Discharge Plan & Authorization to Inject APPLICATION

UIC-CL1-008

GUIDELINES FOR THE PREPARATION OF DISCHARGE PLANS AT EFFLUENT DISPOSAL WELL FACILITIES AND IN SITU EXTRACTION WELL FACILITIES

(Revised 3-98)

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TABLE OF CONTENTS

Introduction

The New Mexico Oil Conservation Division (OCD) regulates Class I and V effluent disposal wells and Class III in situ extraction wells pursuant to authority granted in the New Mexico Water Quality Act and the Oil and Gas Act. OCD administers, through delegation by the New Mexico Water Quality Control Commission (WQCC), all Water Quality Act regulations pertaining to surface and ground water except sewage. However, if the sewage is in a combined waste stream, the OCD will have jurisdiction.

Sections 3104 and 3106 of the WQCC Regulations stipulate that, unless otherwise provided for by the regulations, no person shall cause or allow effluent or leachate to discharge so that it may move directly or indirectly into the ground water unless such discharge is pursuant to a discharge plan approved by the director. Additionally, Section 5101 requires all in situ extraction wells and effluent disposal wells to have an approved discharge plan prior to operation. The Oil and Gas Act (Section 70-2-12.B(22)) authorizes the OCD to regulate the disposition of non-domestic, non-hazardous wastes at oil field facilities to protect public health and the environment. The OCD has combined these requirements into one document, (a "discharge plan") that will provide protection to ground water, surface water and the environment through proper regulation.

A proposed discharge plan shall set forth in detail the methods or techniques the discharger proposes to use which will ensure compliance with WQCC regulations and the Oil and Gas Act. The proposed discharge plan must provide the technical staff and the director of the regulating agency (in this case, the OCD) with sufficient information about the operation to demonstrate that the discharger's activities will not cause state regulations or ground water standards (WQCC Section 3103) to be violated.

In addition to meeting the Part 5 WQCC requirements for injection wells, the discharge plan must address surface facility operations including storage pits, tankage and loading areas. Inadvertent discharges of liquids (ie. leaks and spills, or any type of accidental discharge of contaminants) or improper disposal of waste solids still have a potential to cause ground water contamination or threaten public health and the environment.

For existing facilities presently operating under an approved discharge plan, WQCC UIC regulation 5101.G. stipulates that the expiration date of the plan shall be extended provided the following conditions are met: (1) A discharge plan renewal application should be submitted to the OCD at least 180 days prior to plan expiration, and (2) the discharger is in compliance with the existing plan on the original date of expiration. The extension of the existing plan is effective until the OCD approves or disapproves the renewal application. The renewal application should follow the attached guidelines with emphasis on the items that are not included in the original plan.

After a discharge application plan has been received, the OCD must publish a public notice pursuant to Section 3108 of the regulations, and allow 30 days for public comment before a discharge plan may be approved or otherwise resolved. If significant public interest is indicated,

a public hearing will be held which will delay a decision on plan approval.

Once a plan has been approved, discharges must be consistent with the terms and conditions of the plan. Similarly, if there is any facility expansion or process change that would result in any significant modification of the approved discharge of water contaminants, the discharger is required to notify this agency, and have the modification approved prior to implementation. Approval of a discharge plan application by OCD will not relieve the operator of the necessity to become familiar with other applicable state and federal regulations.

The review of a proposed discharge plan often requires several months depending on complexity. This includes time for requests to the discharger for additional information and clarification, in-house information gathering and analysis, and field investigations of the discharge site, and a public notice and comment period. Review time will, to a large extent, be dependent on the extent to which a facility has generally self-contained processes to prevent movement of fluids and leaching of solids from the work area into the environment.

For example, the review process will be expedited when effluent, process or other fluids are routed to tanks, or lined pits with underdrains for leak detection, when accurate monitoring of fluid volumes and pressure and/or integrity testing is performed for leak detection in below grade or underground tanks, and when the possibility of accidental spills and leaks is addressed by adequate contingency plans (e.g. containment by curbing and drainage to properly constructed sumps). Other examples allowing faster review include recycling of waste oils, proper disposal of dried sludges to minimize potential ground water contamination, and closure of previously used ponds. A more rapid review of discharge plans for such facilities is possible because much less geologic and hydrologic study of the site is required in order to delineate impact.

Similarly, longer review times will be required for operators seeking to continue to use unlined ponds or to utilize other procedures that have a high probability of allowing infiltration and movement of effluent and leachate to the subsurface. For these instances large amounts of technical data generally will be required including: 1) detailed information on site hydrogeology, natural and current water quality, and movement of contaminants; 2) processes expected to occur in the vadose and saturated zones to attenuate constituents to meet WQCC standards at a place of present or reasonably foreseeable future use of ground water; and 3) monitoring of ground water (including post operational monitoring as necessary).

If an operator desires to change or modify effluent or solid waste disposal practices it is not necessary to have completed all such changes prior to plan approval. A commitment to make the changes together with submittal of proposed modification details and a timely completion schedule can be included in the plan. These become plan requirements after the plan is approved.

The following discharge plan application guidelines have been prepared for use by the discharger to aid in fulfilling the requirements of Sections 3106, 3107 and Part 5 (UIC) of the WQCC regulations and to expedite the review process by minimizing OCD requests for additional

information. It sets up a logical sequence in which to present the information required in a discharge plan for this type of facility. It is suggested that you read the entire document before preparing your application. Not all information discussed in the guidelines may be applicable to your facility. However, all sections of the application form must be completed for new or renewal discharge plan applications.

NOTE: A completed "Discharge Application" form including date and signature must be included with the application along with the filing fee described in WQCC 3114. The filing fee should be made payable to - NMED Water Quality Management Fund.

If there are any questions on the preparation of a discharge plan, please contact OCD's Environmental Bureau (2040 South Pacheco, Santa Fe, New Mexico 87505 or by telephone at (505) 827-7131).

DISCHARGE PLAN GUIDELINES

1. Type of Operation

   Indicate the major operational purpose(s) of the facility (ie. Effluent Disposal, In Situ Extraction).

2. Name of Operator or Legally Responsible Party and Local Representative

   Include address and telephone number.

3. Location of Discharge Plan Facility

   Give a legal description of the location (i.e. 1/4. 1/4, Section, Township, Range) and county. Use state coordinates or latitude/longitude on unsurveyed land. Submit a large scale topographic map, facility site plan, or detailed aerial photograph for use in conjunction with the written material. It should depict the location of the injection well(s), storage tanks and/or ponds, process equipment, relevant objects, facility property boundaries, and other site information required in Sections 5 through 9 below. If within an incorporated city, town or village provide a street location and map.

4. Landowner(s)

   Attach the name, telephone number, and address of the landowner(s) of record of the facility site.

5. Facility Description

   Attach a detailed description of the surface and subsurface facility with a diagram indicating location of fences, pits, berms, and tanks on the facility. The diagrams of the facility should depict the locations of discharges, storage facilities, disposal facilities, processing facilities and other relevant areas including drum storage. Show the facility/property boundaries on the diagram. Include process flow in the diagrams.

6. Type and Quantities of Fluids Stored or Used at the Facility

   List all fluids stored or used at the facility (e.g. High TDS salt water, hydrocarbons, etc.). Include general composition, whether a solid or liquid, source, average daily volume produced, estimated volume stored, location (yard, shop, drum storage, etc), and type of containers (tank, drum, etc).

7. Transfer, Storage and Disposal of Fluids and Solids

A Provide sufficient information to determine what water contaminants may be discharged to the surface and subsurface within the facility. Information desired includes whether tanks, piping, and pipelines are pressurized, above ground or buried. If fluids are drained to surface impoundments, skimmer pits, emergency pits, sumps, etc. for further transfer and processing, provide size and show if these units are lined or unlined. Provide fluid flow schematics with sufficient detail to show individual units.

(1) Tankage and Chemical Storage Areas - Storage tanks for fluids other than fresh water must be bermed to contain a volume one-third more than the largest tank. If tanks are interconnected, the berm must be designed to contain a volume one-third more than the total volume of the interconnected tanks. Chemical and drum storage areas must be paved, curbed and drained such than spills or leaks from drums are contained on the pads or in lined sumps.

(2) Surface impoundments - Date built, use, type and volume of materials stored, area, volume, depth, slope of pond sides, sub-grade description, liner type and thickness, compatibility of liner and stored materials, installation methods, leak detection methods, freeboard, runoff/runon protection.

(3) Leach fields - Type and volume of effluents, leach field area and design layout. If non-sewage or mixed flow from any process units or internal drains is, or has been, sent to the leach fields, include dates of use and disposition of septic tank sludges.

(4) Solids disposal - Describe types volumes frequency and location of on-site solids dried disposal. Typical solids include sands, sludges, filters, containers, cans and drums.

B For each of the transfer/storage/disposal methods listed above:

(1) Describe the existing and proposed measures to prevent or retard seepage such that ground water at any place of present or future use will meet the WQCC Standards of Section 3103, and not contain any toxic pollutant as defined in Section 1101.TT.

(2) Provide the location and design of site(s) and method(s) to be available for sampling, and for measurement or calculation of flow.

(3) Describe the monitoring system existing or proposed in the plan to detect leakage or failure of any discharge system. If ground water monitoring exists or is proposed, provide information on the number, location, design, and installation of monitoring wells.

C Off-Site Disposal

If wastewaters, sludges, solids etc. are pumped or shipped off-site, indicate general composition (e.g. waste oils), method of shipment (e.g. pipeline, trucked), and final disposition (e.g. recycling plant, OCD-permitted or domestic landfill). All non-exempt wastes will be tested for hazardous constituents per 40 CFR 261 pursuant to EPA approved methods. Approval from the OCD using Form C-138 is required prior to disposal. Include name, address, and location of receiving facility. If receiving facility is a sanitary or modified domestic landfill show operator approval for disposal of the shipped wastes.

D Proposed Modifications

(1) If protection of ground water cannot be demonstrated pursuant to Section B.1. above, describe what modification (including closure) is proposed to meet the requirements of the Regulations. Describe in detail the proposed changes. Provide the information requested in A. and B. above for the proposed modified facility and a proposed time schedule for construction and completion. (Note: OCD has developed specific guidelines for lined surface impoundments that are available on request.)

(2) For ponds, pits, leach fields, etc. where protection of ground water cannot be demonstrated, describe the proposed closure of such units so that existing fluids are removed, and emplacement of additional fluids and runoff/runon of precipitation are prevented. Provide a work plan and a proposed time schedule for closure.

E All facilities must demonstrate the integrity of buried piping prior to commencement of operations and every five there after. If the facility contains underground process or wastewater pipelines the age and specifications (i.e., wall thickness, fabrication material, etc.) of said pipelines should be submitted. A proposed hydrostatic test method and schedule for testing of piping must be included as part of the submittal. All lines must be tested to a pressure of 3 pounds per square inch above the normal operating pressure in the line, and a duration time for the test will also be proposed for OCD approval. If hydrostatic tests have already been conducted, details of the program and the results should be submitted.

F Inspection, Maintenance and Reporting

(1) Describe proposed routine inspection procedures for surface impoundments and other transfer, storage, or disposal units including leak detection systems. Include frequency of inspection, how records are to be maintained and OCD notification in the event of leaks.

(2) If ground water monitoring is used to detect leakage or failure of the surface impoundments, leach fields, or other approved transfer/storage/disposal systems provide:

(a) The frequency of sampling, and constituents to be analyzed.

(b) The proposed periodic reporting of the results of the monitoring and sampling.

(c) The proposed actions and procedures (including OCD notification) to be undertaken by the discharger in the event of detecting leaks or failure of the discharge system.

(3) Discuss general procedures for containment of precipitation and runoff such that water in contact with process areas does not leave the facility, or is released only after testing for hazardous constituents. Include information on curbings, drainage, disposition, notification, etc.

(4) Describe methods used to detect leaks and ensure integrity of above and below ground tanks, and piping. Discuss frequency of inspection and procedures to be undertaken if significant leaks are detected.

(5) Submit a general closure plan describing what actions are to be taken when the facility discontinues operations. These actions must include:

(a) Removal of all fluids, contaminants and equipment.

(b) Grading of facility to as close to the original contour as is practical.

(c) Proper disposal of fluids, sludges and solids pursuant to rules and regulations in effect at the time of closure.

8. Underground Injection/Extraction Well Facilities

All effluent disposal wells and in situ extraction wells must meet the requirements of Part 5 of the WQCC Regulations in addition to other applicable requirements of WQCC and OCD Rules and Regulations.

A. General Provisions

Before drilling, deepening, or plug back operations, the operator of the well must file the following plans, specifications, and pertinent documents with the OCD 90 days prior to start-up of the planned operation.

(1) Form C-101 "Application for Permit to Drill, Deepen, or Plug Back" (OCD Rules 102, and 1101), and a "Notice of Intent to Discharge" in accordance with WQCC regulation 1201 (New facilities only) must be filed with the appropriate OCD District Office prior to start-up of planned operations.

(2) A Division approved plugging bond in the form of a surety bond or other adequate assurances, such as financial statements or other materials acceptable to the Director, such as: (1) a surety bond; (2) a trust fund with a New Mexico bank in the name of the State of New Mexico, with the State as Beneficiary; (3) a non-renewable letter of credit made out to the State of New Mexico; (4) liability insurance specifically covering the contingencies listed in this paragraph; or (5) a performance bond, generally in conjunction with another type of financial assurance. Such bond or materials shall be approved and executed prior to discharge plan permit approval and shall become effective upon commencement of construction. If an adequate bond is posted by the discharger to a federal or another state agency, and this bond covers all of the measures referred to above, the Director shall consider this bond as satisfying the bonding requirements of this Rule wholly or in part, depending upon the extent to which such bond is adequate to ensure that the discharger will fully perform the measures required hereinabove.

(3) The proposed drilling, evaluation, and testing, programs. Include casing and cementing program, logging procedures, coring program, and deviation checks.

(4) A topographic map that depicts surface bodies of water, watercourses, springs, mines, quarries, water wells (specify use of water), local and regional drainage, and other pertinent surface features within two miles from any proposed well will be provided.

(5) A map showing the number, name, and location of all producing oil and gas wells, injection wells, and abandoned holes within the area of review. The area of review for each well or well field will be an area which extends one mile from the well. A circle repesenting the area of review will be drawn around each proposed injection well.

(6) Attach a tabulation of data on all wells of public record, and other shafts or conduits within the area of review which penetrate the proposed injection zone. Such data will include a description of each well's type, construction, date drilled, location, depth, record of completion, and a schematic of any plugged well illustrating all plugging detail.

Identify those wells which may provide a pathway for migration of contaminant through being improperly sealed, completed or abandoned. Detail what corrective action will be taken prior to start up of operations to prevent any movement of contaminants into fresh water resources of less than/equal to 10,000 mg/l TDS through such conduits due to the proposed injection activity (e.g. plugging open holes). Include completion and plugging records.

If information becomes available after operations have begun, which indicates the presence of a conduit that will require plugging then the injection pressure will be limited to avoid movement of contaminants through such a conduit into protected groundwater.

(7) All applicants must furnish proof that a copy of the discharge plan application has been furnished, by certified or registered mail, to the owner of the surface land on which the well is to be located and to each leasehold operator within one-half mile of the well location.

(8) Maps and cross-sections indicating the general vertical and lateral limits of all ground water having 10,000 mg/l or less TDS within two miles of the site. Show the position and give the geologic name of such ground water within this area relative to the injection formation. Indicate the direction of water movement, where known, for each zone of ground water.

B. Additional Information

(1) All facilities will be identified by a sign posted at the entrance. If the well is not within the facility boundaries, it will be identified by a separate sign posted within 20 feet of the well. All signs will be of durable construction and lettering thereon will be kept in legible condition and shall be large enough to be legible under normal conditions at a distance of 50 feet. Each sign will show the facility name discharge plan number, the well number, the name of the lease, the name of the lessee, owner or operator, and the location by quarter-quarter section, township, and range.

(2) Access for emergency response will be identified. Names, addresses, and phone numbers will be provided.

(3) OCD approval will be obtained from the Director prior to performing remedial work or any other workover. Approval will be requested on OCD Form C-103 "Sundry Notices and Reports on Wells" (OCD Rule 1103.A.) with copies sent to the appropriate District Office.

Provide evaluation, completion and well workover information. Include all logs, test results, completion reports and workover descriptions.

(4) The OCD will be notified when operations of the well are discontinued for a period in excess of six months.

(5) The OCD will be notified prior to any transfer of ownership, control, or possession of the well. A written commitment to comply with the terms and conditions of the previously approved discharge plan and a bond must be submitted by the purchaser and approved by the OCD prior to transfer.

C. Effluent Disposal Wells

Injection will be limited to exempt, and/or non-hazardous oil field wastes. All wastes will be surveyed for Naturally Occurring Radioactive Material (NORM) pusuant to 20 NMAC 3.1 Subpart 14. All non-exempt oil field waste will be tested for the hazardous constituents per 40 CFR 261 pursuant to EPA approved methods, and will require aproval from the OCD prior to acceptance and disposal. Requests will be made using OCD Form C-138.

(1) Class I Exempt, and/or Non-Hazardous Salt Cavern Disposal Wells

(a) Distance to all populated areas, industrial facilities, and all rights of way within a two mile radius of the well will be provided.

(b) Current uses of all adjacent properties within a two mile radius of

the well will be provided.

(c) Proximity to other subsurface activities will be provided. The minimum distance between caverns will be a S/D of 4:1, where S equals the distance between cavern centers and D equals the average maximum diameter of the caverns, unless site specific geomechanical studies show that caverns may be closer.

(d) Actual or estimated depth to cavern top will be provided using logs or other appropriate methods.

(e) Actual or estimated proximity to salt boundary will be provided using logs or other appropriate methods.

(f) A chemical analysis of fresh water from two or more fresh water wells within one mile of the proposed disposal well will be provided. Analysis will be for hazardous constituents per 40 CFR 261 and general chemistry pusuant to EPA approved methods. At least one fresh water well will be up-gradient, and one down-gradient from the proposed disposal well.

(g) Data regarding the potential for seismic activity, regional stress and strain, structural anomalies, and mechanical and chemical properties of the salt formation will be provided.

(h) All active or abandoned conventional and solution mining activities within 10 miles of the well will be provided.

(i) Maps and cross-sections detailing the stratigraphy, structure, and lithology of the formations from the land surface to the underlying formations showing the bedded salt, anhydrite layers, formations above the bedded salt, the confinement strata. Include appropriate geologic names.

(j) Potential for ground subsidence for the proposed storage facility will be provided. A plan outlining the design and implementation of subsidence monitoring will be provided.

(k) The corrosion history will be reviewed for wells within the area of review. Cathodic protection will be required based on current usage in the area of review.

(l) Casing will be designed for the life expectancy of the well to avoid

corrosion, losses of disposal fluids, and potential contamination of fresh water resources. A minimum of one casing string will be set below all fresh water bearing strata, and cemented to the surface. All intermediate and production casing strings will be cemented to the surface. All cement tops, and cement integrity will be verified by cased hole logging methods.

