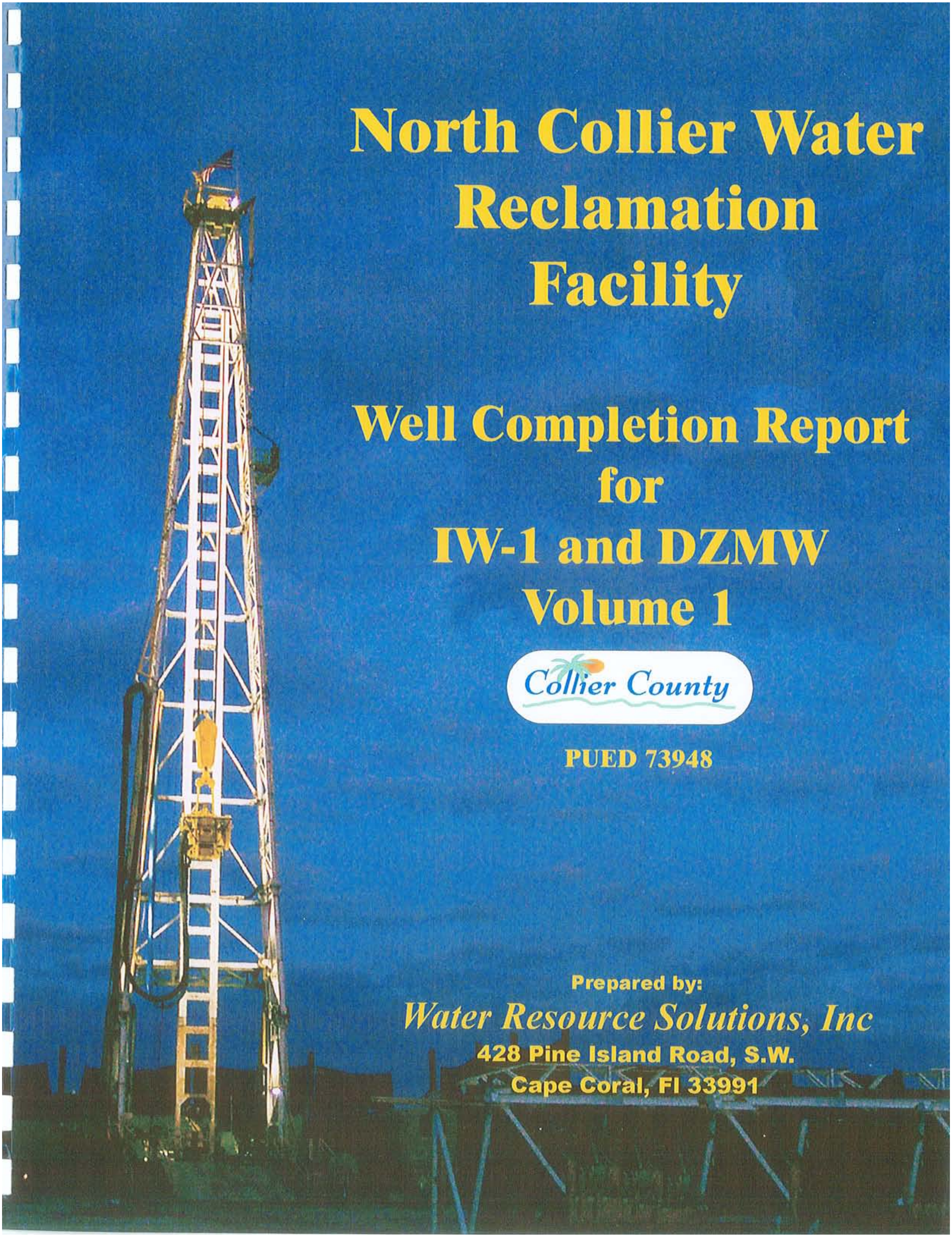

North Collier Water Reclamation Facility

Well Completion Report for IW-1 and DZMW Volume 1

Collier County

PUED 73948

Prepared by:

Water Resource Solutions, Inc

428 Pine Island Road, S.W.

Cape Coral, Fl 33991

North Collier Water Reclamation Facility Well Completion Report for IW-1 and DZMW PUED #73948

Collier County

Project Engineer Mohan Thampi, P.E.

Water Resource Solutions, Inc.

Project Manager Mark S. Pearce, Ph.D.

Project Director Lloyd Horvath, P.E.

January 15, 2004

Mark S. Pearce
Mark S. Pearce, Ph.D.
Date: Jan 15, 2004

Lloyd E. Horvath, P.E.
Licensed Professional Engineer # 25260
Engineer Certificate No. 8027
Date: 1-15-04

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1.0 INTRODUCTION

This Well Completion Report provides the drilling and construction details for the first of two planned 24-inch O.D. injection wells and one dual-zone monitoring well. This report also includes test data and water quality information pertinent to the operation and regulation of these two wells. This Class I injection well program has been initiated as a backup for Collier County's treated effluent reuse system at their North County Water Reclamation Facility (NCWRF), located at 10500 Goodlette-Frank Road, in the northern portion of the City of Naples (Figure 1-1). The NCWRF injection well disposal system, when complete, is designed to handle the proposed maximum daily production of 37.3 MGD. Locations of the recently constructed injection well (IW-1), the dual-zone monitoring well (DZMW), and the recently completed second injection well (IW-2), are plotted on the project site map (Figure 1-2). The final survey showing the location of the wells and the height to well flanges is included in Appendix 1.1

Construction and testing of the injection well (IW-1) and dual-zone monitoring well (DZMW) meet all Underground Injection Control (UIC) program requirements specified in the Florida Administrative Code (F.A.C.), Section 62-528. Additionally, well construction for the first completed injection well (IW-1) was performed in accordance with the Class I Injection Well Construction Permit, number 189741-001, issued by the Florida Department of Environmental Protection (FDEP).

In accordance with regulatory requirements, the following items were satisfactorily established during the construction and testing of well IW-1:

- Confinement
- Mechanical integrity
- Well performance under operating conditions
- Background water quality in the injection zone at well IW-1, and the upper and lower monitoring zones of the dual-zone monitoring well (DZMW).

The evaluation of confinement is based on the examination of drill cuttings, core analyses, drill-stem packer testing (pump tests) and geophysical logging data. Results of this testing indicate that confining and permeable strata exist between the planned injection interval and the USDW. These sediments should satisfactorily restrict the vertical migration of injected effluent, therefore protecting the groundwater resources of the Upper Floridan Aquifer above the base of the USDW.

The mechanical integrity of well IW-1 was demonstrated by the satisfactory performance of a 60-minute casing pressure test of the 23-inch I.D. casing (starting hydrostatic pressure of 200 psi), and the successful performance of a suite of radioactive tracer surveys (RTS). The final test pressure of 197 psi sets a maximum operating pressure during injection activities of 131 psi (2/3 of test value). Results of the RTS indicated no upward movement of the injected test tracer behind the 24-inch O.D. casing string.

Well performance under operating conditions was satisfactorily demonstrated by conducting a 12-hour injection test. Prior to starting the injection test, static wellhead pressure was recorded at 25 psi. Wellhead pressure reached 37.5 psi over a 4-hour period at an injection rate of approximately 17 MGD.

Formation water samples were collected from both upper and lower monitoring zones at DZMW and from the injection zone at IW-1. Samples were analyzed to establish background water quality of each zone. Sampling procedures followed standard chain-of-custody protocol. Sampling of the monitoring zones was performed before the 24-hour injection test.

The details of pilot-hole drilling, well construction, hydraulic testing, geophysical logging and groundwater characterization are presented in the remainder of this document.

2.0 HYDROGEOLOGY

2.1 Stratigraphy

The geologic formations penetrated during the drilling of wells at the NCWRF site (project site) range in age from Holocene to lower Eocene. In descending order, they consist of undifferentiated surficial deposits, the Tamiami Formation, Peace River and Arcadia formations of the Hawthorn Group, Suwannee Limestone, Ocala Formation, Avon Park Formation, and the Oldsmar Formation. A hydrostratigraphic column describing the general geologic conditions at the project site is provided on Figure 2-1. The geologist's log of cutting descriptions is provided in Appendix 2.3. Based upon geophysical log correlation, formation tops generally deepen slightly in an east-to-west direction across the project site. The characteristics of each of these units are described in the remainder of this subsection. For purposes of this report, the drilling pad level coincides with land surface due to the thin bottom (¼-inch) of the temporary steel drilling/containment pad used during drilling operations. Drilling depths and formation tops are referenced below pad level (bpl) throughout this report.

Undifferentiated Surficial Deposits (0 - 30 feet bpl)

Undifferentiated terrace sediments deposited during the period from approximately 0 to 2.8 million years before present (B.P.), are Holocene to Pleistocene age and form the uppermost stratigraphic unit present. The surficial deposits collected during drilling consist primarily of quartz sand, clay and shell. The undifferentiated surficial deposits extend from pad level (land surface) to approximately 30 feet bpl, as determined by a change in lithology from a clayey sand to a predominantly greenish gray to pale olive, more cohesive clay.

Tamiami Formation (30 - 150 feet bpl)

The Pliocene age Tamiami Formation (approximately 3.5 to 4.6 million years B.P.) predominantly consists of moderately to well indurated, fossiliferous, medium-grained, sandy limestone in Collier County (Knapp, et al., 1980). The Tamiami formation includes three distinct member units: the Pinecrest Limestone, the Bonita Springs Marl, and the Ochopee Limestone, in descending depth order.

Drill cutting samples collected at the project site consist of approximately 20 feet of green to olive clay (Bonita Springs Marl) underlain by almost 100 feet of predominantly fossiliferous grainstones (Ochopee Limestone). This interpretation considers that the Pinecrest Limestone is not present at the project location. The Tamiami Formation is determined to extend from approximately 30 to 150 feet bpl. The contact between the Tamiami and Peace River formations is marked by a change from a yellowish gray, fossiliferous limestone to a green, phosphatic clay.

Peace River Formation (Hawthorn Group) (150 - 400 feet bpl)

The Peace River Formation (approximately 6 to 15 million years B.P.), as defined by Scott (1988), is a lower Pliocene to Miocene-age marine siliciclastic unit that underlies the Tamiami Formation. In western Collier County, the Peace River Formation predominantly consists of low-permeability, green, phosphatic, sandy clays and dolosilts.

