDS)	SM 2540 C modified	20	7 days
Alkalinity, total (as $CaCO_3$)	SM 2320B	20	7 days
Carbonate	SM 2320B	20	7 days
Bicarbonate	SM 2320B	20	7 days
pH	SM 4500 H+B	12.45	Upon receipt
Specific Conductance	EPA Method 120.1	0.01 µmhos/cm	28 days

8.3.2 Water Quality Sampling Procedures

Prior to sample collection, purging must be performed for all groundwater monitoring wells to remove stagnant water from within the well casing and/or to ensure that a representative sample is obtained. All purged groundwater will be discharged onto the ground unless it exceeds the human health standards provided in NMED GWQB regulation NMAC §20.6.2.3103, which include TDS greater than 1,000 mg/L. If containment is required, the purge water will be pumped into a bucket, barrel, or storage tank that can be sealed and transported to an appropriate disposal facility.

8.3.2.1 Purging Techniques and Equipment

The purging technique will depend on the site-specific information. In some cases, bailing may appear to be the most convenient or practical method for well purging and sampling; however, bailing will increase suspended solids, will only withdraw water from the top of the water column, and is not appropriate for sampling volatile-sensitive water samples. A suction-lift pump can be used when the groundwater is less than 30 ft bgs; however, it is not appropriate for sampling volatile-sensitive water samples. An electric submersible pump is commonly used for purging and sampling from a variety of depths, though it may cause considerable water agitation. A positive displacement pump is also widely used for groundwater purging and sampling, and is generally considered the best type of pump to collect samples for inorganic and/or organic analyses; however, it is not ideal for sampling volatile-sensitive groundwater samples.

Once the type of pump or bailer is selected, the purge rate should be set low enough to avoid turbulent flow that causes entrainment of fines in the sand pack (over development of the well) and potentially causes stripping of volatile organic compounds. As a rule of thumb, the purge rate should not exceed the pumping rate or bailing rate used for well development. In addition, the purge rate should not exceed the recovery rate for the well. Typically, purge rates should not exceed 0.2 to 0.3 liters per minute (L/min).

For standard well purging, monitoring wells will be purged of at least three well casing volumes (moderate- to high-yield formations) or at least one well casing volume for low-yield formations. To determine the volume of water to be removed, the first step is to measure the DTW and the total depth (TD) of the well casing using the procedures described as outlined in Section 8.2. DTW measurements should be made within 48-hours of purging and sampling wells. Once these measurements have been obtained, the well casing volume is determined using the following equation:

$$V_{WC} = \frac{\pi D^2 h}{4}$$

where:	V_{WC} (ft^3)	=	well casing volume
	D (ft)	=	internal diameter of the well casing
	h (ft)	=	length of the water column in the well casing (TD-DTW)

As a conservative measure or because of project-specific requirements, total well volumes may be required for purging rather than well casing volumes. Total well volume differs from well casing volume in that it includes the volume of water in the filter pack. Total well volume is calculated using the equation:

$$\text{Total Well Volume} = VFP + VWC$$

where:	VFP	=	volume of water in the filter pack

The volume of water in the filter pack is determined by calculating the volume of the water in the borehole less the well casing volume. Compensation for the porosity of the filter pack is included in the equation, and this relationship is expressed as follows:

$$V_{FP} = \left[\frac{\pi D^2 h}{4} - V_{WC}\right](n)$$

where:	V_{FP} (ft^3)	=	filter pack volume
	D (ft)	=	diameter of the borehole
	h (ft)	=	lesser of (a) length of filter pack, or (b) length of water column in the casing
	n	=	filter pack porosity (assume 30 percent)
	V_{WC} (ft^3)	=	well casing volume

Useful conversions:

1 ft^3	=	7.48 gal
1 gal	=	0.134 ft^3

Indicator parameters (pH, temperature, and conductivity) will be monitored and recorded on field forms during purging (Appendix C). Generally, well purging will continue until the pH is within 0.2 standard units, temperature is within 1°C, and electrolytic conductivity is within 10 percent in three consecutive measurements.

Low-yield wells are considered purged after a minimum of one well volume is removed. If possible, low-yield wells should be purged at a rate slow enough so as not to purge the well dry. If a well is purged dry, the well should be sampled as soon as it has recovered enough to have sufficient water volume for the sample. The time between purging and sampling should not exceed 24 hours. For medium or high-yield wells, samples should be collected within two hours of purging if possible. Under no circumstances should there be more than 24 hours between purging and sampling.

Please note that purging and sampling of a well can be done within 12 hours of well installation (i.e., just after well development), if necessary. However, the greater the time lapse between well installation and well sampling, the more representative the sample will be of formation water. It is recommended that wells should be allowed to stand for at least12 hours or greater prior to purging and sampling.

Micropurging is an alternate method for purging wells that is distinctly different from the above-mentioned purging methodology. With micropurging, also referred to as low-flow purging, water is withdrawn directly from the screened interval at low enough pumping rates to ensure that the water sampled is formation water just recently entering the screen. As with traditional sampling, the groundwater is not sampled until the water-quality parameters (pH, temperature, and conductivity) have stabilized. Micropurging does not require a certain volume of water to be evacuated from the well. The intake point of the pump or tubing should to be close to the middle of the screen, so the monitoring-well construction details must be known. Micropurging criteria include the following:

- The intake point of the pump or tubing is in the center of the screen.
- Return water is clear and free of debris and has evacuated all major air bubbles in the tubing and flow-through cell.
- The pumping rate does not exceed 1 L/min (0.1 to 0.5 L/min is usually optimal).
- Drawdown in the well is minimized and does not exceed 10 percent of the screen length.
- Three consecutive measurements of pH, temperature, conductivity, redox potential, and dissolved oxygen have been taken and show changes in value no more than 0.1 for pH, 1°C for temperature, 3 percent for conductivity, 10 millivolts for redox potential, and 10 percent for dissolved oxygen.

8.3.2.2 Sampling Procedures

Once purging is complete, samples can be collected. If sampling using a bailer, obtain a new bailer and rope or cord made out of nylon, polypropylene, or other equivalent material. Tie a bowline knot or equivalent through the bailer loop. Test the knot for security and the bailer itself to ensure that all parts are intact before inserting the bailer into the well. Remove the protective wrapping from the bailer. Lower the bailer to the bottom of the monitoring well and cut the cord at a proper length. Bailer rope should never touch the ground surface at any time during purging and sampling.

Typically, water samples should be collected at or near the midpoint of the well screen. To collect a groundwater sample using a bailer, slowly lower the bailer into the water column, allowing the bailer to fill slowly from the bottom. Once the bailer has been lowered to approximately the mid-point of the screen, slowly raise the bailer to minimize both creating turbulence in the well and drawing fine-grained sediment into the well. Gently empty the water directly from the full bailer into sample containers taking care not to allow contact between the bailer and the sample container.

If purging and sampling from a pump, consider two main criteria for pump selection. First, the construction material of the pump and tubing should not contain materials that interact with the constituents of interest and/or contain constituents that may cause the sample to have a false positive analysis. Second, if the sample is to be analyzed for volatile organic compounds, a pump that minimizes sample agitation and subsequent volatilization should be used. The most appropriate pumps under these conditions are the gear pump or the bladder pump.

Prior to inserting a pump into a monitoring well, it should be thoroughly decontaminated by pumping a Liquinox™ or equivalent decontamination mixture through the pump followed by pumping a distilled or deionized water rinse. Tubing should be dedicated to a single well and should not be re-used. During the collection of samples, the pumping rate should be approximately 0.1 L/min. If a greater pumping rate is used for purging, the pumping rate should be reduced during sampling. Groundwater should be pumped directly into the sample containers.

8.3.2.3 Sampling Equipment

The following list identifies the types of equipment that may be used for a range of groundwater sampling applications. A project-specific equipment list will be selected from this list based on project objectives and well conditions.

- Bailer with rope or string
- Pump with tubing and power source
- pH meter
- Specific conductance meter
- Temperature meter
- Dissolved oxygen meter
- Oxygen reduction potential (ORP) meter
- Turbidity meter
- Flow-through cell
- Water level measurement equipment
- Water sampling data form
- Filtration apparatus (project-dependent)
- Personal protective equipment
- Decontamination equipment
- Permanent pens
- Field logbook

- Sample coolers
- Sample containers and laboratory-supplied preservatives (if any)
- Sample labels
- Custody seals (if required by Sampling & Analysis Plan/Work Plan)
- Chain of custody (COC) forms
- Sample control logs

8.4 General Groundwater Sample Collection Protocols

The following are method-independent sample collection procedures:

- Collect samples intended for volatile organic analysis (VOA) first.
- Fill sample containers quickly and smoothly to avoid agitation, aeration, and loss of volatile components.
- To further avoid loss of volatile components, completely fill samples so that no headspace is present and cap securely with a Teflon®-lined lid.
- Collect samples for semi-volatile, metal, or other analyses in the proper sample containers.
- Label all sample containers with the following information:
    - Project name and/or number
    - Field sample number
    - Depth interval (if applicable)
    - Initials of collector
    - Date and time of collection
    - Sample type and preservative (if any)
- Place samples in coolers as soon as possible and, if required, chill them to <4°C (39°F), using frozen ice packs or double-bagged ice.
- Use protective packaging as dictated by the mode of transport (Section 8.6.2).
- Record sample information in the field logbook and on the sample control log as soon as possible after sample collection, in accordance with the procedures set forth in the Quality Assurance Project Plan.
- Complete COC forms and placed them in the cooler for shipment to the laboratory.
- Ship samples to the laboratory for analysis, carefully observing all minimum holding-time requirements for degradable constituents.

- Set up a decontamination station near the sampling location to decontaminate equipment that will be reused at the next sampling location.

8.5 Quality Control Samples

8.5.1 Equipment Blanks

Equipment blank samples are collected at the end of each sampling event to assess the effectiveness of decontamination procedures and ensure that the sampling equipment did not introduce any contaminants to the samples. Generally, equipment blanks are collected by allowing deionized water to run through or over the sampling equipment and into the sample container. The method for running water over the equipment will vary depending upon the type of equipment being used for each sample, but will generally attempt to emulate the sampling procedures used on the normal samples as closely as possible. One equipment blank will be collected per sampling round and analyzed for the same list of parameters as the other samples collected.

8.5.2 Duplicate Samples

Field duplicate samples will be collected to independently check the laboratory analytical precision and sample matrix variability. The procedures for collecting field duplicates are as follows:

- VOA samples typically consist of two sample vials, referred to as the sample set. Alternating between the primary sample set and the replicate sample set, completely fill each vial and cap immediately in the order shown below:
  - Fill vial #1 - primary sample set
  - Fill vial #1 - replicate sample set
  - Fill vial #2 - primary sample set
  - Fill vial #2 - replicate sample set
- Sample analyses other than VOA will be collected by alternately filling the sample containers as in the VOA procedure, but containers are to be filled incrementally instead of completely, continuing the filling procedure until the sample containers are full.

8.6 Custody Procedures

A project representative will be responsible for custody of the samples until they are transferred to another representative or the analytical laboratory. A sample will be considered under the representative's custody if:

- The sample is in possession or plain view of the project representative.

- The sample is inside a locked space (e.g., a field vehicle) to which no other party has immediate access.

The samples will be accompanied at all times by a properly completed COC form. Any transfers of the samples from one project representative to another prior to final delivery of the samples to the analytical laboratory will be accompanied by the COC form, which will be signed and dated by the receiving project representative. The sampler will retain a copy of the COC form, which will be kept with other project documentation. The original copy of the COC form will remain with the samples.

The COC form will contain the following information:

- Contact information for sampler/project representatives
- Time/date of sample collection
- Signature and initials of sampler and/or sample handlers
- Sample ID number
- Sample matrix
- Sample preservative information
- Analyses to be performed (may be included on a separate form or refer to quote)
- Time/date of sample transfer

Upon receiving samples, the laboratory can use the above information to determine if all samples have arrived as expected and in proper condition.

8.6.1 Field COC Procedures

COC procedures in a sampling program ensure the ability to support data and conclusions in a legal or regulatory environment. The main documents to be used in the COC process will be:

- Sample labels
- Sample custody seals
- Field notebook
- COC forms (provided by laboratory)

8.6.2 Shipping

After collection and labeling and prior to shipping, samples will be placed into coolers and chilled to <4°C (39°F) using frozen ice packs or ice if necessary. The requirements for shipping samples depend on whether the samples will be shipped by a courier (e.g., FedEx) or delivered by the sampler or project representative directly to the analytical laboratory. If the samples will be delivered directly to the laboratory by a project representative, the following procedures apply:

- Samples will be arranged in the coolers such that the bottles remain upright and undamaged until delivery to the analytical laboratory.
- If necessary, samples will be kept <4°C (39°F) until the time of delivery, following the COC procedures as described in this section.

If the samples will be shipped by a courier, the following additional steps will be taken:

- The sample cooler will be lined with a large garbage bag.
- Samples and fresh ice packs or double-bagged ice will be placed inside the lined cooler.
- The garbage bag will be tied using a knot or zip tie such that water cannot escape.
- The COC will be placed in a Ziploc bag and taped to the inside of the cooler lid.
- The exterior of the cooler will be taped such that the cooler cannot open during transit and in a manner that minimizes the possibility of water escaping primary containment in the cooler and leaking out of the cooler.
- If required, a custody seal will be signed and placed across the cooler lid such that opening the cooler would break the custody seal.

A project representative will inform the analytical laboratory that the samples have been shipped to the laboratory. After the laboratory receives the samples, they will inform the project representative that they have received the samples, noting any issues. The laboratory will sign and date the COC upon receiving the samples.

8.7 Calibration Procedures and Frequency

Field Equipment to be used for groundwater monitoring and sampling may include, but is not limited to:

- Multiparameter profiler
- Electric water level meter
- Peristaltic pump
- YSI-556 with multiparameter sonde and flow-through cell

Multiparameter meters will be calibrated at the beginning of each day according to the manufacturer's procedures. If results from the field equipment indicate inaccurate data, equipment will be re-calibrated at that time.

8.8 Field Analytical Procedures

Measurements of field parameters will be collected from the monitoring well network during sampling, or at specified intervals for wells that may not be sampled. Measurement methods will be consistent with the equipment manufacturer's guidance and will be conducted using a downhole multiparameter sonde or a flowthrough cell and multiparameter sonde at ground surface that is connected to the discharge line of a downhole pump. Field parameters to be measured in the monitoring well network include pH, water temperature, dissolved oxygen, ORP, specific conductivity, and DTW.

8.9 Field Data Reporting

Field events and measurements will be recorded by the field staff in a field notebook. The field notes will be written in indelible ink. Corrections or mistakes will be noted by drawing a single line though the incorrect information and initialing near the line.

8.10 Reporting Requirements

Quarterly monitoring reports will be prepared for submittal to the BLM, NMED, and NM OSE. The reports will include field and laboratory data. Quarterly sampling data will be tabulated in a database so that results can be compared over time. One annual report, summarizing the quarterly monitoring reports will be prepared for submittal to the BLM at the end of each monitoring year.

Data interpretation may include construction of potentiometric surfaces, iso-concentration contours for key constituents, water level times series plots, concentration time series plots, statistical analyses, and/or tables summarizing quarterly analytical results. Analytical results will be compared to the appropriate regulatory standards.

9.0 LABORATORY QUALITY ASSURANCE PLANS

To ensure quality of laboratory analysis, the analytical laboratory will be required to analyze QA/QC samples as specified by the analytical methods. The laboratory will analyze method blanks, matrix spikes (MSs), and laboratory control samples (LCSs). Method blanks will be prepared at the frequency prescribed in the individual analytical method or at a rate of 5 percent of the total samples if a frequency is not prescribed in the method. MSs will be analyzed at a frequency of 5 percent for soil and aqueous samples. The percent recoveries will be calculated for each of the spiked analytes and used to evaluate analytical accuracy. The RPD between spiked samples will be calculated to evaluate precision. LCSs, or blank spikes, will be analyzed at the frequency prescribed in the analytical method or at a rate of 5 percent of the total samples if a frequency is not prescribed in the method. If percent recovery results for the LCS or blank spike are outside of the established goals, laboratory-specific protocols will be followed to gauge the usability of the data.

Practical quantitation limits (PQLs) are project-required reporting limits (PRRLs) adjusted for the characteristics of individual samples. The PRRLs are chemical-specific levels that a laboratory should be able to routinely detect and quantitate in a given sample matrix. The PRRL is defined in the analytical method or in laboratory method documentation, and incorporates precision (reproducibility) assumptions for the analysis. The PQL takes into account changes in the preparation and analytical methodology that may alter the ability to detect an analyte, including changes such as use of a smaller sample aliquot or dilution of the sample extract. Physical characteristics such as sample matrix and percent moisture that may alter the ability to detect the analyte are also considered. The laboratory will calculate and report PQLs for all environmental samples.

The laboratory activities are overseen by a comprehensive quality assurance program to ensure that laboratory practices and results adhere to laboratory policies. The laboratory will provide a standard QA/QC report with all reports that includes information regarding surrogate recoveries, spike recoveries, and method blanks.

Laboratory personnel will verify analytical data at the time of analysis and reporting and through subsequent reviews of the raw data for any nonconformances to the requirements of the analytical method. Laboratory personnel will make a systematic effort to identify any outliers or errors before they report the data. Outliers that result from errors found during data verification will be identified and corrected; outliers that cannot be attributed to errors in analysis, transcription, or calculation will be clearly identified in the case narrative section of the analytical data package.

All laboratory data will be evaluated. The data evaluation strategy will not be a full data validation process, but will determine if the analytical results are within the QC limits set for the project. The data usability will be assessed as part of this evaluation.

10.0 SUMMARY

The main objective of this Water Resources Monitoring Plan is to obtain the necessary data to establish the pre-operational groundwater characteristics and to determine potential impacts of mining activities, including water supply pumping from the Capitan aquifer well field. The Plan includes proposed monitoring wells for the Ochoa plant facilities and proposed and existing wells completed in the Capitan Aquifer for the pumping well field (Table 6). The potential impacts of mining activities at the plant facilities include water level declines as a result of dewatering and water quality changes from possible surface contamination sources. The potential impacts of water supply pumping from the Capitan aquifer include groundwater level declines in the Capitan aquifer and water quality changes over time.

Table 6
Ochoa Project Proposed and Existing Groundwater Monitoring Wells

Well Designation	Well Type	Description	Formation/Unit Monitored	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Surface Elevation (Feet AMSL)	Total Depth (Feet)	Depth to Formation (Feet)	Water Level Measurement Frequency	Sampling Frequency	Rationale
Ochoa Plant Facilities Wells											
ICP-MW-01	Monitoring	Proposed Installation	TBD	TBD	TBD	TBD	TBD	TBD	Quarterly	Quarterly	Monitor potential impacts from ponds and facilities.
ICP-MW-02	Monitoring	Proposed Installation	TBD	TBD	TBD	TBD	TBD	TBD	Quarterly	Quarterly	Monitor potential impacts from ponds and facilities.
ICP-MW-03	Monitoring	Proposed Installation	TBD	TBD	TBD	TBD	TBD	TBD	Quarterly	Quarterly	Monitor potential impacts from ponds and facilities.
ICP-MW-04	Monitoring	Proposed Installation	TBD	TBD	TBD	TBD	TBD	TBD	Quarterly	Quarterly	Monitor potential impacts from ponds and facilities.
ICP-MW-05	Monitoring	Proposed Installation	TBD	TBD	TBD	TBD	TBD	TBD	Quarterly	Quarterly	Monitor potential impacts from ponds and facilities.
ICP-MW-06	Monitoring	Proposed Installation	TBD	TBD	TBD	TBD	TBD	TBD	Quarterly	Quarterly	Monitor potential impacts from ponds and facilities.
Capitan Aquifer Wells											
ICP-WS-01	Supply	Installed 2012.	Capitan	32.240507	-103.339255	3,489	4,558	4,351	Quarterly	Quarterly	Monitor potential impacts from the pumping well field.
ICP-WS-02	Supply	Installed 2012.	Capitan	32.245736	-103.33673	3,478	4,574	4,341	Quarterly	Quarterly	Monitor potential impacts from the pumping well field.
ICP-WS-03	Supply	Proposed Installation	Capitan	TBD	TBD	TBD	TBD	TBD	Quarterly	Quarterly	Monitor potential impacts from the pumping well field.
ICP-WS-04	Supply	Proposed Installation	Capitan	TBD	TBD	TBD	TBD	TBD	Quarterly	Quarterly	Monitor potential impacts from the pumping well field.
ICP-WS-05	Supply	Proposed Installation	Capitan	TBD	TBD	TBD	TBD	TBD	Quarterly	Quarterly	Monitor potential impacts from the pumping well field.
ICP-WS-06	Supply	Proposed Installation	Capitan	TBD	TBD	TBD	TBD	TBD	Quarterly	Quarterly	Monitor potential impacts from the pumping well field.
ICP-WS-07	Supply	Proposed Installation	Capitan	TBD	TBD	TBD	TBD	TBD	Quarterly	Quarterly	Monitor potential impacts from the pumping well field.
ICP-WS-08	Supply	Proposed Installation	Capitan	TBD	TBD	TBD	TBD	TBD	Quarterly	Quarterly	Monitor potential impacts from the pumping well field.
Southwest Jal Unit 1	Monitoring	Converted to monitoring well by USGS 1966.	Capitan	32.074123	-103.26800	2,985	5,300	3,908	Quarterly	Opportunistic	Monitor potential impacts from the pumping well field.
Federal Davison 1	Monitoring	Converted to monitoring well by USGS 1967.	Capitan	32.207327	-103.285365	3,355	5,713	3,945	Quarterly	Opportunistic	Monitor potential impacts from the pumping well field.
North Custer Mountain Unit 1	Monitoring	Converted to monitoring well by USGS 1966.	Capitan	32.281027	-103.374611	3,387	5,300	4,397	Quarterly	Opportunistic	Monitor potential impacts from the pumping well field.
South Wilson Deep Unit 1	Monitoring	Converted to monitoring well by USGS 1967.	Capitan	32.461224	-103.447482	3,717	5,390	4,072	Quarterly	Opportunistic	Monitor potential impacts from the pumping well field.
North Cedar Hills Unit 1	Monitoring	Installed 1966.	Capitan	32.509838	-104.127972	3,301	2,500	748	Quarterly	Opportunistic	Monitor potential impacts from the pumping well field.
City of Carlsbad Test Well 3	Monitoring	Installed 1963.	Capitan	32.452839	-104.127972	3,182	906	775	Quarterly	Opportunistic	Monitor potential impacts from the pumping well field.

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FIGURES

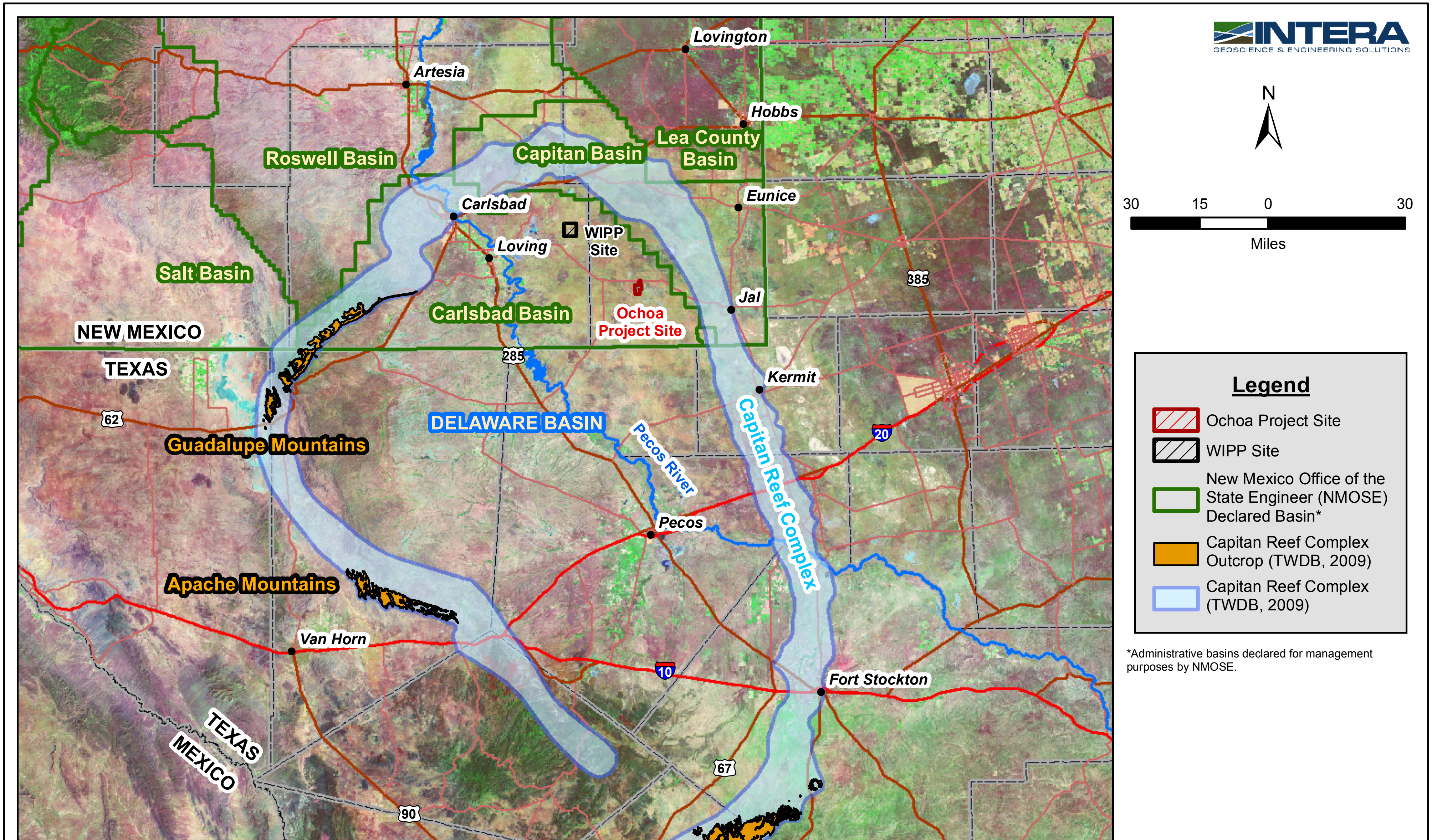
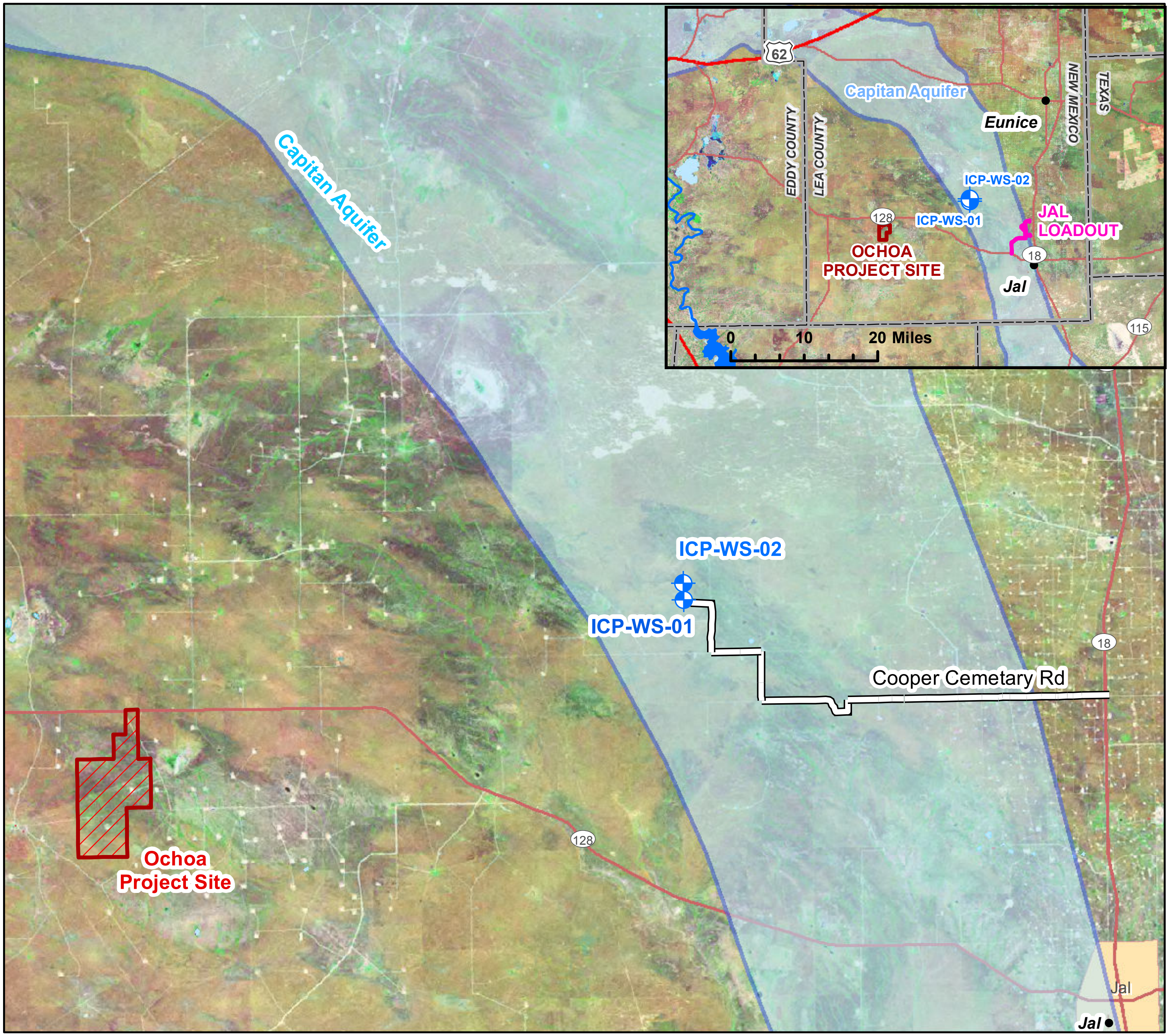