(m) Submit a proposed plan for cavern and well integrity testing. Cavern and well integrity will be demonstrated prior to beginning operations and annually thereafter, and after any workover. The cavern and well will be isolated from one another and each tested to 1.5 times the average operating pressure or 300 psig, whichever is greater, for four hours with zero bleed-off. The cavern pressure must be allowed to stabilize to a rate change of less than 10 psig in 24 hours prior to testing. If integrity of the cavern or well cannot be demonstrated, the well will be shut-in and the OCD Santa Fe Division Office notified immediately.

(n) The cavern size and configuration will be surveyed, using an OCD approved method, prior to beginning operations, and prior to discharge plan renewal, or at least every five years thereafter, or more frequently as the Director may require.

(o) The cavern will be equipped with a hydrocarbon blanket prior to operations to avoid excessive leaching of the cavern roof. Blanket volumes will be sufficient to effectively coat the entire cavern roof. Proposed blanket volumes will be provided. Prior to each discharge plan renewal, or at least every five years, the cavern roof and blanket will be monitored using an OCD approved method.

(p) After the hydrocarbon blanket is in place, and prior to beginning operations at the facility, the cavern will be completely filled with fully saturated brine. Chemical analysis of the brine will also be provided prior to beginning operations. Chemical analysis will include testing for hazardous constituents per 40 CFR 261 and general chemistry pursuant to EPA approved methods.

(q) All wireline logs run for the purpose of evaluating the formation, cavern, and well bore will be provided.

(r) If liners are utilized, they will be designed in accordance with casing requirements and have an overlap of 100 feet in the previous casing string.

(s) Tubing will be equipped with a mechanical packer set within 100 feet above the casing shoe of the lowermost casing string. The casing/tubing annulus will be loaded with an inert packer fluid.

(t) Records of all wastes accepted for disposal will be maintained at the facility. For each volume of waste received, the record will indicate the generator, type, volume, chemical makeup, salinity, and percent solids of such waste.

(u) Acceptance and disposal of wastes at the facility will occur only when an attendant is on duty. The facility will be secured when no attendant is present.

(v) The maximum injection pressure at the wellhead shall not initiate new fractures or propagate existing fractures in the confining zone, or cause the movement of injection or formation fluids into ground water have 10,000 mg/l or less TDS. Shut-in pressure at the surface on the brine withdrawal string or annulus will not be greater than 100 psi. Pressure limiting devices will be installed which will limit the pressures to OCD limits. Pressure limiting devices will be demonstrated annually to operate to the satisfaction of the OCD.

(w) Waste emplacement and brine withdrawal will be down the tubing. Waste emplacement and brine displacement will be volume for volume.

(x) The carrier fluid used to facilitate disposal will be exempt and/or non-hazardous fully saturated brine. The volumes used for disposal are to be recorded and maintained at the facility with results submitted to the OCD Santa Fe Division Office.

(y) The final disposition of the displaced brine will be provided. All displaced brine volumes will be measured, and recorded with results submitted to the OCD Santa Fe Division Office.

(z) Continuous monitoring and recording devices will be installed and mechanical charts made of cavern pressure, injection pressure, flow rate, and flow volumes. All records will be maintained until final closure is achieved.

(aa) Ground subsidence monitoring will be conducted and recorded at

least every five years. Monitoring will take place in the same season of the year. All records will be maintained until final closure is achieved.

(bb) A minimum of one monitor well will be installed upgradient and a minimum of one monitor well will be installed downgradient from the disposal cavern to monitor ground water for potential leakage from the disposal cavern. All wells will be sampled quarterly, from the beginning of operations until final closure is achieved, for hazardous constituents per 40 CFR 261 and general chemistry pursuant to EPA approved methods. Ground water elevations will be measured quaterly for all wells. Sample results and ground water elevations will be submitted to the Santa Fe Division Office.

(dd) In the event of a fluid loss or abnormal pressure increase and/or decrease, the well will be shut-in and the Santa Fe Division Office notified immediately.

(ee) All personnel associated with operations at the cavern disposal facility will have appropriate training in accepting, processing, and disposing of exempt, and non-exempt non-hazardous oil and gas wastes to insure proper disposal. All training documentation will be maintained until final closure is achieved.

(ff) All routine maintenance work on the well and all associated equipment will be recorded and maintained by the operator for the life of the well.

(gg) After disposal operations are completed, and prior to shut-in, the hydrocarbon blanket present within the cavern will be removed and disposed of or recycled according to OCD rules. All oil and gas wastes and carrier fluids remaining at the surface, and facility equipment will be disposed of according to OCD rules. Any remaining cavern space will be completely filled with fully saturated brine. The cavern and its roof will be tested for stability, and size and configuration determined using an OCD approved method. The cavern, wellbore, and cement will be tested for integrity using an OCD approved method.

(hh) Prior to plugging and abandonment the well will be shut-in according to OCD rules and the cavern pressure continuously monitored and recorded until the OCD deems the cavern stable and suitable for plugging and abandonment. Recorded pressures will

be submitted to the OCD quarterly. Shut-in pressure will not exceed overburden pressure. Provide a procedure for any intentional pressure releases during shut-in. Any fluids released as a result of pressure releases will be disposed of according to OCD rules.

(ii) After stabilization is achieved, a cast iron bridge plug will be set within thirty feet of the casing shoe, and pressure tested to the maximum anticipated differential pressure across the plug for ten minutes, with no pressure loss. The bridge plug will then be capped to the surface with cement, and marked in accordance with OCD rules.

(jj) After plugging and abandonment, all surface equipment will be removed and the ground surface returned to natural conditions pursuant to the closure plan.

(kk) The OCD will be notified 72 hours prior to all testing, surveying, or monitoring. A complete record of all testing, surveying, or monitoring will be filed in the Santa Fe Division Office within 30 days.

(ll) All records of waste volumes disposed of, and brine volumes produced will be submitted to the Santa Fe Division Office quarterly along with required chemical testing.

(2) Class I Exempt, and/or Non-Hazardous Disposal Wells

(a) Attach appropriate geological data (i.e. maps and cross-sections) on the geology and geologic structure of the local area, injection zone including lithologic detail, geological name, thickness and depth.

(b) Provide the proposed injection interval. Give the depths of any other perforated intervals and detail on the sacks of cement and/or bridge plugs used to seal off such perforations. Give the depth to and name of the next higher and next lower oil or gas zone in the area of the well, if any.

(c) Casing will be designed to avoid corrosion, losses of disposal fluids, and potential contamination of fresh water resources. A minimum of one water protection casing string will be set below all fresh water bearing strata, and cemented to the surface. All

intermediate casing strings will be cemented to the surface. All cement tops, and cement integrity will be verified by logging.

(d) The proposed stimulation, injection, and operation procedures (Note WQCC 5206 limitations).

(e) Provide the proposed maximum and average injection pressures, rates, and injection volume.

(f) The maximum injection pressure at the wellhead will not exceed 0.2 psi per foot of depth. Pressure limiting devices will be installed which will limit the pressures to OCD limits. Pressure limiting devices will be demonstrated annually to operate to the satisfaction of the OCD.

(g) Submit a proposed mechanical integrity testing program. Prior to commencement of operations, during well workovers, and annually the OCD requires the production casing to be isolated from the formation and tested to 300 psi for 30 minutes. The OCD will be notified at least 72 hours prior to all testing.

(h) Provide an analysis of the formation fluid and the injection fluid using EPA approved methods. Include location and design of site(s) and method(s) of sampling. Analysis will be for hazardous constituents per 40 CFR 261 and general chemistry.

(i) Records of all wastes accepted for disposal will be maintained at the facility. For each volume of waste received, the record will indicate the generator, type, volume, chemical makeup, salinity, and percent solids of such waste.

(j) The following reports will be signed and certified in accordance with WQCC section 5101.H. and submitted quarterly to both the OCD Santa Fe Division and the appropriate District Offices:

(i) Results of the chemical analysis of the injection fluids.
(ii) Monthly average, maximum and minimum values for injection pressures; flow rate and flow volume; and, annular pressure.

(iii) A report listing, by month, the volume of fluids injected.

(k) Monthly reporting of the disposal of produced water will be in

accordance with OCD Rule 1115 which requires monthly submittal of OCD Form C-115 to the OCD Santa Fe Office.

(l) The casing-tubing annulus will be filled with an appropriate Packer fluid and a minimum pressure of 100 psi maintained. Alternate methods required a written request that is to be submitted to the OCD for approval.

(m) Continuous monitoring and recording devices will be installed and mechanical charts made of injection pressure, flow rate, flow volume, and annular pressure. Mechanical charts are to be maintained by the operator for the life of the well.

(n) All routine maintenance work on the well and all associated equipment will be recorded and maintained by the operator for the life of the well.

(o) A plan for plugging and abandonment of the well that meets the requirements of WQCC regulations section 5209.

(3) Class IV Disposal Wells

Class IV wells are used to inject hazardous or radioactive wastes into or above a formation that is within one-quarter mile of an underground source of drinking water (USDW). Class IV wells are generally prohibited by 40 CFR 144.13.

(4) Class V Disposal Wells

Class V wells are shallow waste disposal wells which inject a variety of fluids into or above a formation that is within one-quarter mile of a USDW (40 CFR 144.6). They include shallow non-hazardous industrial waste injection wells, septic systems, storm water drainage wells, and assorted other wells. Class V wells are regulated under the authority of Part C of the Safe Water Drinking Act (SWDA).

Septic systems, leach fields, and other wastewater disposal systems at OCD regulated facilities which inject fluid other than domestic waste sewage below the surface are considered Class V injection wells under the EPA UIC program. All class V wells will be closed unless, it can be demonstrated that protectable groundwater will not be impacted in the reasonably foreseeable future. Class V wells must be closed through the Santa Fe Office. The OCD allows industry to submit closure plans

which are protective of human health, environment and groundwater as defined by the WQCC, and are cost effective.

D. In Situ Extraction Wells

(1) Class III Brine Extraction Wells

(a) Attach appropriate geological data (i.e. maps and cross-sections) on the geology and geologic structure of the local area, injection zone including lithologic detail, geological name, thickness and depth.

(b) Provide the proposed injection interval.

(c) Casing will be designed for the life expectancy of the well to avoid corrosion, losses of disposal fluids, and potential contamination of fresh water resources. A minimum of one water protection casing string will be set below all fresh water bearing strata, and cemented to the surface. All intermediate casing strings will be cemented to the surface. All cement tops, and cement integrity will be verified by logging.

(d) The proposed stimulation, injection, and operation procedures (Note WQCC 5206 limitations).

(e) Provide the proposed maximum and average injection pressures and injection volume. If one well is to be used for injection and extraction, fresh water must be injected down the annulus and brine must be recovered up the tubing. Reverse flow will be allowed for up to once a month for 24 hours for clean out. If an alternative operating method is desired then a written request must be submitted to the OCD which describes the proposed operating procedures and how the mechanical integrity of the casing will be guaranteed.

(f) Submit a proposed mechanical integrity testing program. Prior to commencement of operations or during well work over the OCD requires the casing to be isolated from the formation and tested to 300 psi for 30 minutes. Annually the OCD requires all injection wells to have an open hole pressure test equal to 1.5 times the average operating pressure or 300 psi, which ever is greater, for four hours with ten percent bleed-off allowed. At the time of discharge plan renewal or at least once every five years all injection

wells will be required to perform the above mentioned open hole test with zero bleed-off allowed. If zero bleed-off cannot be achieved, the casing will be isolated from the formation and tested to 300 psi for 30 minutes.

(g) Provide an analysis of the injection fluid and brine. Include location and design of site(s) and method(s) of sampling. Analysis will be for concentrations of Total Dissolved Solids, Sodium, Calcium, Potassium, Magnesium, Bromide, Carbonate/Bicarbonate, Chloride and Sulfate.

(h) Submit a proposed cavern size and configuration testing program. A test will be conducted at the time of each discharge plan renewal, or at least every five years, to determine the size and configuration of the salt cavern. The method and time of testing will be approved by the OCD prior to performing the test. The OCD will be notified at least 72 hours prior to all testing.

(i) Potential for ground subsidence for the proposed storage facility will be provided. A plan outlining the design and implementation of subsidence monitoring will be provided.

(j) Ground subsidence monitoring will be conducted and recorded at least every five years. Monitoring will take place in the same season of the year. All records will be maintained until final closure is achieved.

(j) Compare volumes of fresh water injected to volume of brine to detect underground losses and specify method by which volumes are determined. After approval, submittal of a quarterly report listing, by month, the volume of fluids injected and produced will be required.

(k) A plan for plugging and abandonment of the well that meets the requirements of WQCC regulations section 5209.

(2) Class III Geothermal Wells

(a) Form G-101 "Application for Permit to Drill, Deepen, or Plug Back" (OCD Rule G-201), and a "Notice of Intent to Discharge" in accordance with WQCC regulation 1201 (New facilities only) must be filed with the OCD prior to start-up of planned operations.

(b) Attach appropriate geological data (i.e. maps and cross-sections) on the geology and geologic structure of the local area, injection zone including lithologic detail, geological name, thickness and depth.

(c) The proposed stimulation, injection, and operation procedures (Note WQCC 5206 limitations).

(d) A plan for plugging and abandonment of the well that meets the requirements of WQCC regulations section 5209. **A plugging bond pursuant to OCD Rule G-101 is required prior to commencement of any new well drilling operations.**

(e) Before performing remedial work, altering or pulling casing, plugging or abandonment, or any other workover, approval of OCD must be obtained. Approval should be requested on OCD Form G-103 "Sundry Notices and Reports on Geothermal Resource Wells" (OCD Rule G-203).

8. Spill/Leak Prevention and Reporting Procedures (Contingency Plans)

It is necessary to include in the discharge plan submittal a contingency plan that anticipates where any leaks or spills might occur. It must describe how the discharger proposes to guard against such accidents and detect them when they have occurred. The contingency plan also must describe the steps proposed to contain and remove the spilled substance or mitigate the damage caused by the discharge such that ground water is protected, or movement into surface waters is prevented. The discharger will be required to notify the OCD Director in the event of significant leaks and spills. This commitment and proposed notification threshold levels must be included in the contingency plan.

A Prevention

Describe how spills and leaks will be prevented at the facility. Include specifically how spillage/leakage will be prevented during truck loading and at major transfer points within the facility. Discuss general "housekeeping" procedures for areas not directly associated with the above major processes.

B Containment and Cleanup

Describe procedures for containment and cleanup of major and minor spills at the facility. Include information as to whether areas are curbed, paved, and drained to double lined sumps with leak detection; final disposition of spill materials; etc.

C Notification

Propose a schedule for OCD notification of spills. The OCD requires the discharger to notify the appropriate OCD District Office and the OCD Santa Fe Division Office within 24 hours and written subsequent notification of minor spills or within 15 days (OCD Rule 116 and WQCC 1203).

9. Site Characteristics

A The following hydrologic/geologic information is required to be submitted with all discharge plan applications.

(1) Provide the following information and attach or reference source information as available (e.g. driller's logs):

(a) Soil type(s) (sand, clay, loam, caliche);

(b) Depth to rock at base of alluvium (if available).

(2) Provide information on:

(a) The flooding potential at the discharge site with respect to major precipitation and/or run-off events; and

(b) Flood protection measures (berms, channels, etc.), if applicable.

B Additional Information

Provide any additional information necessary to demonstrate that approval of the discharge plan will not result in concentrations in excess of the standards of WQCC Section 3103 or the presence of any toxic pollutant (Section 1101.TT.) at any place of withdrawal of water for present or reasonably foreseeable future use. Depending on the method and location of discharge, detailed technical information on site hydrologic and geologic conditions may be required to be submitted for discharge plan evaluation. **Check with OCD before providing this information.** However, if required it could include but not be limited to:

(1) Stratigraphic information including formation and member names, thickness, lithologies, lateral extent, etc.

(2) Generalized maps and cross-sections;

(3) Potentiometric maps for aquifers potentially affected;

(4) Porosity, hydraulic conductivity, storativity and other hydrologic parameters of the aquifer;

(5) Specific information on the water quality of the receiving aquifer; and

(6) Information on expected alteration of contaminants due to sorption, precipitation or chemical reaction in the unsaturated zone, and expected reactions and/or dilution in the aquifer.

10. Other Compliance Information

Attach such other information as is necessary to demonstrate compliance with any other OCD rules, regulations and/or orders. Examples include previous Division orders or letters authorizing operation of the facility or any surface impoundments at the location.

SUBSURFACE

DISCHARGE PLAN APPLICATION AND APPLICATION FOR AUTHORIZATION TO INJECT, PER OIL CONSERVATION DIVISION FORM C-108, INTO CLASS I WELL WDW-1 AND PROPOSED WDW-2 AND WDW-3

VOLUME I
SECTIONS I THROUGH VII

NAVAJO REFINING COMPANY
Artesia, New Mexico

Subsurface Project No. 60A4305
Subsurface Project No. 60A4937

October 1999

Prepared By:

SUBSURFACE TECHNOLOGY, INC.
Houston, Texas

SUBSURFACE

October 5, 1999

Mr. Wayne Price
New Mexico Oil Conservation Division
2040 South Pacheco
Santa Fe, New Mexico 87505

RE: Navajo Refining Company WDW-2 Discharge Plan Application
Response to New Mexico Oil Conservation Division Comments Received August 6, 1999, and August 10, 1999
Subsurface Project No. 60A4937

Dear Mr. Price:

Enclosed, please find two sets of replacement pages for the document DISCHARGE PLAN APPLICATION AND APPLICATION FOR AUTHORIZATION TO INJECT, PER OIL CONSERVATON DIVISION FORM C-108, INTO CLASS I WELLS WDW-1 AND PROPOSED WDW-2 AND WDW-3, submitted by Navajo Refining Company (Navajo). These replacement pages address the referenced comments. These responses were prepared for Navajo by Subsurface Technology, Inc. (Subsurface).

A detailed instruction sheet for page replacement is provided as Attachment A. For your convenience, this instruction sheet also explains the reason that each page or section was added or replaced. One copy of these replacement items has also been sent to the New Mexico Oil Conservation Division – District II in Artesia.

Please do not hesitate to contact me at (713) 880-4640 or Darrell Moore of (505) 748-3311 if you have any questions.

Sincerely,

Nancy L. Niemann

Nancy L. Niemann
Senior Geologist

NLN/tjp
Enclosures

c: New Mexico Oil Conservation Division – District II
Darrell Moore (Navajo)
George Walbert (Holly)

price ltr4

Subsurface Technology, Inc.
7020 Portwest Drive Suite 100 Houston TX 77024
713/880-4640 Fax 713/880-3248 1-800-535-4105

ATTACHMENT A

INSTRUCTIONS FOR REPLACEMENT OF PAGES ASSOCIATED WITH ADDENDUM 2

1. Replace the document Table of Contents dated Revised April 16, 1999 with the Table of Contents dated Revised September 22, 1999. This change adds reference to Addendum 2 and Attachment VI-1A.