Samples collected during drilling at the project site consist of low-permeability, green, phosphatic clays and yellowish-gray, variably indurated limestones with lesser olive gray dolosilts. The formation is determined to occur from approximately 150 to 400 feet bpl at the project site. The lower contact is disconformable with the Arcadia Formation and is marked by a change from phosphatic, olive, dolosilt to moldic and sandy limestone. The formation boundary is typically marked by a positive "spike" on the natural gamma ray log that coincides with a "rubble zone" of quartz and phosphatic sand. Neither the rubble zone nor the distinct natural gamma ray signature, however, were noted at the project site.

Arcadia Formation (Hawthorn Group) (400 - 748 feet bpl)

The Arcadia Formation (approximately 17 to 25 million years B.P.) ranges from Miocene to possibly Oligocene in age, and underlies the Peace River Formation. Scott (1988) characterizes the unit as a limestone or dolostone with varying amounts of quartz sand, clay, and phosphate. The Arcadia Formation typically includes limited zones of higher permeability limestones and dolostones separated by beds of lower permeability limestones, clays, and marls. The basal unit of the Arcadia Formation in Collier County is typically a sandy, slightly phosphatic carbonate (Knapp, et al., 1986).

The formation encountered at the project site consists of alternating beds or seams of yellowish-gray limestone and olive-gray clay with lesser dolostone towards the bottom of the formation. Phosphate is common throughout. The upper portion of the formation (400 to 610 feet bpl) predominantly consists of yellowish-gray, fossiliferous packstones and grainstones with a high percentage of olive-gray clay. Mainly coarse-grained, fossiliferous packstones and wackestones are present from 610 feet bpl to the base of the formation with occurrences of dolostone and marl closer to the base. The contact between the Arcadia Formation and the Suwannee Limestone is determined to lie at a depth of approximately 748 feet bpl based on an attenuation of the natural gamma ray signal and a lack of phosphate and marl below that depth.

Suwannee Limestone (748 - 1,280 feet bpl)

The Oligocene-age Suwannee Limestone (approximately 27 to 37 million years B.P.) is typically a fossiliferous, packstone to grainstone composed of moderately to well-sorted foraminifera, pellets, and echinoderm and mollusk fragments. Unlithified lime mud may also be encountered. The upper portion of the formation typically consists of very-pale-orange or light tan, moderately indurated limestones (biomicrite to biosparite), while the lower portion of the formation is somewhat less porous and shows elevated natural gamma ray activity with occasional quartz sand and phosphate grains (ViroGroup, Inc., 1993).

Generally, the upper portion of the Suwannee Limestone encountered during drilling at the project location (748 to 1,020 feet bpl) consists of yellowish-gray to pale-orange, poorly to moderately indurated packstones and grainstones, exhibiting fair to good porosity. Yellowish-gray clay beds are common from 980 to 1,100 feet bpl. Significant dolomitization of limestones is noted from approximately 860 to 910 feet bpl. Samples from the lower portion of the formation (1,100 to 1,280 feet bpl) predominantly consist of yellowish-gray, friable to moderately indurated, medium to coarse-grained grainstones with lesser packstones, containing variable amounts of phosphate. The lower portion of the formation generally exhibits fair to good porosity. The base of the Suwannee Limestone is picked at a depth of approximately 1,280 feet bpl based on a lithologic change from yellowish-gray grainstone to finer-grained, very-pale-orange packstone.

Ocala Limestone (1,280 - 1,695 feet bpl)

The upper Eocene-age Ocala Limestone (approximately 38 to 40 million years B.P.) consists of white to light-brown, chalky, often highly fossiliferous, poorly cemented, foraminiferal limestone, characterized by an abundance of large foraminifera tests (Operculinides sp. and Lepidocyclina sp.). Pelecypods, gastropods, milliolids and echinoids are also common fossil types. Thin interbeds of dolostone and chert may be present in some areas.

The upper portion of the unit (1,280 to 1,400 feet bpl) at the project site consists of very-pale-orange grainstones and packstones. Overall, intergranular porosity and apparent permeability of sediments collected from the upper portion of the unit at the project site are good to fair. Interbedded yellowish-brown dolostones and pale-orange limestones occur from 1,400 to 1,470 feet bpl. Predominantly yellowish-gray to very-pale-orange limestones with occasional beds or seams of yellowish to olive-brown dolostone and mudstone generally lie from 1,470 feet bpl to the base of the unit. Varying degrees of dolomitization of limestones are noted in the lower portion of the unit.

Drill cuttings below approximately 1,580 feet bpl to the base of the unit generally exhibit fair to poor porosity and apparent permeability. Sonic log derived porosity values through this region decline when compared to sediments above. Based on a lithologic change from a poorly indurated, yellowish-gray packstone containing common Ocala-specific foraminifera (Nummulites vanderstoki) to a massive yellowish-brown dolostone, the base of the Ocala Limestone is picked at approximately 1,695 feet bpl at the project site.

Avon Park Formation (1,695 - 2,260 feet bpl)

The Avon Park Formation (approximately 43 to 48 million years B.P.) is middle Eocene in age and unconformably underlies the Ocala Limestone. The formation is characterized by alternating beds of well-indurated, brown, porous, dolostone and light brown to brown, fossiliferous limestone with some lignite and gypsum (Chen, 1965). These lithologies are generally easily distinguished from the poorly indurated limestones of the Ocala Limestone. Foraminiferal assemblages include Dictyoconus cookei and Coskinolina sp. An increase in natural gamma ray activity at the top of the Avon Park Formation is fairly common in wells drilled in southwest Florida (ViroGroup, Inc., 1993).

A generally increasing trend in gamma ray activity is noted below 1,730 feet bpl at the project site. Abundant fossils of the echinoid Neolaganum dalli have been encountered within the upper portion of this unit at some locations but were not recognized at the project site, possibly due to extensive dolomitization throughout the upper portion of the formation. The extensive dolomitization provides areas of very high apparent permeability in some areas of the formation, particularly from 1,695 to 1,760, 1,965 to 1,985, 2,025 to 2,120, and 2,140 to 2,185 feet bpl.

Generally, the upper portion of the formation at the project site (1,695 to 2,050 feet bpl) consists of well-indurated, variably vuggy, olive-brown to olive-gray dolostones. Occurrences of lignite and black dolostone (likely carbonaceous) are noted from 1,925 to 2,010 feet bpl. Overall porosity and apparent permeability vary significantly due to the irregular nature and occurrence of vugs and solution cavities within the dolostones.

The lower portion of the formation at the project site (2,050 to 2,260 feet bpl), exhibits decreased borehole size and generally consists of massive, olive-brown to yellowish-brown, well-indurated, microcrystalline to coarsely-crystalline dolostones with lesser interbedded layers of yellowish-gray grainstones and wackestones. The contact between the Avon Park Formation and the Oldsmar Formation is not clearly defined at this location due to the intensive dolomitization, which has altered the original structure of the limestones and destroyed formation-specific fossils. Thin limestone beds are noted until a depth of 2,250 feet bpl, below which they are absent.

The formation break is estimated at a depth of 2,260 feet bpl at IW-1 based on the following criteria. 1) The last significant limestone bed containing common Avon Park specific foraminifera (Dictyoconus americanus) is noted from 2,240 to 2,250 feet bpl. 2) An increasing resistivity trend on the dual induction log starts at 2,260 feet bpl. 3) Correlation of dual induction and natural gamma signatures from IW-1 with signatures from injection wells drilled at the South County Regional Water Treatment Plant, places significant amounts of lignite and carbonaceous dolostone in the upper portion of the Oldsmar Formation at both sites.

Oldsmar Formation (2,260 - 3,250+ feet bpl)

The lower Eocene-age Oldsmar Formation (approximately 48 to 53 million years B.P.), as described by Chen (1965), conformably underlies the Avon Park Formation and consists of interbedded brown to white, fossiliferous limestones and brown to dark-brown, rather porous, dolostones. The upper portion of the formation typically consists of limestones and dolostones, while the lower portion of the formation is predominantly dolostone (ViroGroup, Inc., 1993). Gypsum and anhydrite may be present, particularly near the base of the formation.

Generally, the upper portion of the Oldsmar Formation (2,260 to 2,590 feet bpl) encountered during drilling at the project site, consists of yellowish-brown, variably vuggy, microcrystalline to finely crystalline dolostones. Common to abundant secondary crystal growth of carbonates is noted in and around vug openings. Lignite and carbonaceous dolostone are noted from 2,310 to 2,420 feet bpl. Areas exhibiting low porosity values in the range of 5 to 15%, occur from 2,410 to 2,420, 2,440 to 2,450, 2,480 to 2,490, 2,525 to 2,535, 2,540 to 2,560 and 2,570 to 2,575 feet bpl, as determined from the borehole compensated sonic porosity log.

A portion of the lower portion of the Oldsmar Formation will serve as the injection zone. Drill cuttings collected from the lower portion of the formation generally consist of moderate to dark-yellowish-brown, variably vuggy dolostones with intermittent fracture development. Common to abundant secondary crystal growth of carbonates is noted in and around vug openings and along some fracture planes. A change in color of dolostones from a yellowish-brown to olive-gray is noted below 3,200 feet bpl. Areas showing enlarged borehole size on the caliper log of the 22-inch diameter open hole lie from 2,595 to 2,610, 2,625 to 2,640, 2,775 to 2,790, 2,840 to 2,850, 2,930 to 2,960 and 2,980 to 2,990 feet bpl. The borehole size from 2,990 to 3,250 feet bpl is very close to gauge, indicating a lesser degree of fracture development.

2.2 Aquifer Designations

Three major aquifer systems were penetrated during drilling operations at the project site. From the shallowest to the deepest these are as follows: the surficial aquifer system, the intermediate aquifer system, and the Floridan aquifer system. Each of these hydrostratigraphic units contains one or more permeable zones that are separated by zones of lower permeability which provide varying degrees of confinement (Figure 2-1).

Surficial Aquifer System (0 - 150 feet bpl)

The surficial aquifer system is approximately 150 feet thick at the project site. The aquifer system includes the undifferentiated terrace sediments consisting of a mixture of quartz sand, shell, and clay to approximately 30 feet bpl (water table aquifer), underlain by approximately 20 feet of clay (Bonita Springs Marl member of the Tamiami Formation). The low-permeability material is underlain by an approximate 100-foot layer of sandy, fossiliferous limestone (Ochopee Limestone member of the Tamiami Formation). The aquifer system terminates with the presence of phosphatic clays and dolosilts present in the Peace River Formation.