Figure 1
Site Location Overview
Ochoa Mine
Water Resources Monitoring Plan



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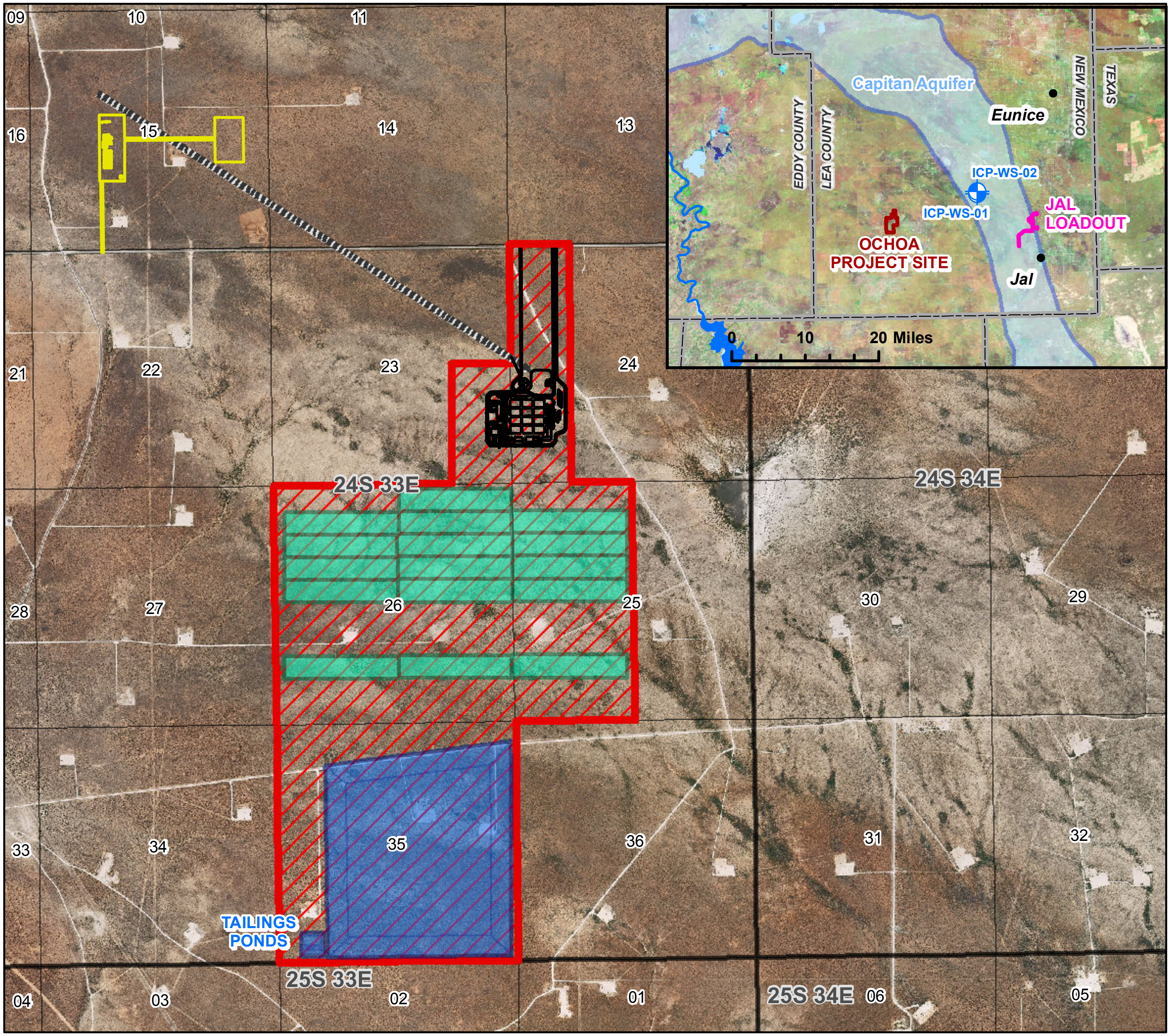
Legend

- Existing ICP Wells
- Access Road
- Ochoa Project Site
- Capitan Reef Complex (TWDB, 2009)

Figure 2
Location of Ochoa Project and Existing Pumping Wells
Ochoa Mine
Water Resources Monitoring Plan



N

0 1,500 3,000 6,000
Feet

Legend

- Existing ICP Wells
- Processing Plant
- Shaft Site
- Decline
- Tailings Pile
- Evaporation Ponds
- Ochoa Project Site
- Jal Loadout
- Township Division
- Section Division

Figure 3
Ochoa Project Plant Facilities
Ochoa Mine Water Resources Monitoring Plan

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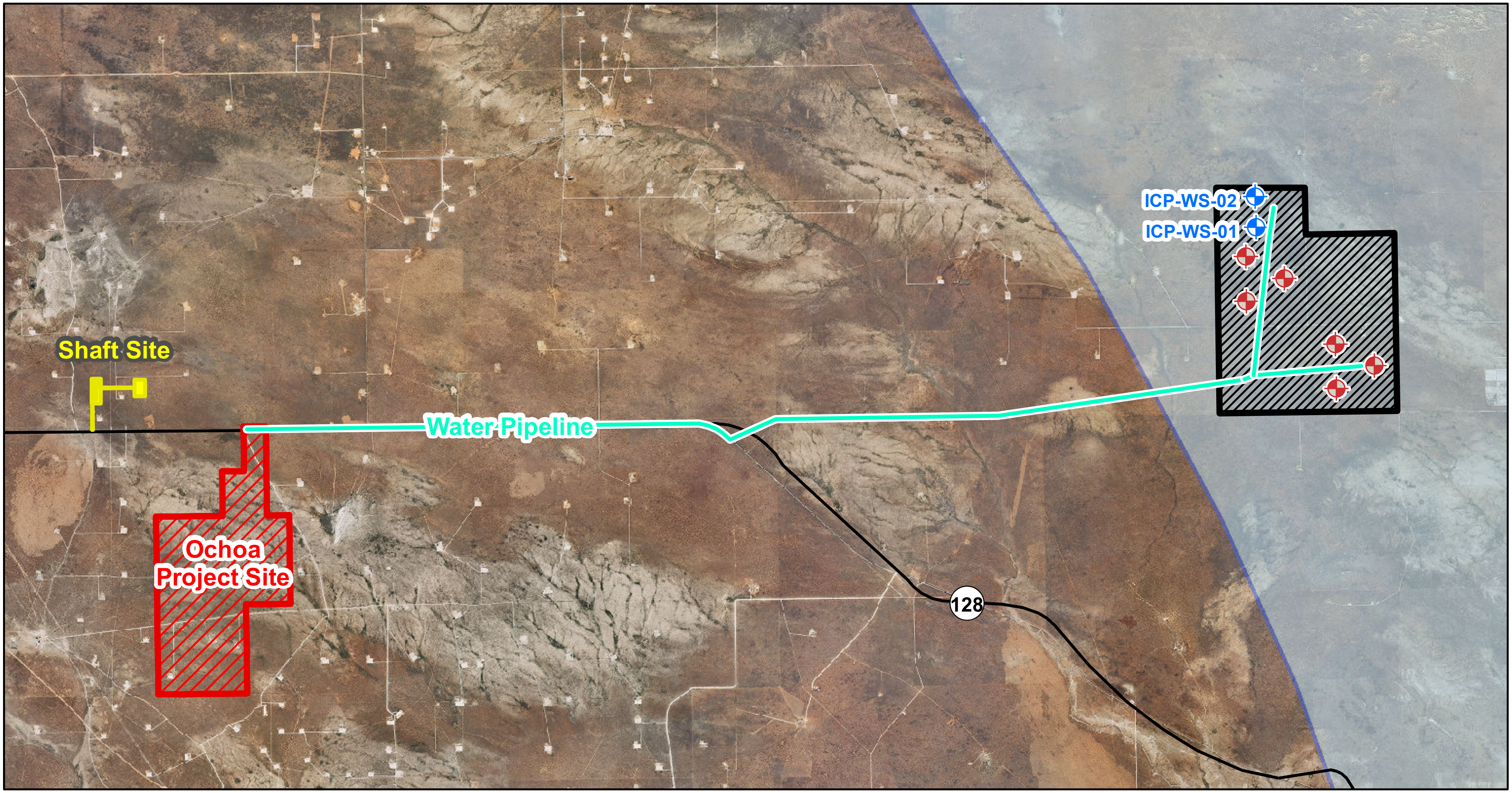

N

2 1 0 2

Miles

Legend

- Existing ICP Wells
- Proposed ICP Wells
- Proposed Water Supply Line
- Shaft Site
- Ochoa Project Site
- Well Field
- Capitan Aquifer Boundary

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Figure 4
Location of the Water Supply Well Field
Ochoa Mine
Water Resources Monitoring Plan

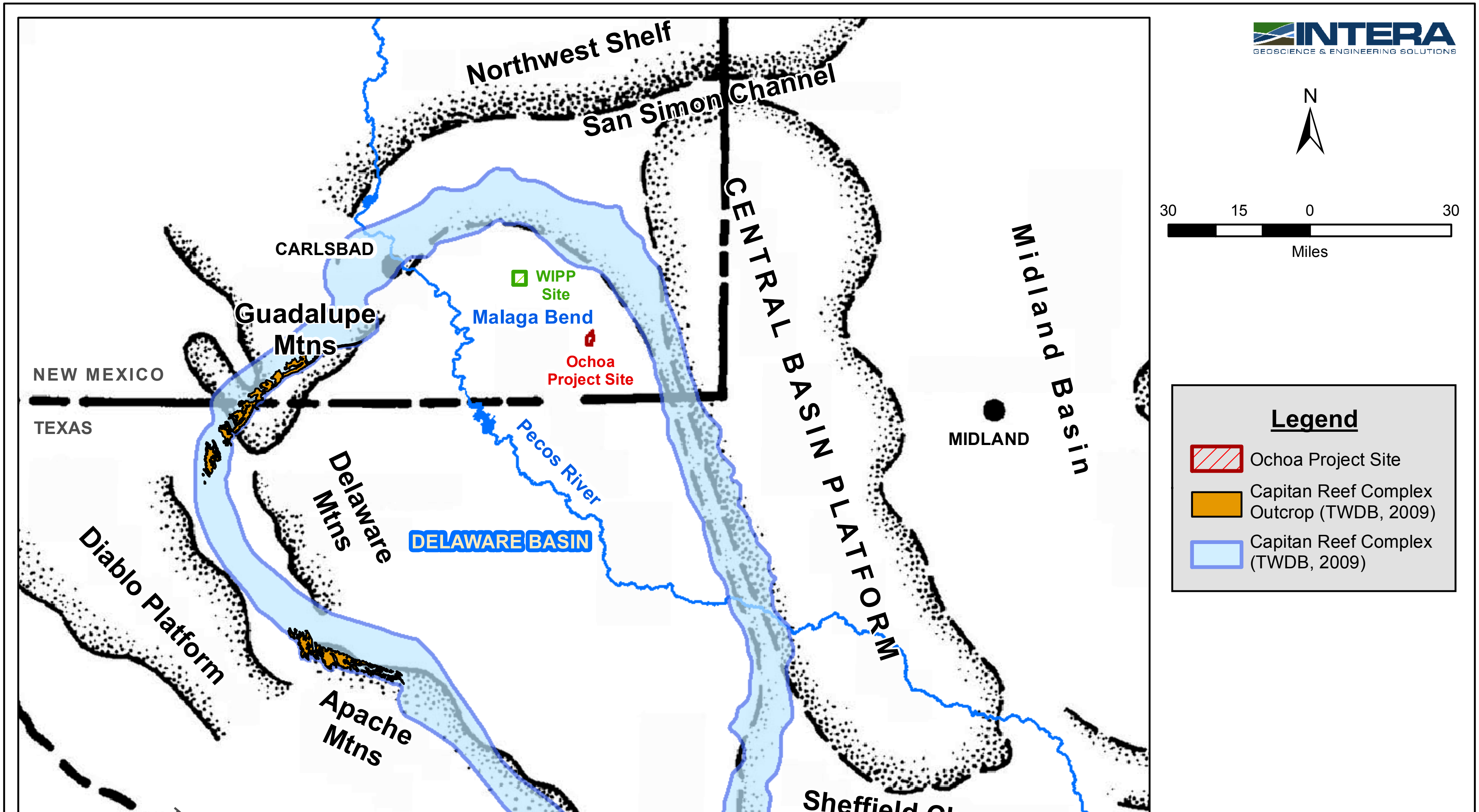

Figure 5
The Delaware Basin and Associated Regional Structural Features
Ochoa Mine Water Resources Monitoring Plan

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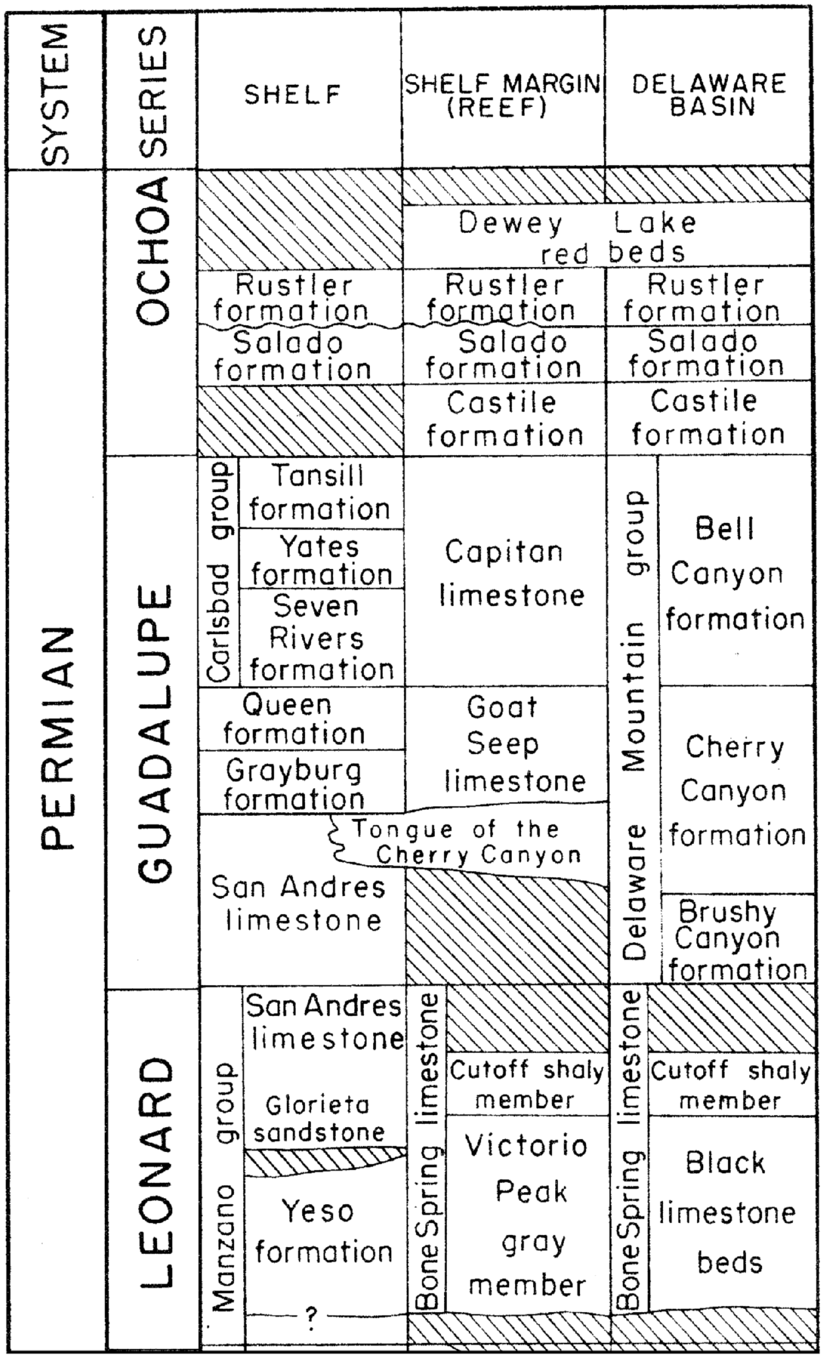

Note: Not to scale.

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Source: Bjorklund and Motts, 1959, Figure 9

Figure 6
Diagram Showing Correlations of Formations of Permian Age in Southeastern New Mexico
Ochoa Mine
Water Resources Monitoring Plan

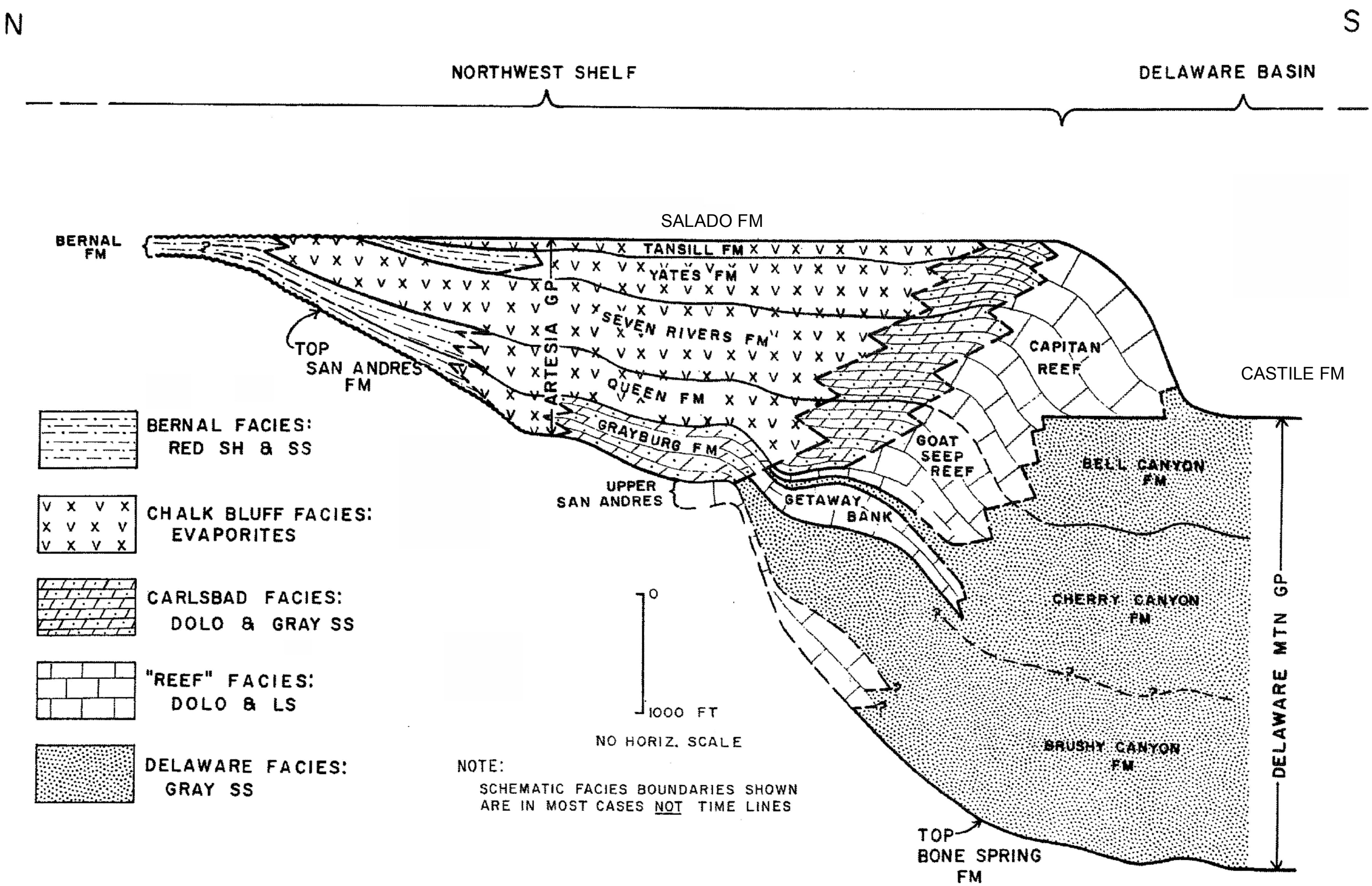

Figure 7
Schematic N-S Cross Section Showing Dominant Aspect of Major Lithofacies and Formational Unit in the Artesia and Delaware Mountain Groups and their Equivalents
Ochoa Mine
Water Resources Monitoring Plan

Source: Meissner, 1972, Figure 2

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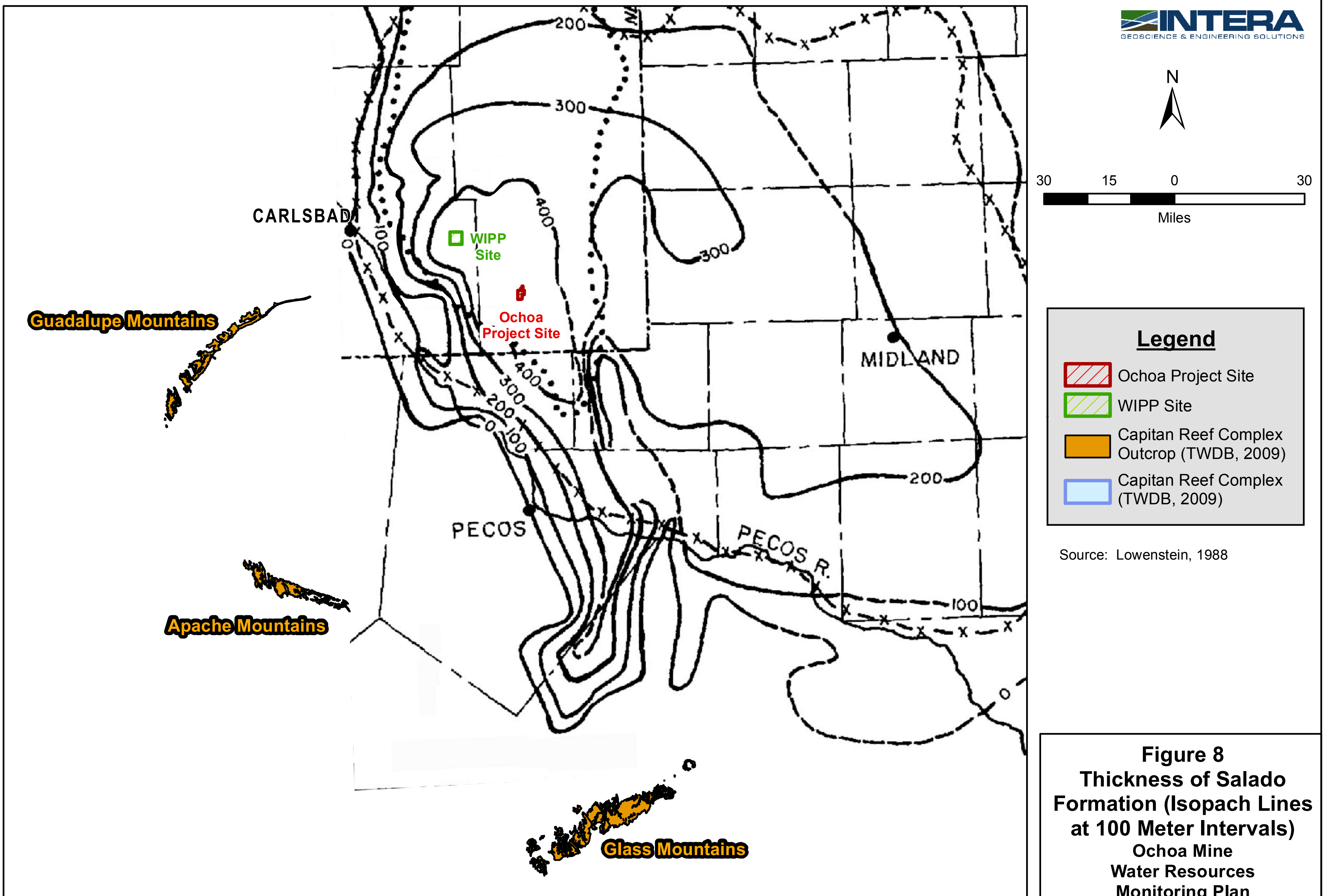

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Figure 8
Thickness of Salado Formation (Isopach Lines at 100 Meter Intervals)
Ochoa Mine
Water Resources Monitoring Plan