2. In Volume I, Add Addendum No. 2 to the document behind Addendum 1. Addendum 2 is the response to OCD comments received on August 6 and August 10, 1999.

3. In Volume I, Section III, replace Attachment III-1 (Injection Well Data Sheet, WDW-1) dated Revised April 16, 1999 with Attachment III-1 (Injection Well Data Sheet, WDW-1) dated Revised September 16, 1999. This rectifies an incorrect perforation depth.

4. In Volume I, Section V, replace page V-1 dated Revised April 16, 1999 with page V-1 dated Revised September 16, 1999. This clarifies the addition of Attachment VI-1A.

5. In Volume I, Section VI, replace pages VI-1 through VI-11 dated Revised April 16, 1999 with pages VI-1 through VI-12 dated Revised September 16, 1999. This changes the reference to Attachment VI-1A on page VI-5 and deletes the sentence mentioned in Comment Item 2 on page VI-7.

6. In Volume I, Section VI, replace Attachment VI-1 (Construction Data for Wells Within 1 Mile of the Proposed Injection Wells) with Attachment VI-1 (Tabulation of Wells within 1 Mile of the Proposed Injection Wells) and Attachment VI-1A (Construction Data for Wells that Penetrate the Injection Zone within 1 Mile of the Injection Wells). This addresses Comment Item 3 by replacing the original Attachment VI-1 with the new Attachments VI-1 and VI-1A.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

ATTACHMENTS

TABLE OF CONTENTS (Continued)

VOLUME II

ATTACHMENTS

TABLE OF CONTENTS (Continued)

ATTACHMENTS

TABLE OF CONTENTS (Continued)

SUBSURFACE

ADDENDUM NO. 2

RESPONSE TO COMMENTS ON THE DISCHARGE PLAN APPLICATION RECEIVED ON AUGUST 6 AND 10, 1999 FROM THE NEW MEXICO OIL CONSERVATION DIVISION

NAVAJO REFINING COMPANY
Artesia, New Mexico

Subsurface Project No. 60A4937

September 1999

Prepared By:

SUBSURFACE TECHNOLOGY, INC.
Houston, Texas

TABLE OF CONTENTS

TABLES

FIGURES

APPENDIX

NEW MEXICO ENERGY, MINERALS & NATURAL RESOURCES DEPARTMENT

Jennifer A. Salisbury
CABINET SECRETARY

Oil Conservation Div.
Environmental Bureau
2040 S. Pacheco
Santa Fe, NM 87505

Memorandum of Meeting or Conversation

Telephone __X___
Personal _____

Time: 3:35 pm
Date: August 6, 1999

Originating Party: **Wayne Price-OCD, Rc Anderson-OCD**

Other Parties: Darrell Moore-Navajo

Subject: Class I WDW-2 DP# UIC-CLI-008

Discussion:

Notified Darrel Moore that OCD-UIC group could not continue evaluation until the following issues were addressed:

1. Class I well WDW-2 was marked as tubing not being lined. Attachment III-2
2. Section VI-6 Active Producing wells second sentence " The mechanical integrity of active producing wells is monitored by the OCD." OCD pointed out we cannot perform this service for them.
3. Attachment VI-1 table for AOR wells is incomplete.

Conclusions or Agreements:

Navajo to address these issues.

Signed: _____

CC: Darrell Moore-Navajo
Mark Ashley-OCD

NAVAJO RESPONSES TO OCD COMMENTS

OCD Comment:

1. **Class I well WDW-2 was marked as tubing not being lined. Attachment III-2.**

   Response:

   The injection tubing in the injection well is not lined. The tubing is 3-1/2 inch 9.2 lb/ft, J-55, seamless, NUE 10rd API injection tubing set at 7528 feet measured depth. Prior to injection operations, Navajo will establish a corrosion monitoring protocol in which coupons of tubular material are constantly exposed to the injected waste stream and periodically evaluated for corrosion.

OCD Comment:

2. **Section VI-6, Active Producing wells, second sentence "The mechanical integrity of active producing wells is monitored by the OCD". OCD pointed out we (OCD) cannot perform this service for them.**

   Response:

   The quoted sentence has been removed from the text of the document.

OCD Comment:

3. **Attachment VI-1 table for AOR wells is incomplete.**

   Response:

   Attachment VI-1 was constructed to list all wells within one mile of the proposed injection wells, and to document the construction details of wells within one mile which penetrate the injection zone. Construction details of wells that do not penetrate the injection zone were not required and were not included. To avoid potential

confusion, Attachment VI-1 has been separated into two attachments. The revised Attachment VI-1 lists all wells within one mile of the injection wells. This attachment provides information on the type, total depth, and completion or plugging date. Attachment VI-1A lists only those wells within one mile of the injection wells that penetrate the injection zone, and provides construction details of those wells.

OCD Comment:

4. **OCD questioned whether Artificial Penetration No. 851 is adequately plugged to prevent vertical fluid migration from the injection zone into shallower, salt-water bearing zones. (This comment was relayed to Navajo in a conversation with Mr. Wayne Price of the OCD on August 10, 1999).**

   Response:

   The Amoco Production Company Smith-McPherson No. 1 (Map ID No. 851) penetrates approximately 90 feet into the Lower Wolfcamp injection zone. The lithology of this portion of the Lower Wolfcamp is low-porosity dolomite and shale. The bottom of the well is stratigraphically equivalent to a measured depth of approximately –7370 feet in WDW-2, or 100 feet below the top of the injection zone in WDW-2.

   The highest perforations in WDW-2 are at a measured depth of –7570 feet. In WDW-2 the lithology of interval between –7370 feet and –7570 feet also consists of low-porosity dolomite and shale, as illustrated on the porosity log of WDW-2 (Attachment VIII-2A). Thus, approximately 200 feet of low-porosity dolomite and shale form a barrier to the propagation of pressure transmitted from WDW-2 to the Amoco Production Company Smith-McPherson No. 1 (Map ID No. 851). Since pressure cannot be effectively transmitted to The Amoco Production Company Smith-McPherson No. 1 (Map ID No. 851), the condition of the wellbore becomes moot.

   In a worst-case situation, however, the effect of pressure communication between WDW-2 and The Amoco Production Company Smith-McPherson No. 1 (Map ID No. 851) may be evaluated in light of the condition of the wellbore in The Amoco Production Company Smith-McPherson No. 1 (Map ID No. 851).

A cement plug was set in the Amoco Production Company Smith-McPherson No. 1 (Map ID No. 851) at ~4500 feet. From the cement plug to the bottom of the well, the wellbore is filled with drilling mud of at least 9.2-lb/gal density. While the presence of the cement plug insures that no contamination of the USDW can occur, it is useful to examine the potential for interformational fluid movement in the presence of the encapsulated mud column below the cement plug. The long-term physical properties of the drilling fluid left in the wellbore act to prevent vertical movement of fluids. These properties form the subject of the following discussion.

Properties of Drilling Fluids

In the drilling industry both chemical and physical properties of the drilling fluid need to be controlled if a stable, open hole is to be maintained. It is important to stress that flow between zones does not occur during trouble-free drilling with a properly designed mud system. If fluids are flowing between zones, the well is generally considered out of control, and every effort is made to prevent this occurrence. Fluid flow into the well during drilling establishes the potential for catastrophic blowout. In addition, it is extremely likely that poorly consolidated formations will cave into the wellbore causing increased costs, future cementing problems, and undesired delays in the drilling operations. Flow between zones will not occur with proper mud in the hole.

Four (4) major physical mud properties, density, viscosity, gel strength, and mud dehydration (with the associated formation of a filtercake), are strictly controlled during drilling operations.

Mud density is used to prevent both formation fluids and the formation from entering the wellbore. In general, to avoid the potential for formation collapse and the influx of fluids into the wellbore, drilling fluids are designed to overbalance the bottom-hole formation fluid pressure by 200 to 500 psi and may average approximately 350 psi (Mitchell, Goodman, and Woods, 1987). This added mud weight is not a hindrance to drilling, and it prevents a variety of operational problems associated with fluid flowing into the wellbore.

Gel strength, which is a natural property of bentonite and natural clay muds, is, in many respects, an undesired property since severe complications during drilling operations can occur when the gel strength is too high (Gray and Darley, 1980). Ideally, drillers only desire a gel strength that is high enough to prevent solids settling and excess water loss during the static periods that occur when drilling a well (Gray and Darley, 1980).

Mud dehydration and the associated formation of a filtercake across permeable zones is controlled for three reasons. First, the formation of a filtercake is required to prevent fluid loss into the reservoir, since high fluid loss has the potential to damage a productive oil or gas zone. Second, the loss of fluid from the mud (mud dehydration) causes the viscosity and the gel strength to increase to problem levels that can hinder drilling operations. Finally, the formation of a thick soft filtercake across permeable zones increases the likelihood for differential sticking of the drillpipe, another undesired circumstance. The adverse effects of improper fluid-loss control also cost money, which provides further incentive to control this mud property.

Viscosity is required to carry the drill cuttings out of the wellbore. Of the four basic mud properties indicated in the preceding paragraphs, only mud viscosity is of little importance to the prevention of fluid migration through a mud-filled abandoned wellbore.

In the next several paragraphs, the following drilling fluid properties are discussed with respect to long-term stability and the potential to inhibit fluid migration:

- Fluid Density
- Gel Strength
- Filtercake Buildup
- Mud Dehydration Potential

Fluid Density

As previously indicated, mud density is used to prevent formation fluids from entering a wellbore during drilling operations (Gray and Darley, 1980, p. 8). The best example of a drilling fluid's ability to prevent reservoir fluid from entering the borehole is

demonstrated when drilling fluids are used to prevent the influx of gas while penetrating high-pressure gas zones. Since the density of a gas is much less than the density of water or drilling fluid, extreme pressure-control problems would exist if gas were able to invade the wellbore. It would be unlikely that gas zones could ever be successfully drilled and completed if drilling fluids were unable to prevent gas influx into the wellbore. When a drilling fluid fails to isolate a gas zone, a blowout can occur.

Fortunately, the hydrostatic force of the mud column can prevent gas invasion, even though the gas is less dense than the drilling mud and would rise to the surface if it reached the wellbore. Drilling fluid density is also important in controlling formation collapse in tectonically stressed areas since mud weight is the only available method to balance formation forces during drilling (Gray and Darley, 1980, pp. 8 and 356).

Mud density, in general, should not change measurably over the long term because mud has gel strength, as discussed in the next section. Figures 1 and 2 and Table I provide information on a 29-year-old mud sample obtained from the annulus of a plugged and abandoned well in South Texas. As the data indicate, the mud density remained fairly constant throughout the column over the 29-year static period, as expected from the basic chemical and physical properties of drilling mud. If solids settling were a major driving force in a mud column, the mud density at the top would be expected to be less than the average column mud weight. It is of some interest to note that the highest-density sample, approximately 12.5 lb/gal, was obtained from the top of the mud column and not from the bottom, as would be expected for significant settling of solids.

A review of the data presented in Table I and Figures 1 and 2 shows that settling is not a likely problem for drilling mud. Since mud density is not likely to change significantly over long periods of time, it is clear that, if the original mud had sufficient density to prevent fluid migration between zones, then the mud, based on density effects alone, will provide a positive seal against fluid migration until the pressure in the injection interval exceeds the resistance provided by the mud density, mud gel strength, and other formation-related factors.

Gel Strength

Gel strength imparts two important properties to drilling fluids. First and foremost, gel strength provides the resistance necessary to prevent drilled solids (cuttings) and the barite weighting material from falling to the bottom during the static periods that occur during drilling operations (Gray and Darley, 1980, p. 17).

The gel strength required to prevent a spherical solid of radius r from settling can be estimated using the following equation:

$$(\rho_b - \rho_f)g(4/3\pi r^3) = G(\pi r^2)$$

or

$$G = 4/3\,(\rho_b - \rho_f)gr$$

where

ρ_b = density of barite (4.2 g/cm^3)
ρ_f = density of water (1.0 g/cm^3)
g = acceleration due to gravity (981 cm/sec^2)
r = radius of barite particle (cm)

If the maximum radius of the barite particles is assumed to be 0.00635 cm (0.0025 inches), which falls within the largest 3% of the solids for standard API barite (Gray and Darley, 1980, p. 533), the shear strength is calculated to be 27.3 dynes/cm^2 or 5.6 lb/100 ft^2. This calculation shows that only a minimal gel strength is required to keep 97% of the barite weighting material suspended. Since the density of barite is 4.2 g/cm^3, the density of bentonite is 2.8 g/cm^3, and the average density of dolomite is 2.95 g/cm^3, it is clear that the gel strength in field muds will be far in excess of the required gel strength to maintain the muds' original density. Only the large drilled solids and the largest 3% of the barite particles have any potential for settling.

Second, gel strength reduces the ability of fluids to flow from the wellbore into the formation. This effect is not usually addressed, but is of some importance for maintaining long-term mud properties.

As indicated previously in this discussion, gel strength, in many ways, is an undesired property of drilling fluids from a driller's standpoint. However, gel strength is an inherent property of bentonite and natural clay muds. The single most significant fact noted by investigators is that clay/water-based drilling fluids used in oil and gas drilling operations continue to develop gel strength when allowed to remain quiescent (Gray and Darley, 1980). It is important to note that even though these fluids develop gel strength, they retain their ability to flow. This means that, unlike cement, a mud column will always provide a hydrostatic head to offset formation pressure. In addition, the mud column, like any other fluid, will transmit the effects of all external forces acting on the system. Thus, a mud column must either move or resist the stresses associated with external stress.

Gel strength provides a significant resistance to vertical migration that is over and above the mud density. The available data supporting large gel strengths are overwhelming. Tables II through IV and Figures 3 through 6 present the typical data provided by investigators. In addition, the data provided in Table II show that the gel strength for a specific 29-year-old mud removed from the Nora Schulze No. 2 well follows the laboratory trend as expected.

Garrison (1939) determined that, for California bentonite (Figures 3 and 4), gel strength followed the mathematical behavior presented in the following equation:

$$\frac{t}{S} = \frac{t}{S'} + \frac{1}{S'K}$$

where

- t = time since shearing stopped
- S = gel strength at time t
- S' = ultimate gel strength
- K = gel rate

However, a similar plot for Weintritt et al.'s data (Figure 5) shows that this trend is not necessarily followed by field muds. A plot of these data indicates gel strength increases directly with time. However, the data would suggest that an ultimate gel strength can be reached that exceeds 20 lb/100 ft^2.

The field mud data suggest that a gel strength of 50 to 100 lb/100 ft^2 would be conservative for muds left in abandoned holes or behind casing. However, even this conservative estimate for gel strength can add significant resistance to vertical fluid migration. A simple expression that can be used to estimate the increased pressure requirements to move fluid into a 1000-foot gelled fluid column in the annulus between the casing and the formation is:

$$P_H = 3.33\ S/D$$

where

P_H = increased resistance provided by gel strength in psi/1000 ft
S = gel strength in lb/100 ft^2
D = hole diameter in inches

Using a gel strength of 20 lb/100 ft^2 and a hole diameter of 8.75 inches, the following value is calculated:

$$P_H = 7.6 \text{ psi/1000 ft}$$

As the above calculation demonstrates, even with a minimum strength of 20 lb/100 ft^2 the mud gel strength provides significant additional resistance, P_H, to fluid movement over a 1000-foot interval. For open-hole considerations, several thousand feet of mud can add significant resistance to vertical migration.

Filtercake Buildup

Although filtercake buildup is not a quantified important issue associated with vertical fluid migration, the fact that it occurs and is a designed mud property is important (Gray and Darley, 1980, Ch. 6). Basically, the existence of filtercake building material in the

drilling mud demonstrates that the solids in the mud cannot migrate into the formation to any significant depth. In fact, filtration theory and filtercake buildup is based on the concept that the solids do not move into the formation (Gray and Darley, 1980, Ch. 6). There are no mechanisms for removing these solids without also removing the fluid that contains them. Short of formation fracture, the fluid removal must be into or along the wellbore, not into the formation. Thus, for abandoned wellbores filled with mud or cement, there is no place for these solids to go. They must remain in the wellbore where they provide structure and density to the mud, and the potential to seal off permeable intervals under dynamic conditions.

Mud Dehydration

It has been suggested that, over a long period of time, drilling muds will dehydrate, crack, and no longer prevent vertical fluid migration. As the mud obtained from the Nora Schulze Well No. 2 indicates, mud in the cased hole will not undergo dehydration. Likewise it would be impossible for a mud directly in contact with a saturated formation to dry out. This can be seen using the information provided in Appendix 1. Therefore, as discussed in the previous section, mud cannot dry and crack unless it lies above the water table. Furthermore, as the above data show, contacting a dehydrated mud with water will cause the mud to swell and seal any conductive cracks.

Conclusions

Given these considerations of mud properties, with respect to The Amoco Production Company Smith-McPherson No. 1 (Map ID No. 851), one is left to consider a borehole filled with liquid mud capable of sealing any porous formation to which it is applied with pressure, encapsulated by a cement plug and the walls of the hole, and acted upon by an external hydrostatic force. Transformational migration of formation fluid or injectate would then be possible only if (1) the mud column were displaced into a porous formation by hydrostatic pressure applied externally, or (2) seepage of one miscible fluid (formation fluid or injectate) through another (drilling fluid) could occur.

In the case of the former, not only would the hydrostatic pressure have to exceed the resistance caused by the density of the mud column and the gel strength, but also the fracture pressure of the recipient formation. While possible, pressures in this range are greater than any predicted pressure buildup in the perforated interval. The fracture pressure gradient in this area is about 1.6 psi/ft, or more than 12,000 psi at the injection interval. In fact, injection pressures that are high enough to fracture formations are prohibited when operating Class I wells. In the latter case, seepage (between the mud and the borehole, for example) would not be possible after the moving fluid reached a state of turbulent flow. Turbulent flow will occur when fluid in motion reaches a speed above the Critical Value of Reynolds (Scott, 1981). This value is, among other factors, directly proportional to channel size through which the fluid moves and inversely proportional to channel surface roughness (Turcotte and Schubert, 1982). Given the borehole wall rugosity and the narrowness of the space (if physically present at all) between the mud and the wellbore wall, the fluid velocity necessary to induce turbulent flow would be extremely small. With the induction of turbulent flow, the two fluids would mix, and the resulting fluid would assume the sealing properties of drilling fluid under differential pressure with the wellbore wall. If turbulent flow is not achieved, the amount of fluid seeping from one zone to another would be so small as to be negligible.

REFERENCES CITED:

Garrison, A. D., "Surface Chemistry of Clays and Shales": Petroleum Transactions, AIME, Vol. 132, pp. 191-203,1939.

Gray, G. R., and H. C. H. Darley, Composition and Properties of Oil Well Drilling Fluids, 4th ed,: Gulf Publishing Company, Houston, p. 630, 1980.

Mitchell, R. F., M. A. Goodman, and E. T. Wood, "Borehole Stresses: Plasticity and the Drilled Hole Effect": Paper SPE 16053, Presented at the 1987 SPE/ADE Drilling Conference, New Orleans, Louisiana, March 15-18, 1987.