Intermediate Aquifer System (150 - 748 feet bpl)

The intermediate aquifer system is approximately 600 feet thick at the project site. The aquifer system includes all water-yielding intervals and confining strata present below the base of the surficial aquifer system and above the top of the Floridan aquifer system. The lower boundary of the intermediate aquifer system is coincident with the base of the Arcadia Formation, which occurs at approximately 748 feet bpl at the project site. Water-bearing zones were encountered during drilling operations from approximately 250 to 380 (Mid-Hawthorn Zone I), 400 to 460 (Mid-Hawthorn Zone II), 530 to 542 (Lower-Hawthorn Zone I) and 610 to 748 feet bpl (Lower-Hawthorn Zone II). These intervals consist of moderately permeable fossiliferous limestones (grainstone, packstone, and wackestone). Confining sediments represent approximately 40% of the system and consist predominantly of clays, marls, dolosilts, and low-permeability dolostones encountered in the lower portion of the Arcadia Formation.

Floridan Aquifer System (748 - 3,250+ feet bpl)

Miller (1986) grouped the Floridan aquifer system in southwest Florida into three units: the upper Floridan aquifer, the middle-confining unit, and the lower Floridan aquifer. As implied by the names selected, this nomenclature divides the Floridan into upper and lower permeable members that are separated by denser confining strata. This basic hydrostratigraphic representation of the Floridan aquifer system has been verified by a number of other workers in the region (Ryder, 1985, Hutchinson, 1993) and generally reflects conditions encountered at the project site. However, extensive dolomitization throughout the middle-confining unit has created areas of higher permeability within that unit making differentiation ambiguous. For the purpose of this report, the middle-confining unit, as defined by Miller (1986), is not differentiated.

The upper Floridan aquifer (748 - 1,695 feet bpl) consists of permeable strata in the Suwannee Limestone and the Ocala Limestone. Based on sonic porosity logs (Appendix 2.1.15) and lithologic descriptions (Appendix 2.3), sediments within the upper Floridan aquifer are fairly permeable at the project site, although less-permeable intervals are present. The aquifer system is predominantly composed of relatively clean, poorly to moderately indurated, packstones and grainstones with limited fractured dolostone. Less permeable intervals consisting of interbedded, yellowish clay and limestone are noted from approximately 980 to 1,100 feet bpl. Drill cuttings and decreasing sonic log porosity values indicate that carbonates exhibiting poor to fair porosity are present from approximately 1,580 feet bpl to the base of the Ocala Formation at 1,695 feet bpl.

The lower Floridan aquifer (1,695 - 3,250+ feet bpl) includes all permeable strata in the Avon Park and Oldsmar Formations. Highly permeable zones within the lower Floridan aquifer occur from 1,695 to 1,760, 1,965 to 1,985, 2,025 to 2,120, 2,140 to 2,185, 2,230 to 2,260, 2,595 to 2,610, 2,625 to 2,640, 2,665 to 2,725, 2,740 to 2,790, 2,820 to 2,865 and 2,930 to 2,990 feet bpl. These intervals are predominantly composed of vugular and fractured dolostones exhibiting very high permeability. Less permeable intervals are present as thin interbeds of limestone and in areas where vugs and fractures within the dolostones are rare or non-existent. Carbonates that exhibit very high porosity occur within the Avon Park Formation (1,695 to 2,260 feet bpl) and the middle portion of the Oldsmar Formation (2,595 to 2,990 feet bpl).

2.3 Water Quality

Water samples were collected for analysis from IW-1 and DZMW by a number of different sampling methods that are detailed in this section. Grab samples of formation water were collected from both wells while advancing the pilot hole by reverse-air drilling; immediately before ending the pumping phase during packer testing of isolated intervals; and immediately after development by reverse-air pumping of the injection interval and monitoring intervals. Results of water quality analyses are summarized for both wells in Tables 2-1 to 2-3 and on Figures 2-2 to 2-5.

2.3.1 Water Sampling and Water Quality Analyses of IW-1

Reverse-Air Drilling

Groundwater samples were collected at thirty-foot depth intervals during reverse-air drilling of the 12.25-inch-diameter pilot hole from 420 to 3,250 feet bpl. Grab samples of water were collected from the return stream at the end of the discharge line as the borehole was advanced. Each sample was field tested for specific conductance and chloride concentration, as required by the FDEP Well Construction Permit, for the purpose of providing a qualitative view of the variation in salinity with depth. Immediately following field testing, water samples were placed on ice and secured for shipment to Sanders Laboratories Environmental Testing Services (Sanders Laboratories), located in Nokomis, Florida. Laboratory analytical parameters included total dissolved solids (TDS), ammonia, and Total Kjeldahl Nitrogen (TKN). The purpose of these analyses was to determine the levels of these constituents in the penetrated formation, and to evaluate the possible introduction of these chemical constituents into the formation due to the reverse-air drilling procedures employed.

It should be noted that the chemical characteristics of the return water are not necessarily representative of the actual formation water since a closed circulation system was employed to eliminate any discharge of saline water to the surface. After setting of casings, fresh makeup water was usually added to the wellbore prior to drilling-out the cement plug to facilitate reverse-air-drilling operations until the formation was penetrated and yielded water. In intervals where permeability and yield are high, more representative samples of formation water are recovered from the reverse-air fluid return stream. The introduction of contaminants from the air is also possible due to the reverse-air drilling process. Summaries of the reverse-air water quality results (both field-tested and laboratory-analyzed) with associated sampling dates and depths are provided in Table 2-1 and on Figures 2-2 and 2-3. Laboratory reports are included in Appendix 2.6.1.

Single-Packer Drill-Stem Tests

Groundwater samples were collected during single-packer drill-stem tests of isolated intervals from 1,198 to 1,357 feet bpl, 1,450 to 1,500 feet bpl, and 1,875 to 1,925 feet bpl. A minimum of five drill-stem and open-hole volumes of formation water were evacuated prior to collecting each sample. Additionally, water samples were not collected until after the electrical conductivity values of the purged formation water indicated stabilization. A representative of WRS collected grab samples directly from the discharge line and prepared/secured each sample for analyses by Sanders Laboratories. Samples were analyzed for chloride, sulfate, TDS, and specific conductance. The sample collected from the interval 1,875 to 1,925 feet bpl was analyzed for additional parameters ammonia and TKN. These data are summarized below and included in Table 2-3.

The analytical results for formation water sampled from the first single-packer test interval (1,198 - 1,357 feet bpl) indicate a TDS concentration of 27,800 milligrams per liter (mg/l) and a chloride concentration of 15,500 mg/l. Analytical results for water samples collected from the second single-packer test interval (1,450 - 1,500 feet bpl) indicate a TDS concentration of 31,500 mg/l and a chloride concentration of 17,500 mg/l. Concentrations of TDS and chloride reported for water samples collected from the third single-packer test interval (1,875 - 1,925 feet bpl) are 35,000 mg/l and 18,500 mg/l, respectively. The additional parameters of ammonia and TKN, monitored for the third test interval, are reported below detection limits. All associated laboratory reports and chain-of-custody forms are included in Appendix 2.6.2.

Final Injection Zone Water Quality Sampling Analyses

Immediately after completing the last wiper trip of the open-hole interval, approximately 67,470 gallons of formation water was evacuated from the injection zone. Well development using a 5-hp submersible pump followed reverse-air purging. On July 30, 2003, a representative of Sander's Laboratories collected formation water samples at the end of the purging process. Stabilization of the formation water was field verified by measuring specification conductance prior to final sample collection.

Laboratory analyses for water samples collected from the injection zone included all primary and secondary drinking water standard parameters and the minimum criteria parameters for sewage effluent as required by the FDEP Well Construction Permit. Results of the analyses indicate that the injection zone formation water is near seawater quality with a TDS concentration of 38,600 mg/l, a chloride concentration of 19,700 mg/l, and a pH of 7.5. Adverse affects to the carbonate formation material are not expected due to the mixing of injected plant effluent with saline formation water. A summary of water quality analytical results for water samples collected from the injection interval, the laboratory report, and associated chain-of-custody form are included in Appendix 2.6.3.

USDW Delineation

The depth to the base of the USDW in well IW-1 is conservatively picked at 1,050 feet bpl, based on sonic porosity and dual inductance log analyses. An R_W value (resistivity of formation water) of 0.47 ohm-meters for a 10,000 mg/l NaCl solution at 90°F, a formation porosity (∅) of 50% from the sonic log, and a 100% water saturation are used to calculate the resistivity of the formation at the point where the 10,000 mg/l TDS level is exceeded.

Re-arrangement of Archie's equation (Dewan, 1983) provides:

$R_t = R_W/\varnothing^2$

where:

R_t is equal to the formation deep resistivity.

R_W is equal to the formation water resistivity; and
$\varnothing$ is equal to the formation porosity.

For the above input values for R_W and $\varnothing$, R_t is equal to 1.88 ohm-meters. The base of the USDW is then selected from the dual induction log at 1,050 feet bpl.

The selected depth of 1,050 feet bpl is considered conservative since a 10,000 mg/l NaCl solution is more conductive than a similar concentration of sea water and formation porosity values of less than 0.5 would yield a higher formation resistivity. Higher formation resistivity values are noted above 1,050 feet on the dual induction log.

2.3.2 Water Sampling and Water Quality Analyses of DZMW

Reverse-Air Drilling

Groundwater samples were collected at thirty-foot depth intervals during the reverse-air drilling of the 12.25-inch-diameter pilot hole from approximately 410 to 1,250 feet bpl. Grab samples of water were collected from the return stream at the end of the discharge line as the borehole was advanced. Each sample was field tested for specific conductance and chloride concentration, as required by the FDEP Well Construction Permit, for the purpose of providing a qualitative view of the variation in salinity with depth. Immediately following field-testing, water samples were placed on ice and secured for shipment to Sanders Laboratories Environmental Testing Services (Sanders Laboratories) located in Nokomis, Florida.

Laboratory analyses included total dissolved solids (TDS), ammonia, and Total Kjeldahl Nitrogen (TKN). The purpose of these analyses was to determine the levels of these constituents in the penetrated formation and to evaluate the possible introduction of these chemical constituents into the formation due to the reverse-air drilling procedures employed.