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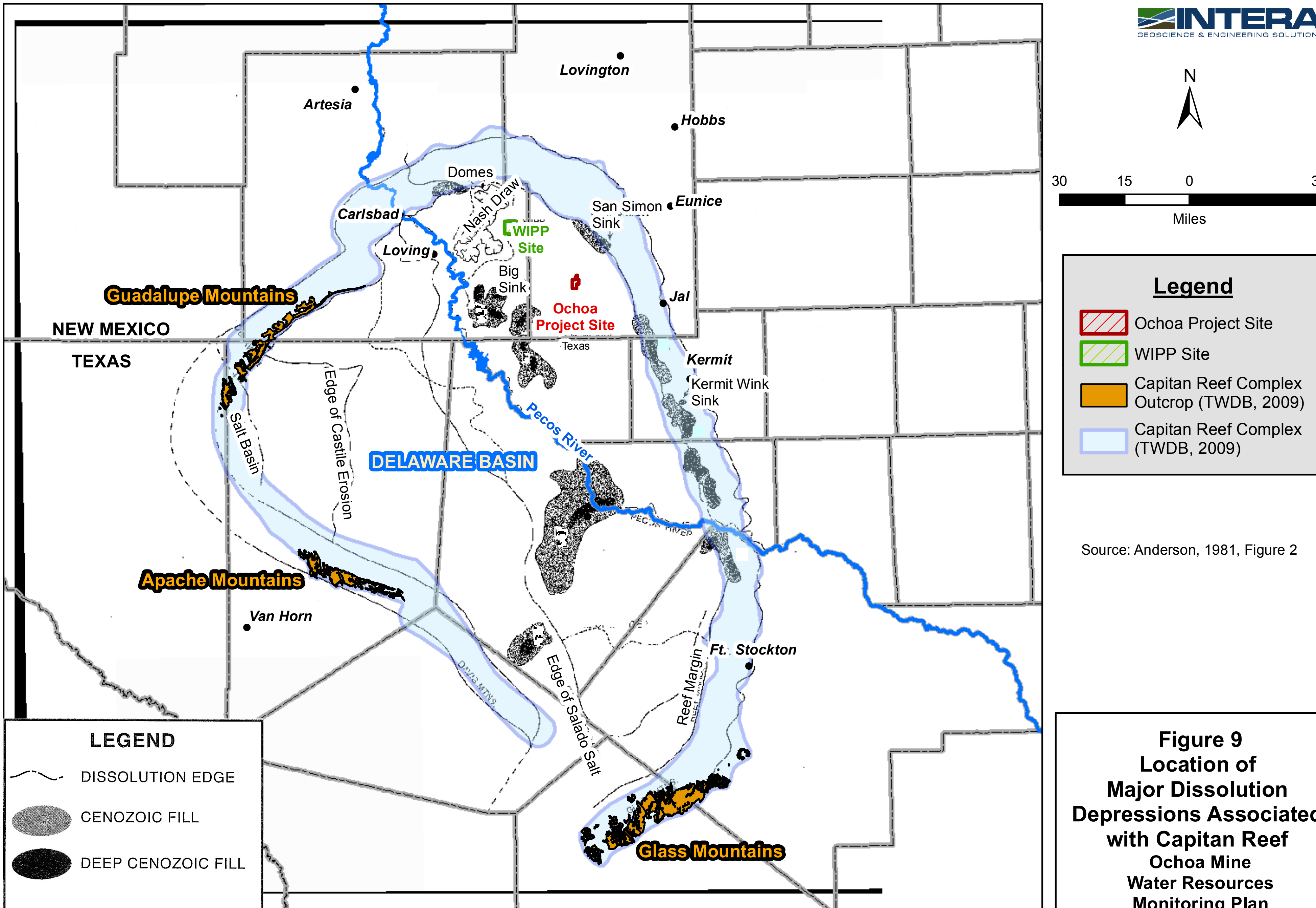

Figure 9
Location of Major Dissolution Depressions Associated with Capitan Reef
Ochoa Mine Water Resources Monitoring Plan

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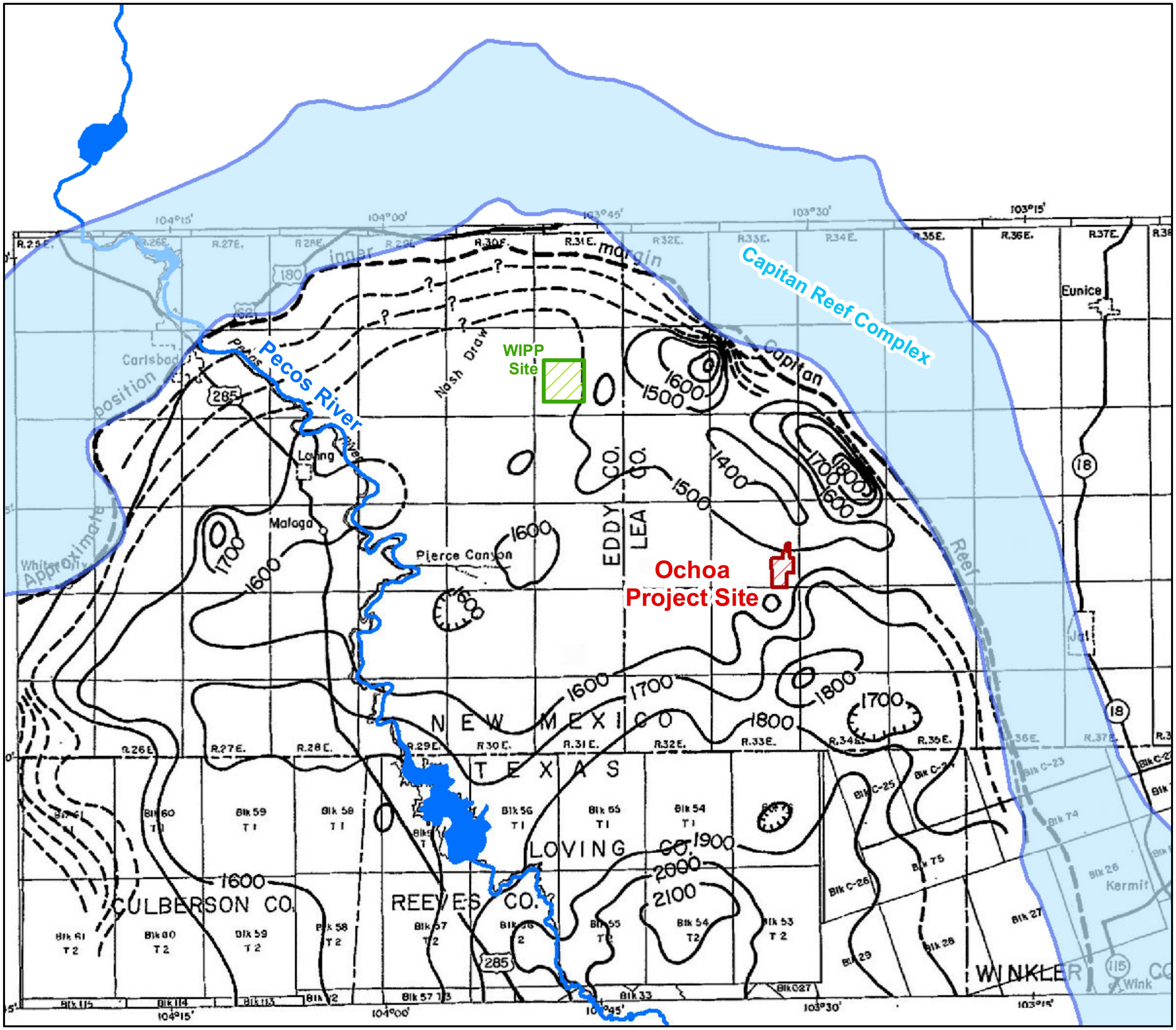

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Legend

- Ochoa Project Site
- WIPP Site
- Capitan Reef Complex (TWDB, 2009)

Source: Bachman, 1983
Contour lines - feet

Figure 10
Isopach Map of Castile Formation
Ochoa Mine Water Resources Monitoring Plan

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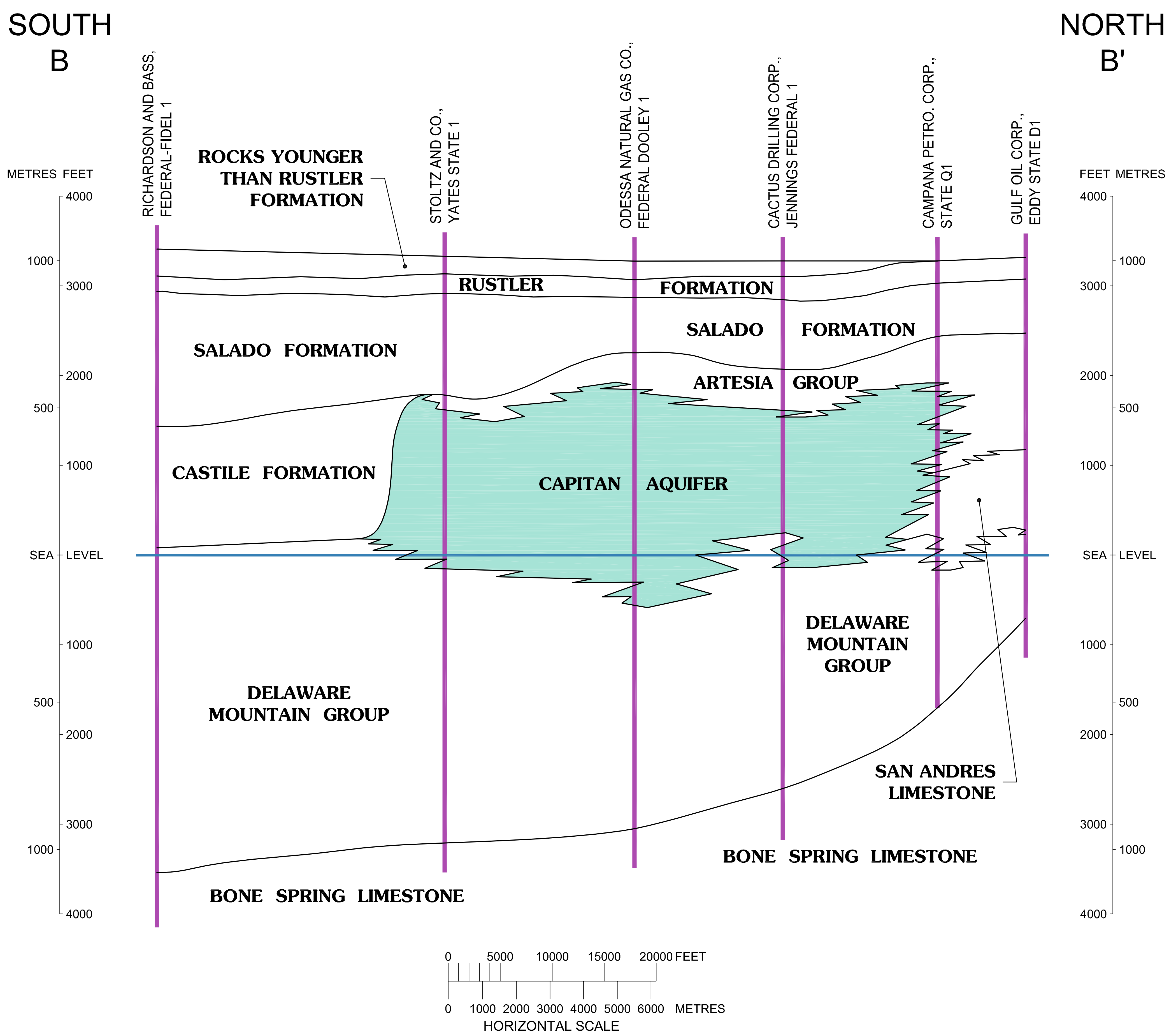
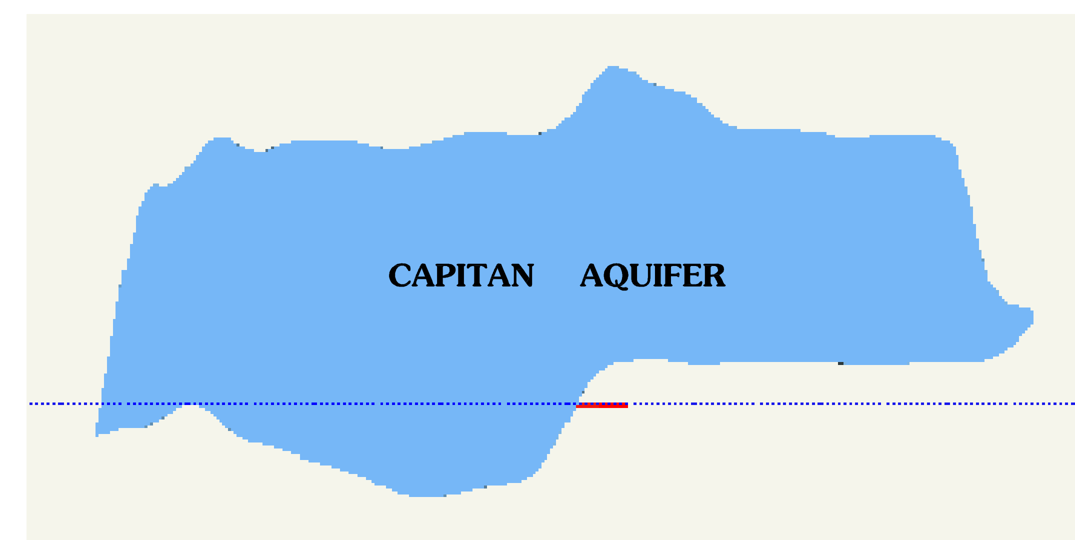
Figure 11
Stratigraphic Section A-A'
Longitudinally Along the Capitan Reef Complex and Aquifer
Ochoa Mine Water Resources Monitoring Plan

INTERA

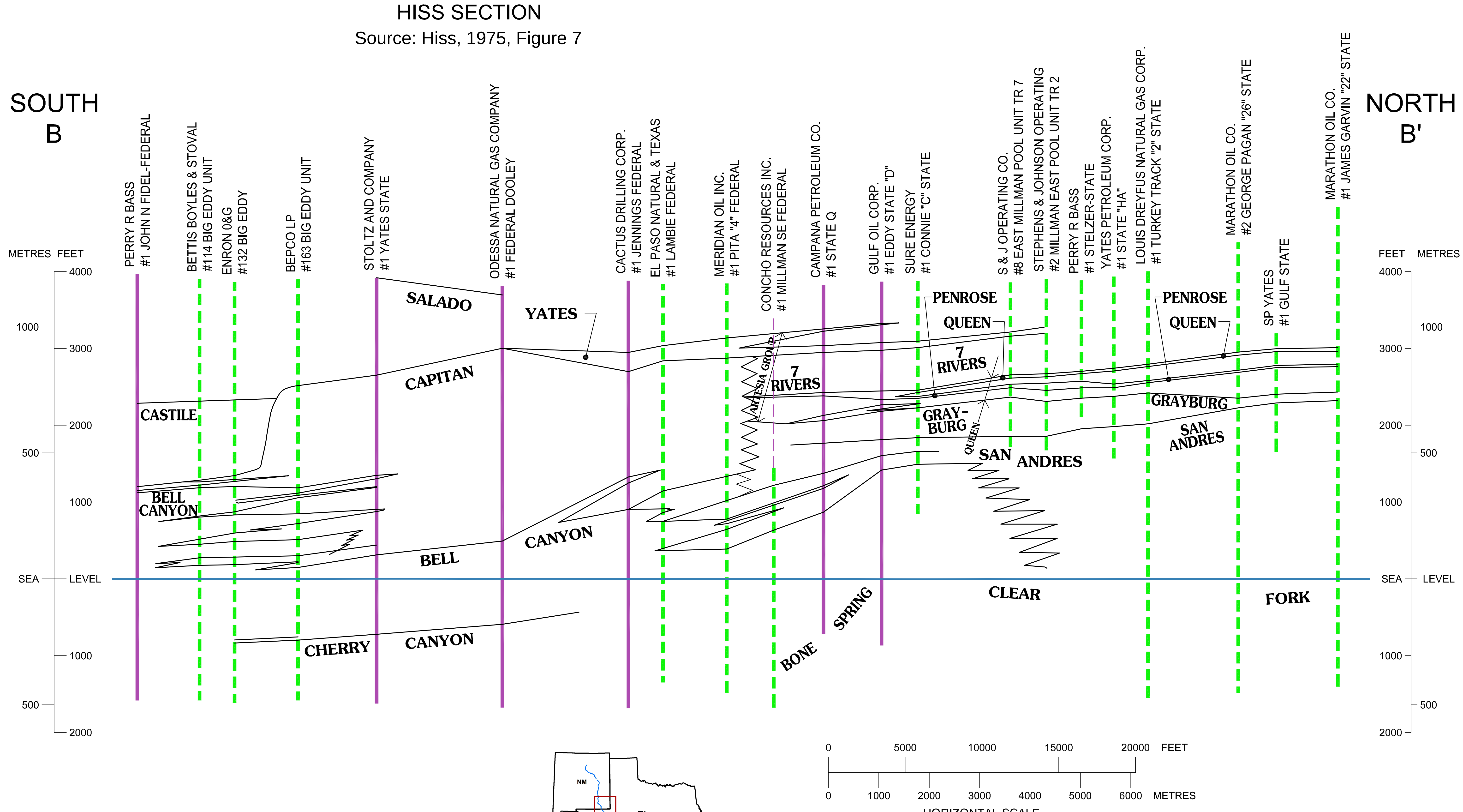
Source: Hiss, 1975, Figure 6



HISS SECTION
Source: Hiss, 1975, Figure 7



INTERA Model
NOT TO SCALE
(1H : 10V)



LAMB SECTION

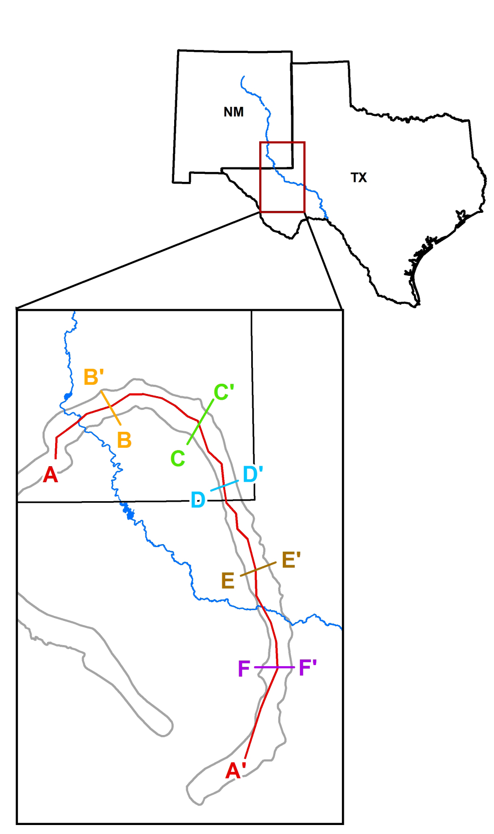


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Figure 12
Stratigraphic Section B-B'
Across the Capitan Reef Complex and Aquifer
Ochoa Mine Water Resources Monitoring Plan

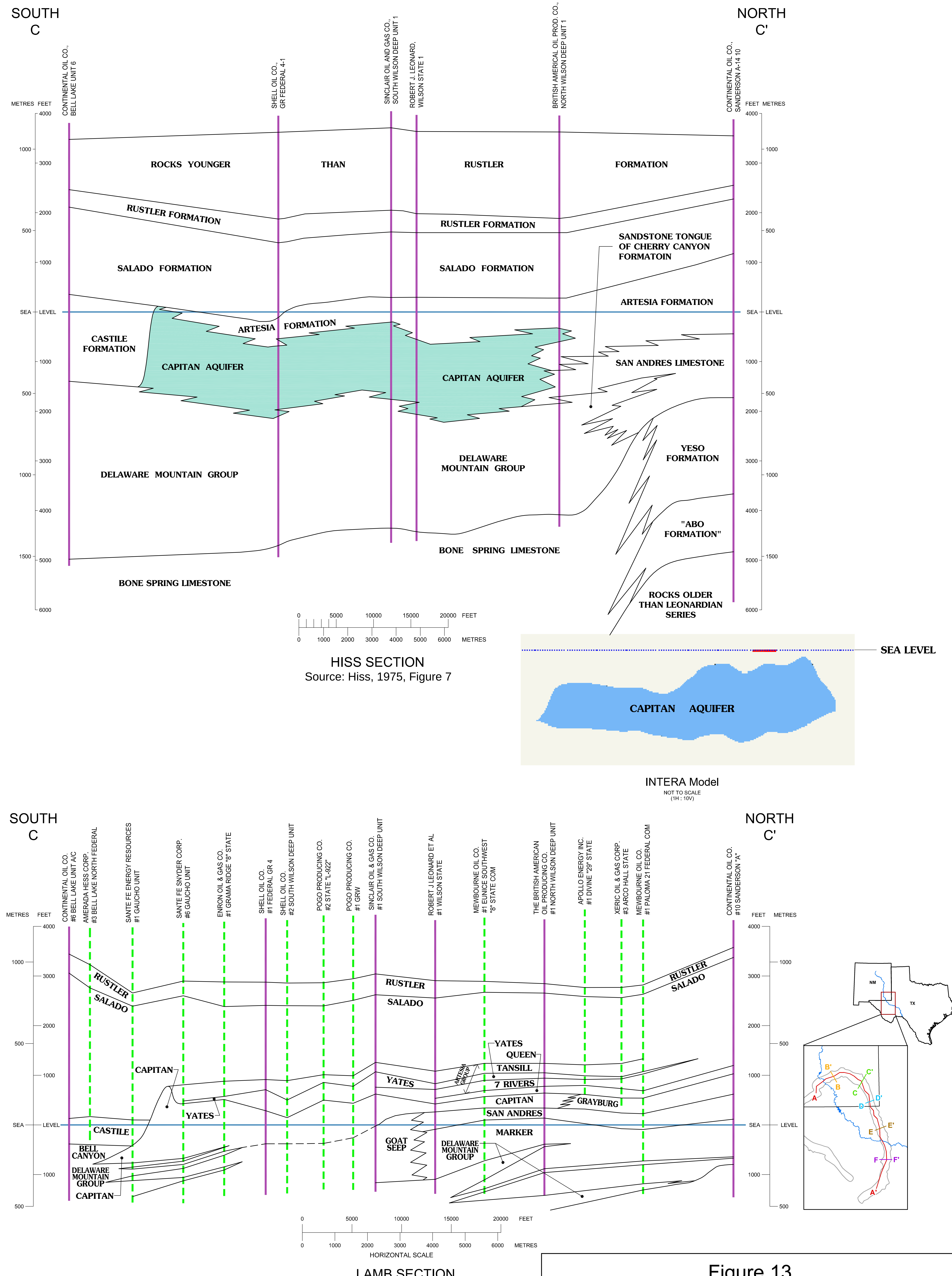
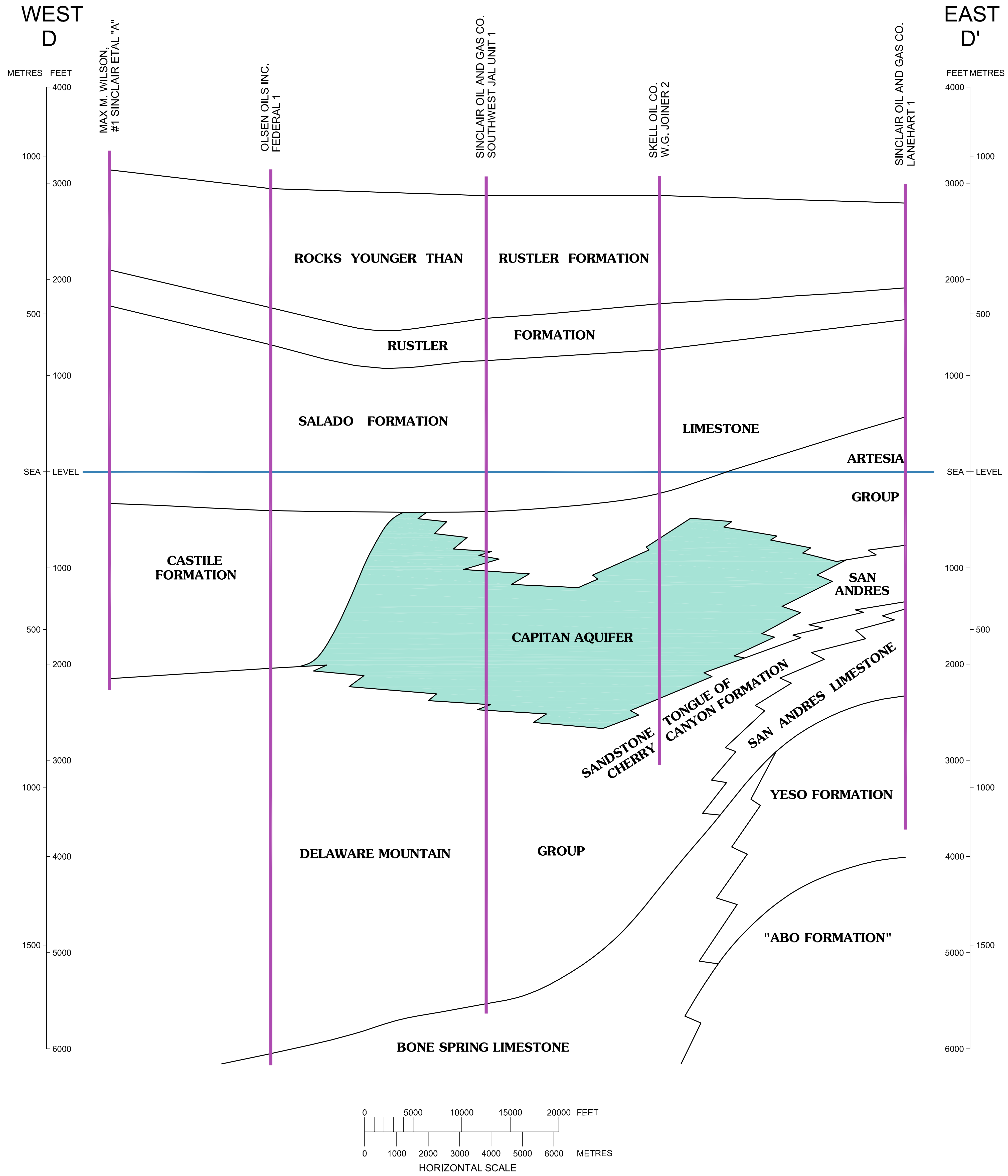
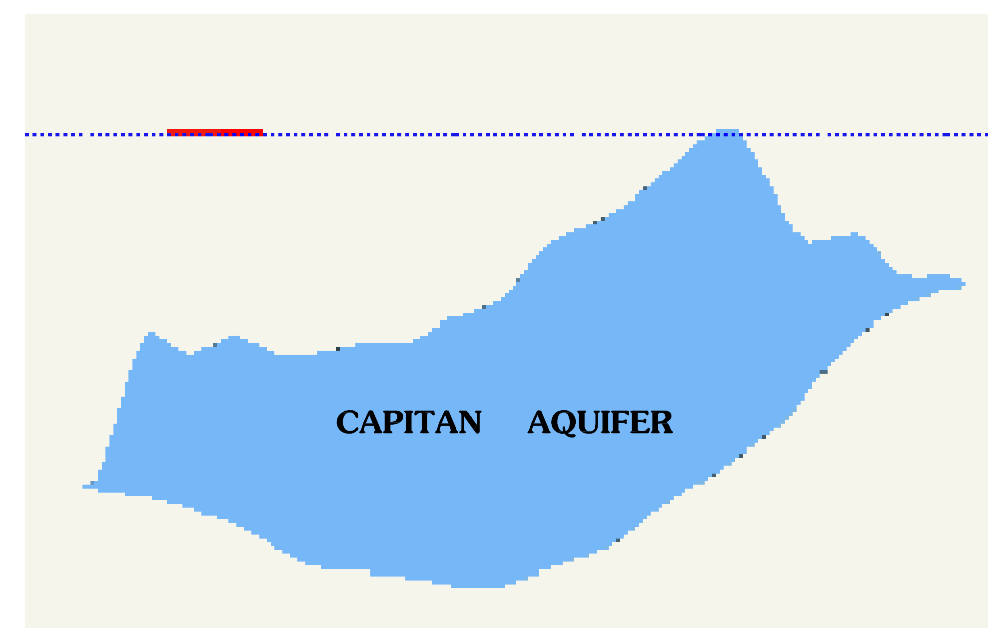