Scott, J. S., Dictionary of Civil Engineering, 1981. Halsted Press. p. 288.

Turcotte, D. L., and Gerald Schubert, Geodynamics, Applications of Continuum Physics to Geological Problems, 1982, John Wiley & Sons, pp. 237-239.

Weintritt, D. J. and R. G. Hughes, "Factors Involved in High-Temperature Drilling Fluids:" J. Pet. Tech. Transactions AIME, Vol. 234, pp. 707-716, 1965

TABLES

ADDENDUM 2

TABLE I

29-YEAR OLD MUD DATA

RECOVERED MUD PROPERTIES FOR NORA SCHULZE NO. 2 WELL

SAMPLE NO	DEPTH (ft)	MUD WEIGHT (lb/gal)	SHEAR STRENGTH (lbs/100 ft^2)	GEL STRENGTH (lbs/100 ft^2)
1	---	---	---	---
2	60	12.0	540	304
3	111	10.9	230	296
4	174	11.0	310	295
5	207	11.2	190	>320
6	240	10.9	170	284
7	273	10.7	180	237
8	306	10.9	285	254
9	339	10.5	190	288
10	372	10.9	245	272
11	405	11.1	280	220
12	438	11.1	255	222
13	471	11.1	301	292
14	504	11.1	300	230
15	537	11.0	490	292
16	570	11.0	225	217
17	603	10.9	240	236
18	636	11.3	650	>320
19	609	11.4	750	---
20	702	11.5	2100	---
21	719	10.9	4700	---
22	725	10.7	890	---
23	731	11.3	7000	---

Average mud weight using all samples - 11.1

Shear strength averaged for samples 3 through 17 - 260 lbs/100 ft^2

Average gel strength of samples 3 through 17 - 267 lbs/100 ft^2

TABLE II

ESTIMATED ULTIMATE GEL STRENGTHS

BENTONITE PERCENT	CURVE	ADDITIVES	GEL STRENGTH dynes/cm^2	GEL STRENGTH lbs/100 ft^2
4.5	1	-------	34.4	7
5.5	2	-------	74.4	16
6.5	3	-------	114.0	24
5.5	4	0.1% Na Tannate	104.0	22
5.5	5	Sodium Hydroxide	99.7	21

(Revised from Garrison)

TABLE III

GEL STRENGTH OF A 4 PERCENT SUSPENSION OF PURE SODIUM MONTMORILLONITE TO WHICH AN EXCESS OF 50 MEQ/LITER OF NaOH HAS BEEN ADDED, MEASURED AT VARIOUS TEMPERATURES AND PRESSURES

		Gel Strength (lb/100 sq ft)		
t(°F)	P(psi)	1 min	10 min	30 min
78	300	2.2	---	35.0
	8000	2.2	---	7.0
212	300	18.0	26.0	100.0
	8000	9.0	9.0	15.0
302	300	240.0	290.0	265.0
	8000	88.0	100.0	100.0

(From Hiller, 1963)

TABLE IV

GEL STRENGTH OF FIELD MUDS

COMPARISON OF MUD PROPERTIES WITH PROGRESSIVE GEL-STRENGTH TESTS
GYP-FERROCHROME LIGNOSULFONATE EMULSION MUDS

	SAMPLE			
	Mud E	Mud F	Mud G	
			No Treatment	3 lb/bbl PCL
Weight, unstirred, lb/gal	11.0	10.7	10.6	
Weight, stirred, lb/gal	11.0	10.3	10.7	
Plastic Viscosity, cp	14	23	16	15
Yield Point, lb/100 sq ft	3	6	2	1
10-sec gel, lb/100 sq ft	1	2	1	0
10-min gel, lb/100 sq ft	8	8	7	3
API filtrate, sl	6.2	3.3	5.2	2.9
pH	10.9	10.6	10.5	10.4
Composition: water % by vol	76	63	75	
Oil, % by vol	5	11	9	
Solids, % by vol	19	16	16	
Solids, % by wt	39	36	37	
Solids, SG	2.7	2.9	3.0	
Filtrate Ion Analysis:				
Chlorides ppm	3500	400	3000	
Sulfate, epm	250	300	130	
Carbonate, epm	24	28	12	
Bicarbonate, epm	12	160	12	
Calcium, epm	44	52	44	

Progressive Gel Strengths lb/100 sq ft	Temperature (°F)							
Time	75°	180°	75°	180°	75°	180°	75°	180°
0 minutes	1	1	2	2	1	1	0	0
3 minutes	2	3	2	5	3	8	1	1
10 minutes	8	18	8	12	7	26	3	3
30 minutes	15	40	11	18	17	58	5	5
60 minutes	27	90	18	16	29	91	6	6
2 hours	31	145	22	22	29	104	7	7
4 hours	37	190	29	42	46	172	10	10
8 hours	46	190	33	42				
16 hours	80	320	40	57	95	320	25	25

(From Weintritt and Hughes 1965)

FIGURES

ADDENDUM 2

SUBSURFACE

WELL : NORA SCHULZE No. 2

LOCATION : CORPUS CHRISTI AREA

MUD TYPE : LIGNOSULFATE ?

MUD DENSITY : 11.0 POUNDS/GALLON

GEL STRENGTH : 0/3 POUNDS FORCE/100 FEET^2

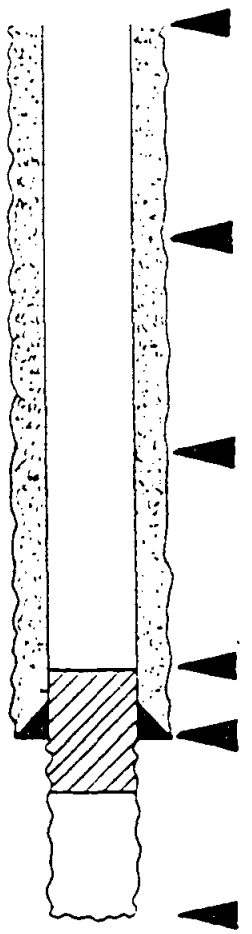
DRILLING COMMENCED : NOVEMBER 13, 1959

WELL P&A : NOVEMBER 25, 1959

DATE OF MUD SAMPLE : AUGUST 26, 1988

DEPTH OF MUD SAMPLES : 12' TO 754' BGL

WELL DIAGRAM



ALL DEPTHS RELATIVE TO GROUND LEVEL

STARTED PUSHING 4" PIPE AT 120'

STARTED DRILLING AT 774'

CEMENT PLUG 1035'-1172'

9-5/8" CASING
SET AT 1122'

TOTAL DEPTH AT 8512'

FIGURE 1

KEN E. DAVIS ASSOCIATES

NORA SCHULZE No. 2
FISHER AND DAVIDSON
ROBSTOWN, TEXAS

FIGURE 2

DEPTH vs. DENSITY and SHEAR STRENGTH

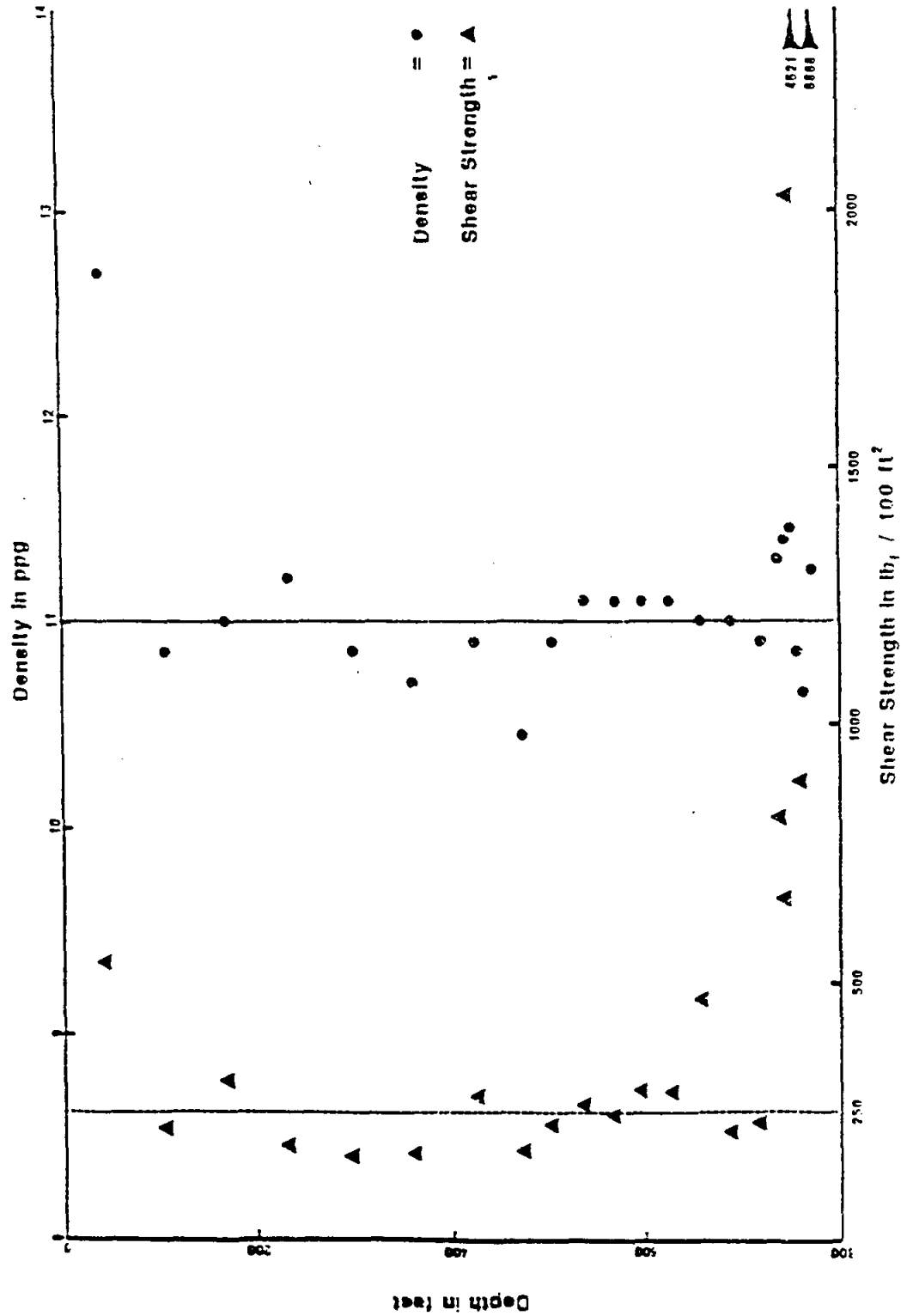


FIGURE 3

GEL STRENGTH IN RELATION TO TIME
AND RATE OF REACTION
(FROM GARRISON, 1939)

SEE TABLE II

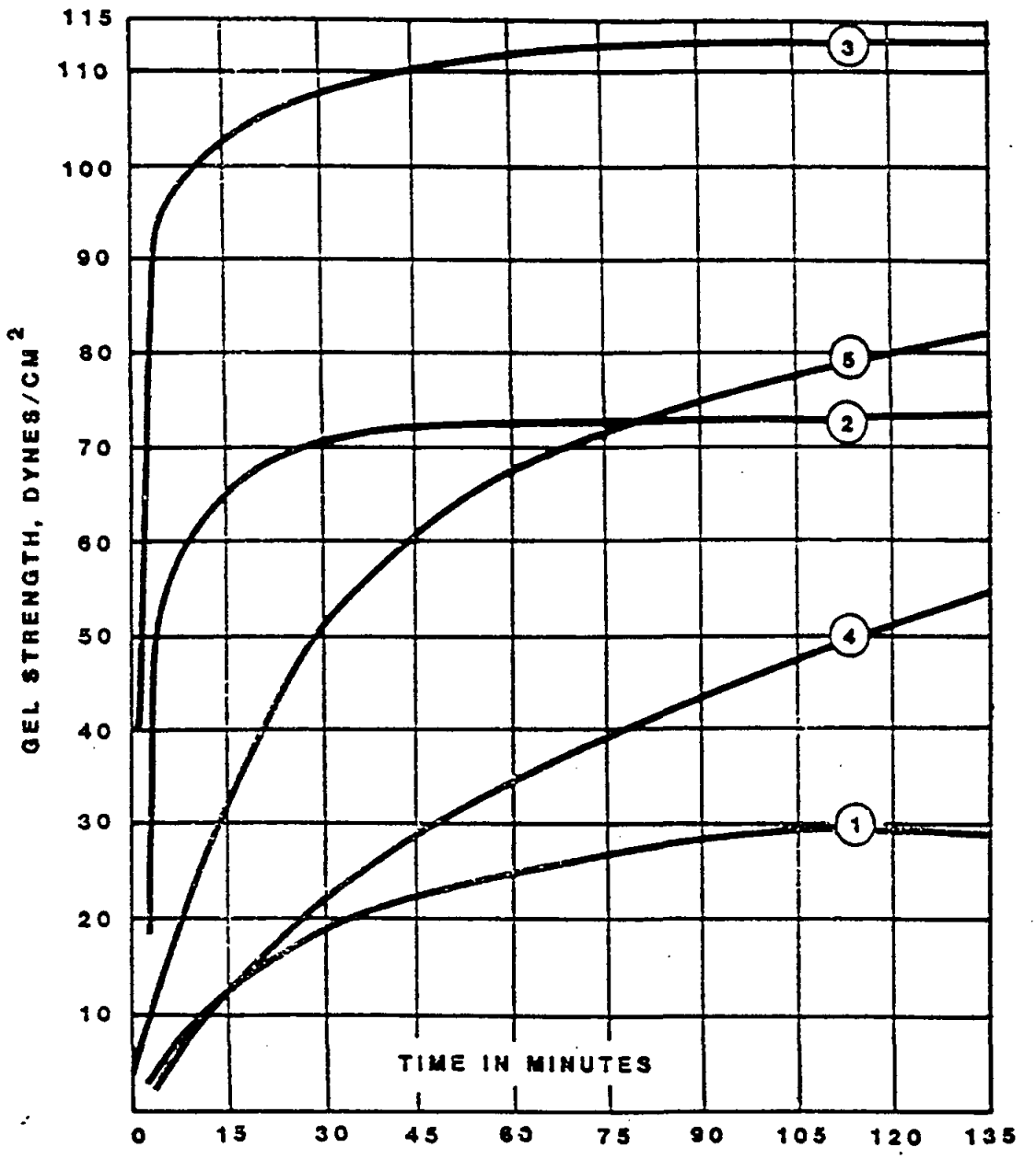


FIGURE 4

GEL STRENGTH AND RATE CONSTANTS
(FROM GARRISON, 1939)

SEE TABLE II

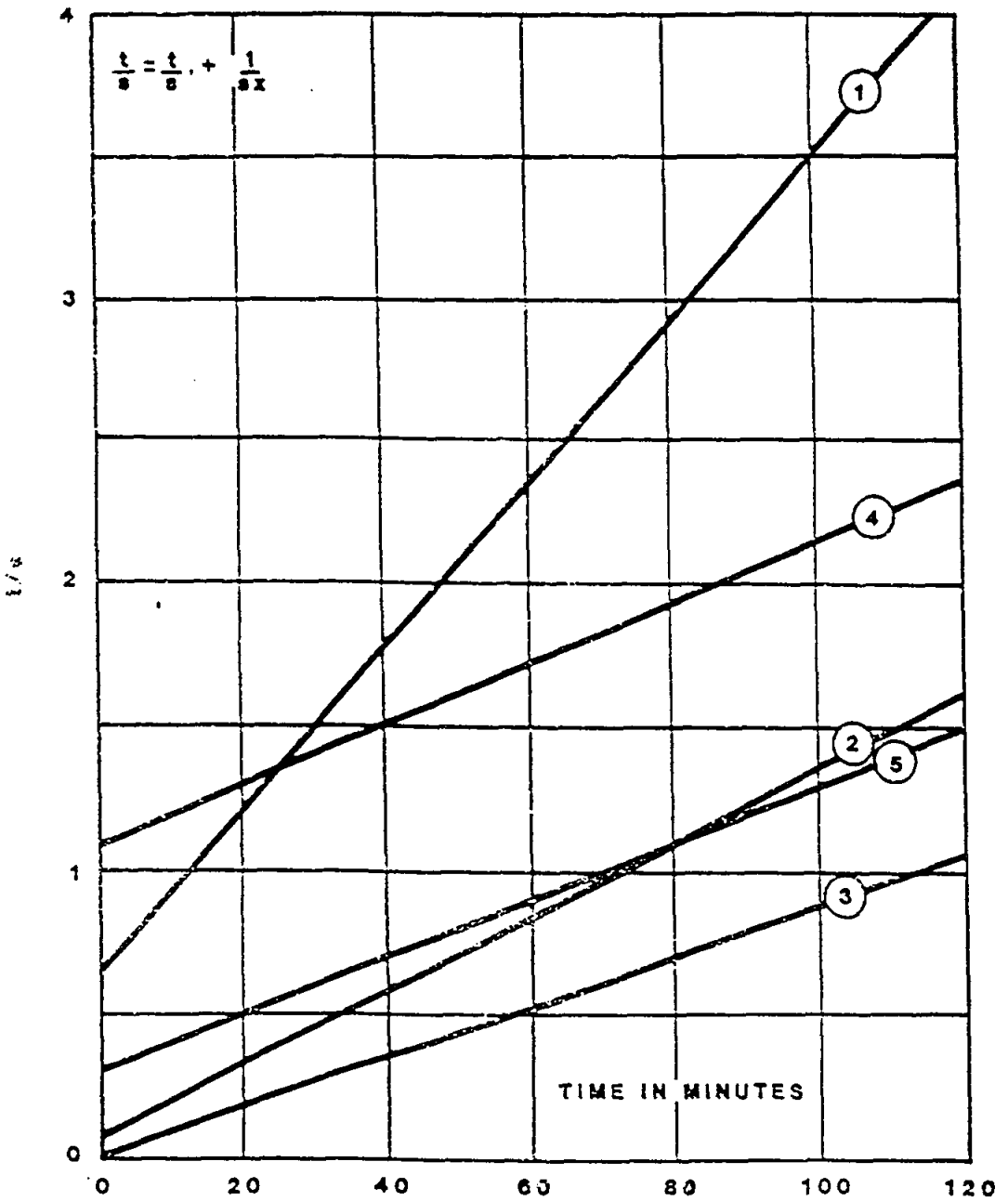


FIGURE 5

GEL STRENGTH vs. TIME
FOR 3 FIELD MUDS AT 75°F
(FROM WEINTRITT AND HUGHES, 1965)