It should be noted that the chemical characteristics of the return water are not necessarily representative of the actual formation water since a closed circulation system was employed to eliminate any discharge of saline water to the surface. After setting of casings, fresh makeup water was usually added to the wellbore prior to drilling-out the cement plug to facilitate reverse-air-drilling operations until the formation was penetrated and yielded water. In intervals where permeability and yield are high, more representative samples of formation water are recovered from the reverse-air fluid return stream. The introduction of contaminants from the air is also possible due to the reverse-air drilling process. A summary of the reverse-air water quality results (both field-tested and laboratory-analyzed) with associated sampling dates and depths is provided in Appendix 2.6.4. Data are also provided in Table 2-2 and on Figures 2-4 and 2-5.

Single-Packer Drill-Stem Tests

Groundwater samples were collected during a single-packer drill-stem test over the isolated interval between 875 to 934 feet bpl. Two additional packer tests (see Section 5.4.2) were performed during drilling operations to assess the hydraulic characteristics of the formation, however water samples were not collected. A minimum of five drill-stem and open-hole volumes of formation water were evacuated prior to collecting the samples. Water samples were not collected until after the electrical conductivity values of the purged formation water indicated stabilization. A representative of WRS collected grab samples directly from the discharge line and prepared/secured each sample for analyses by Sanders Laboratories. Samples were analyzed for chloride, sulfate, TDS, specific conductance, ammonia and TKN. The analytical results for formation water sampled from the single-packer test interval (875 - 934 feet bpl) indicate a TDS concentration of 5,920 mg/l and a chloride concentration of 2,850 mg/l, placing this interval above the USDW. These data are summarized in Table 2-3. All associated laboratory reports and chain-of-custody forms are included in Appendix 2.6.2.

Final Monitoring Zone Water Quality Sampling Analysis

On October 6, a representative of Sanders Laboratory collected groundwater samples from the lower monitoring zone at DZMW (1,204 – 1,250 feet bpl). Approximately 44,100 gallons (23.5 well volumes) of formation water was purged, at an average flow rate of 63 gpm, before sampling was initiated from the lower monitoring zone. The following day, on October 7th, groundwater samples were collected from the upper monitoring zone at DZMW (875 - 931 feet bpl). Approximately 55,750 gallons (11.5 well volumes) of formation water was purged at an average flow rate of 60 gpm before sampling was initiated from the upper monitoring zone. All purged water was pumped into IW-1. Prior to sampling, field testing of the purged formation water for specific conductance confirmed stabilization of water from both monitoring zones.

Laboratory analyses for water samples collected from the monitoring zones included all primary and secondary drinking water standard parameters and the minimum criteria parameters for sewage effluent. Results of the analyses for samples collected from the lower-monitoring zone indicate a TDS concentration of 30,600 mg/l and a chloride concentration of 17,500 mg/l. Results of the analyses for samples collected from the upper-monitoring zone indicate a TDS concentration of 6,360 mg/l and chloride concentration of 2,900 mg/l. Based on these analytical results, the lower-monitoring zone lies below the USDW and the upper-monitoring zone lies above the USDW. A summary of water quality analytical results for water samples collected from the monitoring intervals and associated laboratory reports and chain-of-custody forms, are included in Appendix 2.6.5.

2.4 Confinement Evaluation

2.4.1 Core Analyses

Six sets of 4-inch-diameter rock cores were recovered while advancing the pilot hole of IW-1, employing standard coring procedures. The cores were collected from a depth range between 1,600 and 2,484 feet bpl, over the following intervals: 1,600 to 1,611 feet bpl; 1,703 to 1,714 feet bpl; 2,010.5 to 2,021.5 feet bpl; 2,200 to 2,211 feet bpl; 2,347.5 to 2,358.5 feet bpl; and 2,478 to 2,484 feet bpl. Twelve core samples from the six cored intervals were sent out for laboratory testing by Ardaman and Associates, Inc., located in Orlando, Florida. Each core sample was tested for vertical and horizontal hydraulic conductivity, specific gravity, total porosity, elastic modulus, and compressive strength. Vertical permeability was determined on full-diameter cores using de-aired tap water at backpressures of 70 and 160 psi and a net confining pressure of 30 psi. Selected testing parameters, lithologic descriptions of each rock-core sample, and test results are summarized in Table 2-4. The laboratory reports, including data and descriptions of the test methods, are presented in Appendix 2.7.

Sections of cores were selected for testing from the depths of 1,600, 1,604, 1,605, 1,608, 1,713, 2,019, 2,206.5, 2,209, 2,210, 2,356, 2,357 and 2,483 feet bpl. Vertical hydraulic conductivity values from the laboratory-tested rock core samples range from 3.4×10^{-6} to 2.1 feet/day (Table 2-4). These values may represent upper limits as discussed at the end of this section. A review of the laboratory results, core drilling data (Appendix 2.5), geophysical logs and a visual inspection of the cores indicate that the major confinement zones in IW-1 are located in the limestone regions above 1,690 feet bpl and in the dolostone region located between approximately 2,350 feet and 2,600 feet bpl.

Core samples from 2,019, 2,206.5, 2,209, 2,210, 2,356, 2,357 and 2,483 feet bpl exhibit lab-tested porosity values of less than 10% and lab-tested vertical hydraulic conductivity values in the range of 3.4×10^{-6} to 1.8×10^{-1} feet/day. Further, the low porosity value of the core sample from 2,483 feet bpl (less than 4%), coupled with it's high measured compressive strength (13,410 psi), indicate that the measured vertical hydraulic conductivity of 1.0×10^{-2} feet/day is likely related to flow around the core due to the relatively modest net confining pressure of 30-psi, and is an over estimate of the actual permeability of this unit. This argument is based on the absence of fractures, demonstrated by the high compressive strength, and the low porosity value of 4%, which indicates little physical connection for fluid movement through this core.

2.4.2 Geophysical Logs and Hole Conditions

Limestones lying from the base of the lower monitoring zone at 1,265 feet to 1,400 feet bpl show BHC sonic log porosity values in the range of 50 to 75%. A comparison of the BHC sonic log at depths where cores were retrieved and analyzed indicates that the BHC sonic log values are generally more than twice as large as the lab-tested porosity values for limestone core samples retrieved from the same depth. Straddle-packer tests (Section 5.4.1) performed from 1,347 to 1,364 and 1,369 to 1,386 feet bpl indicate specific capacities in the range of 2 to 8 gpm/ft.

Predominantly dolostones with lesser interbeds of limestone and dolomitic limestone lie from approximately 1,400 to 1,480 feet bpl. BHC sonic porosity values for this interval are generally in the range of 50%. Straddle-packer tests (Section 5.4.1) performed from 1,397 to 1,414 and 1,412 to 1,429 feet bpl indicate specific capacities for these intervals in the range of 0.2 to 2 gpm/ft for horizontal flow.

Predominantly limestone, with rare interbeds of dolomitic limestone and dolostone, occur from approximately 1,480 to 1,695 feet bpl. BHC sonic porosity values for this interval are generally in the range of 35 to 60%. Four samples of rock core (Section 2.4.1), retrieved from 1,600 to 1,608 feet bpl, indicate lab-tested vertical hydraulic conductivity values in the range of 2×10^{-3} to 2×10^{-2} ft/day with porosity values in the range of 30%.

Massive dolostone lies from approximately 1,695 to 2,050 feet bpl. BHC sonic porosity values for this interval are generally very high, however several tested areas indicate values in the range of 20 to 35%. Two samples of rock core (Section 2.4.1) retrieved from 1,713 and 2,019 feet bpl, indicate lab-tested porosity values of 31% and 10%, respectively. BHC sonic porosity values at the latter depth (2,019 feet bpl) are over 60%, indicating a much larger log-derived value than the lab-derived values measured for the tested core.

Predominantly dolostone with lesser interbeds of limestone and dolomitic limestone lie from approximately 2,050 to 2,250 feet bpl. Three samples of rock core (Section 2.4.1), retrieved from 2,206, 2,209 and 2,210 feet bpl, indicate lab-tested vertical hydraulic conductivity values in the range of 4 x 10^{-6}, 1 x 10^{-1}, and 2 x 10^{-2} ft/day, respectively, with porosity values in the range of 5 to 6%. Again, BHC sonic porosity values at the cored depths are over 70%, indicating much larger log-derived values than the lab-derived values measured for the tested cores.

A massive unit of dolostone lies from approximately 2,250 to 2,600 feet bpl. Areas exhibiting BHC sonic porosity values in the range of 5 to 15% lie from 2,410 to 2,575 feet bpl. Three samples of rock core (Section 2.4.1), retrieved from 2,356, 2,357 and 2,483 feet bpl, measured vertical hydraulic conductivity values in the range of 2 x 10^{-2}, 3 x 10^{-6}, and 1 x 10^{-2} ft/day, respectively, and porosity values of 1%, 9%, and 3%, respectively. Again, the lab-measured permeability values do not always correlate with the low lab-measured porosity values and high compressive strength of the cores. These data suggest that water was flowing around the cores rather than through the cores during some of the testing.

2.5 Injection Zone Properties

The injection zone lies in the middle and lower parts of the Oldsmar Formation. The formation is generally composed of brown, fractured and sometimes cavernous dolostones that exhibit extremely high permeability. Enlarged areas of the borehole, caused by collapse and dredging of fractured dolostones, are noted on the caliper log of the 22-inch open hole from approximately 2,595 to 2,610, 2,625 to 2,640, 2,665 to 2,725, 2,740 to 2,790, 2,820 to 2,865, and 2,930 to 2,990 feet bpl. The final video log of the open hole confirms cavernous regions as noted above (Appendix 2.1.26).

The majority of the injection capacity is considered to lie from the base of the 24-inch casing set at 2,575 feet bpl to approximately 3,000 feet bpl. Packer testing during the construction of IW-1 (Section 5.4.1) indicated a formation specific-capacity in the range of

1,000 gpm/ft at a pumping rate of 200 gpm. As indicated on Figure 2-6, less than a 0.1-psi change in bottom-hole pressure was recorded during the packer test. Well test data from the official injection test, provided in Section 5.2, indicate the transmissivity of the injection zone is approximately 10 MGD/ft. The borehole below approximately 3,000 feet bpl shows little evidence of major wall collapse and is generally close to the gage diameter of 22 inches.