Figure 13
Stratigraphic Section C-C'
Across the Capitan Reef Complex and Aquifer
Ochoa Mine Water Resources Monitoring Plan

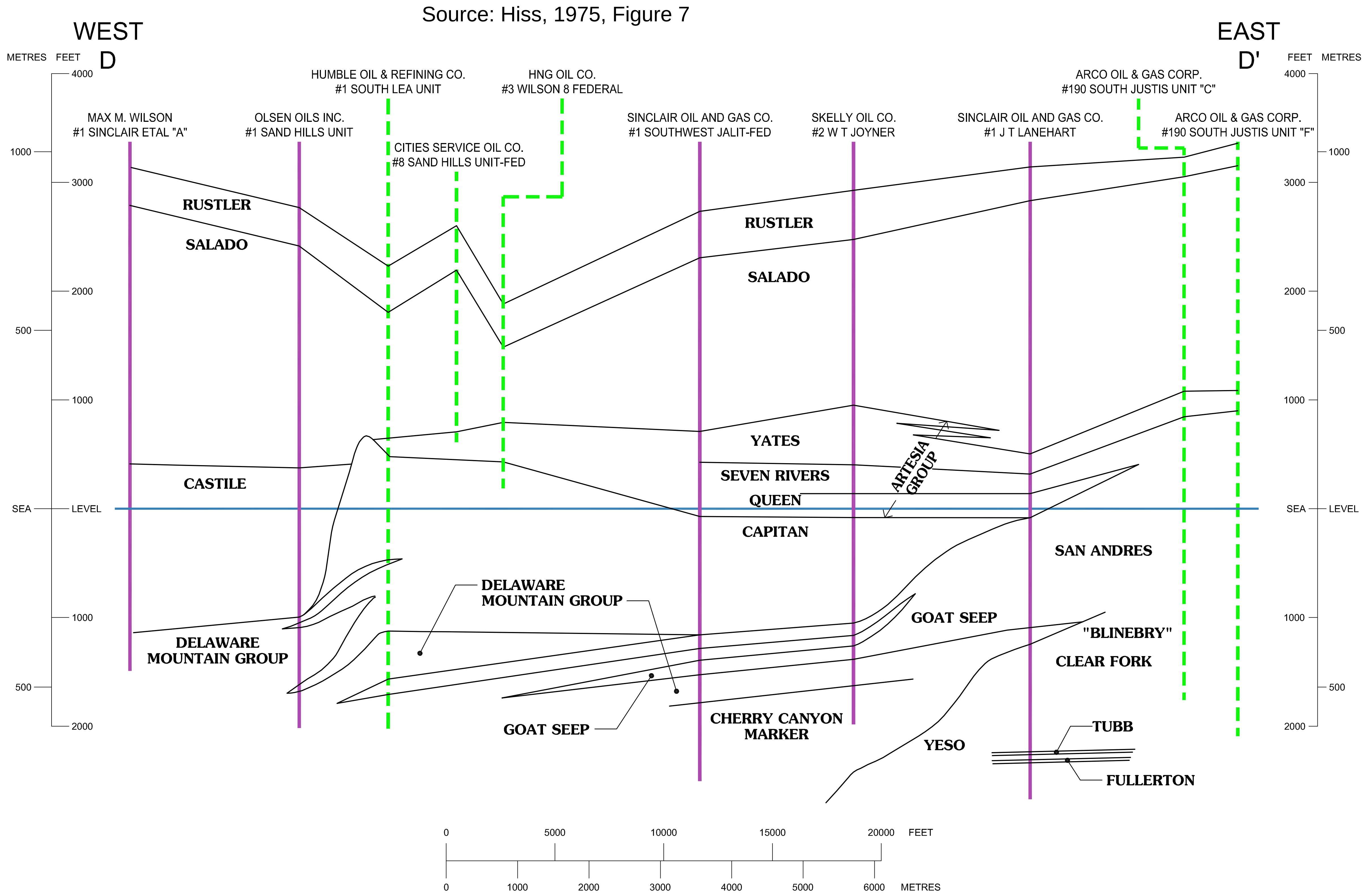
INTERA



HISS SECTION
Source: Hiss, 1975, Figure 7



INTERA Model
NOT TO SCALE
(1H : 10V)



LAMB SECTION

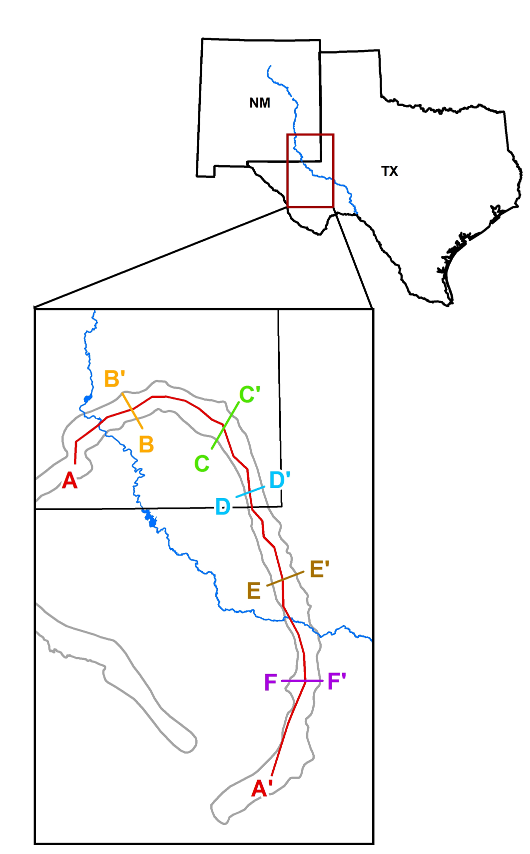
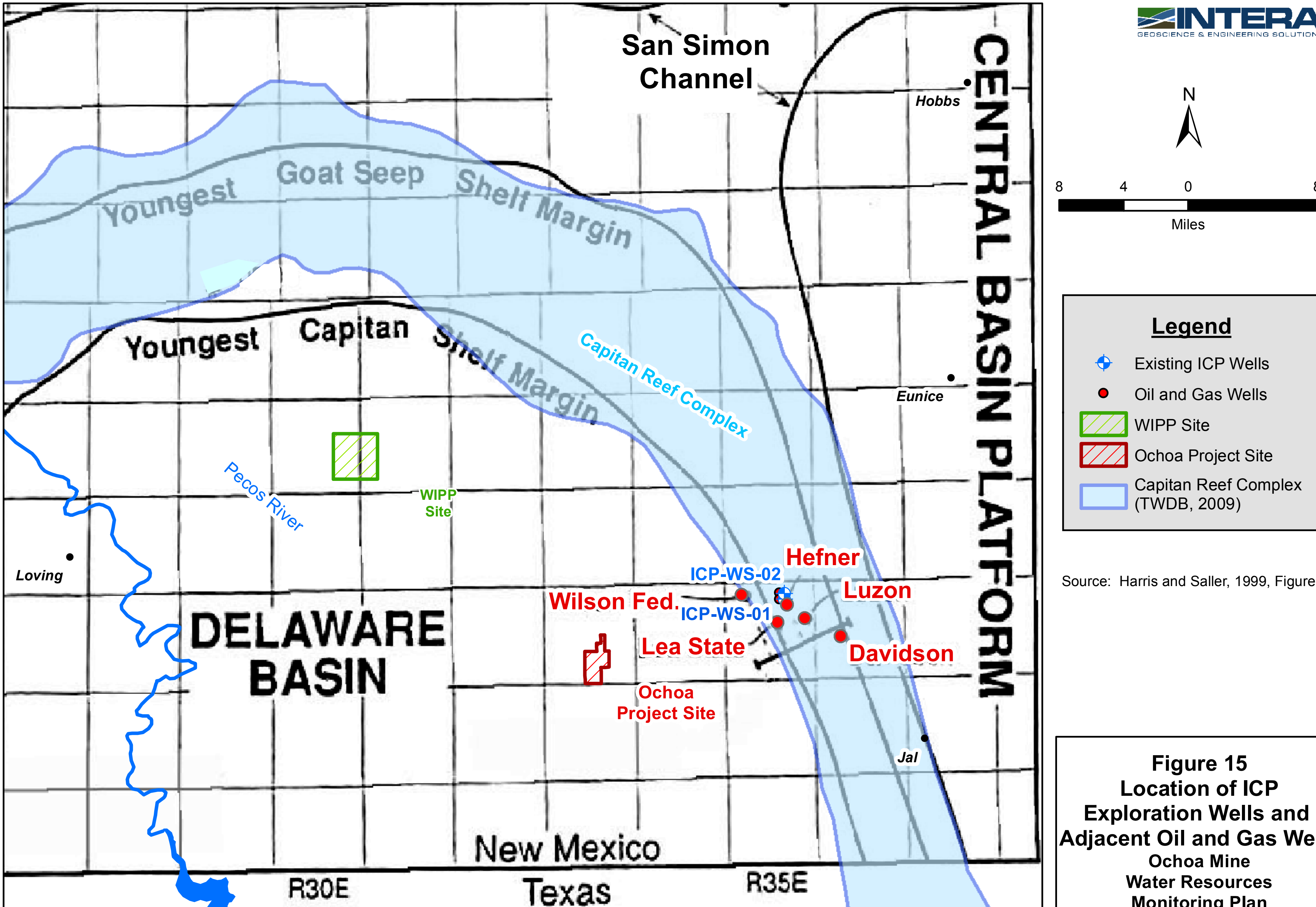
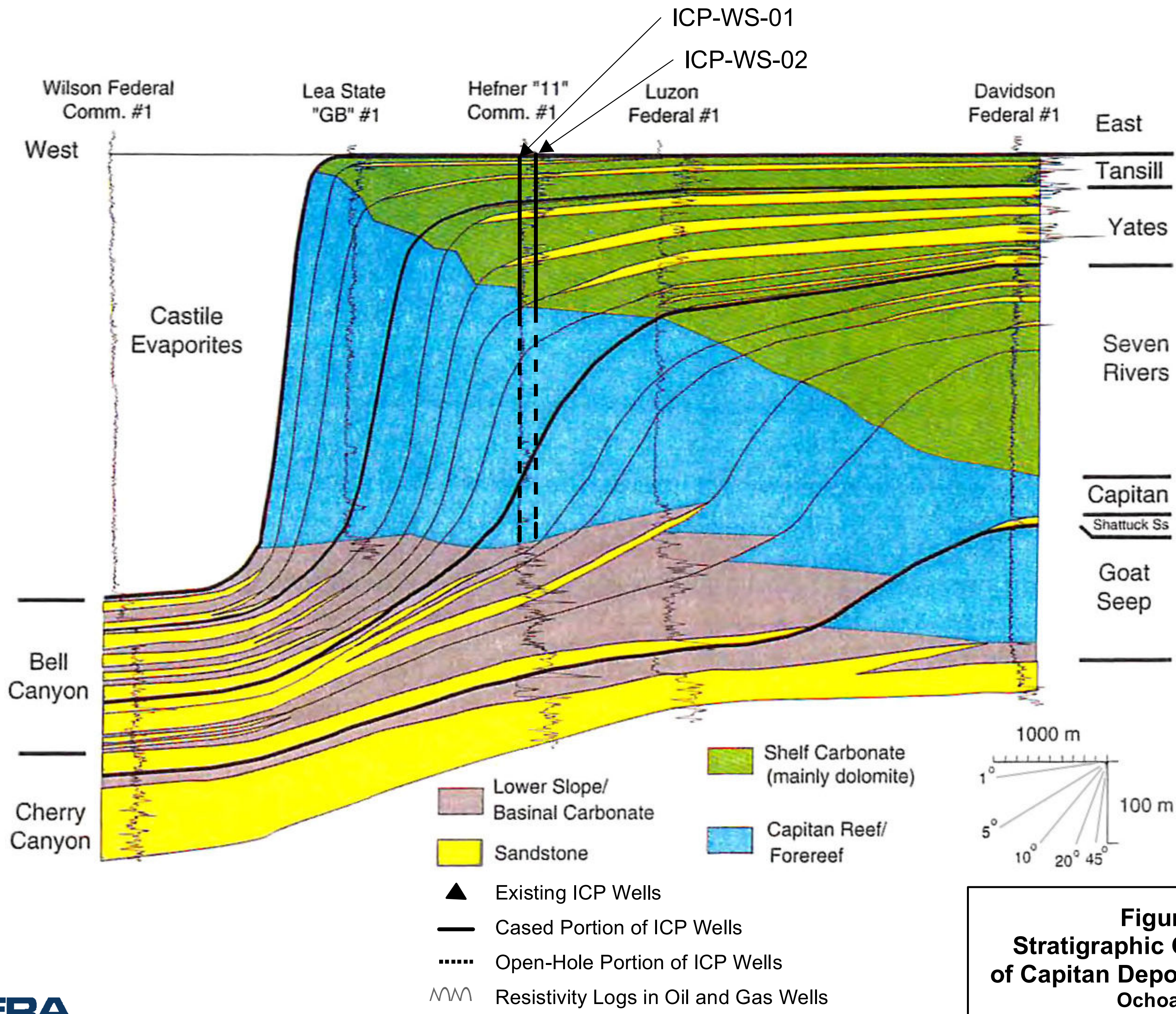


Figure 14
Stratigraphic Section D-D'
Across the Capitan Reef Complex and Aquifer
Ochoa Mine Water Resources Monitoring Plan



Source: Harris and Saller, 1999, Figure1

Figure 15
Location of ICP Exploration Wells and Adjacent Oil and Gas Wells
Ochoa Mine
Water Resources Monitoring Plan



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Source: Harris and Saller, 1999, Figure 7

Figure 16
Stratigraphic Cross Section of Capitan Depositional System
Ochoa Mine
Water Resources Monitoring Plan

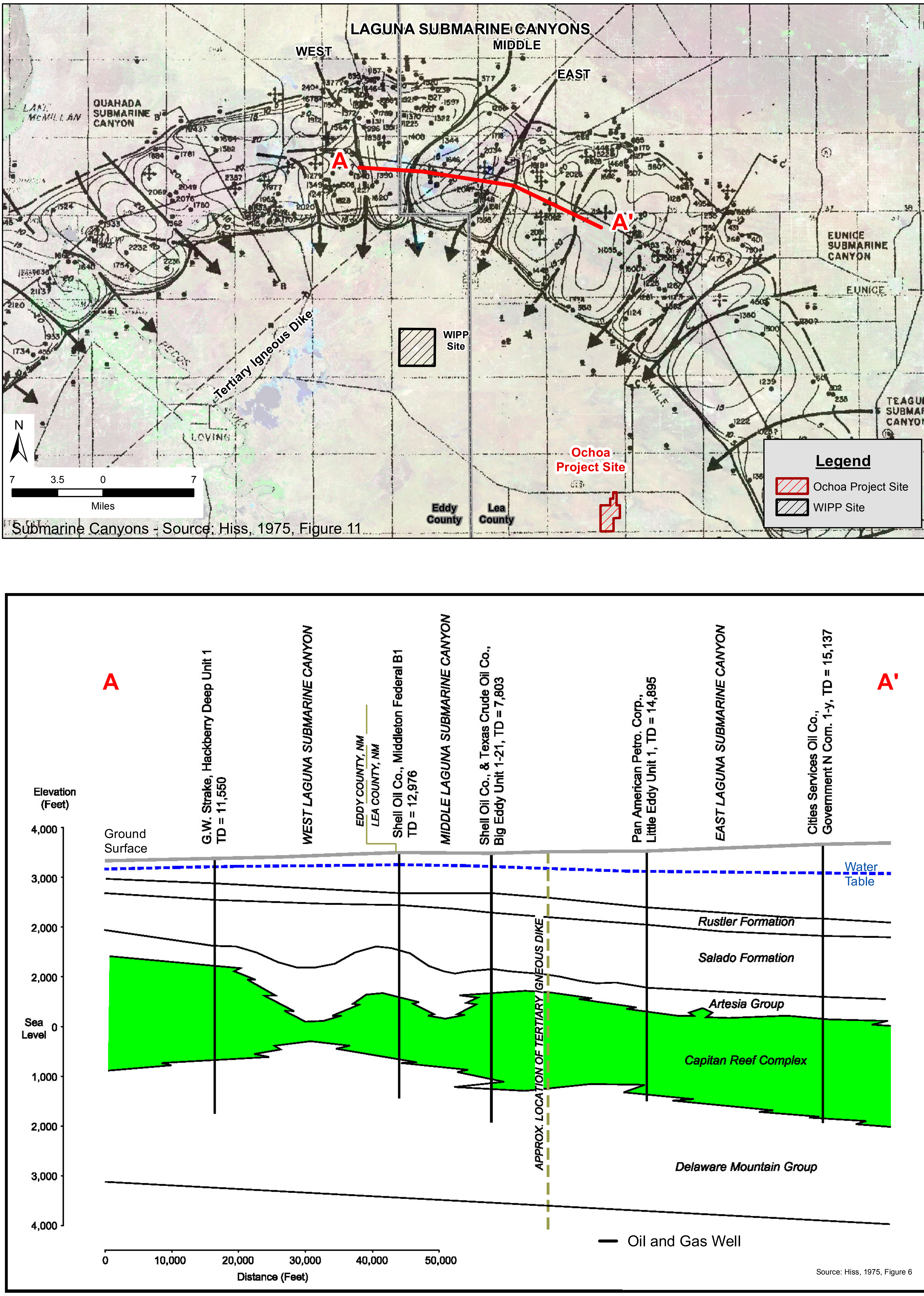

Figure 17
Laguna Submarine Canyons As Presented by Hiss (1975)
Ochoa Mine
Water Resources Monitoring Plan

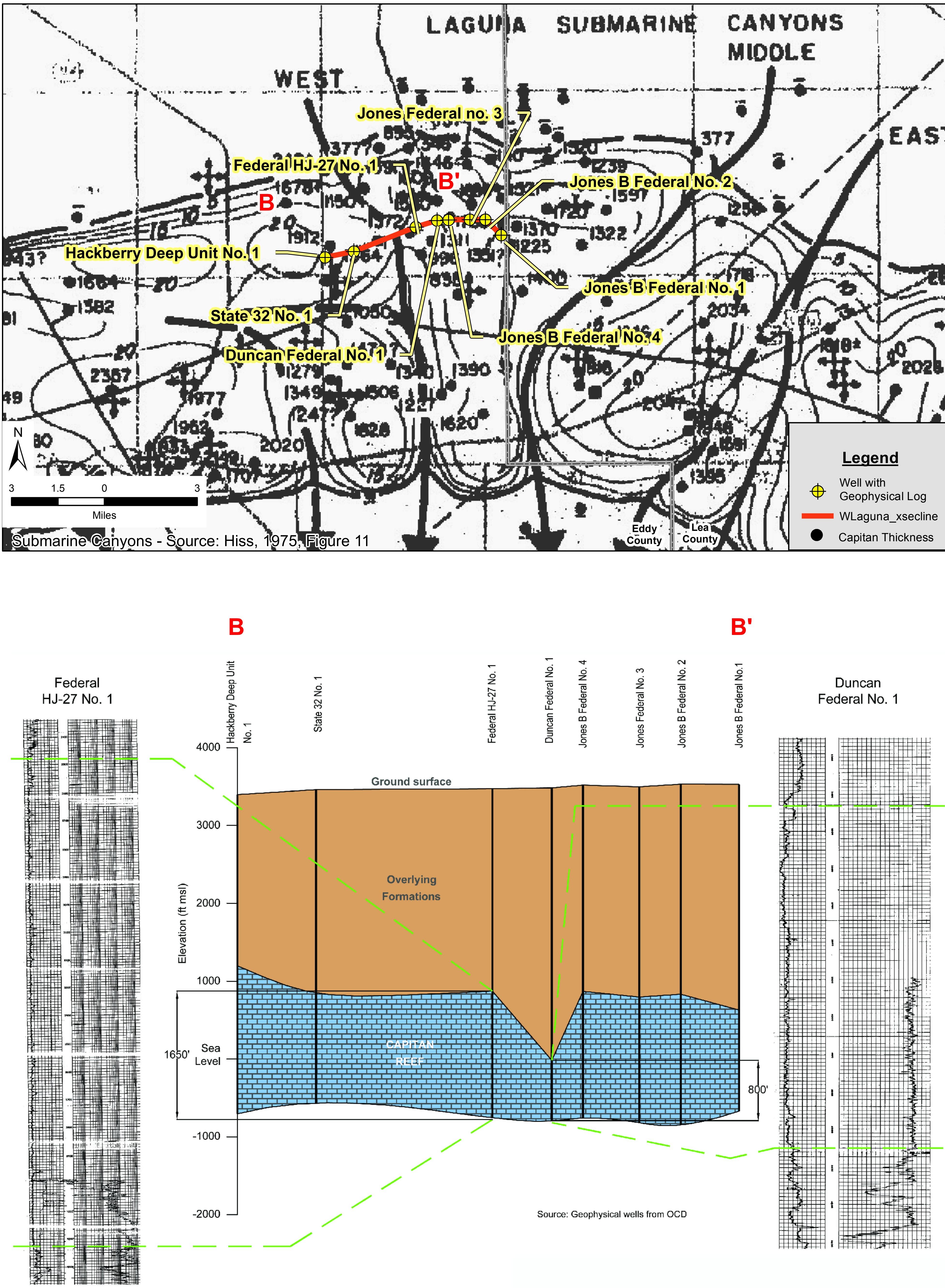

Figure 18
Detailed Analysis of West Laguna Submarine Canyon
Ochoa Mine
Water Resources Monitoring Plan

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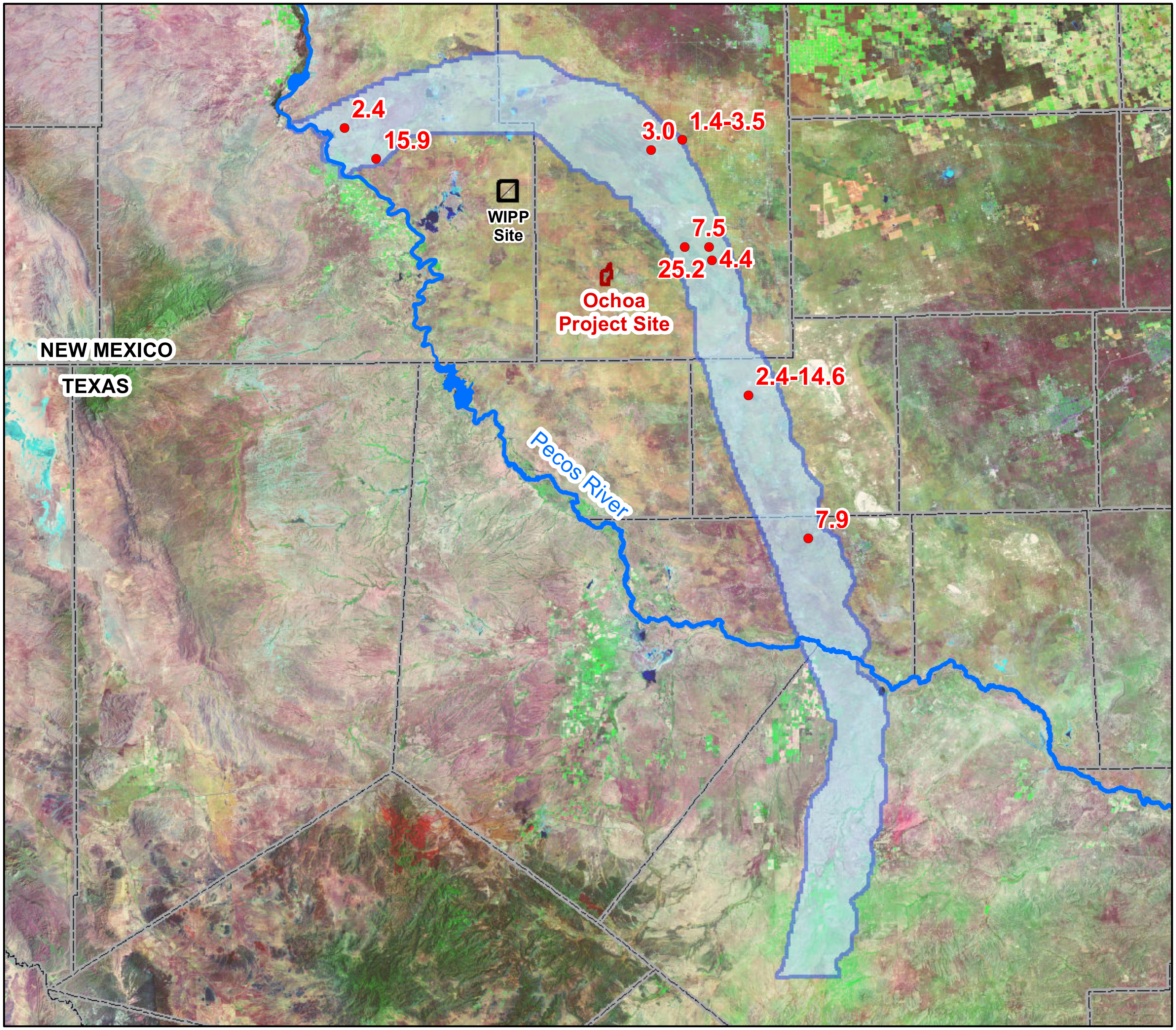
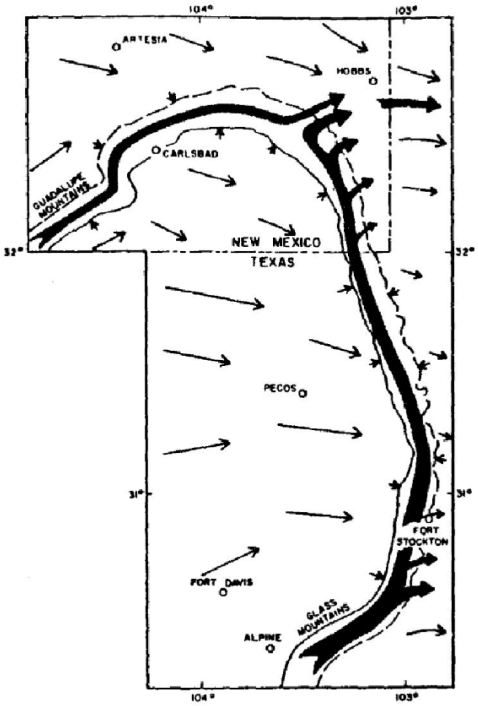
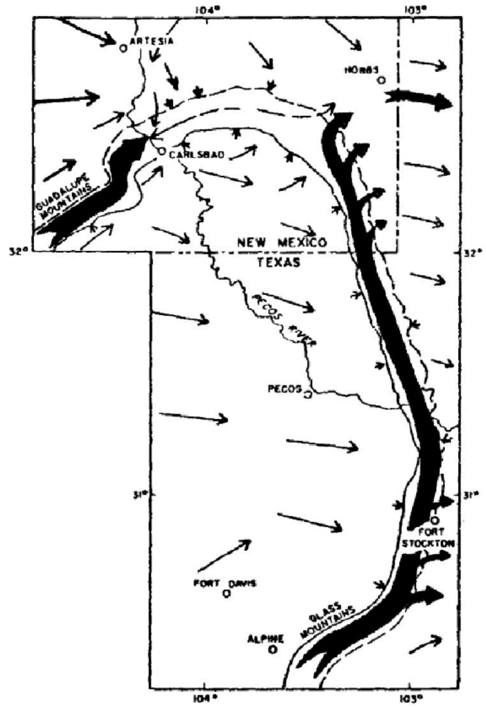


Figure 19
Hydraulic Conductivity Measurements in the Capitan Aquifer
Ochoa Mine Water Resources Monitoring Plan



A. Regimen principally controlled by regional tectonics prior to development of the Pecos River.



B. Regimen influenced by erosion of Pecos River at Carlsbad downward into hydraulic communication with the Capitan aquifer.