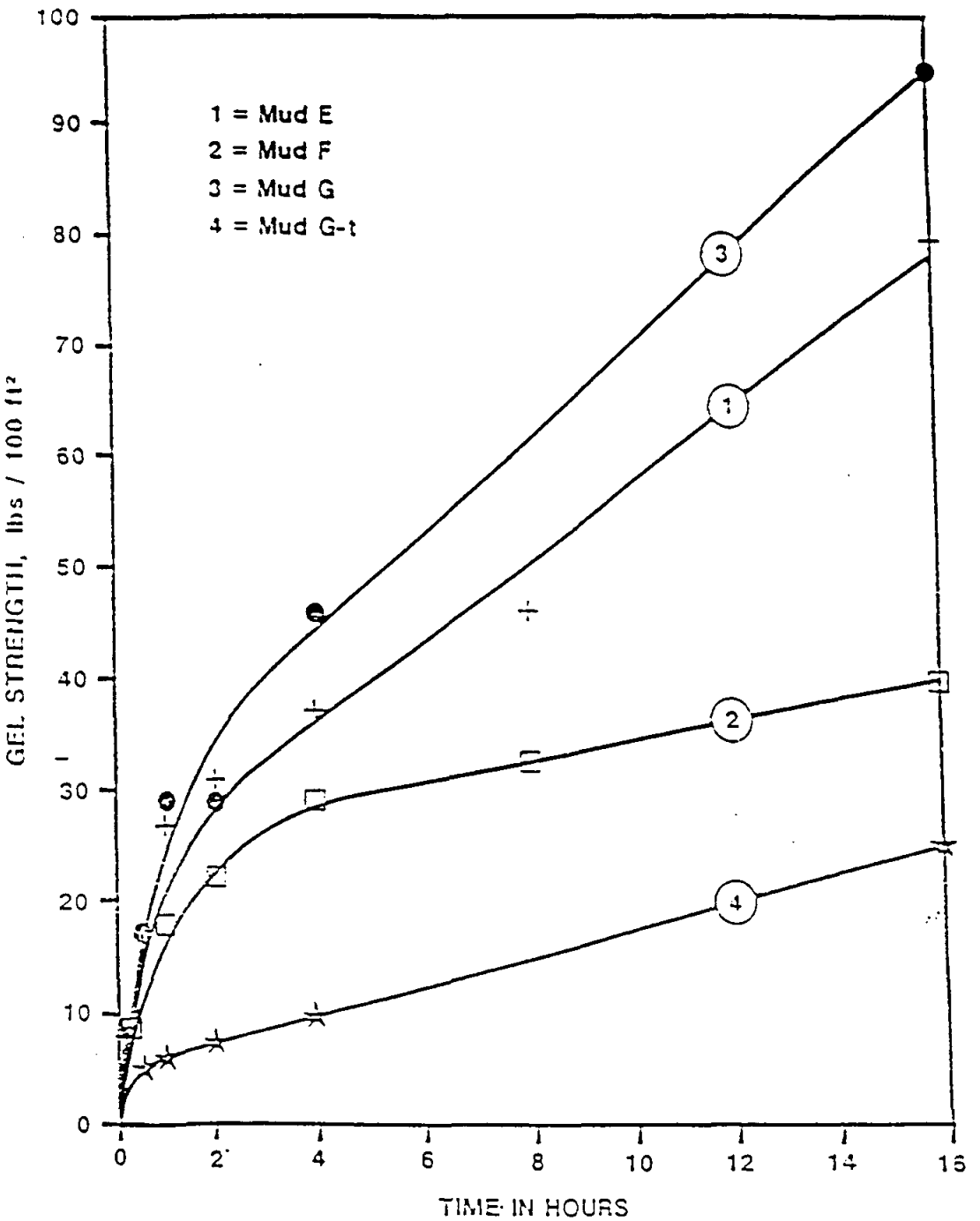
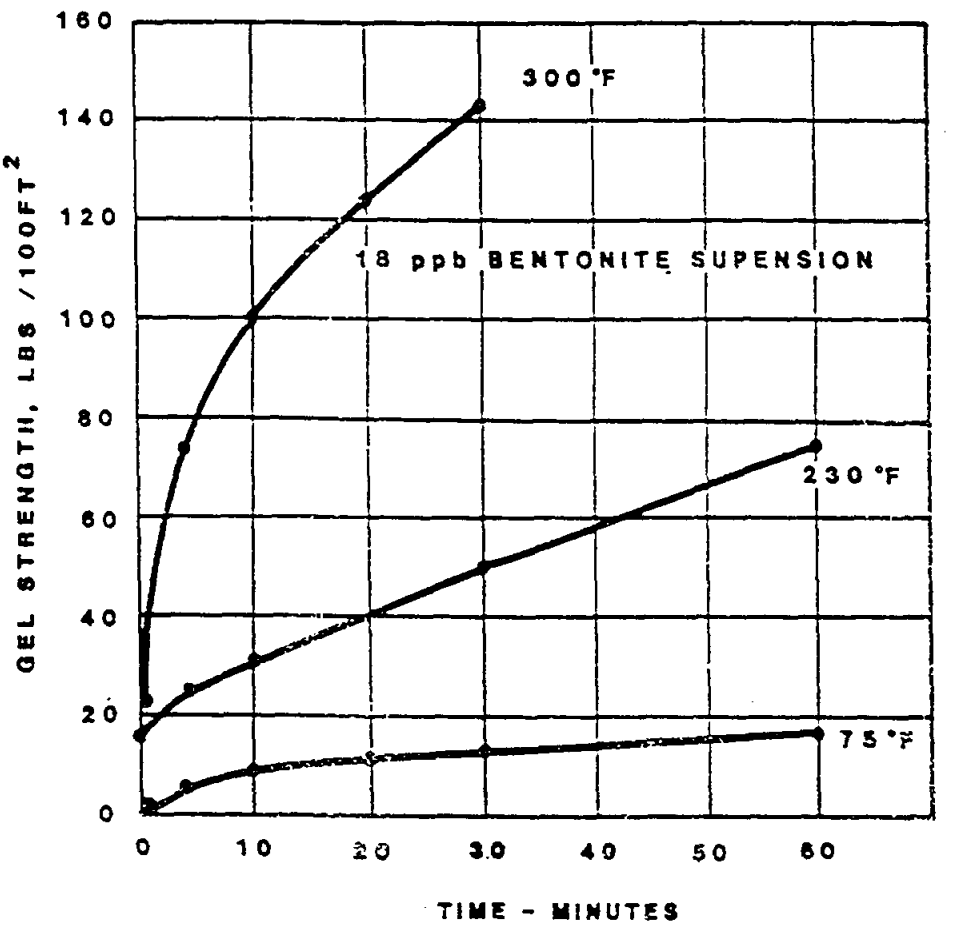


FIGURE 6

EFFECTS OF TIME AND TEMPERATURE
ON GEL STRENGTH
(FROM ANNIS 1976)



APPENDIX

ADDENDUM 2

SUBSURFACE

APPENDIX 1

DRILLING FLUID ENGINEERING MANUAL

MAGCOBAR OPERATIONS
OILFIELD PRODUCTS DIVISION
DRESSER INDUSTRIES, INC.
HOUSTON, TEXAS

REVISED JANUARY, 1972 (C.L.H.Jr.)

yield only 28 barrels per ton, have 3½% solids by volume and would weigh almost 9.4 lb/gal.

Clays have many applications in drilling muds. Increasing the viscosity of a drilling mud may best be accomplished with the least amount of solids by adding the material having the highest yield (Magcogel). Lower fluid loss values can be obtained with bentonite since coarse and medium sized particles are normally produced from the formation. The quality of the mud will be improved by enriching the bentonite or colloidal fraction.

Factors Affecting the Yield of Clays

When dry clay is added to make-up water containing salt or various metallic ions, hydration and dispersion are greatly affected. For example, many drilling muds are prepared with sea water for economy and convenience. A typical analysis of sea water might contain the following components.

Components	Parts per million (ppm)
Sodium	10,550
Chloride	18,970
Sulfate	2,650
Magnesium	1,270
Calcium	400
Potassium	380
Bromine	65
Other components	80

*Brackish water could contain the same components, but at different concentrations.

Water containing any salt concentration can be saturated with additional salt. Saturated salt water contains about 315,000 mg/l sodium chloride. Approximately 120 lb/bbl of salt is required to saturate fresh water.

Figure 5 shows the effect of various concentrations of these ions upon the hydration of bentonite. In general, it can be stated that hydration of fresh water clays decreases rapidly with increasing concentrations of these ions.

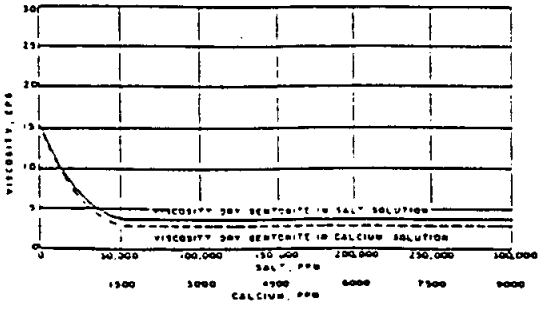
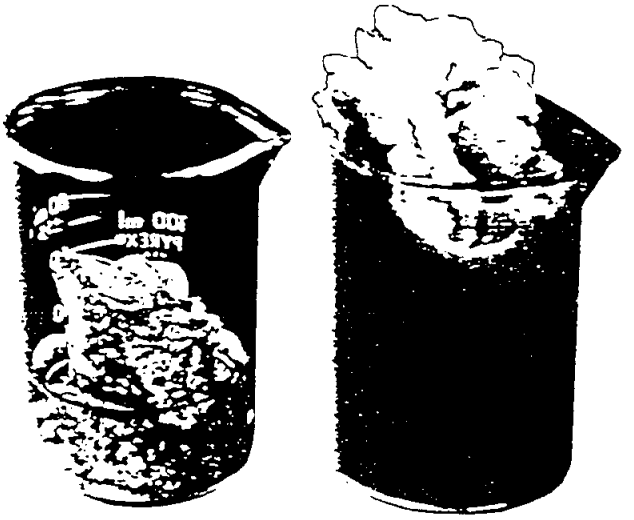


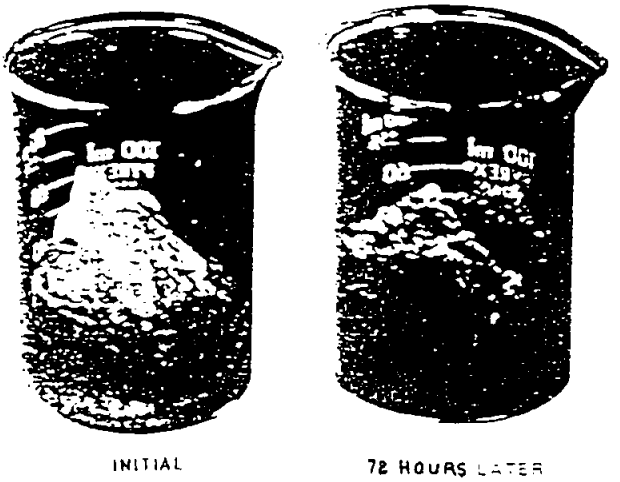
Figure 5. Viscosity effect when adding bentonite to water containing various concentrations of salt or calcium.

This phenomenon is more apparent in Figures 6 and 7. Demonstrated in these examples is the hydration of two identical cubes of bentonite, the first in fresh water and the second in salty water. Figure 6 shows the bentonite cube initially in a beaker of fresh water and then again 72 hours later. Hydration and consequent swelling is readily apparent. Figure 7 shows the bentonite cube initially in the salty water and again 72 hours later.



INITIAL 72 HOURS LATER

Figure 6 Hydration of bentonite in fresh water.



INITIAL 72 HOURS LATER

Figure 7 Hydration of bentonite in salty water.

ATTACHMENT III-1

INJECTION WELL DATA SHEET

OPERATOR: Navajo Refining Company

LEASE: WDW-1 (formerly Mewbourne Oil Company Chalk Bluff 31 State No. 1)

660' FSL, 2310' FEL | 31-T17SR28E

Footage Location | Section | Township | Range

WELL CONSTRUCTION DATA

Surface Casing

Size 13-3/8" Cemented with 525 sx

TOC Surface feet determined by Circulated 86 sx to surface

Hole Size 17-1/2" Set at 390 feet

Intermediate Casing

Size 9-5/8" Cemented with 1000 sx

TOC Surface feet determined by Circulated 133 sx to surface

Hole Size 12-1/4" Set at 2555 feet

Long String

Size 7" Cemented with 1390 sacks

TOC Surface feet determined by Temperature log, cement bond log

Hole Size 8-3/4" Set at 9094 feet

Total Depth 10,200', Plugged back to 9004 feet

Injection Interval

7450 feet to 9016 feet, permitted

7924 feet to 8476 feet, perforated

(perforated or open-hole; indicate which)

Tubing size 4-1/2" lined with not lined set in a 7" x 3.5" retrievable packer at 7879 feet. Other type of tubing/casing seal if applicable None

OTHER DATA

1. Is this a new well drilled for injection? ___ Yes _X_ No

   If no, for what purpose was the well originally drilled? The well was drilled in 1993 as an exploratory well

Revised September 16, 1999

2. Name of the injection formation: Lower Wolfcamp, Cisco, and Canyon Formations

3. Name of Field or Pool (if applicable): Not applicable

4. Has the well ever been perforated in any other zones(s)? List all such perforated intervals and give plugging detail, i.e., sacks of cement or plug(s) used. No

5. Give the names and depths of any over or underlying oil or gas zones (pools) in the area:

   Within one mile: Yates (500 feet), Seven Rivers (600 feet), Grayburg (1600 feet to 1900 feet), San Andres (2000 feet), Abo (5400 feet to 6200 feet), and Morrow (9900 feet)

V. AREA OF REVIEW

A map that shows all non-freshwater wells in the vicinity of the proposed Class I wells is provided as Attachment V-1. Also shown on Attachment V-1 is the area of review (AOR), which consists of the area within 1 mile of the proposed Class I wells. The wells within the AOR are marked with map identification numbers (Map ID Nos.) that are keyed to the list of wells in Attachment VI-1. Construction details of wells that penetrate the Injection Zone are tabulated in Attachment VI-1A.

All freshwater wells in the vicinity of the proposed injection wells are shown in Attachment V-2. The freshwater wells are keyed to the list of wells in Attachment XI-1.

VI. INJECTION ZONE WELLS

VI.A Protocol for Identifying Wells

Search Protocol for Non-Freshwater Artificial Penetrations

As Navajo's agent, Envirocorp employed the services of Federal Abstract Company in the research and acquisition of data concerning non-freshwater wells. Federal Abstract understands the necessity for complete records and makes every diligent effort to complete this task. Envirocorp and Federal Abstract examined public and private sources of data to identify producing and abandoned oil and gas wells and disposal wells in the AOR.

The Oil Conservation Division (OCD) is the primary agency in which files are researched for oil and gas well records. The OCD is the state repository for oil and gas well and Class II well records, as the state regulatory authority for the oil and gas industry. In order to retrieve well records, the following general procedure is used for researching each well within a given area:

Map Review

Before the retrieval process can begin, it is necessary to know the operator, lease name, county in which the well is located, and the township, range, and section in which the well is found. This information is normally found on commercially prepared oil and gas base maps. Maps are produced by commercial firms, who obtained the data to build the oil and gas bases from "scout" tickets (completion information received from individual oil companies) in the early years and then, in later years, from the OCD itself. The commercial firms continually update the maps by plotting information filed by oil and gas operators with the OCD. Changes in the status of existing wells are noted, as well as information on new wells. Attachment V-1 is a modified version of the oil and gas base map provided by Midland Map Company, a recognized commercial supplier of oil and gas base maps for southeastern New Mexico.

Well Records Review

The OCD filing system is the best source of oil and gas well data in New Mexico. Microfiche and microfilm files of historical well records are searched as well as the hard copy files of well records not yet placed on microfilm. These files are organized by quarter-quarter section, township, and range.

Scout Tickets

Scout tickets were available for the wells in the AOR from IHS Energy Group (formerly Petroleum Information Dwights LLC). Information about nearly every well in the AOR was available, including some wells for which records were not available from the OCD. Scout tickets were also available from The Subsurface Library, Midland, Texas.

VI.B Well Data Tabulations and Well Records

Two hundred fifty-four (254) well locations have been identified within or slightly beyond one mile of WDW-1 and proposed WDW-2 and WDW-3. The well locations are shown in Attachment V-1. A tabulation of total depth, status, and drill date for all of the wells in the one-mile AOR is provided in Attachment VI-1. Wells in Attachment VI-1 are identified with Map ID numbers that are keyed to the map in Attachment V-1. Scout tickets for the wells in the AOR of proposed WDW-2 for which no records were available from the OCD are presented as Attachment VI-2A.

For wells within the one-mile AOR, which pentrate the Injection Zone, a more comprehensive tabulation is presented in Attachment VI-1A. This tabulation also provides information on well construction and borehole filling.

Wells That Do Not Penetrate the Injection Zone (232 Wells)

Two hundred thirty-two (232) of the wells are documented to have been drilled to depths of less than 7270 feet, which coincides with the top of the injection zone in proposed WDW-2. The top of the injection zone in WDW-1 is at 7450 feet. The wells did not penetrate the proposed injection zone. These wells are:

Map ID Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 82, 84, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 121, 122, 123, 125, 126, 127, 128, 129, 130, 131, 133, 135, 136, 138, 139, 140, 141, 142, 143, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 158, 159, 160, 162, 163, 164, 165, 166, 168, 169, 170, 171, 172, 173, 751, 752, 753, 755, 756, 772, 781, 785, 786, 789, 791, 793, 796, 797, 799, 800, 801, 802, 805, 806, 807, 808, 812, 814, 836, 837, 838, 839, 840, 841, 842, 843, 844, 846, 849, 850, 852, 853, 854, 856, 857, 858, 859, 860, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 888, 895, 896, 897, 901, and 910.

Mis-Plotted or Duplicate Locations (9 Well Spots)

Nine (9) well locations appear on Attachment V-1 for which well records could not be found in the files of the OCD and for which scout tickets were not available. All of these well locations are mis-plotted or duplicate locations.

Six (6) of these locations (Map ID Nos. 30, 85, 108, 119, 132, and 137 within one mile of WDW-1 and proposed WDW-3) appear only on a commercial base map prepared by the Midland Map Company (Attachment V-1). These locations do not appear on a commercial base map prepared by the Geomap Company or on the lease map prepared by Midland Map Company. A representative of Midland Map Company confirmed that five of the six well locations on the oil and gas base map, Map ID Nos. 85, 108, 119, 132, and 137, are duplicate locations for existing wells. The Midland Map representative stated that the locations will be removed from the map. Map ID No. 30 is the incorrect, duplicate location plotted on the Midland Map base map for Map ID No. 14, the Arco Empire Abo Unit G No. 20 (formerly the Kersey Ramapo No. 5). The correct location of Map ID No. 14 is shown on the Midland Map lease map.

Within one mile of proposed WDW-2, three well locations are mis-plotted on Attachment V-1. These mis-plotted locations are incorrect duplicate locations for other wells, as discussed below.