3.0 WELL CONSTRUCTION PROGRAM

3.1 Well Construction of IW-1

The drilling and well construction of IW-1 were performed by Youngquist Brothers, Inc. (Contractor), using a platform-mounted OIME-1000 top-head-driven rotary rig equipped with a blowout preventor at the wellhead for fluid control. The rig's derrick has a pulling capacity of one million pounds and is designed to drill with 120-foot-long stands of drill pipe. The FDEP Class I Injection well construction permit for IW-1 is provided in Appendix 3.1. Weekly reports summarizing daily site operations were sent to the Technical Advisory Committee (TAC) throughout the duration of this project and are presented in Appendix 3.2.1. The final well construction details are provided on Figure 3-1.

An approved containment pad for drilling fluids was installed prior to initiation of drilling activities (diagram included in Appendix 3.3). Pad monitoring wells were installed inside 8-inch-diameter boreholes at each of the four corners of the containment pad structure. Each pad monitoring well was constructed using a 4-inch-diameter PVC casing with a sand-packed 10-foot long slotted-screen section open from approximately 10 to 20 feet below land surface. All of the wells were cemented in place from the top of the sand pack to land surface then completed with a 4-inch removable PVC cap. The pad monitoring wells were completed above land surface (Figure 3-5). Well construction and the initial groundwater sampling for background concentrations were performed on January 21, 2003. Sampling results for the pad monitoring wells are included in Appendix 3.4.

Drill cuttings were collected and described at 10-foot depth intervals during all pilot-hole drilling (See Geologist's Log in Appendix 2.3). These lithologic descriptions were verified during reaming operations. A geolograph was employed during pilot-hole-drilling operations to continuously record drilling speed (rate of penetration). The driller on shift also noted the average rate of penetration and weight on bit every five feet

(Appendix 2.4.1). Formation water samples were collected at 30-foot depth intervals throughout the reverse-air drilling process and field-tested for chloride concentration and specific conductance (Appendix 2.6.1). Inclination surveys were performed at 90-foot depth intervals in both pilot and reamed boreholes using a wire-line instrument equipped with an inclination unit capable of measuring from 0 to 1.5 degrees of deviation from vertical. Inclination survey results are presented in Table 3-1.

ASTM Type II cement was used in all cementing operations. Temperature logs were performed approximately seven hours following the cementing events except for those 20-barrel or less stages placed for the purpose of stabilizing lifts of gravel. For these low-volume cementing events, a temperature log was performed every third stage. The top of each cement stage was hard-tagged in the annulus and correlated with the associated temperature log results before subsequent cement stages were placed. Specifications for the cement and a summary of compressive strength analysis of cement sample cubes collected during each cementing event is provided in Appendix 3.7.1. Appendix 3.5.1 summarizes the volume of cement pumped and the annular height for each cement stage. A summary of geophysical surveys completed during the construction of IW-1 is provided in Table 3-3. Copies of all associated geophysical logging plots are provided in Appendix 2.1.1 through 2.1.26.

Drilling, reaming, cementing and all other aspects of well construction were performed according to project specifications. The FDEP, prior to each casing installation, approved the requested casing setting depths (Appendix 3.10.1). Mill certificates for all casing strings are provided in Appendix 3.8.1 through 3.8.3.

Results of drilling fluid and cement weight measurements, inclination surveys, temperature and other geophysical logging, mechanical integrity testing and well injection testing proved satisfactory. Drilling fluids were contained within the walls of the drilling pad throughout the project. Weekly field testing of pad monitoring well water samples indicated that there were no significant releases of brackish water to the environment during well construction.

3.1.1 48-inch Conductor Casing Installation

On January 30, 2003, before initiating pilot-hole drilling, a 60-inch-diameter steel pit casing was installed to 8 feet bpl and plumbed into the circulation system to act as a sump for drilling fluids. The pit casing also acts as a support structure to allow for mud-rotary drilling to proceed. Following the drilling of the 12.25-inch-diameter pilot hole to 400 feet bpl, which was completed on January 31, 2003, a 59.5-inch-diameter flat-bottom bit was used to ream, by mud-rotary circulation, to a depth of 415 feet bpl. The reaming operation was performed using 40-foot-long joints of drill pipe and a 34.8-foot-long stabilizer as part of the bottom hole assembly (BHA). After reaching the target depth of the borehole, two wiper runs were performed with conditioned drilling fluid to clean the hole. Caliper/natural gamma ray logging runs (Appendix 2.1.1) were performed in the borehole from pad level to the termination depth to estimate annular volume for cementing and to confirm the total depth of the reamed borehole for setting casing.

On February 4, 2003, after completion of the geophysical logging, a 48-inch O.D., 0.375-inch wall spiral-welded steel conductor casing with centralizers was set to a depth of 410 feet bpl. The casing string consists of eight, approximately 50-foot-long joints (including the header joint), and a 12-foot-long cut section. A tally of the 48-inch conductor casing string is presented in Table 3-5. Mill certificates for the 48-inch casing are provided in Appendix 3.8.1. Certified welders welded each casing joint at the rig floor before placement in the borehole.

After the casing string was centered, final welding proceeded to secure the casing before cementing operations began. The conductor casing was cemented to the surface in one stage by employing the pressure grouting method, pumping 200 barrels (1,122 cubic feet) of cement mixed with 12% bentonite at the head, followed by 332 barrels (1,863 cubic feet) of neat cement at the tail. The cement plug inside the 48-inch casing was tagged at 408 feet bpl.

3.1.2 34-inch Surface Casing Installation

Drilling of the 12.25-inch pilot hole resumed once the cement plug was drilled out of the 48-inch casing. The pilot hole was advanced by reverse-air circulation to 1,456 feet bpl. Water from an on-site 6-inch domestic-use well was used to sustain reverse-air drilling until sufficient formation water facilitated ample circulation. On February 10, 2003, following the pilot hole drilling to 1,456 feet bpl, geophysical logging was performed from 400 to 1,456 feet bpl. Geophysical logging included caliper/natural gamma ray, dual induction, temperature, sonic with log derived TDS, and flowmeter logging runs.

Following logging, drilling operations were temporarily suspended as the pilot hole was cemented back to a depth of 1,357 feet bpl and a single-packer drill-stem test (#1) was conducted over the interval from 1,198 to 1,357 feet bpl. The cementing event was performed on February 11, 2003, as 22 barrels (123 cubic feet) of cement mixed with 12% bentonite were pumped. On February 12, 2003, after performing the single-packer drill-stem test earlier that day, the pilot hole was cemented back further, pumping 191 barrels (1,070 cubic feet) of cement mixed with 12% bentonite. This cement stage was hard-tagged at a depth of 474 feet bpl.

On February 13, 2003, a nominal 42-inch-diameter flat-bottom bit was used to ream, by reverse-air circulation, to a depth of 1,310 feet bpl. The reaming operation was performed using 120-foot-long stands of drill pipe and a 39.17-foot-long stabilizer as part of the BHA. Recovery of cement chips, from the pilot hole cement-back, found in the formation cuttings, indicated that the reamed hole tracked the pilot hole closely. Upon reaching the target depth of the reamed borehole, two wiper runs were performed, followed by caliper/natural gamma logging runs (Appendix 2.1.9) from 410 to 1,308 feet bpl.

From February 20 to February 21, 2003, after completion of the geophysical logging, a 34-inch O.D., 0.375-inch wall spiral-welded steel surface casing with centralizers was set at a depth of 1,300 feet bpl. The casing string consisted of 26 joints (including the header joint) of casing ranging in length from 45.00 to 50.15 feet and one 12.1-foot-long cut section. A tally of the 34-inch surface casing string is presented in Table 3-6. Mill certificates for the 34-inch casing are provided in Appendix 3.8.2. Certified welders welded each casing joint at the rig floor before placement in the borehole.

After the casing string was centered, final welding proceeded to secure the casing before cementing operations began. On February 21, 2003, the surface casing was cemented in place by the pressure grouting method, pumping 221 barrels (1,240 cubic feet) of neat cement. The annular fill from this first stage covered the depth interval from 1,310 to 997 feet bpl. Cementing of the remaining annulus was accomplished by tremie grouting in three additional stages, the last of which was completed on February 23, 2003 when cement returns reached the surface. Cement-top temperature surveys were performed following each cementing event and are included in Appendix 2.1.10. Each cement stage following the first stage consisted of cement mixed with 12% bentonite. A total of 221 barrels (1,240 cubic feet) of neat cement and 827 barrels (4,639.5 cubic feet) of cement mixed with 12% bentonite were used in the cementing of the 34-inch surface casing string (Appendix 3.5.1). On February 24, 2003, cement inside the 34-inch casing was tagged at 1,276 feet bpl.

3.1.3 Drilling and Testing of the Pilot Hole from 1,310 to 3,250 feet bpl

Drilling of the 12.25-inch pilot hole resumed on February 24, 2003, as the cement plug inside the 34-inch casing was drilled out. The pilot hole was advanced by reverse-air circulation to 1,500 feet bpl on February 25, 2003. Drilling operations were suspended intermittently as single-packer drill-stem tests (Section 5.4.1) and rock coring (Section 2.4.1) were conducted at various depth intervals. The following serves as a chronology of events during pilot-hole drilling, ending on March 23, 2003 with a television survey of the borehole.

- Conduct single-packer test (#2) from 1,450 to 1,500 feet bpl on February 26, 2003.
- Resume drilling pilot hole to 1,600 feet bpl on February 26, 2003.