0 50 MILES

0 50 KILOMETRES

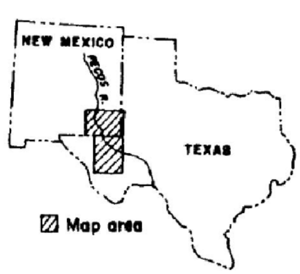
EXPLANATION

Capitan aquifer

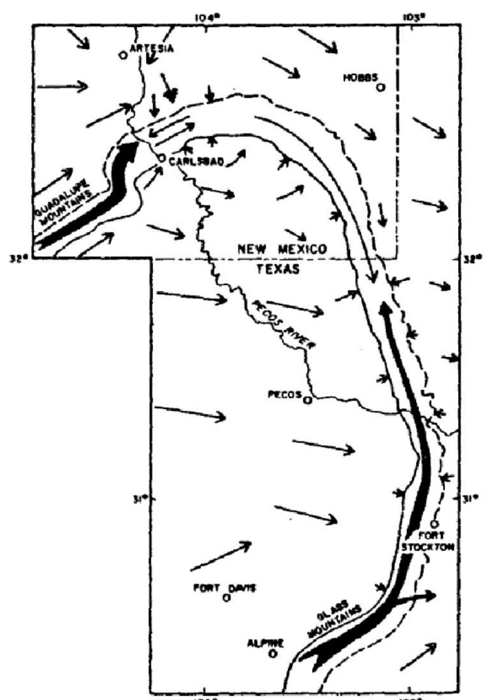
Highly diagrammatic ground-water flow vectors:

1. Vector size indicates relative volume of ground-water flow.

2. Orientation indicates direction of ground-water movement.



INDEX MAP



C. Regimen influenced by both communication with the Pecos River at Carlsbad and the exploitation of ground-water and petroleum resources.

Figure 20
Flow Regimes of the Capitan Aquifer
Ochoa Mine
Water Resources Monitoring Plan

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Source: Hiss, 1975, Figure 35.

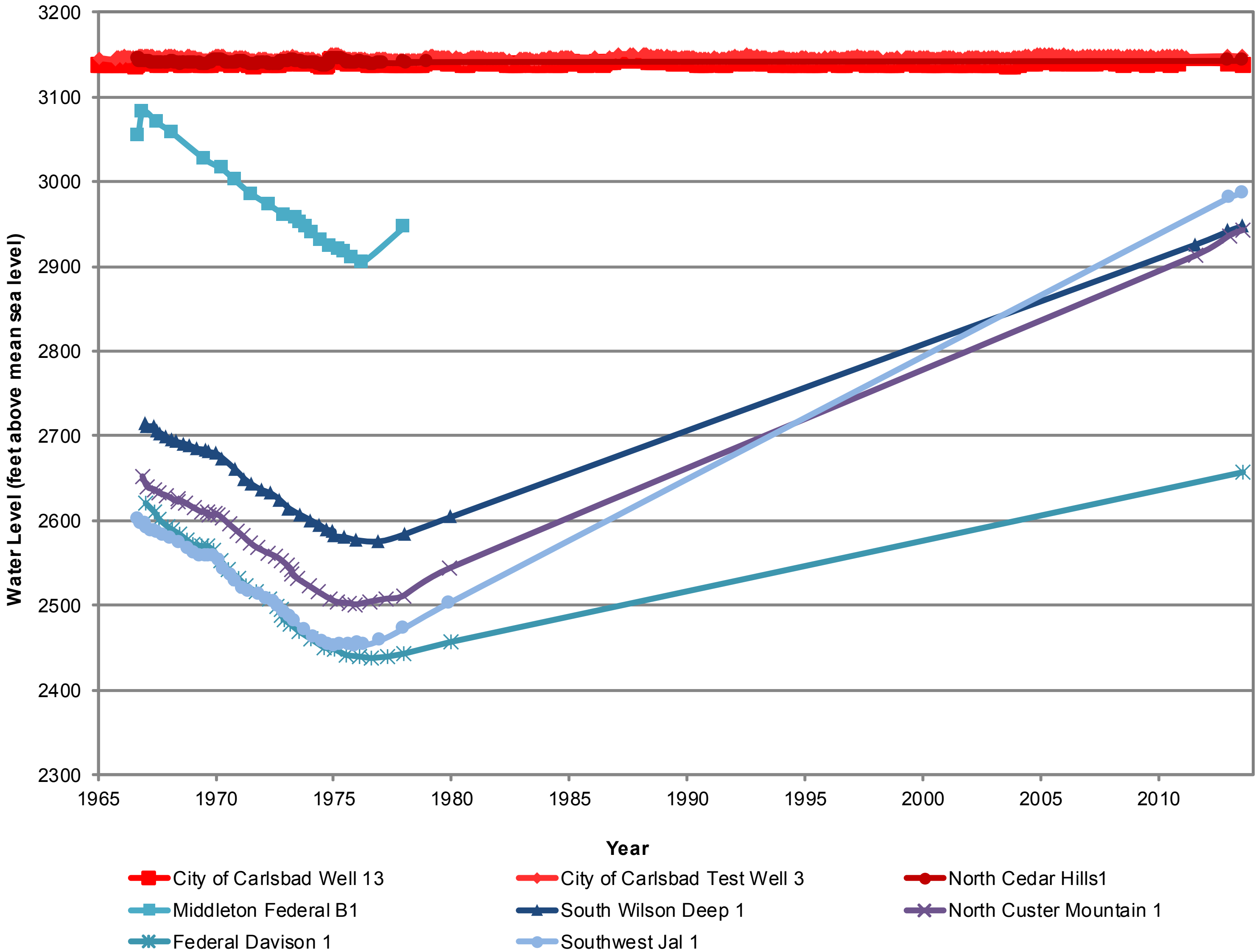

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Figure 21
Water Levels in the Capitan Aquifer
Ochoa Mine
Water Resources Monitoring Plan

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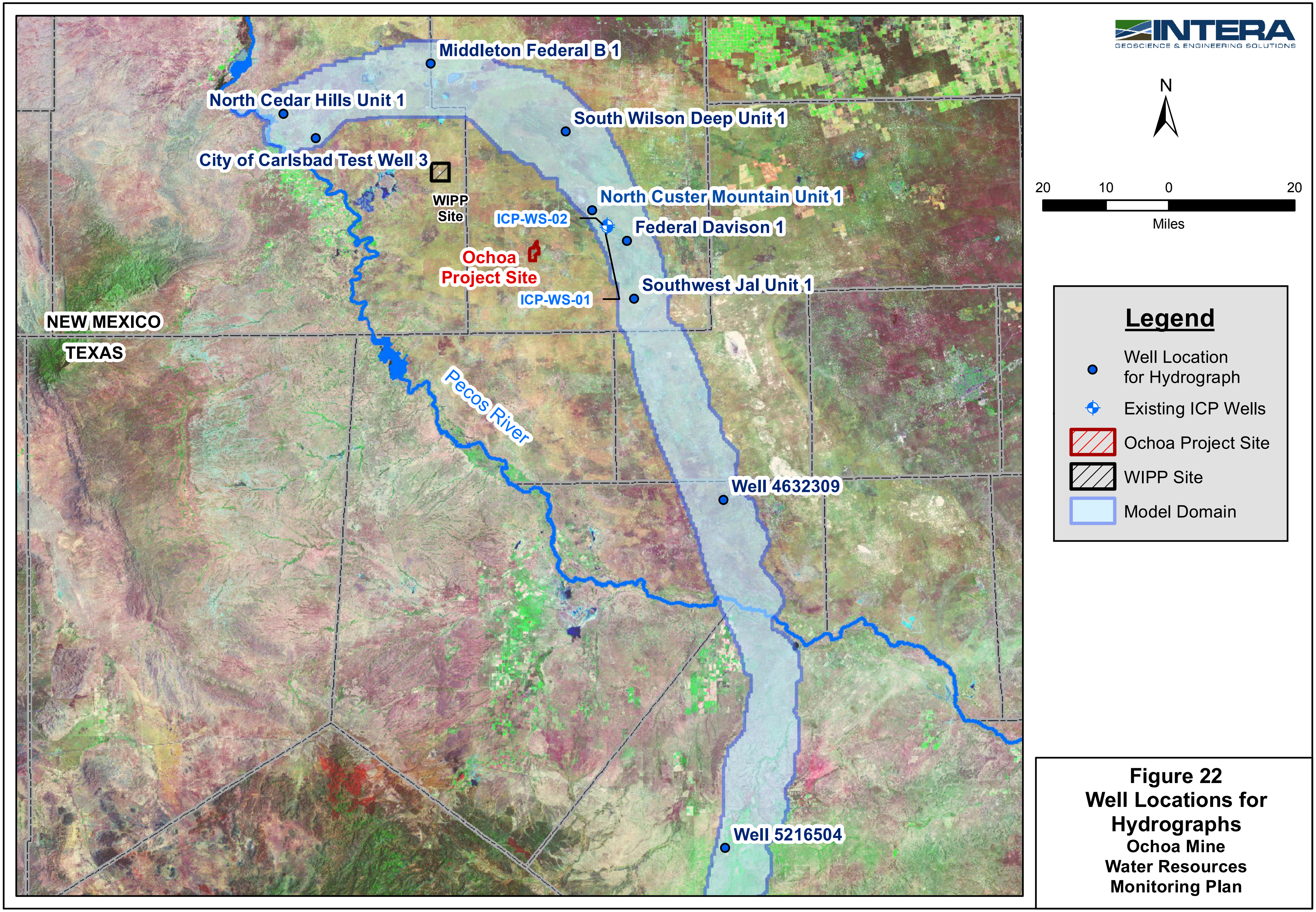
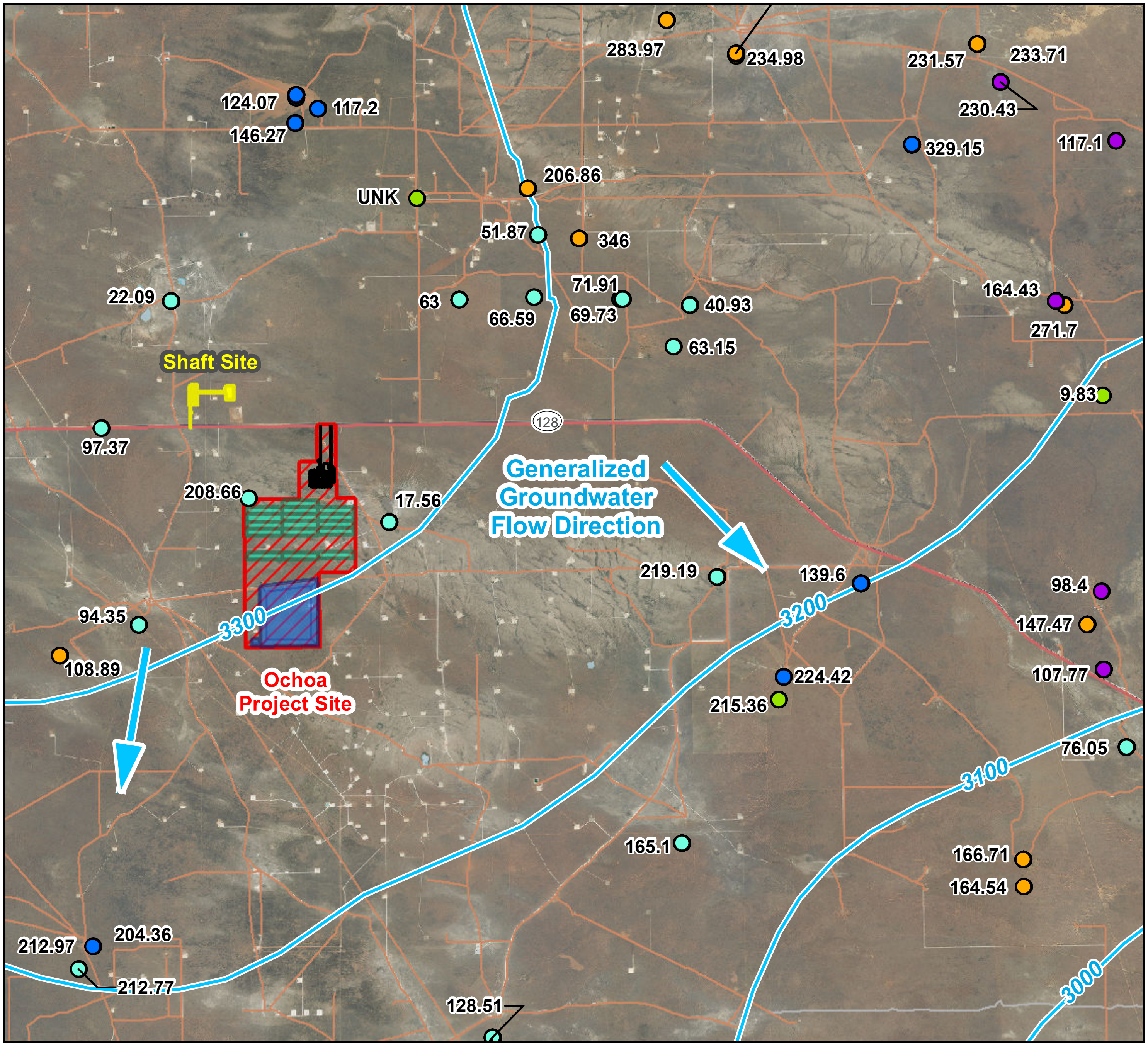


Figure 22
Well Locations for Hydrographs
Ochoa Mine
Water Resources
Monitoring Plan

S:\Projects\ICP-001_Intercontinental_Potash\GIS\MapDocuments\Task27_GWMonitoringPlan\Figure22_WellLocationHydro.mxd 1/31/2014



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N

2 1 0 2
Miles

Legend

Formation (groundwater depth, ft bgs)

- UNKNOWN
- ALLUVIUM AND SURFACE DEPOSITS
- CHINLE FORMATION
- OGALLALA FORMATION
- RUSTLER FORMATION
- RUSTLER FORMATION,LOWER MEMBER
- SUNRISE FORMATION
- Generalized Groundwater Contour (ft)
- Ochoa Project Site
- Shaft Site
- Processing Plant
- Tailings Pile
- Evaporation Ponds

Depth to groundwater, feet below ground surface (ft bgs).

Figure 23
Depth to Shallow Groundwater
Ochoa Mine
Water Resources Monitoring Plan

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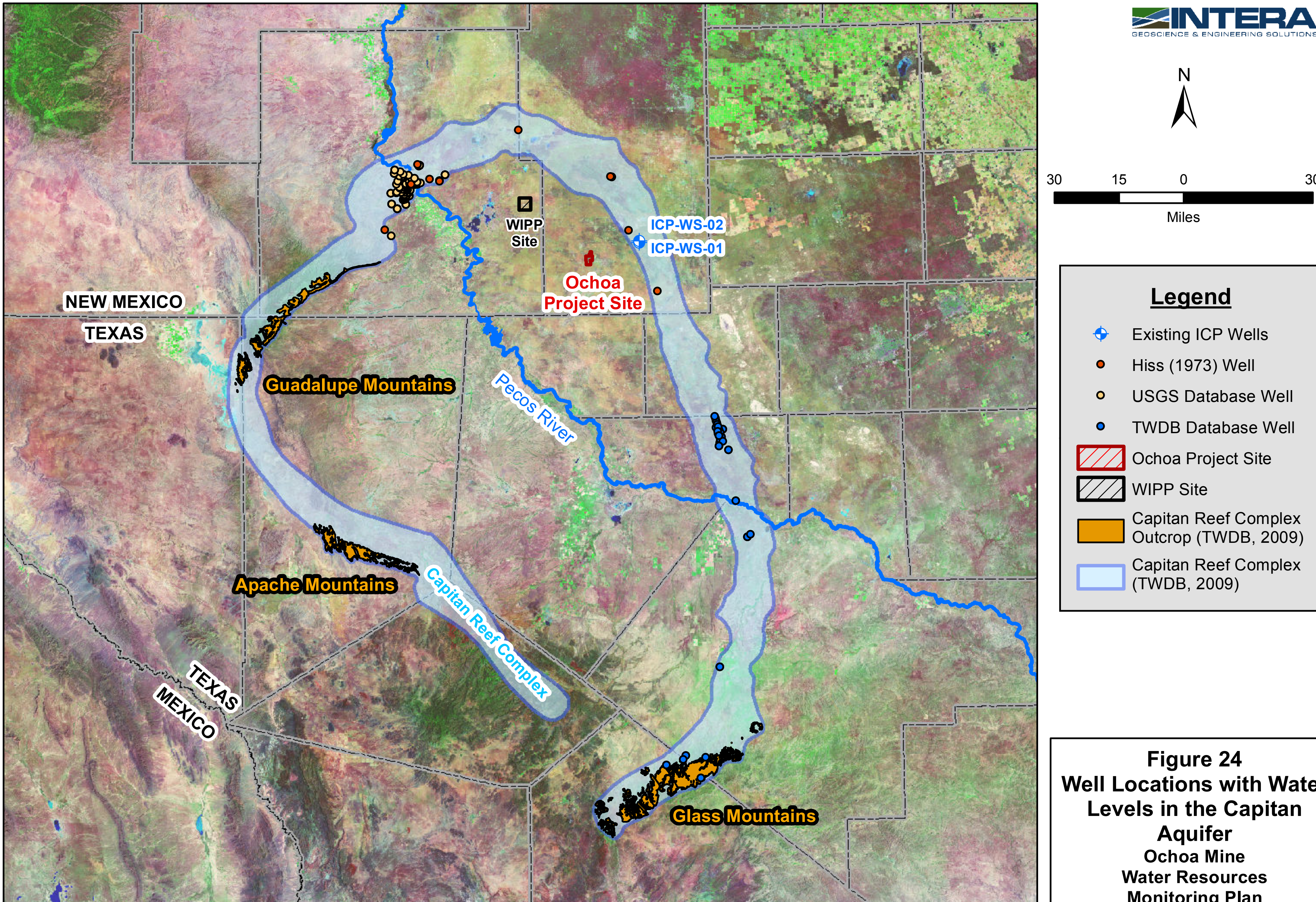

Figure 24
Well Locations with Water Levels in the Capitan Aquifer
Ochoa Mine
Water Resources Monitoring Plan

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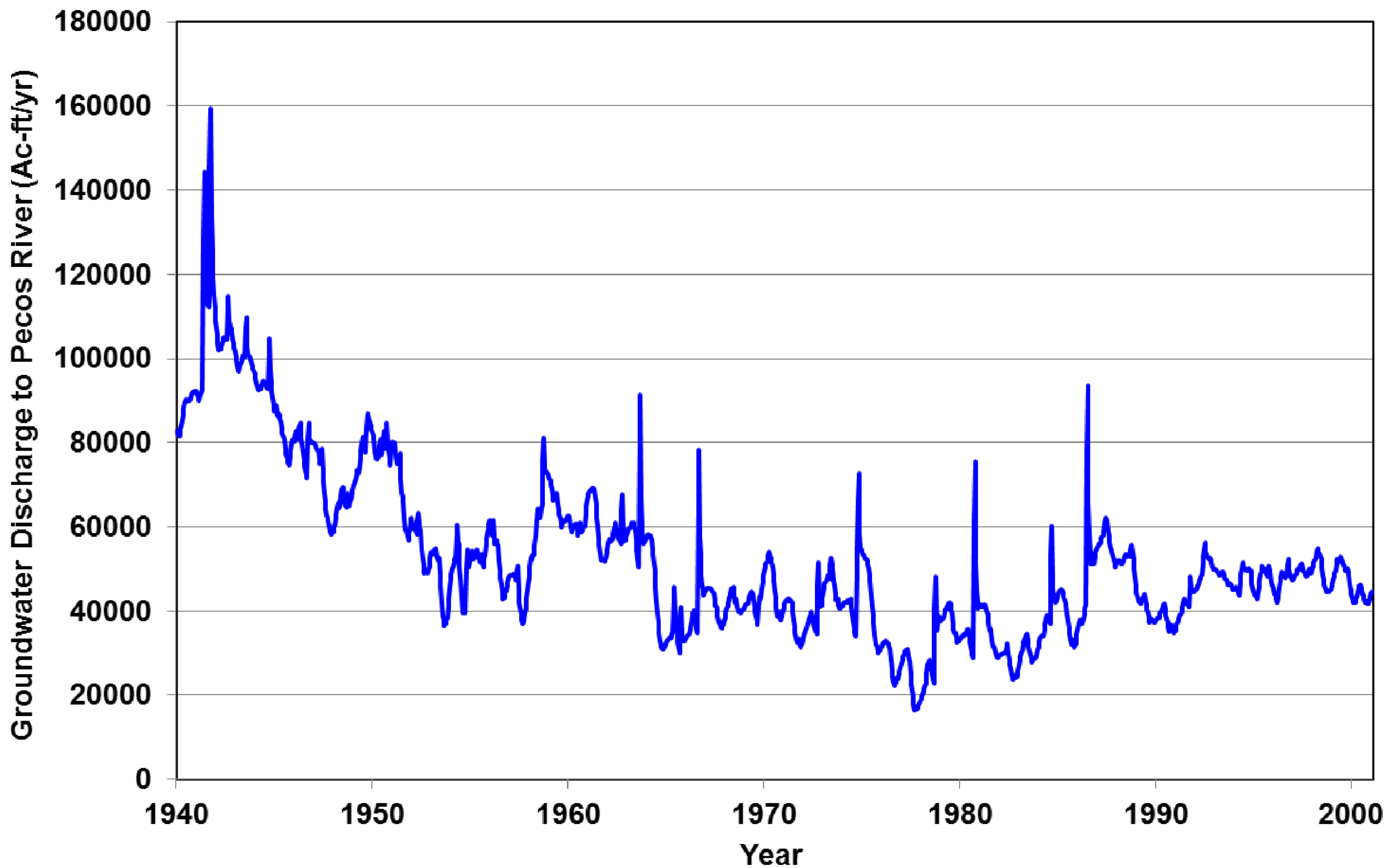

Figure 25
Groundwater Discharge to Pecos River
Based on CAGW Model
Ochoa Mine
Water Resources Monitoring Plan

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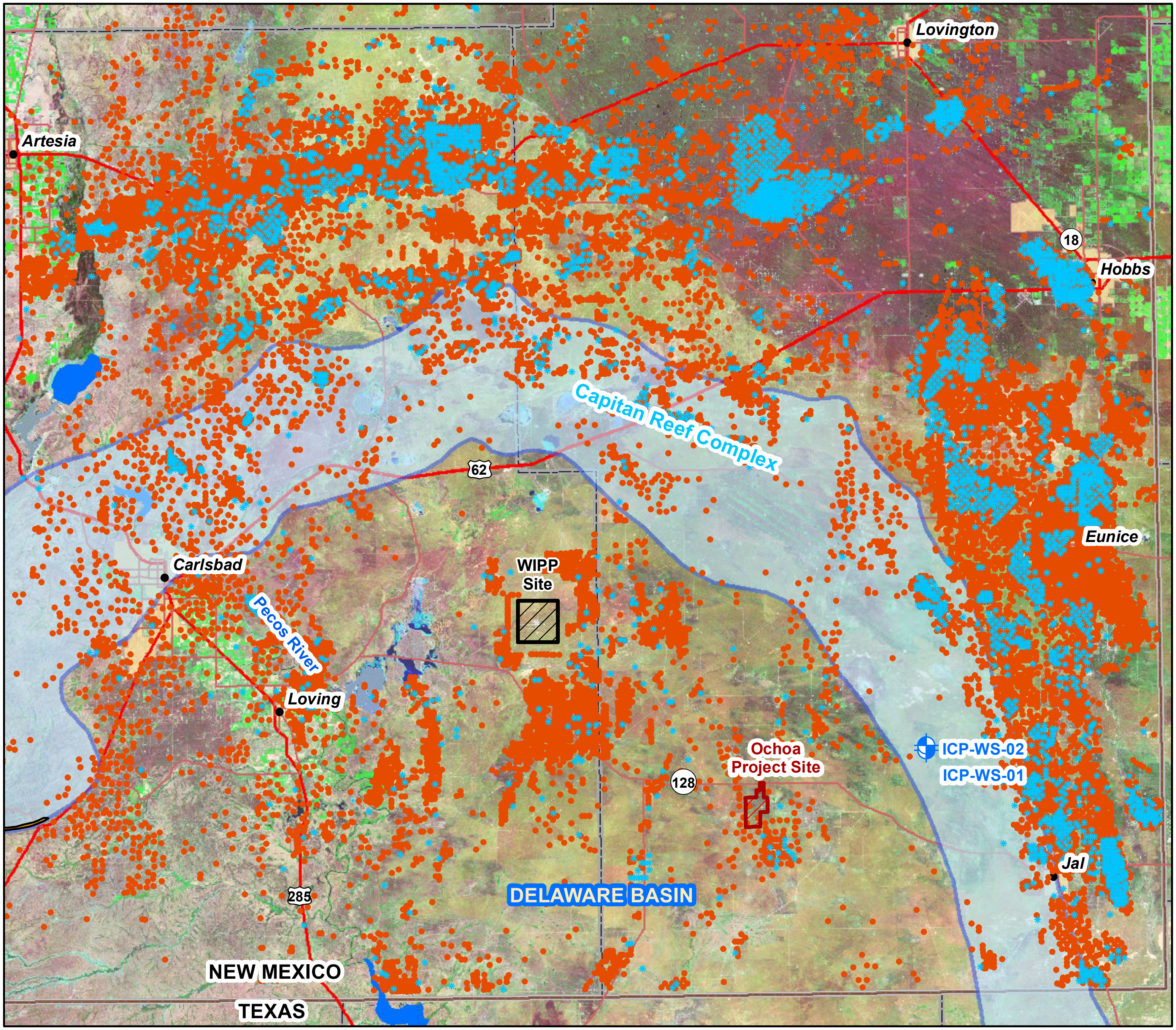

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N

10 5 0 10
Miles

Legend

- Ochoa Project Site
- WIPP Site
- Capitan Reef Complex (TWDB, 2009)
- Existing ICP Wells

Oil and Gas Wells

- Active Injection Wells
- Active Production Wells

*Administrative basins declared for management purposes by NMOSE.