Map ID No. 754 is the incorrect location for Map ID No. 756, the ARCO Permian Empire Abo Unit K No. 17. The well spot on the Midland Map map for Map ID No. 754 is labeled "17." The form "Sundry Notices and Reports on Wells" that was filed on May 18, 1959, for Map ID No. 756 states that the form was "Filed to show change in well location..." A copy of the original "Notice of Intention to Drill" with the originally permitted location was not available from the files of the OCD in Santa Fe. The Midland Map Company's lease and oil and gas base maps show the incorrect location of the well as Map ID No. 754. Subsurface plotted the correct location for this well as Map ID No. 756 on Attachment V-1. A representative of Midland Map Company confirmed that Map ID No. 756 is the correct location for the well. The representative stated that the well will be correctly spotted on the company's new maps and that the well spot for Map ID No. 754 will be removed. Information to support the conclusion that Map ID No. 754 is mis-plotted is included in Attachment VI-2B.

Map ID No. 792 is an incorrect location on the Midland Map oil and gas base map for Map No. 814, the ARCO Permian Empire Abo Unit K No. 141. Midland Map Company's lease map shows Map ID No. 814 but not Map ID No. 792. A representative of Midland Map Company confirmed that the correct location for the well is the location of Map ID No. 814. The representative said that the well spot for Map ID No. 792 will be removed from the oil and gas base map and that the location for Map ID No. 814 will be added to the oil and gas base map.

Map ID No. 795 is an incorrect location for Map ID No. 765. Midland Map shows the location of Map ID No. 795 on both their lease map and their oil and gas base map. Map ID No. 795 is labeled on Midland Map Company's lease map as Well No. 1. A representative of Midland Map Company concluded after examining their series of historical maps that Map ID No. 795 was permitted sometime between 1959 and 1960. Map ID No. 765 was permitted in 1959 as the William Hudson Hudson-State Abo No. 1. A discrepancy in the location of Map ID No. 765 is evident upon

examination of the "Notice of Intention to Drill." The location for Map ID No. 765 was typed in on the "Notice of Intention to Drill" as 990 feet from the South line and 330 feet from the East line of the section, which is the location of Map ID No. 795. On this form, the word South was crossed out, and North was written in by hand. On the plat of the section in the upper left portion of the same form, the well is spotted at the location of Map ID No. 765. Map ID No. 795 was spotted by Midland Map Company on their maps at the typed-in location on the "Notice of Intention to Drill." The same well was also spotted at the correct location, that of Map ID No. 765. Information to support the conclusion that Map ID No. 795 is mis-plotted is included in Attachment VI-2C.

The mis-plotted well locations are:

Map ID Nos. 30, 85, 108, 119, 132, 137, 754, 792, and 795.

One (1) Map ID No., No. 120, was not used.

Injection Zone Penetrations (13 Wells)

Thirteen (13) wells reached total depths of 7270 feet or greater and penetrated the proposed injection zone. Each of these wells is discussed in detail in Sections VI.C through VI.E. The wells that penetrated the injection zone are:

Map ID Nos. 59, 81, 83, 124, 134, 144, 157, 161, 167, 848, 851, 855, and 861.

Attachment VI-1A includes construction details, total depth, status, and drill date for the injection zone penetrations in the AOR. Well records available from the OCD for these wells are provided in Attachment VI-2.

VI.C Well Schematics

Map ID Nos. 59, 81, 83, 124, 134, 144, 157, 161, 167, 848, 851, 855, and 861 penetrated the injection zone within one mile of WDW-1 and proposed WDW-2 and WDW-3. Schematics of all plugged and abandoned wells within one mile of WDW-

1 and proposed WDW-2 and WDW-3 that penetrate the injection zone are included with the well records in Attachment VI-2.

VI.D Condition of Artificial Penetrations

Each of the wells that penetrates the injection zone was evaluated to determine if it will allow movement of fluids into or between USDWs. For the purpose of this demonstration, the artificial penetrations may be categorized as follows:

Class I Waste Disposal Well (1 well):

Map ID No. 59 is Navajo's WDW-1, a Class I nonhazardous oilfield waste disposal well. The well was constructed by Navajo in July and August 1998. Injection into the Lower Wolfcamp-Cisco-Canyon injection zone via Navajo's WDW-1 is permitted by OCD Discharge Plan UIC-CLI-008-1. No waste water has been injected into the well to date.

Class II Saltwater Disposal Wells (1 well):

Map ID No. 83, the I&W Inc., Walter Solt SWD-1, is a Class II saltwater disposal well that is currently active. The well injects into the Wolfcamp in four sets of perforations: 7518 to 7534 feet, 7742 to 7756 feet, 7778 to 7787 feet, and 7810 to 7812 feet. The injection zone coincides with the shallowest formation proposed for injection by the proposed Navajo injection wells. The well has surface and intermediate or production casing set to prevent contamination of the USDW. The casing/formation annulus is cemented across the injection zone, as presented in Attachment VI-3. At the end of the well's useful life, the operator will plug and abandon the well according to OCD regulations with cement plugs set to protect the USDW and with heavy mud left in the wellbore. The Class II well in the AOR is listed below:

Map ID No. 83.

No corrective action is required for this well.

Active Producing Wells (8 wells):

Active producing wells include producing and shut-in oil and gas wells. These wells have surface and intermediate or production casing set to prevent contamination of the USDW. In all wells, except Map ID No. 861, the casing/formation annulus is cemented across the injection zone. Reported top of cement, where available, or calculated top of cement for each casing string in each well is presented in Attachment VI-3. Map ID No. 861, with casing only to 1995 feet and mud-filled open hole from 1995 feet to 10,372 feet, is not cased through the injection zone. At the end of the wells' useful lives, the operators will plug and abandon the wells according to OCD regulations with cement plugs set to protect the USDW and with heavy mud left in the wellbore. The active producing wells within the AOR are listed below:

Map ID Nos. 81, 124, 134, 144, 161, 167, 855, and 861.

Navajo proposes to reenter Map ID No. 861 and convert the well to a Class I well, the Navajo WDW-2, as discussed in Section III.

No corrective action is required for these wells.

Plugged and Abandoned Producing Wells (2 wells):

Plugged and abandoned producing wells are former producing wells with surface and intermediate or production casing set that have been plugged with cement plugs and heavy mud. The cement plugs were placed between the injection zone and the USDWs. The plugged and abandoned producing wells within the AOR are listed below:

Map ID No. 157 and 848

No corrective action is required for these wells.

Plugged and Abandoned Dry Holes (1 well):

Plugged and abandoned dry holes have surface casing and may have intermediate or long-string casing set through the injection zone. Dry holes were plugged with heavy mud and cement plugs. The cement plugs were placed between the requested injection zone and the USDWs. The plugged and abandoned dry hole is listed below:

Map ID No. 851.

No corrective action is required for this well.

VI.E Cone of Influence and Area of Review Determination

The cone of influence is defined here as the area within which increased injection zone pressures caused by injection of wastes would be sufficient to cause fluid movement through any well or other conduit into a USDW. This demonstration shows that the extremely conservative worst-case cone of influence of the proposed injection operations is smaller than the one-mile radius AOR in which artificial penetrations were investigated.

In the worst case, an undocumented abandoned well is imagined to be open to both the injection zone and the base of the USDW. In addition, the well is imagined to be filled to within 100 feet of the ground surface with formation brine from the injection zone and fresh water from the base of the USDW. The cone of influence can be calculated by comparing the hydraulic heads of the injection zone and the lowermost USDW. It is only where the injection zone head is above the USDW head that fluid movement from the injection zone into the USDW could occur. This worst-case model of the potential effect of injection upon the USDW is extremely conservative, because no wells within one mile of the proposed injection wells are open to both the injection zone and the USDW and filled with brine.

The injection zone for Navajo's proposed injection wells has a native pressure such that the resulting hydraulic head is lower than the head of the lowermost USDW. The pre-injection pressure of the injection interval was measured on July 30, 1998,

in Navajo's WDW-1 to be 2928 psia at 7924 feet (7911 feet below ground level, BGL) (Attachment VIII-9B).

A sample of fluid was retrieved from formation fluid swabbed on July 25, 1998, from the perforations of the deeper Cisco interval, from 8220 feet to 8476 feet in Navajo's WDW-1. The total dissolved solids (TDS) concentration of the sample was 33,000 mg/l, and the specific gravity of the sample at room temperature was 1.034. Formation fluid was swabbed on July 29, 1998, from the perforations of the shallower Cisco interval, from 7924 feet to 8188 feet in Navajo's WDW-1. The analysis of a sample of this fluid indicated that the TDS concentration of the sample was 18,000 mg/l, and the specific gravity at room temperature was 1.018. The chemical analysis of the formation fluid samples is included as Attachment VII-4. These values compare favorably with information from the analysis of fluid retrieved during drillstem test (DST) No. 5, which was conducted on August 26, 1993, in WDW-1 (see Attachment VIII-9). The salinity of the formation fluid retrieved during DST No. 5 was reported in Attachment VIII-9 as a chlorides concentration of 25,000 ppm. The formation fluid is therefore assumed to have a sodium chloride concentration of 25,000 ppm. The specific gravity of such a fluid is approximately 1.02.

The pre-injection pressure, P_i, at the top of the injection zone in proposed WDW-2 at 7270 feet BKB (7257 feet BGL) is 2635 psia, as calculated below, based on a formation fluid specific gravity of 1.018. Using the lightest specific gravity in this calculation yields a high P_i, which is conservative.

$$\begin{aligned} P_i(7257 \text{ feet}) &= P_i(7911 \text{ feet}) - (7911 \text{ feet} - 7257 \text{ feet})\ (0.433 \text{ psi/ft})\ (1.018) \\ &= 2928 \text{ psia} - 288 \text{ psi} \\ &= 2640 \text{ psia} \end{aligned}$$

The head of the lowermost USDW is estimated to be 100 feet BGL. This estimate is reasonably conservative, as it is based on a static water level measurement of 81 feet in Water Well No. 18.28.8.330 (Attachment XI-1). The total depth of the well is unknown.

The critical pressure, P_c, at 7257 feet BGL that would be necessary to raise the hydrostatic head of the injection interval to the head of the lowermost USDW at 100 feet BGL is 3152 psia, as calculated below:

$$
\begin{aligned}
P_c = &\ (\text{Top of Injection Zone - Base of USDW})\ (0.433\ \text{psi/ft})(1.018) \\
&+ (\text{Base of USDW - Head of USDW})\ (0.433\ \text{psi/ft}) \\
= &\ (7257\ \text{feet} - 473\ \text{feet})\ (0.433\ \text{psi/ft})\ (1.018) \\
&+ (473\ \text{feet} - 100\ \text{feet})\ (0.433\ \text{psi/ft}) \\
= &\ 3152\ \text{psia}
\end{aligned}
$$

The critical increase in reservoir pressure, ΔP_c, above the native pressure, that is necessary to raise the hydrostatic head of the injection interval to the head of the lowermost USDW is, therefore, 512 psi, as calculated below:

$$
\begin{aligned}
\Delta P_c = &\ P_c - P_i \\
= &\ 3152\ \text{psia} - 2640\ \text{psia} \\
= &\ 512\ \text{psi}
\end{aligned}
$$

An increase in reservoir pressure greater than 512 psi would be sufficient to raise the head of the injection zone above the head of the lowermost USDW. The cone of influence is the area around the injection wells within which the increase in reservoir pressure caused by injection is greater than 512 psi.

Contour plots of the predicted pressure increase in the injection zone (Attachment VI-5) were generated using the maximum injection rates proposed for WDW-1, WDW-2, and WDW-3 in Section VII. A Visual Basic program, PREDICTW, was used to calculate the pressure increase throughout the injection zone at the end of 20 years of injection into the proposed wells. The theoretical basis for PREDICTW is discussed in Attachment VI-6. The gridded pressure increases created by PREDICTW are contoured using SURFER, a commercial contouring software package.

Conservative values for reservoir thickness and permeability were used to overestimate the predicted increase in reservoir pressure. The reservoir was assumed to have a thickness of 85 feet. The permeability of the reservoir was assumed to be

250 md. The modeled kh, 21,250 md-ft (= 250 md x 85 feet), is less than 10% of the kh, 284,839 md-ft, that was determined from the pressure falloff test conducted in Navajo's WDW-1 on July 30 and 31, 1998 (See Section VIII and Attachment VIII-9B). Using a low kh will yield a predicted pressure increase that is much greater than expected and a cone of influence that is much larger than expected.

The porosity was assumed to be 10%.

The viscosity of the formation fluid with TDS concentration of 25,000 ppm at 130°F is 0.53 cp (Attachment VI-7). The compressibility of the pore volume of the formation (Canyon Reef as shown on Attachment VI-8), c_r, is 5.5×10^{-6} psi^{-1}. The compressibility of the formation fluid (distilled water as shown on Attachment VI-8), c_w, is 2.9×10^{-6} psi^{-1}. The total compressibility ($c_t = c_r + c_w$) is 8.4×10^{-6} psi^{-1}.

WDW-1 and proposed WDW-2 and WDW-3 are modeled as injecting for 20 years from August 1, 1999 through July 31, 2019, at a maximum total rate of 1000 gallons per minute (gpm) distributed among the three wells. The maximum per-well injection rate modeled is 500 gpm for 20 years.

The I & W, Inc. Walter Solt SWD-1 (Map ID No. 83), a Class II well, injects into the lower Wolfcamp through four sets of perforations between 7518 and 7812 feet. Historical injection records available from the OCD for 1994 through 1997 indicate that the average injection rate is 17.6 gpm. This rate is used for the historical injection period from June 1, 1988, through July 31, 1999. For the future injection period, from August 1, 1999 through July 31, 2019, the Walter Solt SWD-1 is expected to inject at 58.3 gpm, or 2000 barrels per day (bpd), the maximum rate requested by the original permit application for the Walter Solt SWD-1.

The 512-psi pressure-increase contour, which defines the outline of the worst-case cone of influence, is located less than one mile from WDW-1 and proposed WDW-2 and WDW-3, as shown in Attachment VI-5. An improperly abandoned wellbore or other conduit filled with formation fluid that is located farther than one mile from the proposed wells would not transmit sufficient pressure from the injection zone to move fluids into the USDW. Navajo researched public and private sources of

information about wells within the one-mile AOR. Only 13 of 254 wells drilled in the AOR penetrated the injection zone. Information was presented in Section VI.D that demonstrates that each of the injection zone penetrations is properly constructed to prevent migration of fluids into the USDW.