- Perform coring (#1) from 1,600 to 1,611 feet bpl on February 27, 2003.
- Resume drilling pilot hole to 1,703 feet bpl on February 27, 2003.
- Perform coring (#2) from 1,703 to 1,714 feet bpl on February 28, 2003.
- Resume drilling pilot hole to 1,925 feet bpl on February 28, 2003.
- Conduct single-packer test (#3) from 1,875 to 1,925 feet bpl on March 3, 2003.
- Resume drilling pilot hole to 2,010.5 feet bpl on March 3, 2003.
- Perform coring (#3a) from 2,010.5 to 2,021.5 feet bpl on March 5, 2003.
- Resume drilling pilot hole to 2,200 feet bpl on March 6, 2003.
- Perform coring (#4) from 2,200 to 2,211 feet bpl on March 7, 2003.
- Resume drilling pilot hole to 2,347.5 feet bpl on March 8, 2003.
- Perform coring (#5) from 2,347.5 to 2,358.5 feet bpl on March 9, 2003.
- Resume drilling pilot hole to 2,478 feet bpl on March 10, 2003.
- Perform coring (#6) from 2,478 to 2,484 feet bpl on March 11, 2003.
- Resume drilling pilot hole to 2,500 feet bpl on March 12, 2003.
- Perform geophysical logging to include caliper/natural gamma, temperature, and flowmeter (static and dynamic) logging runs from 1,300 to 2,500 feet bpl on March 13, 2003.
- Resume drilling pilot hole on March 13, 2003.
- Reach termination depth of pilot hole at 3,250 feet bpl on March 21, 2003.
- Perform geophysical logging to include caliper/natural gamma, dual induction, high-resolution temperature, borehole compensated sonic/VDL, and flowmeter (static and dynamic from 2,539 to 2,960 feet bpl) logging runs from 1,300 to 3,250 feet bpl on March 21-23, 2003.
- Conduct single-packer test #4 from 2,539 to 3,250 feet bpl on March 23, 2003.
- Perform a television survey of the borehole from 1,300 to 2,963 feet bpl on March 23, 2003.

Due to the size and shape of the pilot hole, reaming trips from 1,276 feet bpl (depth of cement plug inside the 34-inch casing) to 1,700 feet bpl, using both 20-inch and 22-inch-diameter reaming bits, were performed to facilitate straddle-packer testing (see Section 5.4.1). The packer bladders were fitted with sleeves to provide a better seal within the borehole. Following the straddle-packer tests, the base of the upper basket of a specially fabricated bridge plug, designed to fit inside the drill pipe, was installed and cemented in the pilot hole at 2,585 feet bpl. The pilot hole was then filled to a depth of 1,641 feet bpl employing alternate cementing and gravel-pumping events. The cementing of this part of the pilot hole, initiated on April 3, 2003, was accomplished with 82 cement stages, using various cement slurries including neat, cement mixed with up to 24% bentonite, calcium chloride accelerator, sodium silicate, and in some instances, sand. A cumulative total of 1,186 barrels (6,654 cubic feet) of cement was pumped in filling the pilot hole. Gravel-pumping operations ended on April 26, 2003, after an estimated cumulative total of 10,275 cubic feet or 95 loader buckets (estimated 108 cubic feet per bucket) of gravel was placed in the pilot hole. On April 27, 2003, a final neat cement cap was placed atop the cement and gravel mixture from 1,641 to 1,632 feet bpl. Summary data for of the cementing and gravel-pumping operations are presented in Appendices 3.5.1 and 3.6.1, respectively.

The following serves as a chronology of events prior to starting pilot-hole cementing.

- Perform straddle-packer test #1 inside the pilot hole (perforated pipe centerline at 1,355.5 feet bpl) on March 24, 2003.
- Perform straddle-packer test #2 inside the pilot hole (perforated pipe centerline at 1,420 feet bpl) on March 24, 2003.
- Ream pilot hole, using a 20-inch O.D. mill-toothed bit, from 1,276 feet bpl (depth of cement plug inside the 34-inch casing) to 1,700 feet bpl on March 25, 2003.
- Perform caliper/natural gamma logging run of the reamed borehole from 1,300 to 1,700 feet bpl on March 26, 2003.
- Perform straddle-packer (sleeved) test #3 inside the reamed borehole (perforated pipe centerline at 1,377 feet bpl) on March 26, 2003.
- Perform straddle-packer (sleeved) test #4 inside the reamed borehole (perforated pipe centerline at 1,405 feet bpl) on March 26, 2003.

- Ream 20-inch borehole, using a 22-inch O.D. mill-toothed bit, from 1,276 feet bpl (depth of cement plug inside the 34-inch casing) to 1,700 feet bpl on March 30-31, 2003.
- Install bridge plug in the 12.25-inch pilot hole and cement in place on April 2, 2003. Of note, the base of the upper basket of the bridge plug was set at 2,585 feet bpl.
- Begin cementing up the pilot hole from the top of the bridge plug on April 3, 2003.
- Hard tag the top of cement in the pilot hole at 2,524 feet bpl and introduce gravel for fill in the pilot hole on April 9, 2003.
- Re-drill the interval, using a 12.25-inch-diameter bit, from 2,473 to 2,560 feet bpl on April 11, 2003. The purpose for this was to assess the fill when re-cementing this interval. Results of the re-cementing proved satisfactory.
- Resume cementing the pilot hole to 2,249 feet bpl on April 12, 2003, followed by a combination of cementing and gravel pumping events.
- Tag the top of gravel at 1,641 feet bpl on April 27, 2003.
- Place a neat cement cap atop the last lift of gravel, from 1,641 to 1,632 feet bpl, on April 27, 2003.

On April 28, 2003, a 32.5-inch-diameter flat-bottom bit was used to begin reaming, by reverse-air circulation, the cement plug inside the 34-inch casing at 1,276 feet bpl. The reaming operation was performed using 120-foot-long stands of drill pipe and a 34.8-foot-long stabilizer as part of the BHA. Recovery of cement chips found in the formation cuttings, as well as results of inclination surveys run at 90-foot depth intervals, indicated that the reamed hole tracked the pilot hole closely. On May 29, 2003, the target depth of 2,580 feet bpl was reached. On May 30, 2003, following two wiper runs over the reamed interval, caliper/natural gamma logging runs were performed from 1,300 to 2,582 feet bpl (Appendix 2.1.19).

3.1.4 24-inch Injection Casing Installation

From May 30 to June 1, 2003, after completion of the geophysical logging, a 24-inch O.D., 0.50-inch wall steel, mill-coated, injection casing (longstring) with centralizers was set at a depth of 2,575 feet bpl. The casing string consisted of 63 joints (including the header joint) of casing ranging in length from 36.15 to 43.70 feet. The original total string length measured 2,583 feet, leaving 8 feet of stickup prior to cementing. A tally of the 24-inch casing string is presented in Table 3-7, and mill certificates are provided in Appendix 3.8.3. Certified welders welded each casing joint at the rig floor before placement in the borehole.

After the casing string was centered, welding proceeded to secure the casing header joint, using gussets, before preparing for cementing operations. On June 1, 2003, the injection casing was cemented in place by the pressure grouting method, pumping 103 barrels (578 cubic feet) of neat cement. The annular fill from this first stage covered the 10-foot interval from 2,580 to 2,570 feet bpl. Cementing of the remaining annulus was accomplished by tremie grouting in 99 additional stages, the last of which was completed on July 31, 2003, when cement returns were seen at the surface. A cumulative total of (17,804 cubic feet) 3,173.5 barrels of cement was pumped in filling the annulus of the injection casing to pad level. The first 22 cement stages consisted of neat cement filling the annulus to a depth of 2,330 feet bpl. Beginning on June 9, 2003, lifts of gravel were pumped intermittently with low-volume stages of cement to fill larger voids in the borehole. These low-volume cement "caps" were pumped in intervals where the borehole narrowed in an attempt to stabilize the gravel. The first lift of gravel was placed atop the 36th cement stage, the top of which was hard-tagged at 2,186 feet bpl. Gravel-pumping operations ended on July 6, 2003, after an estimated cumulative total of 30,807 cubic feet or 285.25 loader buckets (estimated 108 cubic feet per bucket) were placed in the annulus to an approximate depth of 1,690 feet bpl. Cement stages 23 through 100 consisted of various combinations of neat, cement with up to 12% bentonite, and the addition of calcium chloride accelerator. Details of the cementing and gravel-pumping operations are presented in Appendices 3.5.1 and 3.6.1, respectively.

3.1.5 Open-Hole Drilling

Drilling operations resumed on July 12, 2003, when the cement plug inside the 24-inch longstring casing was drilled out from 2,568 to 2,575 feet bpl. Reverse-air circulation was employed using a 22-inch-diameter tricone button bit to drill out the cement plug and ream the open-hole interval from 2,575 to 3,250 feet bpl (total depth). On July 29, 2003, the open-hole section of the well was completed to 3,250 feet bpl. Wiper trips, for the purpose of cleaning and conditioning the borehole, were performed immediately after reaching total depth. On July 30, 2003, well development of the open hole was performed, first by reverse-air purging then immediately followed by pumping at a lower rate using a 5-hp submersible pump. Approximately 39,900 gallons (8.5 drill-stem volumes) of formation water was evacuated from the open-hole interval by reverse-air pumping at an average rate of 814 gpm for 49 minutes. The bottom of the drill string was set at approximately 1 foot above the bottom of the open hole during purging. An additional 27,570 gallons (6-drill stem volumes) of formation water was pumped from the well, using the submersible pump, over a 530-minute pumping period. An average pumping rate of 75 gpm was maintained during the first 240 minutes, followed by pumping at a reduced average rate of 33 gpm over the final 290 minutes of pumping. The submersible pump intake was set at approximately 175 feet bpl during pump development. All purged formation water was conveyed to on-site collection/holding tanks for temporary storage.

Following well development and confirmation of formation water stabilization by field testing for electrical conductivity, a representative of Sanders Laboratories collected water samples pumped from the injection zone. These water samples were collected for laboratory analyses that included all primary and secondary drinking water standard parameters and the minimum criteria parameters for sewage effluent. The temporarily stored formation water was reintroduced down the well after sampling was completed. A caliper/natural gamma logging run of the open-hole interval (Appendix 2.1.21) was performed, following the water sampling, on July 30, 2003. The bottom of the open hole was tagged at 3,250 feet bpl.

3.1.6 Cement Bond Log Evaluation

A cement bond log was performed over the entire length of the injection casing from 2,600 feet bpl to 100 feet bpl (Appendix 2.1.22). A review of the bond log clearly shows a strong casing signal over the upper 270 feet of casing, as expected, since this portion of the casing was not supported by cement at the time of logging. A comparison of the bond log signal between 270 feet bpl and pad level, with the remaining sections below 270 feet bpl, shows that in general casing signals are weak and formation signals are weak to moderate along the cemented portion of the casing. Results of the cement bond log indicate that cement has been placed along the entire length of the casing and that there is satisfactory bonding between the cement and the casing and between the cement and the formation.

Due to the 24-inch casing size, which is considerably larger than the size (diameter) of casing that the cement bond tool was designed for, the contractor used the single 5-foot receiver instead of dual receivers, to record both amplitude and VDL signals. A letter is provided by the contractor (Appendix 3.11) that describes the logging technique used in larger-diameter casings and the difference in receiver signals between logging smaller casings with a standard tool set-up and logging larger casings with an alternate tool set-up.