Figure 26
Active Injection and Production Wells in Southeastern New Mexico
Ochoa Mine
Water Resources Monitoring Plan

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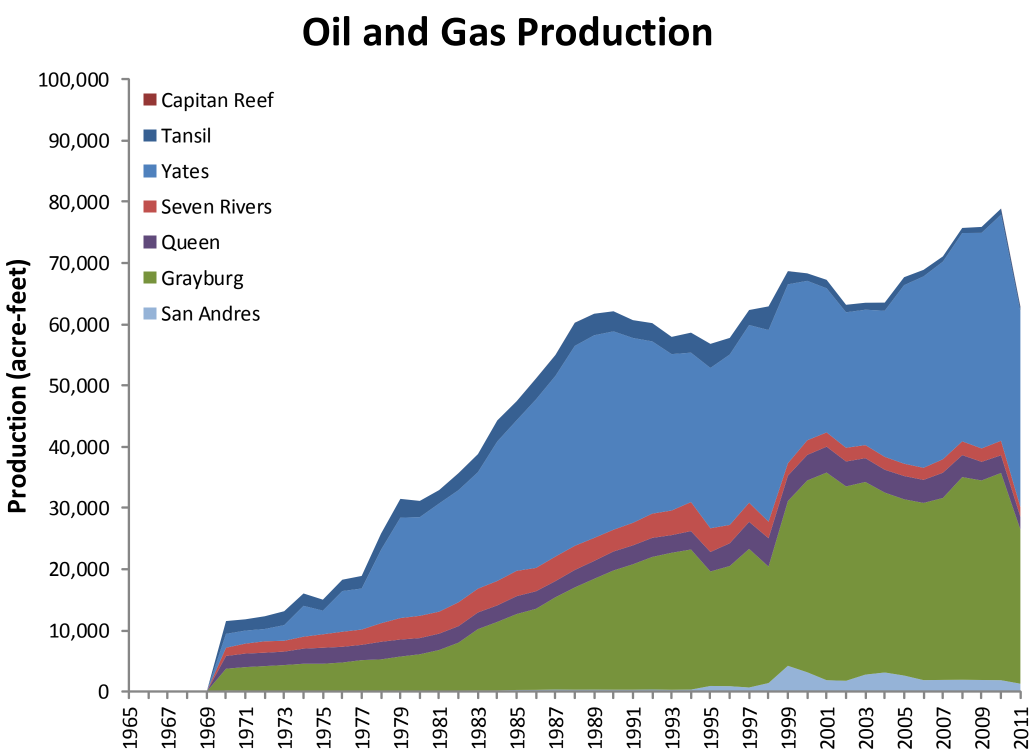

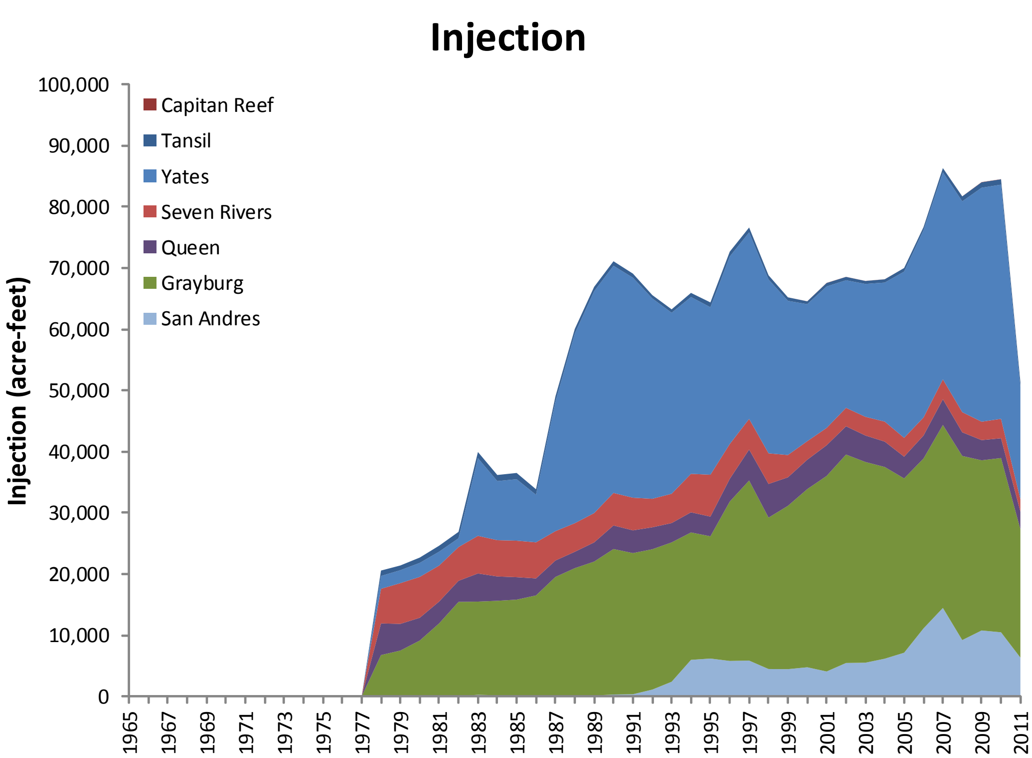

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Figure 27
Oil and Gas Production and Injection in Southwest New Mexico
Ochoa Mine
Water Resources Monitoring Plan

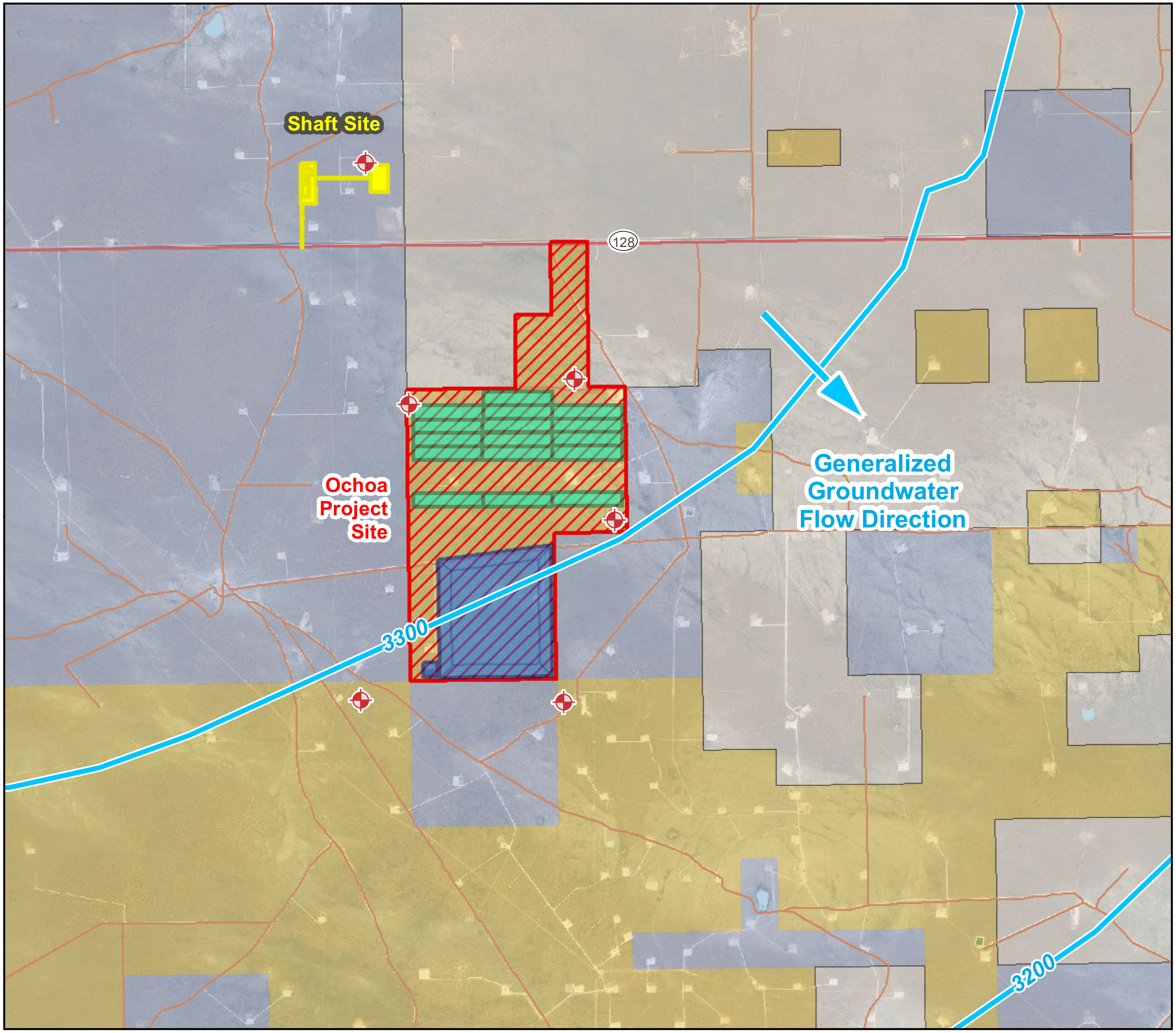

Figure 28
Plant Facilities Monitoring Well Network
Ochoa Mine
Water Resources Monitoring Plan

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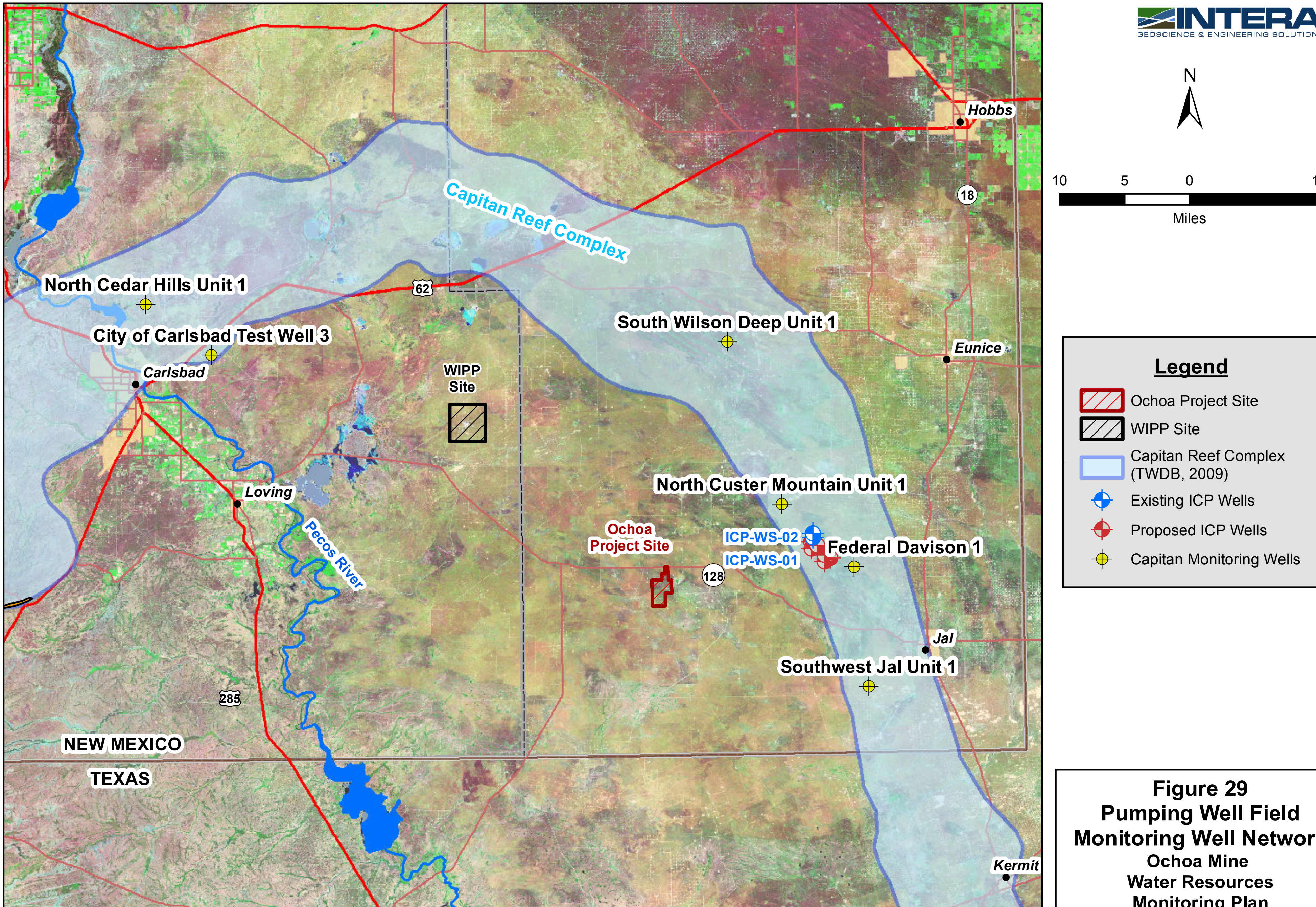

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Figure 29
Pumping Well Field Monitoring Well Network
Ochoa Mine Water Resources Monitoring Plan

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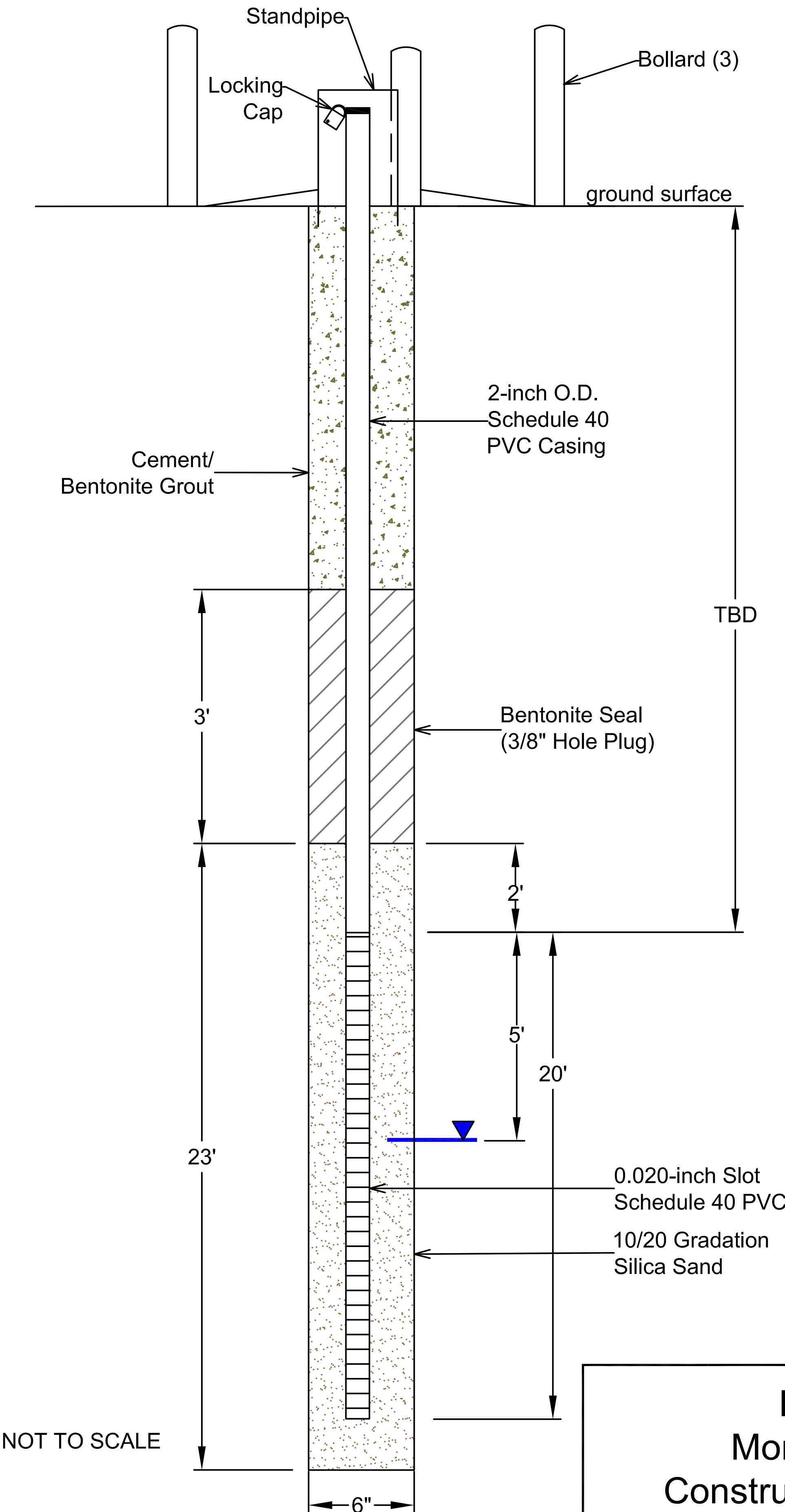


INTERA

Figure 30
Monitoring Well Construction Schematic
Ochoa Mine
Water Resources Monitoring Plan

APPENDIX A

NMED Monitoring Well Installation Guidelines

NEW MEXICO ENVIRONMENT DEPARTMENT
GROUND WATER QUALITY BUREAU
MONITORING WELL CONSTRUCTION AND ABANDONMENT GUIDELINES

Purpose: These guidelines identify minimum construction and abandonment details for installation of water table monitoring wells under ground water Discharge Permits issued by the NMED's Ground Water Quality Bureau (GWQB) and Abatement Plans approved by the GWQB. Proposed locations of monitoring wells required under Discharge Permits and Abatement Plans and requests to use alternate installation and/or construction methods for water table monitoring wells or other types of monitoring wells (e.g., deep monitoring wells for delineation of vertical extent of contaminants) must be submitted to the GWQB for approval prior to drilling and construction.

General Drilling Specifications:

1. All well drilling activities must be performed by an individual with a current and valid well driller license issued by the State of New Mexico in accordance with 19.27.4 NMAC. Use of drillers with environmental well drilling experience and expertise is highly recommended.
2. Drilling methods that allow for accurate determinations of water table locations must be employed. All drill bits, drill rods, and down-hole tools must be thoroughly cleaned immediately prior to the start of drilling. The borehole diameter must be drilled a minimum of 4 inches larger than the casing diameter to allow for the emplacement of sand and sealant.
3. After completion, the well should be allowed to stabilize for a minimum of 12 hours before development is initiated.
4. The well must be developed so that formation water flows freely through the screen and is not turbid, and all sediment and drilling disturbances are removed from the well.

Well Specifications (see attached monitoring well schematic):

5. Schedule 40 (or heavier) polyvinyl chloride (PVC) pipe, stainless steel pipe, carbon steel pipe, or pipe of an alternate appropriate material that has been approved for use by NMED must be used as casing. The casing must have an inside diameter not less than 2 inches. The casing material selected for use must be compatible with the anticipated chemistry of the ground water and appropriate for the contaminants of interest at the facility. The casing material and thickness selected for use must have sufficient collapse strength to withstand the pressure exerted by grouts used as annular seals and thermal properties sufficient to withstand the heat generated by the hydration of cement-based grouts. Casing sections may be joined using welded, threaded, or mechanically locking joints; the method selected must provide sufficient joint strength for the specific well installation. The casing must extend from the top of the screen to at least one foot above ground surface. The top of the casing must be fitted with a removable cap, and the exposed casing must be protected by a locking steel well shroud. The shroud must be large enough in diameter to allow easy access for removal of the cap. Alternatively, monitoring wells may be completed below grade. In this case, the casing must extend from the top of the screen to 6 to 12 inches below the ground surface; the monitoring wells must be sealed with locking, expandable well plugs; a flush-mount, watertight well vault that is rated to withstand traffic loads must be emplaced around the wellhead; and the cover must be secured with at least one bolt. The vault cover must indicate that the wellhead of a monitoring well is contained within the vault.
6. A 20-foot section (maximum) of continuous-slot, machine slotted, or other manufactured PVC or stainless steel well screen or well screen of an alternate appropriate material that has been approved for use by NMED must be installed across the water table. Screens created by cutting slots into solid casing with saws or other tools must not be used. The screen material selected for use must be compatible with the anticipated chemistry of the ground water and appropriate for the contaminants of interest at the facility. Screen sections may be joined using welded, threaded, or mechanically

locking joints; the method selected must provide sufficient joint strength for the specific well installation and must not introduce constituents that may reasonably be considered contaminants of interest at the facility. A cap must be attached to the bottom of the well screen; sumps (i.e., casing attached to the bottom of a well screen) should not be installed. The bottom of the screen must be installed no more than 15 feet below the water table; the top of the well screen must be positioned not less than 5 feet above the water table. The well screen slots must be appropriately sized for the formation materials and should be selected to retain 90 percent of the filter pack. A slot size of 0.010 inches is generally adequate for most installations.

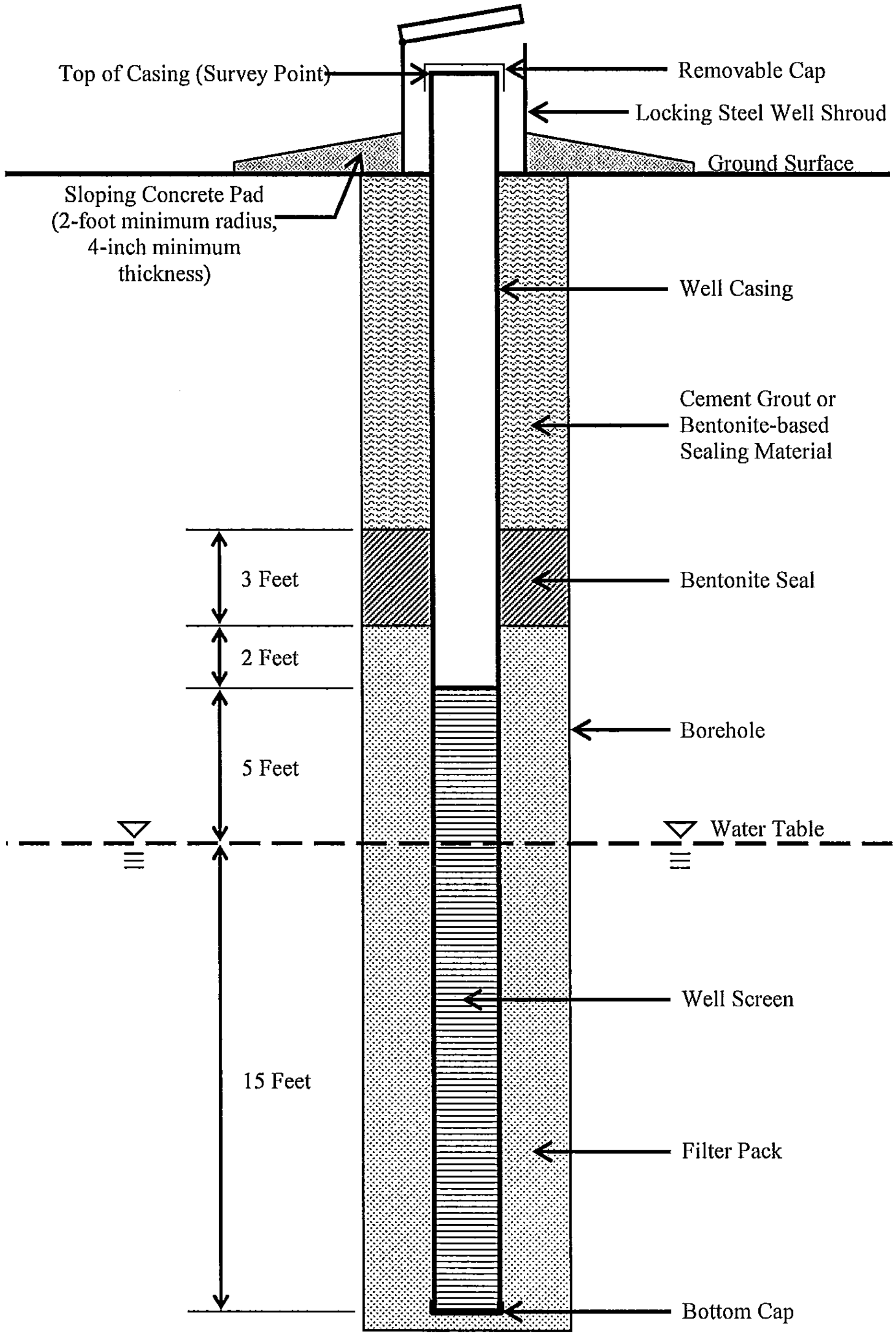
7. Casing and well screen must be centered in the borehole by placing centralizers near the top and bottom of the well screen.
8. A filter pack must be installed around the screen by filling the annular space from the bottom of the screen to 2 feet above the top of the screen with clean silica sand. The filter pack must be properly sized to prevent fine particles in the formation from entering the well; clean medium to coarse silica sand is generally adequate as filter pack material for 0.010-inch slotted well screen. For wells deeper than 30 feet, the sand must be emplaced by a tremmie pipe. The well should be surged or bailed to settle the filter pack and additional sand added, if necessary, before the bentonite seal is emplaced.
9. A bentonite seal must be constructed immediately above the filter pack by emplacing bentonite chips or pellets (3/8-inch in size or smaller) in a manner that prevents bridging of the chips/pellets in the annular space. The bentonite seal must be 3 feet in thickness and hydrated with clean water. Adequate time should be allowed for expansion of the bentonite seal before installation of the annular space seal.
10. The annular space above the bentonite seal must be sealed with cement grout or a bentonite-based sealing material acceptable to the State Engineer pursuant to 19.27.4 NMAC. A tremmie pipe must be used when placing sealing materials at depths greater than 20 feet below the ground surface. Annular space seals must extend from the top of the bentonite seal to the ground surface (for wells completed above grade) or to a level 3 to 6 inches below the top of casing (for wells completed below grade).
11. For monitoring wells finished above grade, a concrete pad (2-foot minimum radius, 4-inch minimum thickness) must be poured around the shroud and wellhead. The concrete and surrounding soil must be sloped to direct rainfall and runoff away from the wellhead. The installation of steel posts around the well shroud and wellhead is recommended for monitoring wells finished above grade to protect the wellhead from damage by vehicles or equipment. For monitoring wells finished below grade, a concrete pad (2-foot minimum radius, 4-inch minimum thickness) must be poured around the well vault and wellhead. The concrete and surrounding soil must be sloped to direct rainfall and runoff away from the well vault.

<u>Abandonment</u>:

12. Approval for abandonment of monitoring wells used for ground water monitoring in accordance with Discharge Permit and Abatement Plan requirements must be obtained from NMED prior to abandonment.
13. Well abandonment must be accomplished by removing the well casing and placing neat cement grout, bentonite-based plugging material, or other sealing material approved by the State Engineer for wells that encounter water pursuant to 19.27.4 NMAC from the bottom of the borehole to the ground surface using a tremmie pipe. If the casing cannot be removed, neat cement grout, bentonite-based plugging material, or other sealing material approved by the State Engineer must be placed in the well using a tremmie pipe from the bottom of the well to the ground surface.
14. After abandonment, written notification describing the well abandonment must be submitted to the NMED. Written notification of well abandonment must consist of a copy of the well plugging record submitted to the State Engineer in accordance with 19.27.4 NMAC, or alternate documentation containing the information to be provided in a well plugging record required by the State Engineer as specified in 19.27.4 NMAC.