ATTACHMENT VI-1

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

SUBSURFACE

ATTACHMENT VI-1

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
1	E. L. Fulton State No. 1 36-17S-27E Unit A	Active Oil	528	8/30/41	
2	Delhi Oil Corp. State No. 13 36-17S-27E Unit A	P&A Dry	1993	6/24/48	
3	J. E. Bedingfield Delhi No. 7 36-17S-27E Unit A	Active Oil	540	4/21/50	
4	Barney Cockburn Bedingfield-State No. 2 36-17S-27E Unit G	Active Oil	1736	12/6/47	
5	J. E. Bedingfield Unit G No. 2 36-17S-27E Unit G	Active Oil	532	3/6/49	
6	Barney Cockburn B. S. No. 5 36-17S-27E Unit G	Active SWD	1733	3/23/49	
7	E. L. Fulton Conklin-State No. 1 36-17S-27E Unit G	Active Oil	533	1/10/42	
8	S & A Oil Co. Gates-State No. 1 36-17S-27E Unit H	Active Oil	557	8/4/50	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
9	Guy Stevenson Gates-State No. 2 36-17S-27E Unit H	Active Oil	551	10/10/52	
10	Barney Cockburn Cockburn-Homan No. 1 36-17S-27E Unit H	Active Shut In	1804	6/20/49	
11	Kersey & Co. State No. 1 36-17S-27E Unit I	P&A Oil	590	10/28/41	
12	Kersey & Company Ramapo No. 3 36-17S-27E Unit I	P&A Oil	1857	1/3/50	
13	Kersey & Co. Ramapo No. 2 36-17S-27E Unit I	P&A Oil	1900	5/7/48	
14	Kersey & Co. Ramapo No. 5 36-17S-27E Unit I	P&A Oil	5980	8/24/61	
15	William P. Dooley Ramapo No. 3 36-17S-27E Unit J	Active Oil	591	2/13/42	
16	Martin Yates, III William P. Dooley No. 2 36-17S-27E Unit J	Active Oil	1790	2/27/48	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
17	Martin Yates III Dooley-State No. 3 36-17S-27E Unit J	Unknown	5865	4/22/61	Scout ticket only.
18	Martin Yates, III Dooley-State Abo No. 2 36-17S-27E Unit J	Active Inj. Gas	5970	2/26/61	
19	Martin Yates, III William P. Dooley No. 4 36-17S-27E Unit K	Active Oil	1747	2/3/49	
20	William P. Dooley Ramapo No. 2 36-17S-27E Unit K	Active Oil	514	5/15/47	
21	Martin Yates, III William P. Dooley No. 1 36-17S-27E Unit K	Active SWD	1710	1/20/48	
22	L. Texas Enterprises South Red Lake Grayburg Unit No. 43 36-17S-27E Unit K	Active Oil	1785	12/11/81	
23	Martin Yates, III Dooley-State Abo No. 3 36-17S-27E Unit K	Active Oil	5865	4/19/61	
24	William P. Dooley Ramapo No. 1 36-17S-27E Unit K	Active Oil	510	10/16/41	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
25	William P. Dooley Ramapo No. 4 36-17S-27E Unit N	Active Oil	541	9/29/42	
26	Martin Yates, III William P. Dooley No. 3 36-17S-27E Unit N	Active SWD	1812	4/16/48	
27	Martin Yates, III Dooley-State Abo No. 1 36-17S-27E Unit N	Active Oil/Gas	5925	2/2/60	
28	Burnham Oil Co. State B-6961 No. 1-A 36-17S-27E Unit O	P&A Oil	1500	5/13/47	
29	Gulf Oil Corp. Eddy State 1 (NCT-C) No. 1 36-17S-27E Unit O	Active Inj. Gas	6200	9/8/59	
30	36-17S-27E Unit P	NA	NA	NA	Mis-plotted location. Duplicate location for Map ID No. 14.
31	Kersey & Co. Ramapo No. 4 36-17S-27E Unit P	Active Oil/Gas	6013	5/16/60	
32	J. E. Bedingfield Blake-State No. 1 30-17S-28E Unit P	Active Oil	615	3/7/53	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
33	J. E. Bedingfield and Malco, Resler & Yates State No. 1 31-17S-28E Unit A	P&A Oil	2004	7/15/52	
34	Charles Powell Powco State No. 1 31-17S-28E Unit B	Active Oil	652	11/15/75	
35	J. E. Bedingfield Delhi-State No. 1 31-17S-28E Unit B	P&A Oil	637	12/23/52	
36	Hegwer Drilling Co. Powco State No. 2 31-17S-28E Unit B	Active Oil	747	7/15/86	
37	The Astins State No. 1 31-17S-28E Unit D	Unknown	531	06/23/42	Scout ticket only.
38	Aston & Fair State 31 No. 1X 31-17S-28E Unit D	Active Shut In	525	1/5/46	
39	C. T. McLaughlin Bedingfield State 1 No. 1 31-17S-28E Unit D	P&A Oil	2307	2/16/50	
40	David C. Saikin B-5862 Hudson No. 1 31-17S-28E Unit E	Active Oil	1816	5/29/48	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
41	Metex Pipe & Supply Hudson-Saikin No. 2 31-17S-28E Unit E	Active Oil	1950	7/7/84	
42	Franklin, Aston & Fair, Inc. State F No. 1 31-17S-28E Unit F	Active Oil	5971	6/7/60	
43	Aston & Fair State No. Y-1 31-17S-28E Unit F	Active Oil	1926	5/8/48	
44	J. E. Bedingfield Malco State No. 1 31-17S-28E Unit G	Active Shut In	1852	10/12/53	
45	Pan American Petroleum Corp. State of New Mexico CC No. 1 31-17S-28E Unit G	Active Oil	6025	8/10/60	
46	Hondo Oil & Gas Co. State A No. 47 31-17S-28E Unit H	Active SWD	6180	9/23/65	
47	DEPCO, Inc. State 647 No. 213 31-17S-28E Unit I	Active Oil	1945	6/17/66	
48	Hondo-Western-Yates State A No. 9 31-17S-28E Unit I	Active Inj. Gas	6106	4/29/60	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
49	Franklin, Aston & Fair, Inc. State AG No. 1 31-17S-28E Unit J	Active Oil	1937	12/23/62	
50	Pan American Petroleum Corp. State of New Mexico BJ No. 2 31-17S-28E Unit J	Active Oil	6094	3/13/60	
51	Pan American Petroleum Corp. State BM No. 1 31-17S-28E Unit K	Active Inj. Gas	6046	4/10/60	
52	Barney Cockburn Ramapo-State No. 2 31-17S-28E Unit L	Active Oil	1996	7/16/55	
53	Pan American Petroleum Corp. State BE No. 2 31-17S-28E Unit L	Active Oil	5971	4/29/60	
54	Barney Cockburn Ramapo-State No. 1 31-17S-28E Unit M	Active Oil	1975	5/1/48	
55	Pan American Petroleum Corp. State BE No. 1 31-17S-28E Unit M	Active Inj. Gas	6006	1/31/60	
56	Pan American Petroleum Corp. State BD No. 1 31-17S-28E Unit N	Active Oil	6050	1/22/60	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
57	Franklin, Aston & Fair, Inc. State AD No. 1 31-17S-28E Unit N	Active Oil	1938	3/1/63	
58	Otis A. Roberts Parker-State No. 1 31-17S-28E Unit O	P&A Dry	742	1/18/42	
59	Mewbourne Oil Company Chalk Bluff 31 State No. 1 Illinois Camp Morrow North Field 31-17S-28E Unit O	P&A Dry	10200	9/9/93	Navajo Refining Company WDW-1. Recompleted 8/4/98.
60	Pan American Petroleum Corp. State BJ No. 1 31-17S-28E Unit O	Active Oil	6094	2/24/60	
61	DEPCO, Inc. State 647 No. 219 31-17S-28E Unit P	Active SWD	2012	5/8/67	
62	Hondo-Western-Yates State A No. 5 31-17S-28E Unit P	Active Oil	6122	3/12/60	
63	J. E. Bedingfield Aston-State No. 1 32-17S-28E Unit D	P&A Dry	651	5/12/53	
64	Pan American Petroleum Corp. State BV No. 1 32-17S-28E Unit E	Active Inj. Gas	6013	9/13/60	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
65	Sinclair Oil & Gas Co. State Eddy 32 No. 2 32-17S-28E Unit F	Active Oil	6171	8/24/60	
66	International-Yates State 647 No. 211 32-17S-28E Unit K	Active Oil	2003	6/8/66	
67	Hondo-Western-Yates State A No. 7 32-17S-28E Unit K	Active Oil	6083	3/27/60	
68	International-Yates State 647 No. 208 32-17S-28E Unit L	Active SWD	1930	5/15/66	
69	Hondo-Western-Yates State A No. 8 32-17S-28E Unit L	Active Oil	6075	4/13/60	
70	DEPCO, Inc. State 647 No. 220 32-17S-28E Unit M	Active SWD	1998	5/9/67	
71	Hondo-Western-Yates State A No. 4 32-17S-28E Unit M	Active Oil	6132	3/5/60	
72	DEPCO, Inc. State 647 No. 212 32-17S-28E Unit N	Active SWD	1954	6/17/66	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
73	Hondo-Western-Yates State A No. 3 32-17S-28E Unit N	Active Oil	6172	2/14/60	
74	Atlantic Richfield Co. Empire Abo Unit H No. 261 32-17S-28E Unit N	Active Oil	6220	7/25/75	
75	Atlantic Richfield Company Empire Abo Unit H No. 272 32-17S-28E Unit O	Active Oil	6370	7/18/77	
76	Pan American Petroleum Corp. State BK No. 1 5-18S-28E Unit C	Active Oil	6254	7/18/60	
77	Atlantic Richfield Co. Empire Abo Unit I No. 261 5-18S-28E Unit C	Active Oil	6350	1/4/79	
78	Pan American Petroleum Corp. State BN No. 1 5-18S-28E Unit D	Active Oil	6273	3/27/60	
79	Atlantic Richfield Co. Empire Abo Unit I No. 251 5-18S-28E Unit D	Active Oil	6250	1/12/79	
80	Signal Oil and Gas Co. State No. 1-E 5-18S-28E Unit E	Active Oil	6265	5/10/60	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
81	Phillips Oil Company Illinois Camp A Com No. 1 Empire Penn Gas Field 5-18S-28E Unit E	Active Gas	10450	8/10/83	Injection zone penetration construction details provided in Attachment VI-1A Perfs: 10172 - 10184 feet 10070 - 10075 feet
82	Leonard Oil Co. State E-2715 No. 2 5-18S-28E Unit F	Active Oil	6265	12/30/59	
83	Metek Pipe & Supply (original) I&W, Inc. Walter Solt State No. 1 5-18S-28E Unit L	Active SWD	8500	8/12/83	Injection zone penetration construction details provided in Attachment VI-1A Perfs: 7518 - 7534 feet 7632 - 7642 feet (cemented) 7742 - 7756 feet 7778 - 7787 feet 7810 - 7812 feet
84	Robert G. Hanagan Graridge-State No. 1 5-18S-28E Unit L	Active Shut In	6365	8/25/63	
85	5-18S-28E Unit M	NA	NA	NA	Mis-plotted location. Not a well per Midland Map Company representative.
86	SDX Resources S. A. Solt No. 4 5-18S-28E Unit M	Active Oil	2850	7/23/96	
87	DEPCO, Inc. State 647 No. 216 6-18S-28E Unit A	Active Oil	3280	3/14/67	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
88	Hondo-Western-Yates State A No. 2 6-18S-28E Unit A	Active Oil	6241	2/29/60	
89	Resler and Sheldon State No. 1 6-18S-28E Unit B	Active Inj. Gas	6194	12/21/59	
90	Atlantic Richfield Co. Empire Abo Unit I No. 231 6-18S-28E Unit B	Active Oil	6250	11/1/75	
91	Pan American Petroleum Corp. State BB No. 3 6-18S-28E Unit C	Active Oil	6033	12/29/59	
92	Atlantic Richfield Co. Empire Abo Unit J No. 231 6-18S-28E Unit G	Active Oil	6380	10/22/75	
93	Hondo Oil & Gas Co. State EA No. 1 6-18S-28E Unit D	Active Oil	6119	12/30/59	
94	ARCO Oil and Gas Co. Empire Abo Unit J No. 213 6-18S-28E Unit E	Active Oil	6225	6/2/80	
95	Pan American Petroleum Corp. State BB No. 1 6-18S-28E Unit E	Active Oil	6202	10/30/59	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
96	Atlantic Richfield Co. Empire Abo Unit J No. 214 6-18S-28E Unit E	Active Oil	6267	12/28/78	
97	Atlantic Richfield Co. Empire Abo Unit J No. 211 6-18S-28E Unit E	Active Oil	6200	2/11/75	
98	Atlantic Richfield Co. Empire Abo Unit J No. 222 6-18S-28E Unit F	Active Oil	6303	3/13/77	
99	David C. Saikin & Henry F. Oliver State No. 1 6-18S-28E Unit F	P&A Dry	705	2/21/42	
100	Franklin, Aston & Fair, Inc. State AB No. 1 6-18S-28E Unit F	Active Oil	1985	8/8/63	
101	Pan American Petroleum Corp. State BB No. 2 6-18S-28E Unit F	Active Oil	6206	11/26/59	
102	Atlantic Richfield Co. Empire Abo Unit J No. 223 6-18S-28E Unit F	Active Inj. Gas	6250	5/19/78	
103	Atlantic Richfield Co. Empire Abo Unit J No. 221 6-18S-28E Unit F	Active Oil	6305	4/23/76	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
104	ARCO Oil and Gas Co. Empire Abo Unit J No. 235 6-18S-28E Unit G	Active Oil	6300	7/8/79	
105	Atlantic Richfield Co. Empire Abo Unit J No. 234 6-18S-28E Unit G	Active Oil	6260	8/27/78	
106	Hondo-Western-Yates State A No. 1 6-18S-28E Unit G	Active Oil	6242	1/26/60	
107	Atlantic Richfield Co. Empire Abo Unit J No. 232 6-18S-28E Unit G	Active Oil	6345	4/13/76	
108	6-18S-28E Unit G	NA	NA	NA	Mis-plotted location. Not a well per Midland Map Company's representative.
109	Atlantic Richfield Co. Empire Abo Unit J No. 233 6-18S-28E Unit G	Active Oil	6300	6/5/78	
110	Hondo-Western-Yates State A No. 6 6-18S-28E Unit H	Active Oil	6253	3/24/60	
111	ARCO Oil and Gas Co. Empire Abo Unit J No. 241 6-18S-28E Unit H	Active Oil	6386	4/12/81	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
112	Hondo-Western-Yates State A No. 30 6-18S-28E Unit I	Active Oil	6350	8/24/60	
113	Atlantic Richfield Co. Empire Abo Unit J No. 232 6-18S-28E Unit J	Active Shut In	6350	2/5/79	
114	Barney Cockburn State No. 1 6-18S-28E Unit J	P&A Dry	2095	8/15/49	
115	Sunray Mid-Continent Oil Co. N. M. State T No. 1 6-18S-28E Unit J	Active Oil	6179	5/23/79	
116	Atlantic Richfield Co. Empire Abo Unit K No. 231 6-18S-28E Unit J	Active Oil	6350	8/13/78	
117	Miller Bros. Oil Co. Capital State No. 1 6-18S-28E Unit J	P&A Dry	2396	3/21/55	
118	Pan American Petroleum Corp. State BB No. 5 6-18S-28E Unit K	Active Oil	6210	2/22/60	
119	6-18S-28E Unit K	NA	NA	NA	Mis-plotted location. Not a well per Midland Map Company's representative.
120	Number Not Used.				Number Not Used.

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
121	Pan American Petroleum Corp. State BB No. 4 6-18S-28E Unit L	Active Oil	6194	1/23/60	
122	ARCO Oil and Gas Co. Empire Abo Unit K No. 211 6-18S-28E Unit L	Active Oil	6312	7/17/80	
123	Signal Oil and Gas Co. State No. 2-M 6-18S-28E Unit M	Active Oil	6225	10/21/60	
124	Mewbourne Oil Company Chalk Bluff 6 State No. 1 North Illinois Camp Morrow 6-18S-28E Unit M	Active Gas	10200	4/16/92	Injection zone penetration construction details provided in Attachment VI-1A Perfs: 10084 - 10092 feet
125	Chambers & Kennedy Sunray Mid-Continent No. 1 6-18S-28E Unit N	Active Oil	6243	8/5/60	
126	Pan American Petroleum Corp. State CD No. 1 6-18S-28E Unit O	P&A Dry	6412	5/1/61	
127	Dickson Petroleum, Inc. Kimberly St. No. 1 6-18S-28E Unit P	P&A Dry	1750	12/30/85	
128	D. & H. Oil Co. State No. 1 6-18S-28E Unit P	P&A Dry	2246	5/13/52	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
129	Pan American Petroleum Corp. Malco Refineries F No. 11 1-18S-27E Unit A	Active Oil	6118	11/5/59	
130	Pan American Petroleum Corp. USA Malco Refineries F No. 6 1-18S-27E Unit B	Active Oil	6078	7/7/59	
131	Malco Refineries Hill No. 4 1-18S-27E Unit C	Unknown	1840	5/10/48	Scout ticket only.
132	1-18S-27E Unit C	NA	NA	NA	Mis-plotted location. Not a well per Midland Map Company's representative.
133	Pan American Petroleum Corp. USA Malco Refineries F No. 8 1-18S-27E Unit C	Active Inj. Gas	6173	9/16/59	
134	Mewbourne Oil Company Chalk Bluff Federal Com No. 2 North Illinois Camp Morrow 1-18S-27E Unit F	Active Gas	10140	8/24/91	Injection zone penetration construction details provided in Attachment VI-1A Perfs: 9999 - 10024 feet
135	Pan American Petroleum Corp. USA Malco Refineries F No. 4 1-18S-27E Unit F	Active Oil	6087	5/31/59	
136	Pan American Petroleum Corp. USA Malco Refineries F No. 7 1-18S-27E Unit G	Active Oil	6205	8/2/59	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
137	1-18S-27E Unit G	NA	NA	NA	Mis-plotted location. Not a well per Midland Map Company representative.
138	Atlantic Richfield Co. Empire Abo Unit J No. 191 1-18S-27E Unit G	Active Oil	6259	9/7/75	
139	Pan American Petroleum Corp. USA Malco Refineries F No. 9 1-18S-27E Unit H	Active Oil	6218	10/13/59	
140	Atlantic Richfield Co. Empire Abo Unit J No. 202 1-18S-27E Unit H	Active Inj. Gas	6296	5/13/76	
141	Atlantic Richfield Co. Empire Abo Unit J No. 203 1-18S-27E Unit H	Active Oil	6225	10/10/78	
142	Manhattan Oil Cronin No. 1 1-18S-27E Unit H	Unknown	2900	4/1/25 7/1/27	Scout ticket only.
143	Atlantic Richfield Co. Empire Abo Unit J No. 201 1-18S-27E Unit H	Active Oil	6225	7/19/75	
144	Mewbourne Oil Company Chalk Bluff Federal Com No. 3 North Illinois Camp Morrow 1-18S-27E Unit I	Active Gas	10150	1/16/93	Injection zone penetration construction details provided in Attachment VI-1A Perfs: 9950 - 9954 feet 9957 - 9972 feet

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
145	Humble Oil & Refining Co. Federal Empire Abo No. 2 1-18S-27E Unit I	Active Oil	6185	9/29/59	
146	Atlantic Richfield Co. Empire Abo Unit K No. 193 1-18S-27E Unit J	Active Oil	6225	10/26/78	
147	Humble Oil & Refining Co. Federal Empire Abo No. 1 1-18S-27E Unit J	Active Oil	6180	8/20/59	
148	Atlantic Richfield Co. Empire Abo Unit K No. 192 1-18S-27E Unit J	Active Oil	6250	6/25/78	
149	Atlantic Richfield Co. Empire Abo Unit K No. 191 1-18S-27E Unit J	Active Oil	6350	9/23/76	
150	Atlantic Richfield Co. Empire Abo Unit K No. 194 1-18S-27E Unit J	Active Oil	6325	11/14/78	
151	Atlantic Richfield Co. Empire Abo Unit K No. 184 1-18S-27E Unit K	Active Oil	6200	7/25/78	
152	Atlantic Richfield Co. Empire Abo Unit K No. 183 1-18S-27E Unit K	Active Oil	6210	7/24/77	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
153	Atlantic Richfield Co. Empire Abo Unit K No. 181 1-18S-27E Unit K	Active Oil	6203	10/30/75	
154	Pan American Petroleum Corp. USA Malco Refineries F No. 5 1-18S-27E Unit K	Active Oil	6163	5/22/59	
155	Atlantic Richfield Co. Empire Abo Unit K No. 182 1-18S-27E Unit K	Active Inj. Gas	6369	6/1/76	
156	Pan American Petroleum Corp. USA Malco Refineries F No. 12 1-18S-27E Unit N	Active Oil	6174	12/5/59	
157	Mewbourne Oil Company Chalk Bluff Fed. Com No. 1 North Illinois Camp Morrow 1-18S-27E Unit N	P&A Gas	10120	3/7/91 5/25/91 P&A	Injection zone penetration construction details provided in Attachment VI-1A Perfs: 9936 - 9946 feet 9964 - 9967 feet
158	Humble Oil & Refining Co. Empire ABO Federal No. 5 1-18S-27E Unit O	P&A Oil	6300	4/9/71	
159	Humble Oil & Refining Co. Federal Empire Abo No. 3 1-18S-27E Unit O	P&A SWD	6365	11/8/59	
160	Humble Oil & Refining Co. Federal Empire Abo No. 4 1-18S-27E Unit P	Active Oil	6250	12/2/61	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
161	Mewbourne Oil Company Federal T No. 1 North Illinois Camp Morrow 12-18S-27E Unit A	Active Shut In	10141	9/13/90	Injection zone penetration construction details provided in Attachment VI-1A Long-string casing is cemented from 10141 to 6000 feet (Attachment VI-3)
162	Collier Energy, Inc. Crossfire Federal No. 1 12-18S-27E Unit H	Active Oil	1652	9/11/85	
163	Santa Rita Exploration Corp. Sun State No. 1 7-18S-28E Unit A	Active Oil	2502	3/28/84	
164	Santa Rita Exploration Corp. Sun State No. 2 7-18S-28E Unit B	P&A Dry	2000	12/10/84	
165	Fred Pool Drilling, Inc. Laurel State No. 1 7-18S-28E Unit C	Active Oil	1690	2/23/87	
166	Fred Pool Drilling, Inc. Laurel State No. 2 7-18S-28E Unit E	Active Oil	1690	11/10/88	
167	ARCO Oil & Gas Company Morexco, Inc. State BY No. 1 Artesia Q-GB-SA 7-18S-28E Unit F	Active Oil	10400	6/10/85 12/20/95 Recompleted to Grayburg	Injection zone penetration construction details provided in Attachment VI-1A Perfs: 10116 - 10124 feet (cemented) 1627 - 46 feet