3.1.7 Wellhead and Pad Completion

The final wellhead completion of IW-1 is detailed on Figure 3-2. After completion of the well, a 24-inch flange was welded to the 24-inch injection casing with the top of the flange set 18 inches above the drilling pad level. A 24-inch ball valve conforming to AWWA-C-507 is bolted to the flange. Two 3-inch take-off ball valves are placed on the 24-inch flange approximately 6 inches below the flanged connection to the 24-inch ball valve and are placed 90° degrees from each other for well access below the ball valve. A 24x24x24-inch flanged "T" was bolted to the 24-inch ball valve. Wellhead details above this point may be reviewed on Figure 3-2. A 20-foot x 20-foot x 6-inch thick, reinforced concrete well pad was constructed after completion of the wellhead, including a 10-foot by 8-foot addition at the northwest corner of the pad to support the transmission piping at the wellhead (Appendix 3.12.1).

3.2 Well Construction of DZMW

The Contractor, using the same platform-mounted OIME-1000 top-head-driven rotary rig employed to construct IW-1, performed the drilling and well construction of the dual zone monitoring well (DZMW). The FDEP Class I Injection permit for DZMW is included in Appendix 3.1. Weekly summary reports to the TAC are provided in Appendix 3.2.2. The final well construction details are provided on Figure 3-3.

An approved containment pad for drilling fluids was installed prior to initiation of drilling activities (diagram in Appendix 3.3). Pad monitoring wells, constructed identical to those used at IW-1, were installed at each of the four corners of the containment pad structure on August 4, 2003. Each of the pad monitoring wells was completed above land surface (Figure 3-5). Well construction and the initial groundwater sampling for background concentrations were performed on August 7, 2003.

Drilling, reaming, cementing and other aspects of well construction, as well as associated sediment and groundwater sampling/analyses and other testing, were performed according to project specifications, using the same methodology as that used during the construction of IW-1. Rate-of-penetration and weight-on-bit data for pilot-hole drilling are included in Appendix 2.4.2. Each casing setting depth was approved by the FDEP prior to installing the casing string (Appendix 3.10.2). Mill certificates for each casing string are provided in Appendix 3.9.1 through 3.9.3. Results of drilling fluid and cement weight measurements, inclination surveys, temperature and other geophysical logging efforts proved satisfactory. Results of compressive-strength testing of cement-stage cubes are provided in Appendix 3.7.2. Drilling fluids were contained within the walls of the drilling pad throughout the well construction. A summary of geophysical logs performed during the construction of DZMW is provided in Table 3-4.

Weekly field-testing of pad monitoring well (PMW) water samples (summarized in Appendix 3.4) indicated that there were no significant releases of brackish water to the environment during the construction of IW-1 or DZMW. An increase in salinity over a one-week period in pad monitoring well PMW-3 at DZMW was noted during the construction of IW-2. This increase was attributed to a surface leak at a temporary valve to the upper-monitoring-zone at the wellhead of DZMW. The leaking valve was replaced and pad monitoring well PMW-3 (DZMW) should be purged until the salinity of purged water stabilizes to near initial levels.

3.2.1 24-inch Intermediate Casing Installation

A 60-inch-diameter steel pit casing, identical to that used at IW-1 and constructed before site-drilling activities began late in January 2003, was installed to 8 feet bpl. From August 8th to 11th, 2003, a 42.5-inch-diameter flat-bottom bit was used to drill, by mud-rotary circulation, to a depth of 410 feet bpl. The drilling operation was performed using 40-foot-long joints of drill pipe and a 44-foot-long bottom hole assembly (bit, sub and stabilizer). After reaching an approximate 10-foot interval of competent rock at the planned target depth, circulation with conditioned drilling fluid proceeded in the bottom of the borehole for several hours for the purpose of cleaning the hole. Caliper/natural gamma ray logs were performed on August 11th (Appendix 2.2.1), immediately after satisfactory inclination surveys were conducted in the borehole at 90-foot depth intervals from 360 feet bpl upwards (Table 3-2).

On August 11, 2003, after completion of the geophysical logging, a 24-inch O.D., 0.375-inch wall spiral-welded mild-steel intermediate casing with centralizers was set at a depth of 405 feet bpl. The casing string consists of nine approximate 42-foot-long joints (including the header joint), and a 26.5-foot-long cut joint. The total string length measured 405.5 feet, leaving 0.5 feet of stick-up prior to cementing. A tally of the 24-inch intermediate casing string is presented in Table 3-8. Mill certificates for the 24-inch casing are provided in Appendix 3.9.1. Certified welders welded each casing joint at the rig floor before placement in the borehole.

After the casing string was centered, final welding proceeded to secure the casing using gussets before cementing operations began. On August 11, 2003, the intermediate casing for the dual-zone monitoring well (DZMW) was cemented in a single stage as cement returns reached the surface. The pressure grouting method was employed, pumping 1,122 cubic feet (200 barrels) of cement mixed with 12% bentonite at the head, followed by 2,244 cubic feet (400 barrels) of neat cement at the tail (Appendix 3.5.2). A temperature log was conducted approximately 10 hours after finishing cementing (Appendix 2.2.2). The cement plug inside the 24-inch casing was tagged at 397.5 feet bpl.

3.2.2 14-inch Upper-Monitoring-Zone Casing Installation

On August 14, 2003, the cement plug inside the 24-inch casing, extending from 397.5 to 410 feet bpl, was drilled out using a 12.25-inch-diameter bit by reverse-air circulation. Pilot-hole drilling continued until a target depth of 950 feet bpl was reached. On August 15, 2003, following a caliper/natural gamma logging run from 950 to 300 feet bpl (Appendix 2.2.3), a single-packer drill-stem test was conducted for the purpose of isolating target monitoring intervals to assess specific capacity (see Section 5.4.2). An inflatable packer was employed using the same methodology as that used for testing IW-1.

On August 16, 2003, the 12.25-inch-diameter pilot hole was advanced to a target depth of 1,250 feet bpl. Immediately after cleaning the borehole, a suite of geophysical logs was performed to total depth, consisting of BHC sonic porosity, dual induction, temperature, and caliper/natural gamma logging runs, as well as a log-derived TDS plot (Appendix 2.2.4 to 2.2.8). On August 17, 2003, immediately following the geophysical logging, a second single-packer drill-stem test was performed to characterize flow conditions within the planned lower-monitoring-zone interval (see Section 5.4.2).

Reaming of the pilot hole proceeded in two stages by reverse-air circulation using 120-foot-long stands of drill pipe and a 122-foot-long stand of drill collars. A 17.5-inch-diameter borehole was advanced from 397.5 to 876 feet bpl, followed by cleaning the borehole and required inclination surveys at 90-foot intervals. On August 19, 2003, a 22-inch-diameter borehole was advanced from 397.5 to 875 feet bpl. The purpose of reaming two different sized boreholes at different termination depths was to facilitate the seating of an exterior hole plug to cement the 14-inch casing in place. On August 20, 2003, after re-introducing the 12.25-inch bit to clean out the borehole, caliper/natural gamma ray logging runs were performed to a depth of 885 feet bpl (Appendix 2.2.9).

On August 18, 2003, the FDEP approved setting the upper-monitoring-zone casing at a depth of 875 feet bpl. From August 20 to August 21, 2003, after completion of the geophysical logging, a 14-inch O.D., 0.5-inch wall, API 5L, Grade B, seamless steel casing with centralizers was set at a depth of 875 feet bpl. The casing string consists of 22 joints (including the header joint) of casing ranging in length from 35.84 to 40.56 feet and a 4-foot-long exterior rubber hole plug. The original total string length measured 883 feet leaving 8 feet of stick-up prior to cementing. A tally of the 14-inch casing is presented in Table 3-9. Mill certificates for the 14-inch casing are provided in Appendix 3.9.2. Certified welders welded each casing joint at the rig floor before placement in the wellbore.

After the casing string was set to 875 feet bpl and centered, final welding proceeded to secure the casing using gussets before cementing operations began. On August 21, 2003, after tagging the top of the exterior hole plug at 872 feet bpl, ten 5-gallon buckets of gravel were poured down the annulus. The gravel was capped by a 2.25-barrel shot of neat cement, with 3% CaCl accelerator added, by the tremie method, to make sure the hole plug was sealed prior to pumping larger cement stages. The annular fill from this first cementing event covered the 10-foot interval from 872 to 862 feet bpl. Cementing of the remaining annulus was accomplished by tremie grouting in three additional stages, the last of which was completed on August 26, 2003, when cement returns reached the surface. Cement-top temperature surveys were performed following the first and second major cement stages (Appendix 2.2.10). The first major cement stage consisted of neat cement. The second and third (final) major cement stages consisted of cement mixed with 12% bentonite. A total of 736 cubic feet (131.25 barrels) of neat cement and 1,240 cubic feet (221 barrels) of cement mixed with 12% bentonite were used in the cementing of the 14-inch casing string (Appendix 3.5.2).

On August 23, 2003, the 12.25-inch-diameter pilot hole was advanced to 1,265 feet bpl. A caliper/natural gamma log was performed immediately after cleaning the borehole, confirming the drilled depth at 1,265 feet bpl (Appendix 2.2.11). On August 24, 2003, immediately following 30 minutes of air development, a third single-packer drill-stem test was performed to characterize flow conditions within the interval from 875 to 934 feet bpl. The centerline of the single packer was set in the borehole at a depth of 934 feet bpl (Section 5.4.2). Soon after air development ended, the well was allowed to flow freely at approximately 60 gpm for one hour. Drawdown was not assessed during the test due to flowing conditions. Results of the third packer test indicated sufficient yield for groundwater monitoring in the interval from 875 to 934 feet bpl. Laboratory analytical parameters of sampled water from the packer test interval included chloride, sodium, sulfate, calcium, TDS, pH, and conductivity (See Section 2.3.2).