Deviation from Monitoring Well Construction and Abandonment Requirements: Requests to construct water table monitoring wells or other types of monitoring wells for ground water monitoring under ground water Discharge Permits or Abatement Plans in a manner that deviates from the specified requirements must be submitted in writing to the GWQB. Each request must state the rationale for the proposed deviation from these requirements and provide detailed evidence supporting the request. The GWQB will approve or deny requests to deviate from these requirements in writing.

MONITORING WELL SCHEMATIC
(Not to Scale)



APPENDIX B

NM OSE Well Guidelines

RULES AND REGULATIONS GOVERNING WELL DRILLER LICENSING; CONSTRUCTION, REPAIR AND PLUGGING OF WELLS

<u>Adopted August 31, 2005</u>

John R. D'Antonio, Jr., PE

State Engineer

INDEX

WELL DRILLER LICENSING; CONSTRUCTION, REPAIR AND PLUGGING OF WELLS
19.27.4 NMAC

TITLE 19 NATURAL RESOURCES AND WILDLIFE
CHAPTER 27 UNDERGROUND WATER
PART 4 WELL DRILLER LICENSING; CONSTRUCTION, REPAIR AND PLUGGING OF WELLS

19.27.4.1 ISSUING AGENCY: Office of the State Engineer.
[19.27.4.1 NMAC - N, 8-31-2005]

19.27.4.2 SCOPE: The rules for well driller licensing, drill rig supervisor registration, and well drilling within the state of New Mexico. These rules also apply to mine drill holes that encounter water. These rules do not apply to oil wells, gas wells, or cathodic protection wells.
[19.27.4.2 NMAC - N, 8-31-2005]

19.27.4.3 STATUTORY AUTHORITY: Section 72-12-1 NMSA provides that the water of underground streams, channels, artesian basins, reservoirs, or lakes having reasonably ascertainable boundaries are declared to be public waters which belong to the public and are subject to appropriation for beneficial use. Section 72-2-8 NMSA gives the state engineer authority to adopt regulations and codes to implement and enforce any provision of any law administered by him. Section 72-12-12 NMSA states that it shall be unlawful for any person, firm, or corporation to drill or to begin the drilling of a well for water from an underground source without a valid, existing license for the drilling of such wells issued by the state engineer of New Mexico. Section 72-12-13 NMSA states any person desiring to engage in the drilling of one or more wells for underground water within the boundaries of any underground source shall file an application with the state engineer for a driller license. Sections 72-12-14 through 72-12-17 NMSA further detail requirements for well drillers in New Mexico. Sections 72-13-1 through 72-13-12 NMSA detail the requirements for the drilling of artesian wells.
[19.27.4.3 NMAC - N, 8-31-2005]

19.27.4.4 DURATION: Permanent.
[19.27.4.4 NMAC - N, 8-31-2005]

19.27.4.5 EFFECTIVE DATE: August 31, 2005, unless a later date is cited at the end of a section.
[19.27.4.5 NMAC - N, 8-31-2005]

19.27.4.6 OBJECTIVE: To update written rules for well driller licensing, drill rig supervisor registration, and well drilling within the state of New Mexico.
[19.27.4.6 NMAC - N, 8-31-2005]

19.27.4.7 DEFINITIONS: Unless defined below or in a specific section of these rules, all other words used herein shall be given their customary and accepted meaning. The use of a masculine pronoun to refer to individuals is for grammatical convenience and is intended to be gender neutral.

A. Artesian well: A well that penetrates a saturated hydrogeologic unit and allows underground water to rise or move appreciably into another geologic unit, or allows underground water to rise to freely flow at the land surface. For regulatory purposes, the determination of whether a well or bore hole is artesian shall be made by the state engineer, taking into consideration the potential for loss of water at the land surface or into another geologic unit.

B. Drill rig supervisor: A person registered by the office of the state engineer who may provide onsite supervision of well drilling activities. A drill rig supervisor shall only provide onsite supervision when he is operating under the direction of a licensed well driller.

C. Drilling: see definition for well drilling.

D. Mine drill hole: A deep narrow hole drilled to explore for or delineate deposits or accumulations of ore, mineral, or rock resources.

E. Well: A bore hole, cased or screened bore hole, or other hydraulic structure that is drilled, driven, or dug with the intent of penetrating a saturated geologic unit. The intended use may be for developing a source of water supply, for monitoring water levels, for monitoring water quality, for exploratory purposes, for water remediation, for injection of water, for geothermal purposes, or for other purposes.

F. **Well drilling, well drilling activities:** The activities associated with the drilling of a well, including, but not limited to, the construction, drilling, completion, repair, deepening, cleaning, plugging, and abandonment of a well.
[19.27.4.7 NMAC - N, 8-31-2005]

19.27.4.8 **LICENSE REQUIRED:** Any person who engages in the business of well drilling within the state of New Mexico shall obtain a well driller license issued by the state engineer (except, under New Mexico state law, a well driller license is not required for driven wells that do not require the use of a drill rig and which have an outside casing diameter of two and three-eighths (2⅜) inches or less). A person found engaged in the business of well drilling within the state of New Mexico without a license can be prosecuted in accordance with New Mexico Statutes. A well driller license is not required for work on pumping equipment.
[19.27.4.8 NMAC - Rp, SE 66-1, Article 4-1, 8-31-2005]

19.27.4.9 **EXISTING WELL DRILLER LICENSE RECOGNIZED:** A person holding a valid and current well driller license in the state of New Mexico on August 31, 2005 shall have his license recognized. Any amendment or change to a license shall be made pursuant to the requirements of 19.27.4.16 NMAC and 19.27.4.17 NMAC. A licensed well driller may request that his license be renewed by filing an application with the state engineer prior to the expiration of the current license (see 19.27.4.20 NMAC). A well driller that allows his license to expire and does not reinstate the license within the grace period provided for under 19.27.5.19 NMAC shall apply for a new license in accordance with the requirements of 19.27.4.12 NMAC.
[19.27.4.9 NMAC - N, 8-31-2005]

19.27.4.10 - 19.27.4.11 **RESERVED**

19.27.4.12 **APPLICATION FOR A NEW LICENSE:** An applicant for a well driller license shall meet the following requirements to be considered for licensure.

A. **Qualified applicant:** A qualified applicant for a well driller license shall:

(1) have passed the national ground water association general exam; and

(2) have passed the appropriate national ground water association methodology exam(s) for each type of drilling method for which the applicant has requested to be licensed (the state engineer shall make the final determination of the test(s) necessary should a question arise regarding applicability of available test(s) to applied method(s) of well construction); and

(3) have at least two (2) years of relevant, on-site experience working under the supervision of a licensed well driller; and

(4) effective July 1, 2006, have passed the New Mexico general drilling exam.

B. **Application - form and content:** An application for a well driller license shall be completed on a form prescribed by the state engineer. The application shall include the name, address, and the phone number of the applicant, the state of residency of the applicant, three letters of reference (one of which shall be from a well driller licensed in New Mexico, or a state's licensing authority, attesting to the applicant's well drilling ability), documentation of prior well drilling experience, proof of required bonds, proof of required insurances, documentation that applicant has passed the required exams listed in Paragraphs (1), (2) and (4) of Subsection A of 19.27.4.12 NMAC, the name of each registered drill rig supervisor that the applicant plans to supervise, if known, the type of well drilling methods the applicant is applying to be licensed for, and other information deemed necessary by the state engineer. The application must also contain a description of each active drill rig owned or controlled by the applicant. The description of the drill rig shall be on a form prescribed by the state engineer and shall include a side-view photograph of the rig.

C. **Filing fee:** A fee of fifty dollars ($50) is required to accompany an application for a new license.

D. **Bond requirements:** Each applicant for a well driller license shall file a bond in the penal sum of five thousand dollars ($5,000) on a form acceptable to the state engineer. The surety backing the bond shall be acceptable to the state engineer. A well driller license shall be valid only so long as the bond remains in effect. The bond shall:

(1) be conditioned upon proper compliance with state law and the rules and regulations of the state engineer; and

(2) be effective for the period of time for which the license is issued; and

(3) stipulate the obligee as the "office of the state engineer"; and

(4) not be represented to the public as a performance bond.

E. Insurance requirements: Each applicant for a well driller license shall file with the state engineer proof of general liability insurance in the minimum amount of three hundred thousand dollars ($300,000) and proof of appropriate insurance under the Workers' Compensation Act.
[19.27.4.12 NMAC – Rp SE 66-1, Article 4-2, 8-31-2005]

19.27.4.13 NATIONAL GROUND WATER ASSOCIATION EXAMS: The national ground water association exams shall consist of the general drilling exam and the appropriate drilling methodology exam(s) developed and administered by the national ground water association. If an applicant has passed the national ground water association general exam and appropriate methodology exams in another state, the applicant shall provide written proof to the state engineer. The fee to take the national ground water association exams will be established by the national ground water association.
[19.27.4.13 NMAC - N, 8-31-2005]

19.27.4.14 NEW MEXICO GENERAL DRILLING EXAM: This section has an effective date of July 1, 2006. The New Mexico general drilling exam will be offered at least four (4) times a year by the state engineer or his authorized representative.

A. Exam fee: The fee to take the New Mexico general drilling exam will be based on the approximate cost of administering the test.

B. Test - content: The New Mexico general drilling exam may include questions on the following subjects:

(1) New Mexico water law as it pertains to well driller licensing, well drilling and construction, and the administration of underground water;

(2) the state engineer's rules and regulations pertaining well driller licensing, well drilling and construction, and the administration of underground water;

(3) New Mexico environment department's rules, regulations, and guidelines pertaining to set back requirements, well disinfection, sampling of underground water, and water analysis;

(4) the proper methods and techniques for well drilling;

(5) geologic formations and proper terminology used in describing underground material types;

(6) basic groundwater geology and the occurrence and movement of underground water;

(7) legal description of well location, latitude and longitude, and the New Mexico coordinate system;

(8) global positioning system terminology and receiver operation;

(9) other topics and subjects related to well driller licensing, well construction, and well drilling within the state of New Mexico.

C. Passing the exam: The applicant shall obtain a minimum score of seventy percent (70%) to pass the New Mexico general drilling exam.

D. Re-examination: An applicant who fails to obtain the minimum passing score on the exam may retake the exam.

(1) The fee to retake the New Mexico general drilling exam will be based on the approximate cost of administering the test.

(2) Any applicant found cheating on the exam, as determined by the tester or testing agency, will not be permitted to reapply to take the exam for a period of one (1) year from the date of the transgression.
[19.27.4.14 NMAC - N, 7-1-2006]

19.27.4.15 APPLICATION REVIEW AND LICENSING REQUIREMENTS: If the state engineer finds that an applicant has fulfilled the requirements for licensure as set forth in 19.27.4.12 NMAC, the state engineer shall issue a well driller license to the applicant. The license shall set forth the conditions under which the well driller shall operate his well drilling activities within the state of New Mexico. The license shall also state which drilling methods the well driller may engage in.

A. License duration: A license issued by the state engineer will be valid for a period of two (2) years.

B. Driller identification card: The state engineer will issue a well driller identification card to each licensed well driller. When drilling within the state of New Mexico, a well driller shall have his identification card available for inspection upon request.

C. Drill rig marking: The name and license number of the well driller shall be clearly displayed on each drill rig under his control.

D. **Oversight of registered drill rig supervisor:** A licensed well driller may allow a registered drill rig supervisor to provide onsite supervision of well drilling activities. The licensed well driller is responsible for the actions of each drill rig supervisor that he directs to provide such onsite supervision of well drilling activities.
[19.27.4.15 NMAC - Rp, SE 66-1, Articles 4-4 and 4-5, 8-31-2005]

19.27.4.16 **CHANGES TO LICENSE:** A licensed well driller shall notify the state engineer in writing within 10 days of any change to his current license, including:

A. change in address or any other contact information; or

B. change in drill rig supervisor; or

C. severing ownership or control of an active drill rig; or

D. acquiring ownership or control of an active drill rig (the description of the drill rig shall be on a form prescribed by the state engineer and shall include a side-view photograph of the rig).
[19.27.4.16 NMAC - Rp, SE 66-1, Article 4-9, 8-31-2005]

19.27.4.17 **REQUEST TO BE LICENSED IN ADDITIONAL DRILLING METHODOLOGY:** A licensed well driller shall apply in accordance with the requirements of 19.27.4.12 NMAC to be licensed in an additional drilling methodology.
[19.27.4.17 NMAC - N, 8-31-2005]

19.27.4.18 **RESERVED**

19.27.4.19 **LICENSE EXPIRATION:** A well driller license shall expire on the date set out on the license. An application to renew a license shall be filed in accordance with 19.27.4.20 NMAC at least ten (10) days prior to the expiration date. If an application to renew a license is not filed with the state engineer prior to the expiration of the current license, the license shall automatically expire. The state engineer will allow a forty-five (45) day grace period after the expiration of a well driller license during which time a well driller may file an application to renew his well driller license and request to have the expired license reinstated. If an application to renew a well driller license is not filed within this time period, the license shall be considered expired without option for reinstatement. A well driller that allows his license to expire and does not reinstate the license within the forty-five (45) day grace period must apply for a new license in accordance with the requirements of 19.27.4.12 NMAC.
[19.27.4.19 NMAC - N, 8-31-2005]

19.27.4.20 **LICENSE RENEWAL:** A licensed driller may request that his license be renewed by filing an application with the state engineer prior to the expiration of his current license. The application for renewal of a well driller license shall be completed on a form prescribed by the state engineer.

A. **Form – content:** The application for renewal of a well driller license shall include the name, address, phone number, and license number of the well driller, the state of residency of the well driller, proof of required bonds, proof of required insurances, a list of registered drill rig supervisors that the well driller supervises, evidence of meeting the continuing education requirements, and other information deemed necessary by the state engineer.

B. **Filing fee:** A fee of fifty dollars ($50) shall accompany the application.

C. **Continuing education requirements:** During each two (2) year licensing period, a licensed well driller shall complete a minimum of eight (8) continuing education hours approved by the state engineer. The continuing education hours shall relate to well drilling. At least two (2) hours of the continuing education shall be specific to regulatory requirements regarding well drilling in the state of New Mexico.
[19.27.4.20 NMAC - Rp, SE 66-1, Article 4-6, 8-31-2005]

19.27.4.21 **REPRIMANDS, SUSPENSION OR REVOCATION OF WELL DRILLER LICENSE:** The state engineer may issue a written reprimand, a compliance order issued pursuant to Section 72-2-18 NMSA, or, after notice and hearing held pursuant to 19.25.2 NMAC and 19.25.4 NMAC, suspend or revoke a well driller license if it is found that a well driller:

A. made a material misstatement of facts in his application for license; or

B. failed to submit or submitted an incomplete well record or well log; or

C. made a material misstatement of facts in a well record or well log; or

D. drilled a well in any declared underground water basin without a state engineer permit; or

E. violated the conditions of the state engineer permit under which the well was being drilled; or

F. violated the conditions of his well driller license; or

G. the licensed well driller or his registered drill rig supervisor was not present at the drilling site during well drilling activities; or

H. violated the rules and regulations of the state engineer; or

I. failed to assure the protection of the public safety, health, welfare, and property in the well construction process.

[19.27.4.21 NMAC - Rp, SE 66-1, Article 4-10, 8-31-2005]

19.27.4.22 - 19.27.4.24 RESERVED

19.27.4.25 APPLICATION FOR REGISTRATION AS A DRILL RIG SUPERVISOR: A person registered by the office of the state engineer as a drill rig supervisor may provide onsite supervision of well drilling activities. A drill rig supervisor shall work under the direction of a licensed well driller. The licensed well driller is responsible for the actions of each drill rig supervisor that he directs to provide onsite supervision of well drilling activities. An applicant for registration as a drill rig supervisor shall meet the following requirements.

A. Qualified applicant: A qualified applicant for a registration as a drill rig supervisor shall:

(1) have at least two (2) years of relevant, on-site experience working under the supervision of a licensed well driller; and

(2) be at least eighteen (18) years of age; and

(3) effective July 1, 2006, have passed the New Mexico general drilling exam.

B. Application - form and content: An application for registration as a drill rig supervisor shall be completed on a form prescribed by the state engineer. The application shall include the name, address, and phone number of the applicant, a letter of reference from a well driller licensed in New Mexico, or a state's licensing authority, attesting to applicant's well drilling ability, the license number and contact information of the well driller the applicant plans to work for, if known, documentation of prior well drilling experience, documentation that the applicant has passed the New Mexico general drilling exam, and other information deemed necessary by the state engineer.

C. Filing fee: There is no filing fee for the application.

[19.27.4.25 NMAC - N, 8-31-2005]

19.27.4.26 APPLICATION REVIEW AND REGISTRATION REQUIREMENTS FOR DRILL RIG SUPERVISOR: If the state engineer finds that the applicant has fulfilled the requirements for registration as set forth in 19.27.4.25 NMAC, the state engineer shall register the applicant as a drill rig supervisor. The registration shall set forth the conditions under which the drill rig supervisor may provide onsite supervision of well drilling activities within the state of New Mexico.

A. Registration duration: A registration issued by the state engineer will be valid for a period of two (2) years.

B. Identification card: The state engineer will issue a drill rig supervisor identification card with the registration. Each drill rig supervisor, when providing onsite supervision of well drilling activities within the state of New Mexico shall have his identification card available for inspection upon request.

[19.27.4.26 NMAC - N, 8-31-2005]

19.27.4.27 RENEWAL OF DRILL RIG SUPERVISOR REGISTRATION: A registered drill rig supervisor may request that his registration be renewed by filing an application with the state engineer prior to the expiration of his current registration.

A. Form – content: The application shall be on a form prescribed by the state engineer and shall include the name, address, phone number, and registration number of the drill rig supervisor, the license number and contact information of the well driller the drill rig supervisor is currently working under, evidence of meeting the continuing education requirements, and other information deemed necessary by the state engineer.

B. Filing fee: There is no filing fee for the application.

C. Continuing education requirements: During each two (2) year registration period, a registered drill rig supervisor shall complete a minimum of eight (8) continuing education hours approved by the state engineer. The continuing education hours shall relate to well drilling. At least two (2) hours of the continuing education shall be specific to regulatory requirements regarding well drilling in the state of New Mexico.

D. New Mexico general drilling exam: Persons registered as drill rig supervisor in the state of New Mexico on or before July 1, 2006 shall be required to pass the New Mexico general drilling exam on or before August 31, 2010.
[19.27.4.27 NMAC - N, 8-31-2005]

19.27.4.28 RESERVED

19.27.4.29 WELL DRILLING – GENERAL REQUIREMENTS: All wells shall be constructed to prevent contamination, to prevent inter-aquifer exchange of water, to prevent flood waters from contaminating the aquifer, and to prevent infiltration of surface water. A licensed well driller shall ensure that an appropriate well permit or emergency authorization has been granted by the state engineer prior to the well drilling. A licensed well driller shall ensure that the well drilling activities are made in accordance with 19.27.4.30 NMAC, 19.27.4.31 NMAC, and the following requirements:

A. On-site supervision of well drilling: A licensed well driller or registered drill rig supervisor shall be present at the drilling site during well drilling.

B. Materials: Materials used in well drilling shall conform to industry standards acceptable to the state engineer. Acceptable standards include, but are not limited to, standards developed by the American water works association (AWWA), the American standard for testing materials (ASTM), the American petroleum institute (API), and the national sanitation foundation (NSF). The state engineer shall make the final determination of applicability of standards if any of the acceptable standards are different from one another. Materials used in well construction shall be in new or good condition. No materials shall be used that may cause water contamination. Only potable water shall be placed in a well during well drilling.

C. Cleaning of drilling equipment: All down-hole equipment shall be maintained in a clean and sanitary condition to prevent contamination and to protect the public health. To reduce the potential of contaminating a well, equipment shall be disinfected prior to well drilling with a chlorine solution of household chlorine bleach diluted at one part bleach to nine parts water. Adequate contact time shall be allowed for the disinfectant to sanitize the equipment before rinsing (laboratory testing will not be required).

D. Well setbacks: All wells shall be set back a minimum of fifty (50) feet from an existing well of other ownership, unless a variance has been granted by the state engineer. All wells shall be set back from potential sources of contamination in accordance with New Mexico environment department regulations and other applicable ordinances or regulations.

E. Casing height: The top of all well casings shall extend a minimum of eighteen (18) inches above land surface. All vents installed in the well casing shall be protected against the entrance of foreign material by installation of down-turned and screened "U" bends. All other openings in casings shall be sealed to prevent entrance of foreign material and flood waters.

F. Subsurface vault: The completion of a well within a subsurface vault is not recommended due to difficulty in performing well repairs and cleaning. If a well is completed within a subsurface vault, the casing shall extend a minimum of eighteen (18) inches above the floor of the vault.

G. Surface pad: A concrete pad is recommended on all wells. It is recommended that:

(1) the surface area of the concrete pad be a minimum of four (4) square feet; and

(2) the concrete pad be centered around the well; and

(3) the pad be at least four (4) inches in thickness and slope away from the well; and

(4) when surface casing is used, the surface pad should seal the top of the annular space between the production casing and the surface casing.

H. Access for water level monitoring: Every well shall be constructed with a wellhead opening of at least one half (½) inch diameter to allow the water level to be measured. A water-tight removable cap or plug shall be securely placed in the opening. An artesian well that flows at land surface upon completion of the well shall be equipped with a valve to which a pressure gauge may be attached.

I. Requirement to cover or cap wells: During well drilling, a well shall be securely covered or capped unless a licensed well driller or registered drill rig supervisor is on-site attending to the well. A permanent well cap or cover shall be securely affixed to the well casing upon completion. All permanent caps shall have a well access opening in accordance with Subsection H of 19.27.4.29 NMAC.

J. Well identification tag: The state engineer may require that a well be tagged with a well identification tag. If a well tag is required, the well driller shall affix the tag in plain view. The state engineer will provide a well tag when a permit is issued. Replacement well tags will be issued upon request. The permit holder is responsible for maintaining the well identification tag. A missing, damaged, or illegible well identification tag shall be replaced with a duplicate tag.

K. Well record: The well driller shall keep a record of each well drilling activity as the work progresses.

(1) Time for filing: The well driller shall file a complete well record with the state engineer and the permit holder no later than twenty (20) days after completion of the well drilling.

(2) Form – content: The well record shall be on a form prescribed by the state engineer and shall include the name and address of the permittee, the well driller's name and license number, the state engineer file number, the name of each registered drill rig supervisor that supervised well drilling activities, the location of the well (reported in latitude and longitude using a global positioning system (gps) receiver capable of five (5) meters accuracy), the date when drilling or other work began, the date when drilling or other work concluded, the depth of the well, the depth to water first encountered, the depth to water upon completion of the well (measured by a method approved by the state engineer), the estimated well yield, the method used to estimate well yield, the size and type of casing, the location of perforations, the location of the sanitary seal, and other information deemed necessary by the state engineer. The well record shall include a completed well log. The well log shall include detailed information on the depth and thickness of all strata penetrated, including whether each stratum was water bearing.

L. Geologic formation samples: When requested by the state engineer, the well driller shall furnish lithologic samples ("drill cuttings") of the geologic units penetrated during drilling operations. The method of sampling, interval of sampling, and the quantities required will be specified by the state engineer. Lithologic samples shall be placed in sample bags supplied by the state engineer.
[19.27.4.29 NMAC - Rp, SE 66-1, Articles 4-11, 4-12, and 4-13, 8-31-2005]

19.27.4.30 WELL DRILLING - NON-ARTESIAN WELL REQUIREMENTS: A licensed well driller shall ensure that the well drilling activities associated with the drilling of non-artesian wells are made in accordance with 19.27.4.29 NMAC and the following requirements:

A. Annular seal: All wells shall be constructed to prevent contaminants from entering the hole from the land surface by sealing the annular space around the outermost casing. When necessary, annular seals will be required to prevent inter-aquifer exchange of water, to prevent the loss of hydraulic head between geologic zones, and to prevent the flow of contaminated or low quality water. Sealing operations shall be made with cement grout or bentonite-based sealing material acceptable to the state engineer. Casings shall be centered in the bore hole so grout or sealing materials may be placed evenly around the casing.

(1) Annular space: The diameter of the hole in which the annular seal is to be placed shall be at least four (4) inches greater than the outside diameter of the outermost casing. The diameter of the hole in which the annular seal is to be placed may be reduced to three (3) inches greater than the outside diameter of the outermost casing if pressure grouting from the bottom up is used for grout placement and the well casing is centralized in the bore hole. If surface casing is used, the inside diameter of the surface casing shall be at least three (3) inches greater than the outside diameter of the production casing.

(2) Annular seal completed to land surface: Annular seals shall extend from land surface to at least twenty (20) feet below land surface. If a well is completed less than twenty (20) feet below land surface, the seal shall be placed from land surface to the bottom of the blank casing used. The annular seal shall extend to land surface unless a pitless adapter is installed. For wells completed with a pitless adapter, the top of the seal shall extend to one (1) foot below the pitless adapter connection. All sealing materials placed deeper than twenty (20) feet below land surface shall be placed by tremie pipe or by pressure-grouting through the well casing and up the annulus.

(3) Annular seals to prevent inter-aquifer exchange of water or loss of hydraulic head between geologic zones: Sufficient annular seal shall be placed to prevent inter-aquifer exchange of water and to prevent loss of hydraulic head between geologic zones. Sufficient annular seal shall be placed to prevent loss of hydraulic head through the well annulus, through perforated or screened casing, or through an open bore interval.

(4) Annular seals to prevent the contamination of potable water: Wells which encounter non-potable, contaminated, or polluted water at any depth shall have the well annulus sealed and the well properly screened to prevent the commingling of the undesirable water with any potable or uncontaminated water. The use of salt-tolerant sealing materials may be required by the state engineer in wells that encounter highly mineralized water.

(5) Annular seal requirements for community water supply wells: Community water supply wells shall also be completed with annular seals in accordance with New Mexico environment department regulations and other applicable ordinances or regulations.

B. Well casing: The well casing shall have sufficient wall thickness to withstand formation and hydrostatic pressures placed on the casing during installation, well development, and use.

C. Well plugging: A non-artesian well that is abandoned or not properly constructed shall be immediately plugged. A plan for plugging the well shall be filed with - and approved by - the state engineer prior to plugging. The state engineer may require that the plugging process be witnessed by an authorized representative.

(1) Methods and materials: To plug a well, the entire well shall be filled from the bottom upwards to land surface using a tremie pipe. The well shall be plugged with neat cement slurry, bentonite based plugging material, or other sealing material approved by the state engineer for use in the plugging of non-artesian wells. Wells that do not encounter a water bearing stratum shall be immediately plugged by filling the well with drill cuttings or clean native fill to within ten (10) feet of land surface and by plugging the remaining ten (10) feet of the well to land surface with a plug of neat cement slurry, bentonite based plugging material, or other sealing material approved by the state engineer.

(2) Contamination indicated: Wells encountering contaminated water or soil may require coordination between the office of the state engineer and the New Mexico environment department (or other authorized agency or department) prior to the plugging of the well. Specialty plugging materials and plugging methods may be required.