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
168	Morexco, Inc. Tejon State No. 1 7-18S-28E Unit G	Unknown	2500	12/4/96	Scout ticket only.
169	Marbob Energy Corp. West Artesia Grbg. Ut. Tr. 4 No. 27 8-18S-28E Unit D	Active Oil	2520	8/28/81	
170	Leonard Oil Co. State #1-D No. 1 8-18S-28E Unit D	Active Oil	2385	5/15/58	
171	J. E. Bedingfield Humble No. 1 7-18S-28E Unit G	P&A Dry	2377	4/28/58	
172	Burnham Oil State A No. 1 36-17S-27E Unit N	Unknown	2200	5/31/47	Scout ticket only.
173	J. B. Adamson Ramapo No. 2 31-17S-28E Unit L	Unknown	1996	8/1/55	Scout ticket only.
751	ARCO Oil and Gas Company Empire Abo Unit J No. 17 (was Pan American Petroleum Corp. Malco Refineries No. F-2) 1-18S-27E Unit F	P&A	5960	03/26/59 01/22/87	
752	ARCO Permian Empire Abo Unit K No. 17 1-18S-27E Unit L	O&G	6091	05/22/95	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
753	ARCO Oil and Gas Company Empire Abo Unit L No. 171 1-28S-27E Unit M	O&G	6300	5/22/79	
754	Mis-Plotted Location for Map ID No. 756 1-18S-27E Unit M				
755	Valley Refining Co. Hill No. 1 1-18S-27E Unit N	D&A	2404	10/20/43 12/20/43	
756	ARCO Permian Empire Abo Unit L No. 17 (was Pan American Petroleum Corp. Malco Refineries No. F-3) I-18S-27E Unit M	O&G	6150	06/25/59	
772	Fred Turner, Jr. State H No. 1 2-18S-27E Unit H	O&G	6140	03/09/59	
781	Malco Refining Company State B No. 2 2-18S-27E Unit J	D&A	4164	08/12/46	
785	ARCO Permian Empire Abo Unit K No. 16 (was Atlantic Refining Company State AO No. 2) 2-18S-27E Unit I	O&G	6114	02/06/95	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
786	ARCO Permian Empire Abo Unit K No. 15 (was Atlantic Refining Company State AO No. 1) 2-18S-27E Unit J	O&G	6100	03/23/59	
789	ARCO Permian Empire Abo Unit K No. 143 2-18S-27E Unit K	O&G	6108	05/13/79	
791	ARCO Permian Empire Abo Unit K No. 161 2-18S-27E Unit I	O&G	6225	09/13/79	
792	Mis-Plotted Location for Map ID No. 814 2-18S-27E Unit J				
793	ARCO Permian Empire Abo Unit L No. 143 2-18S-27E Unit N	O&G	6093	12/20/78	
795	Mis-Plotted Location for Map ID No. 765 2-18S-27E Unit P				
796	ARCO Permian Empire Abo Unit L No. 151 2-18S-27E Unit O	O&G	6285	11/04/75	
797	ARCO Permian Empire Abo Unit L No. 155 2-18S-27E Unit O	O&G	6202	05/01/79	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
799	ARCO Permian Empire Abo Unit L No. 16 (was Gulf Oil Corporation Eddy State No. I-1) 2-18S-27E Unit P	O&G	6115	01/20/59	
800	ARCO Permian Empire Abo Unit L No. 156 2-18S-27E Unit P	O&G	6225	04/12/79	
801	ARCO Permian Empire Abo Unit L No. 15 (was Pan American Petroleum Corp. State AS No. 1) 2-18S-27E Unit O	O&G	6220	11/19/58	
802	ARCO Permian Empire Abo Unit L No. 154 2-18S-27E Unit O	O&G	6200	12/04/78	
805	ARCO Permian Empire Abo Unit L No. 153 2-18S-27E Unit O	Gas Injection	6303	04/20/77	
806	ARCO Permian Empire Abo Unit L No. 152 2-18S-27E Unit O	O&G	6335	06/17/76	
807	ARCO Permian Empire Abo Unit L No. 142 2-18S-27E Unit N	O&G	6200	01/12/79	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
808	ARCO Oil and Gas Company Empire Abo Unit L No. 132 2-18S-27E Unit M	Gas	6200	07/01/76	
812	ARCO Permian Empire Abo Unit L No. 14 (was Pan American Petroleum Corp. State AR No. 1) 2-18S-27E Unit N	O&G	6112	10/21/58	
814	ARCO Permian Empire Abo Unit L No. 141 2-18S-27E Unit K	O&G	6203	05/17/77	
836	ARCO Oil and Gas Company Empire Abo Unit K No. 16 (was Pan American Petroleum Corp. Malco Refineries No. J-1) 11-18S-27E Unit A	O&G	6211	07/01/59	
837	ARCO Oil and Gas Company Empire Abo Unit M No. 151 11-18S-27E Unit A	O&G	6310	08/01/78	
838	ARCO Oil and Gas Company Empire Abo Unit L No. 153 11-18S-27E Unit B	O&G	6252	05/06/79	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
839	ARCO Oil and Gas Company Empire Abo Unit M No. 15 (was Pan American Petroleum Corp. Malco Refineries No. C-1) 11-18S-27E Unit B	O&G	6260	04/06/58	
840	ARCO Oil and Gas Company Empire Abo Unit M No. 152 11-18S-27E Unit B	O&G	6300	08/23/78	
841	ARCO Oil and Gas Company Empire Abo Unit M No. 141 11-18S-27E Unit C	O&G	6225	05/21/79	
842	ARCO Oil and Gas Company Empire Abo Unit M No. 14 (was Pan American Petroleum Corp. Malco Refineries No. A-1) 11-18S-27E Unit C	P&A	6315	09/05/57	
843	ARCO Oil and Gas Company Empire Abo Unit L No. 133 11-18S-27E Unit C	O&G	6225	05/23/79	
844	ARCO Oil and Gas Company Empire Abo Unit M No. 13 (was Pan American Petroleum Corp. Malco Refineries No. B-2) 11-18S-27E Unit D	P&A	6114	04/26/58 12/03/88	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
846	ARCO Oil and Gas Company Empire Abo Unit M No. 131 11-18S-27E Unit E	P&A	6325	07/10/78 05/11/85	
848	Amoco Production Company Malco S No. 1 11-18S-27E Unit F	P&A	10168	10/16/71 12/03/85	Injection zone penetration construction details provided in Attachment VI-1A Cement plug is present at the top of the liner, which is set above the top of the injection zone.
849	ARCO Oil and Gas Company Empire Abo Unit N No. 14 (was Pan American Petroleum Corp. Malco Refineries No. A-2) 11-18S-27E Unit F	P&A	6208	02/03/61 06/15/90	
850	ARCO Oil and Gas Company Empire Abo Unit N No. 131 (was Pan American Petroleum Corp. Malco Refineries No. B-1) 11-18S-27E Unit E	P&A	6120	03/27/58 12/03/88	
851	Amoco Productuion Company Smith-McPherson No. 1 (was Stanolind Oil and Gas Co. Ruth C. McPherson No. 1) 11-18S-27E Unit J	P&A	7270	09/01/56 06/06/73	Injection zone penetration construction details provided in Attachment VI-1A Injection zone is not cased and is mud-filled.
852	Oscar Howard An Etz No. 3 11-18S-27E Unit N	D&A	1828	03/15/27 04/15/27	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
853	Oscar Howard An Etz No. 2 11-18S-27E Unit O	D&A	1827	10/18/26 02/04/27	
854	B. R. Polk, Jr. Vickers No. 1 11-18S-27E Unit N	D&A	1794	09/08/49 10/14/49	
855	Amoco Production Company Federal DH Gas Com. No. 1 11-18S-27E Unit M	Oil	11915	05/18/84	Injection zone penetration construction details provided in Attachment VI-1A
856	Robert G. Cox Federal EA No. 2 12-18S-27E Unit D	Shut In	6248	11/27/71	
857	Robert G. Cox Federal EA No. 1 12-18S-27E Unit D	Oil	6253	07/08/75	
858	Rhonda Operating Company Federal EA No. 3 12-18S-27E Unit D	D&A	6295	03/16/80	
859	Fred Pool Drilling, Inc. Comstock Federal No. 9 12-18S-27E Unit G	O&G	1586	04/25/87	
860	Fred Pool Drilling, Inc. Chukka Federal No. 1 12-18S-27E Unit F	Oil	1600	04/23/85	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
861	Navajo Refining Company Proposed WDW-2 (was Fred Pool Drilling, Inc. Chukka Federal No. 2) (was Amoco Production Co. Diamond Federal Gas Com. 1) 12-18S-27E Unit E	Proposed Class I Well	10372	07/18/73	Injection zone penetration construction details provided in Attachment VI-1A Plugged-back total depth is 1912 feet. Proposed recompletion is detailed in Section III, Well Data.
862	Fred Pool Drilling, Inc. White Oak Federal No. 2 (was McKee McGruder No. 3) 12-18S-27E Unit J	O&G	3664	06/29/48	
863	McKee-Jones Magruder No. 1 12-18S-27E Unit L	D&A	594	02/18/43	
864	Collier Energy, Inc. Comstock Federal No. 2 12-18S-27E Unit K	O&G	1600	03/16/85	
865	Fred Pool Drilling, Inc. Comstock Federal No. 8 12-18S-27E Unit L	D&A	2000	10/10/86 01/01/87	
866	Fred Pool Drilling, Inc. Comstock Federal No. 3 12-18S-27E Unit M+B40	O&G	1530	05/19/86	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
867	R. E. McKee, et al. Magruder No. 2 12-18S-27E Unit M	D&A	2510	12/14/44 02/27/45	
868	The Eastland Oil Company Comstock Federal No. 10 (was Fred Pool Drilling, Inc.) 12-18S-27E Unit N	Shut In	2040	12/16/89	
869	The Eastland Oil Company Comstock Federal No. 1 (was Collier Energy, Inc.) 12-18S-27E Unit N	O&G	2400	12/10/84	
870	The Eastland Oil Company Comstock Federal No. 5 (was Collier Energy, Inc. White Oak Federal No. 1) 12-18S-27E Unit O	O&G	1625	04/19/85	
871	Picher Oil & Gas Michael Cronin No. 3 12-18S-27E Unit P	P&A	2200	05/20/26 02/15/32	
872	Picher Oil & Gas Michael Cronin No. 1 12-18S-27E Unit P	P&A	2002	11/27/23 02/15/32	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
873	Cities Service Oil Company Magruder No. B-4 (was Robert E. McKee Magruder No. 4) 12-18S-27E Unit P	P&A	2000	07/30/52 06/15/66	
874	Robert E. McKee Magruder No. 5 12-18S-27E Unit P	P&A	1994	02/08/54 08/02/62	
875	Picher Oil & Gas Michael Cronin No. 2 12-18S-27E Unit P	P&A	2004	02/22/26 02/15/32	
876	Hassenfush-Donnelly State No. 1 13-18S-27E Unit A	P&A	2030	01/01/26	
877	Eastland Oil State No. 2 13-18S-27E Unit A	D&A	2696	01/01/26	
878	Fred pool Drilling, Inc. Artesia State No. 2 13-18S-27E Unit C	O&G	1613	09/28/85	
879	Fred Pool Drilling, Inc. Artesia State No. 1 13-18S-27E Unit C	O&G	1575	04/13/85	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
880	Dale Resler State No. 3 13-18S-27E Unit C	P&A	2047	01/29/45 03/07/45	
881	Anadarko Petroleum Corp. Tract 8 No. 2 13-18S-27E Unit D	Oil	1608	08/27/85	
882	Dale Resler, Stanley L. Jones Tract 8 No. 1 (was State No. 2) 13-18S-27E Unit D	Oil	1950	12/11/44	
883	Dale Resler – Jones State No. 1 13-18S-27E Unit E	P&A	2353	01/26/45 03/07/45	
884	Casa Petroleum, Inc. Federal No. 1 13-18S-27E Unit F	Oil	3020	06/18/84	
885	Ralph Nix and Jerry Curtis Page No. 1 13-18S-27E Unit F	P&A	2000	11/28/54 03/19/55	
886	Dale Resler Jones-Govt. No. 1 13-18S-27E Unit F	D&A	2000	03/14/45	
888	Dickson Petroleum, Inc. Anadarko 13 Federal No. 1 13-18S-27E Unit G	D&A	2150	12/30/84 01/25/85	

ATTACHMENT VI-1 (Continued)

TABULATION OF WELLS WITHIN 1 MILE OF THE PROPOSED INJECTION WELLS

ID NO.	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	DATE COMPLETED OR PLUGGED	REMARKS
895	Anadarko Petroleum Corp. Artesia State Unit Tract 4 No. 1 (was Stanley L. Jones State No. 1) 14-18S-27E Unit A	P&A	2060	06/30/44 11/23/92	
896	Resler State No. 1 14-18S-27E Unit G	D&A	2375		
897	Dale Resler State No. 2 14-18S-27E Unit H	O&G	1888	02/08/45	
901	William and Edward Hudson Hill No. 1 1-18S-27E Unit L	D&A	1763	0618/48	
910	Compton-Smith State No. 1 2-18S-27E Unit G	D&A	1080		

ATTACHMENT VI-1A

CONSTRUCTION DATA FOR WELLS THAT PENETRATE THE INJECTION ZONE WITHIN 1 MILE OF THE INJECTION WELLS

ATTACHMENT VI-1A

CONSTRUCTION DATA FOR WELLS THAT PENETRATE THE INJECTION ZONE WITHIN 1 MILE OF THE INJECTION WELLS

ID NO	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	CASING			DATE COMPLETED OR PLUGGED	PLUGGING		MUD DATA		REMARKS
				DIAMETER (in)	DEPTH (ft)	SX OF CEMENT		DEPTH (ft)	SX OF CEMENT	FILLED (Y/N)	MUD WEIGHT (lb/gal)	
59	Mewbourne Oil Company Chalk Bluff 31 State No. 1 Illinois Camp Morrow North Field 31-17S-28E Unit O	P&A Dry	10200	13-3/8	390	525	9/9/93 9/10/93 P&A	9734 8528 7866 6648 5520 3734 2350 - 2605 440 0-30	45 45 55 45 45 45 65 40 10	Y	9.2-9.8	Proposed Navajo Refining Company WDW-1.
81	Phillips Oil Company Illinois Camp A Com No. 1 Empire Penn Gas Field 5-18S-28E Unit E	Active Gas	10450	13-3/8 8-5/8 5-1/2 2-7/8	663 4000 10450 9922	650 1400 2007	8/10/83	NA	NA	NA	NA	Perfs: 10172 - 10184 feet 10070 - 10075 feet
83	Metek Pipe & Supply (original) I&W, Inc. Walter Solt State No. 1 5-18S-28E Unit L	Active SWD	8500	13-3/8 8-5/8 5-1/2 2-7/8	354 1745 8466 7500	350 650 520	8/12/83	NA	NA	NA	NA	Perfs: 7518 - 7534 feet 7632 - 7642 feet (cemented) 7742 - 7756 feet 7778 - 7787 feet 7810 - 7812 feet
124	Mewbourne Oil Company Chalk Bluff 6 State No. 1 North Illinois Camp Morrow 6-18S-28E Unit M	Active Gas	10200	13-3/8 9-5/8 7 4-1/2 2-3/8	400 2600 9445 9077 - 10198 9990	500 1100 1895 175	4/16/92	NA	NA	NA	NA	Perfs: 10084 - 10092 feet
134	Mewbourne Oil Company Chalk Bluff Federal Com No. 2 North Illinois Camp Morrow 1-18S-27E Unit F	Active Gas	10140	13-3/8 9-5/8 5-1/2 2-7/8	416 2610 10148 9939	450 1025 1020	8/24/91	NA	NA	NA	NA	Perfs: 9999 - 10024 feet
144	Mewbourne Oil Company Chalk Bluff Federal Com No. 3 North Illinois Camp Morrow 1-18S-27E Unit I	Active Gas	10150	13-3/8 9-5/8 7 4-1/2 2-3/8	400 2600 8968 8600 - 10150 9972	100 250 1200 200	1/16/93	NA	NA	NA	NA	Perfs: 9950 - 9954 feet 9957 - 9972 feet

ATTACHMENT VI-1A (Continued)

CONSTRUCTION DATA FOR WELLS THAT PENETRATE THE INJECTION ZONE WITHIN 1 MILE OF THE INJECTION WELLS

ID NO	OPERATOR/LEASE	TYPE	TOTAL DEPTH (ft)	CASING			DATE COMPLETED OR PLUGGED	PLUGGING		MUD DATA		REMARKS
				DIAMETER (in)	DEPTH (ft)	SX OF CEMENT		DEPTH (ft)	SX OF CEMENT	FILLED (Y/N)	MUD WEIGHT (lb/gal)	
157	Mewbourne Oil Company Chalk Bluff Fed. Com No. 1 North Illinois Camp Morrow 1-18S-27E Unit N	P&A Gas	10120	13-3/8 9-5/8 7 4-1/2	400 2604 9450 9051 - 10119	425 1025 1350 175	3/7/91 5/25/91 P&A	7010 2650 450 0-50	8, CIBP 17 17 8	Y	Unknown	Perfs: 9936 - 9946 feet 9964 - 9967 feet Plugging data from Notice of Intent to Abandon filed 5/25/95.
161	Mewbourne Oil Company Federal T No. 1 North Illinois Camp Morrow 12-18S-27E Unit A	Active Shut In	10141	13-3/8 8-5/8 5-1/2 4	472 2589 9473 10140 (liner)	450 900 430 80	9/13/90					
167	ARCO Oil & Gas Company Morexco, Inc. State BY No. 1 Artesia Q-GB-SA 7-18S-28E Unit F	Active Oil	10400	13-3/8 8-5/8 5-1/2 2-7/8	418 2600 10400 1706	500 1150 1000	6/10/85 12/20/95 Recompleted to Grayburg	10050 7050 5950 2600	35', CIBP 100' 100' 100'	Y	Unknown	Perfs: 10116 - 10124 feet (cemented) 1627 - 46 feet
848	Amoco Production Company Malco S No. 1 11-18S-27E Unit F	P&A	10168	11-3/4 8-5/8 5-1/2	1000 6348 6277-10138	970 300 855	10/16/71 12/03/85	9495 7863-7613 6995 5350-5250 1050-950 Surface	NA 25 15 40 350 10	Y		Cement plug is present at the top of the liner, which is set above the top of the injection zone.
851	Amoco Production Company Smith-McPherson No. 1 (was Stanolind Oil and Gas Co. Ruth C. McPherson No. 1) 11-18S-27E Unit J	P&A	7270	13-3/8 9-5/8 4-1/2	572 960-1790 2990-4500	700 250 NA	09/01/56 06/06/73	4119-3735 3040-2900 2040-1922 1010-910 602-502 Surface	30 30 40 50 60 10	Y		Injection zone is not cased and is mud-filled.
855	Amoco Production Company Federal DH Gas Com. No. 1 11-18S-27E Unit M	Oil	11915	13-3/8 9-5/8 5-1/2	502 2200 11915	700 1400 2720	05/18/84	11610 10700	55 55			Long-string casing is cemented from total depth to above the top of the confining zone. Perfs (Strawn, Morrow): 9295-9308 feet 9789-9846 feet
861	Navajo Refining Company Proposed WDW-2 (was Fred Pool Drilling, Inc. Chukka Federal No. 2) (was Amoco Production Co. Diamond Federal Gas Com. 1) 12-18S-27E Unit E	Proposed Class I Well	10372	8-5/8	1995	800	07/18/73			Y		Plugged-back total depth is 1912 feet. Proposed recompletion is detailed in Section III, Well Data.

NA - Not applicable