(3) Plugging record: A licensed well driller shall keep a record of each well plugged as the work progresses. The well driller shall file a complete plugging record with the state engineer and the permit holder no later than twenty (20) days after completion of the plugging. The plugging record shall be on a form prescribed by the state engineer and shall include the name and address of the well owner, the well driller's name and license number, the name of each drill rig supervisor that supervised the well plugging, the state engineer file number for the well, the location of the well (reported in latitude and longitude using a global positioning system (gps) receiver capable of five (5) meters accuracy), the date when plugging began, the date when plugging concluded, the plugging material(s) used, the depth of the well, the size and type of casing, the location of perforations, the location of the sanitary seal, and other information deemed necessary by the state engineer. The plugging record shall include a completed well log. The well log shall include detailed information on the depth and thickness of all strata plugged, including whether each stratum was water bearing.

D. Repair requirements: A well driller license is not required to install or repair pumping equipment.

[19.27.4.30 NMAC - Rp, SE 66-1, Article 4-14, 8-31-2005]

19.27.4.31 WELL DRILLING - ARTESIAN WELL REQUIREMENTS: No artesian well shall be constructed that allows ground water to flow uncontrolled to the land surface or move appreciably between geologic units. For regulatory purposes, the determination of whether a well is artesian shall be made by the state engineer. A licensed well driller shall ensure that well drilling activities associated with the drilling of artesian wells are made in accordance with 19.27.4.29 NMAC and the following requirements:

A. Plan of operations: The permittee or owner of the land upon which the well drilling is planned shall provide a description of the proposed work on a form prescribed by the state engineer. The plan of operations shall list the materials to be used and include the cementing and testing procedures. The plan of operations shall be completed by a licensed well driller. A plan of operations must be approved by the state engineer before the drilling of any artesian well. Drilling of an artesian well shall be made in accordance with a plan of operations approved by the state engineer.

B. Construction inspection: The casing, cementing, plugging, and testing of an artesian well shall be witnessed by an authorized representative of the state engineer.

C. Artesian wells - no prior knowledge of artesian stratum: In the course of drilling a well, if a previously unidentified artesian stratum is encountered, such that underground water is flowing uncontrolled to the land surface or between geologic units, the flow shall be controlled immediately. The state engineer shall be immediately notified that an artesian stratum was encountered, and a plan of operations shall be submitted in accordance with Subsection A of 19.27.4.31 NMAC.

D. Casing and coupling material requirements: Couplings and threaded steel casing used in the construction of an artesian well shall meet minimum American petroleum institute (API) specifications (the API casing specifications are listed in the table below). If the well casing or joint connection proposed in the plan of operations is not listed in the table below, the specifications for the casing and connections shall be approved by the state engineer prior to well drilling. If casing length exceeds one thousand (1,000) feet and the diameter of the casing is thirteen and three-eighths (13⅜) inch diameter or larger, H-grade or better shall be used. The casing for artesian wells shall be inspected by an authorized representative of the state engineer prior to well construction.

Outside Diameter (inches)	Weight with Couplings (lbs/ft)	Wall Thickness (inches)	Coupling O.D. (inches)	Coupling Length (inches)	Threads per Inch	Minimum Grade of Casing
4½	9.50	.205	5.000	5	8	F-25
5½	13.00	.225	6.050	6¾	8	F-25
6	15.00	.233	6.625	7	8	F-25
6⅝	17.00	.245	7.390	7¼	8	F-25
7	17.00	.231	7.656	7¼	8	F-25
7⅝	20.00	.250	8.500	7½	8	F-25
8⅝	24.00	.264	9.625	7¾	8	F-25
9⅝	29.30	.281	10.625	7¾	8	F-25
10¾	32.75	.279	11.750	8	8	F-25
11¾	38.00	.300	12.750	8	8	F-25
13⅜	48.00	.330	14.375	8	8	F-25
16	55.00	.312	17.000	9	8	F-25
20	94.00	.438	21.000	9	8	F-25

E. Casing installation requirements: The casing shall be centered within the bore hole so grout may be evenly placed around the casing. A commercially made float shoe shall be installed on the lowermost joint of casing to be landed unless an alternate method for cementing has been approved by the state engineer. The casing shall be un-perforated and the well shall be designed in a manner to prevent the commingling of water from the artesian stratum with water in an overlying or underlying geologic unit.

F. Annular space: The diameter of the hole in which the cement seal shall be placed shall be at least four (4) inches greater than the outside diameter of the casing set through the confining formation overlying the artesian aquifer. The diameter of the hole in which the cement seal shall be placed may be reduced to three (3) inches greater than the outside diameter of the casing set through the confining formation overlying the artesian aquifer if pressure grouting from the bottom up is used for grout placement and the well casing is centralized in the bore hole. If surface casing is used, the inside diameter of the surface casing shall be at least three (3) inches greater than the outside diameter of the production casing.

G. Annular space cementing requirements: The annular seal shall consist of a neat cement slurry acceptable to the state engineer. The cement seal shall originate within the artesian stratum and shall be continuously placed to land surface. The cementing process shall be witnessed by an authorized representative of the state engineer. When necessary, sufficient annular seal shall be placed to prevent inter-aquifer exchange of water and to prevent loss of hydraulic head between geologic zones.

H. Annular space – cement placement: The cement slurry shall be placed in the annular space by one of the following methods:

(1) Tremie method: The neat cement slurry shall be pumped using a tremie pipe to fill the annular space of the well from the origin of the seal within the artesian stratum to land surface. Flow of undiluted cement out of the top of the annular space shall be established with the tremie pipe suspended in the annulus. The lower end of the tremie shall remain immersed in the cement slurry for the duration of pumping. The tremie pipe may be gradually removed as cement level in the annulus rises.

(2) Pressure grout method: The neat cement slurry shall be pumped down the inside of the casing, through the float shoe, and up the annular space until undiluted cement slurry circulates out of the annulus at land surface. Excess cement may be displaced out of the casing from behind with drilling fluid, but the drilling fluid shall not be pumped entirely to the level of the float shoe except to lodge a drillable plug at the bottom of the casing. Should undiluted cement slurry not be displaced out the top of the annulus in a continuous pressure grouting operation, the cementing job may be completed by the use of the tremie method. If the tremie method is employed, a tremie pipe shall be suspended in the annulus to the approximate level of the competent cement grout. The neat cement slurry shall be pumped to fill the annular space of the well from the top of the competent cement grout to land surface.

I. Sealing off formations: The compressive strength of neat cement shall be five hundred (500) psi or more before well drilling is resumed. Cement must be allowed to set a minimum of forty-eight (48) hours before well drilling is resumed. Shorter set times may be requested if approved accelerants are used. Sealing off of the formations shall be checked by a method acceptable to the state engineer. In the case of remediation of unanticipated artesian bore holes, the compressive strength of neat cement shall be one thousand (1,000) psi or more before artesian head is shut-in at the wellhead.

J. Repair requirements: When an artesian well is in need of repair, the permittee or owner of the land upon which the well is located shall provide a plan of operations to the state engineer. The plan of operations shall be prepared in accordance with Subsection A of 19.27.4.31 NMAC. Before repairs are made to an artesian well, the well shall first be inspected by an authorized representative of the state engineer to determine if the condition of the well is such that it may be repaired. When a leak in the casing is found and the casing and well are otherwise in good condition, the state engineer may allow the well to be repaired. A packer or bridge plug may be required to complete necessary well repairs. The use of a lead packer is prohibited. An inspection shall be made at the completion of the work to determine if the repair is satisfactory. During an inspection, the well shall be open to allow for the entrance of equipment for testing and inspection.

K. Plugging requirements: An artesian well that is abandoned or not properly constructed shall be immediately plugged. Plugging of an artesian well shall require submittal of a plan of operations in accordance with Subsection A of 19.27.4.31 NMAC. The well shall be plugged from the bottom upwards with a neat cement slurry. The well plugging shall be witnessed by an authorized representative of the state engineer.

(1) Well plugging, contamination indicated: Wells encountering contaminated water or soil may require coordination between the office of the state engineer and the New Mexico environment department (or other authorized agency or department) prior to the plugging of the well. Specialty plugging materials and plugging methods may be required.

(2) Plugging record: A licensed well driller shall keep a record of each well plugged as the work progresses. A plugging record shall be filed in accordance with Paragraph 3 of Subsection C of 19.27.4.30 NMAC.
[19.27.4.31 NMAC - Rp, SE 66-1, Articles 4-15, 4-16, 4-17, 4-18, and 4-19, 8-31-2005]

19.27.4.32 - 19.27.4.35 RESERVED

19.27.4.36 REQUIREMENTS FOR MINE DRILL HOLES THAT ENCOUNTER WATER: Any person drilling a mine drill hole that encounters a water bearing stratum shall plug that hole in accordance with Subsection C of 19.27.4.30 NMAC or Subsection K of 19.27.4.31 NMAC within 30 days of encountering the water bearing stratum.

A. Well record required: Within thirty (30) days after the date of the discovery of water, a well record shall be filed in accordance with Subsection K of 19.27.4.29 NMAC.

B. Artesian water encountered: If artesian water is encountered in the process of drilling a mine drill hole, the drill hole shall be constructed or plugged in accordance with 19.27.4.31 NMAC.
[19.27.4.36 NMAC - Rp, SE 66-1, Article 4-21, 8-31-2005]

19.27.4.37 REQUEST FOR VARIANCE: The rules in 19.27.4.29 NMAC, 19.27.4.30 NMAC, and 19.27.4.31 NMAC are not intended to cover every situation encountered during well drilling. Geologic conditions vary across the state, and may warrant the need to deviate from the rules contained in 19.27.4.29 NMAC, 19.27.4.30 NMAC, or 19.27.4.31 NMAC. A request for a variance to a rule in 19.27.4 NMAC shall be submitted in writing by an qualified applicant, permit holder, or licensed well driller. It is recommended that a request for variance be prepared by a licensed well driller. The request shall include a detailed justification for the variance and shall demonstrate that such a variance is necessary to preclude unreasonable hardship or that application of a rule in 19.27.4 NMAC would not be practicable. The state engineer may grant the variance if he finds the request to be reasonable and just. The state engineer shall respond in writing to the request for variance and, if the variance if granted, the state engineer may impose terms and conditions.
[19.27.4.37 NMAC - Rp, SE 66-1, Article 4-22, 8/31/2005]

19.27.4.38 LIBERAL CONSTRUCTION: This part shall be liberally construed to carry out its purpose.
[19.27.4.38 NMAC - N, 8/31/2005]

19.27.4.39 SEVERABILITY: If any portion of this part is found to be invalid, the remaining portion of this part shall remain in force and not be affected.
[19.27.4.39 NMAC - N, 8-31-2005]

HISTORY OF 19.27.4 NMAC:

Pre NMAC History: The material in this part was derived from that previously filed with the State Records Center and Archives.
SE-66-1, Rules and Regulations Governing Drilling of Wells and Appropriation and Use of Ground Water in New Mexico, Article 4, Well Drillers Licensing, Construction, Repair and Plugging Of Wells, originally filed with the Supreme Court Law Library 11/1/66. Filed with the State Records Center 6/27/91.

History of Repealed Material:
SE-66-1, Rules and Regulations Governing Drilling of Wells and Appropriation and Use of Ground Water in New Mexico, Article 4, Well Drillers Licensing, Construction, Repair and Plugging of Wells - Repealed 8/31/2005.

APPENDIX C

Field Forms

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

Pumping Well Data Sheet

Page_____of_____
Date: ___________.
Sampler:_________________

Pumping Well ID:____.
Diameter (inches):____.
Total Depth (ft):____.
Measuring Point:____.

Depth to Water (ft):______________________________.
Water Column Height (ft):__________________________.
Screen Interval (ft bgs):___________________________.

Transducer Model: ____.
Transducer Serial Number: ____.
Time of Transducer Installation:____.
Depth of Transducer (ft): ____.

Pump Model: ______________________________.
Pump Serial Number: ___________________________.
Depth of Pump Intake (ft):_________________________.
Available Water Above Pump Intake (ft):_______________.

Flow Rate Meter #1 Model:____.
Flow Rate Meter #1 Units:____.

Flow Rate Meter #2 Model:__________________________.
Flow Rate Meter #2 Units:__________________________.
Flow Rate Meter #2 Initial Totalizer Reading (gal): _________.

Water Quality Meter Model: ____.
Water Quality Meter Serial Number:____.

Water Level Meter Model:__________________________.
Water Level Meter Serial Number:____________________.

Time	DTW (ft)	Sonic Flow Rate	Sonic Totalizer	Flow Rate #1	Totalizer #1	Flow Rate #2	pH	Temp (°C)	SpC (µS/cm)	DO (mg/L)	ORP (mV)

DTW: Depth to Water
SpC: Specific Conductivity
ORP: Oxidation Reduction Potential
DO: Dissolved Oxygen
Temp: Temperature

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

Pumping Well Data Sheets

Page_____of_____
Date: ___________.
Sampler:__________________

Pumping Well ID:____.

Time	DTW (ft)	Sonic Flow Rate	Sonic Totalizer	Flow Rate #1	Totalizer #1	Flow Rate #2	pH	Temp (°C)	SpC (µS/cm)	DO (mg/L)	ORP (mV)

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GEOSCIENCE & ENGINEERING SOLUTIONS

Observation Well Data Sheet

Page_____of_____
Date: ___________.
Sampler:___________

Observation Well ID:______________________________ Depth to Water (ft):_________________________.
Diameter (inches):_________________________________ Water Column Height (ft):____________________.
Total Depth (ft):___________________________________ Screen Interval (ft bgs):______________________.
Measuring Point:___________________________________ Transducer Installed: YES/ NO

Transducer Model: ____.
Transducer Serial Number: ____.
Time of Transducer Installation:______________________________________.
Depth of Transducer (ft): ____.

Time	DTW (ft)	Comments	Time	DTW (ft)	Comments

APPENDIX D

NM OSE Notice of Intent ICP-WS-01

File Number: ______________
(For OSE Use Only)

NEW MEXICO OFFICE OF THE STATE ENGINEER

NOTICE OF INTENTION TO DRILL WELLS OR RECOMPLETE EXISTING WELLS TO APPROPRIATE NONPOTABLE GROUNDWATER FROM AN AQUIFER THE TOP OF WHICH IS AT A DEPTH OF 2500 FEET OR MORE PURSUANT TO NMSA 1978 §§ 72-12-26 and 27

1. FILER OF NOTICE (required):

Name: INTERA, Incorporated Phone: 505-246-1600
Contact: David Jordan, P.E.
Address: 6000 Uptown Boulevard NE, Suite 220, Albuquerque, New Mexico, 87110

Party on whose behalf the notice is being filed; required if different from filer **(required):**

Name: Intercontinental Potash Corp. (USA) Phone: 575-942-2799
Contact: Randy Foote
Address: 600 West Bender Boulevard, Hobbs, New Mexico, 88240

2. SOURCE OF WATER (required):

Deep Nonpotable Underground Water Basin: Capitan
Target Aquifer(s): Capitan Formation
Estimated depth to top of aquifer (feet): 4325
Estimated total dissolved solids content (parts per million): 11,000

Please provide as "Attachment A" a description of the target aquifer and overlying confining strata, geologic cross sections of the target aquifer and overlying confining strata, and a map showing the lateral extent and depth of the target aquifer and overlying confining strata. Also include any other studies that form the basis for the contention that the target aquifer meets the criteria of 72-12-25 NMSA, addressing total dissolved solids content of the target aquifer groundwater, and hydraulic separation of target aquifer from shallower aquifer systems and surface water. "Attachment A" is required for this form to be complete and the NOI accepted for filing by the state engineer.

3. OWNER OF LAND ON WHICH WELL IS TO BE LOCATED (required):

Name: New Mexico State Land Office Phone: 505-827-5760

If not the same as the filer or appropriator, the access agreement(s) granting the filer and/or the appropriator the right of entry and permission to construct the well(s) for which this Notice of Intention (NOI) is being filed must be submitted as "Attachment(s) B" to this form for this form to be complete and the NOI accepted for filing by the state engineer.

4. LOCATION OF WELL (A, B, or C required, D and E required if known):

A. X = ________ feet, Y = ________ feet, N.M. Coordinate System ______ Zone in the ______________ Grant. U.S.G.S. Quad Map ________

B. Latitude: 32 d 14 m 25.864 s Longitude: 103 d 20 m 21.363 s

C. East ________ (m), North ________ (m), UTM Zone 13, NAD __ (27 or 83)

D. Tract No. ____, Map No. ____ of the __________ Hydrographic Survey

E. Lot No. ____, Block No. ____ of Unit/Tract __________ of the __________ Subdivision recorded in __________ County.

Do Not Write Below This Line

5. **COMMON DESCRIPTION FOR LOCATION OF WELL (required):**

The proposed well(s) for which this NOI is filed is to be located in the county of Lea.
Description by common landmarks: Go 8.4 miles West of the intersection of Cooper Cemetary and State Highway 18, travelling on Cooper Cemetary. The Well will be located about 2.2 miles North from the road at this point.

6. **WELL INFORMATION (required):**

Proposed depth of well 5,500 ft; Outside diameter of casing 9 5/8 inches.
Name of well driller and NMOSE license number United Drilling 1192B
Proposed production interval from 4325 ft bgs to 5500 ft bgs.

An artesian well plan of operations for well construction must be submitted for approval as "Attachment C" to this form for this form to be complete and the NOI accepted for filing by the state engineer.

7. **QUANTITY (required):**

Proposed pumping rate: 1,000 gallons per minute
Diversion amount: 1,614 acre-feet per annum
Consumptive use amount: 1,614 acre-feet per annum

8. **ESTIMATED DURATION OF THE PROPOSED DIVERSION (required):**

40 years based on estimated volume of 64,560 acre-feet

9. **PURPOSE OF USE (required):**

Domestic: ☐ Livestock: ☐ Irrigation: ☐ Municipal: ☐ Commercial: ☐ Oil and gas exploration and production: ☐ Prospecting: ☐ Mining: ☑ Road construction: ☐ Agriculture: ☐ Generation of electricity: ☐
Industrial: ☑ Geothermal: ☐
Other (specify): ____

10. **PLACE OF USE (required):**

Within the land area with the following description:

Subdivision	Section	Township	Range	Acres
W 1/2 of NW 1/4 & W 1/2 of SW 1/4	24	24S	33E	160
E 1/2 of SE 1/4	23	24S	33E	80
W 1/2	25	24S	33E	320
---	26	24S	33E	640
---	35	24S	33E	640
			TOTAL:	1840

11. **COMMON DESCRIPTION OF PLACE OF USE (required):**

County of: Lea
Description by common landmarks: Travel 1.4 miles west of the intersection of Delaware Basin and State Highway 128 on State Highway 128. The Ochoa Project area is located directly to the south of the Highway at this location.

12. **OWNER OF LAND UPON WHICH WATER IS TO BE BENEFICIALLY USED (required):**

United States Bureau of Land Management

13. **DATE (month and year) FOR PLACING WATER TO BENEFICIAL USE (required):**

October, 2015

Do Not Write Below This Line

File Number: ____ Form: wr-30
Trn Number: ____

14. **ADDITIONAL INFORMATION:**

The well ID for this Notice of Intent is ICP-WS-01, permitted as CP-01058 by the New Mexico Office of the State Engineer.

15. **ADDITIONAL STATE ENGINEER REQUIREMENTS ON THE APPROPRIATION OF WATER FROM A WELL DRILLED UNDER THIS NOI:**

a. Driller's well record must be filed with the state engineer no later than twenty (20) days after the completion of well drilling in accordance with 19.27.4 NMAC and § 72-13-5 NMSA.

b. A representative sample of deep aquifer water collected in a manner acceptable to the state engineer shall be analyzed for total dissolved solids (TDS) in parts per million, including concentrations of common anions and cations that constitute common components of measured TDS. All analyses shall be performed by a certified laboratory. Analytical results including description of sampling protocol and sample chain of custody shall be submitted to the state engineer within 20 days of analysis. Specific analyses for radionuclides, arsenic, and other parameters of interest may be requested in anticipation of cooperative agency concerns regarding use and treatment of well water as well as disposition of waste streams. These additional analyses may also aid in establishing hydraulic separation of the aquifer. The state engineer may require additional information in order to validate the aquifer depth and water quality.

c. Prior to pump testing or appropriating any water from the well drilled under this NOI, the filer shall submit to the state engineer copies of all required permits for discharge of water on the land surface or re-injection of the water or wastewater issued by the NM Environment Department or any other state or federal agency having jurisdiction over such disposal.

d. Prior to any diversion of water from the well drilled under this NOI, the well shall be equipped with a functioning totalizing meter acceptable to the State Engineer, installed at the well bead before the first supply line branch. The filer shall notify the Office of the State Engineer in writing of the make, model, serial number, the initial reading, and the date of installation of the totalizing meter.

e. Records of the amount of water diverted from the well drilled under this NOI shall be submitted to the Office of the State Engineer on or before the 10th day of January, April, July, and October for the three preceding calendar months.

f. Water shall be sampled and analyzed for total dissolved solids on a quarterly basis in a manner acceptable to the Office of the State Engineer. Results shall be submitted to the Office of the State Engineer within 20 days of analysis.

g. Pursuant to § 72-8-1 NMSA, the state engineer and his representatives shall be allowed entry upon private property for the performance of their respective duties, including access to the well for meter reading, water level measurement, and water quality sampling.

h. Pursuant to §§ 72-13-8 and 72-13-9 NMSA, water diverted shall be conserved and conducted in such a manner so as to prevent waste.

16. **ONLY THOSE APPROPRIATIONS FROM AQUIFERS DETERMINED BY THE STATE ENGINEER TO BE 2500 FEET IN DEPTH OR GREATER THAT CONTAIN NON-POTABLE WATER (1000 PPM OR GREATER DISSOLVED SOLIDS) NOT HYDROLOGICALLY CONNECTED TO ANY OTHER SOURCE OF WATER WILL BE RECOGNIZED AS VALID WATER RIGHTS.**

i. ACKNOWLEDGMENT

ACKNOWLEDGMENT FOR CORPORATION

I, Randy Foote, affirm that the foregoing statements are true to the best of my knowledge and belief.

By: [signature]

Signature of Officer

State of (New Mexico)
ss.
County of (Lea)

This instrument was acknowledged before me on 10-27-2011,
(date)

by Randy Foote as Chief Operating Officer
(Name of Officer) (Title of Officer)

of Intercontinental Potash Corp. (USA), a Colorado corporation, on behalf of said corporation.
(Name of Corporation Acknowledging) (State of Corporation)

My commission expires 4-29-14

[signature]
Notary Public

OFFICIAL SEAL
GLORIA HERNANDEZ
Notary Public
State of New Mexico
My Comm. Expires 4-29-14

ACKNOWLEDGEMENT FOR INDIVIDUAL

(I, We)________________________ affirm that the foregoing statements are true to the best of my knowledge and belief.

____
Applicant Signature

____
Applicant Signature

State of (________________)
ss.
County of (________________)

This instrument was acknowledged before me on ________________,
(date)

by ________________.
(Name of Applicant)

My commission expires ____________

____
Notary Public

NEW MEXICO OFFICE OF THE STATE ENGINEER

INSTRUCTIONS - NOTICE OF INTENTION TO DRILL WELLS OR RECOMPLETE EXISTING WELLS TO APPROPRIATE NONPOTABLE GROUNDWATER FROM AN AQUIFER THE TOP OF WHICH IS AT A DEPTH OF 2500 FEET OR MORE PURSUANT TO NMSA 1978 §§ 72-12-26 and 27:

a. This form should not be used for an appropriation from a nonpotable deep underground water basin declared by the state engineer unless it is for one of the following specific uses: oil and gas exploration and production, prospecting, mining, road construction, agriculture, generation of electricity, industrial, or geothermal.
b. Completion of sections 1 through 13 of this Notice of Intention (NOI) form is required.
c. An NOI is reviewed for completeness and compliance with §§ 72-12-26 and 27. If incomplete or noncompliant the NOI will not be accepted for filing and it will be returned with a statement of deficiencies.
d. A completed and compliant NOI shall be filed in triplicate at the appropriate OSE District Office with a $25 filing fee. A separate NOI must be submitted for each proposed well.
e. Upon filing of an NOI with the state engineer, the filer shall cause the NOI to be published in the county in which the proposed well is to be located once a week for three consecutive weeks as required by § 72-12-26. The published notice shall also include: *Any person may bring an action in the district court of the county in which any such well is situated for damages or for injunctive relief with respect to any claimed impairment of existing water rights due to an appropriation of nonpotable water under 72-12-25 to 72-12-28 NMSA 1978. Applications to appropriate nonpotable water under § 72-12-28 are not subject to protest or hearing before the State Engineer.*
f. Pursuant to § 72-12-26, drilling of a well may not commence prior to the tenth day after the last date the notice was published. Affidavit of publication shall be filed with the Office of the State Engineer within 10 days of publication.
g. The well shall be drilled in accordance with 19.27.4 NMAC by a driller licensed in the State of New Mexico from surface through an appreciable portion of the first confining unit overlying the deep artesian aquifer.
h. The well shall be set back a minimum of 50 feet from an existing well of other ownership unless a variance has been granted by the state engineer. The well shall be set back from potential sources of contamination in accordance with rules and regulations of the New Mexico Environment Department.
i. The Office of the State Engineer requires that the well be drilled under a valid state engineer permit. An exploratory permit may be used for this purpose and will be issued by the state engineer for drilling a well only upon proof that the foregoing conditions have been satisfied.
j. A state engineer approved artesian well plan of operations for well construction must be adhered to during drilling and shall specify construction of the interval from ground surface down through an appreciable portion of the first confining layer that is found below a depth of 2500 feet. This shall be a condition to the state engineer permit required to drill the well.

LINE BY LINE INSTRUCTIONS

1. Required; name, contact, phone, and address required for the person proposing to drill wells or recomplete existing wells to appropriate nonpotable deep water.
2. Required;
3. Required; access agreements are required for all public and private lands listed as the drill site not owned by the filer or appropriator and shall be submitted with the NOI and are required for the NOI to be complete and accepted for filing.
4. A, B, or C required specifying point location; and D and E are required if known.
5. Required; describe well location by county in which it is to be drilled and by commonly known landmarks.
6. Required; An artesian well plan of operations for well construction must be submitted for approval as "Attachment C" to this form for this form to be complete and the NOI accepted for filing by the state engineer. The proposed well shall be drilled by an NM OSE licensed well driller.
7. Required; state assumptions made regarding well pumping schedule.
8. Required; estimate the number of years that water will be diverted and placed to beneficial use; estimate the volume of groundwater that this is based upon.
9. Required; specify all proposed purpose(s) of use.
10. Required; attach additional pages if necessary.
11. Required; describe place of use by county and using commonly known landmarks.
12. Required;
13. Required; describe when the application of water to beneficial use will begin.
14. Use this space and attach additional pages for additional information related to the proposed appropriation.

Do Not Write Below This Line

File Number: ______________
Trn Number: ______________

Assistance in preparing the notice for publication is available. This Notice of Intention form should be addressed to the **Office of the State Engineer** at the district office determined by the proposed well location:

District No. 1. 5550 San Antonio Dr. NE, Albuquerque, NM 87109; Phone # 505-383-4000

District No. 2. 1900 West Second St., Roswell, NM 88201; Phone # 575-622-6521

District No. 3. P.O. Box 844, Deming, NM 88031; Phone # 575-546-2851

District No. 4. 1680 Hickory Loop, Suite J, Las Cruces, NM 88005; Phone # 575-524-6161

District No. 5 100 Gossett Drive, Suite A, Aztec, NM 87410; Phone # 505-334-4571

District No. 6. P.O. Box 25102, Santa Fe, NM 87504-5102; Phone # 505-827-6120

District No. 7. P.O. Box 481, Cimarron, NM 87714; Phone # 575-376-2918