3.2.3 6.625-inch Lower-Monitoring-Zone Casing Installation

On August 24, 2003, after the satisfactory completion of a cement bond log of the 14-inch casing cement (Appendix 2.2.12), a 6.625-inch O.D., 0.562-inch wall mild-steel lower-monitoring-zone casing with centralizers, was set at a depth of 1,204 feet bpl. The casing string consisted of 30 joints of casing ranging in length from 39.45 to 40.72 feet. The first eight joints (323 total linear feet) have had their mill varnish removed as required. A tandem set of cement baskets welded to the outer wall of the casing were positioned at 1 foot and 4 feet above the bottom end of the first joint in the casing string. The original total string length measured 1,210.4 feet, leaving 6.4 feet of stick-up prior to cementing. A tally of the 6.625-inch casing string is presented in Table 3-10. Mill certificates for the 6.625-inch casing are provided in Appendix 3.9.3. Certified welders welded each casing joint at the rig floor before lowering into the wellbore.

After the casing string was centered, final welding proceeded to secure the casing using gussets before cementing operations began. On August 25, 2003, five 5-gallon buckets of gravel were poured down the annulus and capped by a 0.25-barrel shot of neat cement, with 3% CaCl accelerator, by the tremie method. A second 1-barrel shot of neat cement with accelerator followed 78 minutes after the first. The annular fill from these first two cementing events covered the 14-foot interval from 1,200 to 1,186 feet bpl. Cementing of the remaining annulus was accomplished by tremie grouting in three additional stages, the last of which was completed on August 25, 2003. The top of the annular cement was hard-tagged the following day at a depth of 931.4 feet bpl. Cement-top temperature surveys were performed following the three major cementing events (Appendix 2.2.13). Neat cement was used in each cementing event. A total of 335 cubic feet (59.75 barrels) of neat cement was used in the cementing of the 6.625-inch casing string (Appendix 3.5.2).

3.2.4 Sector Bond Log Evaluation

A sector bond log was performed inside the 6.625-inch casing to evaluate the region from 931 to 1,204 feet bpl. The sector bond log is used to evaluate the degree of bonding between the casing and the cement, and the cement and the borehole wall. Review of the sector bond log (Appendix 2.2.14) shows good connection between the 6.625-inch casing, the cement, and the borehole wall. Good connection is indicated throughout this interval by the lack of casing signal return. Small intervals showing a lesser degree of bonding correlate well with cement-stage tags, and likely represent signatures of contaminated cement that typically form on the top of each cement stage. Results of the sector bond log indicate that the cement in the interval from 931 to 1,204 feet bpl has established isolation between the upper and the lower monitoring zones.

3.2.5 DZMW Wellhead and Pad Completion

The final DZMW wellhead completion is provided on Figure 3-4. A 4-inch steel pipe sub was installed in the annulus between the 14-inch O.D. and the 6.625-inch O.D. casings to facilitate the use of a standard submersible pump to sample the upper monitoring zone. The 6.625-inch casing and the 4-inch pipe sub are secured in place by a 0.75-inch-thick steel plate welded to the top of the 14-inch casing. The 0.75-inch-thick plate that seals the 14-inch casing was finished with two couplings having 1-inch and 1.5-inch diameters, respectively (see Figure 3-4). The 6.625-inch casing was completed with an altered 6-inch flange finished with three couplings having 0.75-inch, 1-inch, and 1.5-inch diameters, respectively. A 20-foot x 20-foot x 6-inch-thick, reinforced concrete well pad will be constructed after completion of the wellhead (Appendix 3.12.2).

4.0 MECHANICAL INTEGRITY TESTING

In accordance with the Florida Administrative Code (FAC) 62-528.410(7) mechanical integrity testing of the injection casing was performed on IW-1, which is a tubingless type completion, that included:

- A successful pressure test of the injection casing conducted at an initial pressure of 200 psi,
- A background temperature survey,
- A video survey of the casing and open hole to a depth of 3,239 feet bpl, and
- A successful set of radioactive tracer surveys (RTS), including pre-RTS and post-RTS natural gamma ray surveys.

The pressure test of the 24-inch injection casing was performed on July 11, 2003. Prior to the video and RTS tests, approximately 187,000 gallons of freshwater from the on-site production well was pumped at approximately 80 gpm down IW-1 to increase clarity for the video survey and to form a uniform-density freshwater bubble near the base of the casing for the RTS. The background temperature survey was performed concurrently with the RTS.

The following summary and conclusions were reached in the performance of the Mechanical Integrity Test (MIT):

- Pressure on the casing decreased from 200 to 197 psi during the pressure test, which represents a 1.5% loss in pressure over the one-hour test period. The observed pressure drop remained within the (5%) limit established in Florida Administrative Code 62-528.300(6)(e). Based on the test pressure of 200 psi, the maximum permittable operating pressure for IW-1 is 131 psi (2/3 of the maintained test pressure value), as discussed in Section 4.2.

- Analysis of the video survey indicates that the overall condition of the steel casing was excellent. The open-hole section of the well was video surveyed to 3,239 feet bpl and appeared in good condition, as discussed in Section 4.3.

- The RTS did not indicate any upward movement of injected fluid behind the casing, as discussed in Section 4.4.

Based on the information gathered during the MIT, it is concluded that IW-1 demonstrates mechanical integrity.

4.1 Background Temperature Survey

A background temperature survey (Appendix 2.1.23) was performed from pad level to the bottom of the 24-inch casing and the open hole to 2,800 feet bpl. The open-hole portion of the well exhibited a relatively constant temperature in the range of 95 to 96°F, with a maximum open-hole temperature of 96°F recorded at a depth of 2,600 feet bpl.

4.2 Casing Pressure Test

In preparation for the official pressure test of the 24-inch injection casing, trial tests were conducted during the previous night shift. On July 11, 2003, a pressure of 200 psi was applied to the inside of the casing string at the start of the test. A 3-psi loss (1.5%) of pressure was recorded over the duration of the 60-minute test. Test data are summarized in WRS's Casing Pressure Test Log form presented as Table 4-1. Mr. Richard Orth, a representative of the FDEP, witnessed the casing pressure test. A copy of the associated field notes documenting test activities and signed/certified by Mr. Orth, is presented as Appendix 4.1. The pressure gauge calibration record used in the official test is also provided in Table 4-1. Results of this test indicate casing integrity.

Immediately following the satisfactory completion of the test, successive 5-gallon volumes of water were released from the casing and the associated reduced pressure readings were recorded. Approximately 57 gallons of water were removed before the pressure gauge returned to 0 psi. The following equation was used to calculate the compressibility of fluid:

$$K \text{ (compressibility of fluid)} = \frac{1}{V \text{ (volume of fluid)}} * \frac{\text{Delta V (change in fluid volume)}}{\text{Delta P (change in pressure (psi))}}$$

Given a total water volume of 55,566 gallons, a change in water volume of 57 gallons, and an associated pressure change of 200 psi, the calculated value for the compressibility of the water in the casing equals 5.1×10^{-6} per psi. Since the measured compressibility of water is representative of the values typically associated with water, it is concluded that there was no trapped air in the system and therefore, the test was valid.

4.3 Video Survey

The video survey (Appendix 2.1.26) was performed on August 28 and 29, 2003 from pad level to a total depth of 3,239 feet bpl. Prior to performing the video survey, approximately 187,000 gallons of clear, potable water was pumped from the on-site production well at approximately 80 gpm down IW-1 to increase clarity.

On August 28, 2003, the video survey was conducted with good visibility from pad level to 1,300 feet bpl, where clarity quickly deteriorated. The video survey was temporarily suspended while the well was flushed with freshwater overnight to increase clarity. On August 29, 2003, the video survey resumed down-hole from the base of the casing set at 2,575 feet bpl, with good visibility, to a total depth of 3,239 feet bpl, where visibility was no longer acceptable. The video survey continued with acceptable visibility, recording the casing uphole from the base at 2,575 feet bpl to 1,300 feet bpl. Recording continued uphole with deteriorating clarity to 1,200 feet bpl, at which point the video tool recorded the side view back down to 1,300 feet bpl. This concluded the video survey and the video tool was withdrawn from the well.

The overall condition of the steel casing appeared excellent with casing welds clearly visible approximately every 40 feet. No casing or welding defects were apparent from the video survey. The base of the casing was visually confirmed at 2,575 feet bpl. The cement at the base of the casing appeared to be in good condition.

4.4 Radioactive Tracer Survey

The RTS was conducted on August 29, 2003. The test included a background gamma ray log, two low-flow-rate (approximately 5 feet/min) radioactive tracer surveys, a higher-flow-rate (approximately 14 feet/min) radioactive tracer survey, and a final background gamma ray survey. The logging results of these tests are provided in Appendix 2.1.24. The radioactive source used during the test was Iodine – 131 supplied by Medtech Diagnostic Services with an assayed strength of 1 millicurie per ml. A total of 5 ml of radioactive source was loaded into the tool, prior to running the RTS. A copy of the source invoice is included in Appendix 4.2.

The tool used for the test consists of an ejector and three gamma ray detectors. The ejector is located above the detectors designated GRM and GRB and below the detector designated GRT. A diagram of the tool with distances and locations of the ejector and detectors is shown on the log provided in Appendix 2.1.24. The casing collar locator detected the bottom of the casing at 2,575 feet bpl. The first dynamic test was run with the ejector set five feet above the base of the casing (2,570 feet bpl). A line was connected to the stripper head to supply water for the low-flow-rate test. The water injection rate for the first test was set at 108 gpm (5 feet/min downhole velocity). Once the tool was set stationary in the proper position, one millicurie of Iodine – 131 was ejected from the tool, and the responses on all three detectors were monitored for 60 minutes. After 15 seconds, the middle detector (GRM) began to register an increased signal. The signal on the lower detector (GRB) increased after 100 seconds. No increase in the signal from the upper detector (GRT) was noted during the entire test.

After recording for 60 minutes, the hole was logged out of position (LOP) upward 200 feet to 2,375 feet bpl. After the LOP was complete, the hole was logged back down to 2,675 feet bpl, noting an increase in gamma signal below the base of the casing from 2,586 to 2,610 feet bpl. The hole was flushed and prepared running the second low-rate dynamic test.

The second low-rate dynamic test was conducted for 30 minutes at an injection rate of 108 gpm with the ejector located 5 feet above the base of the casing using 1 millicurie of Iodine-131. The signal on the GRM increased after 20 seconds and the tracer front reached the GRB after 120 seconds.

After recording for 30 minutes, the hole was logged out of position (LOP) upward 200 feet to 2,375 feet bpl. No increase in gamma signal was noted on the GRT at anytime during the test. After the LOP was complete, the hole was logged back down to 2,675 feet bpl, again noting an increase in gamma signal from 2,586 to 2,610 feet bpl. The hole was flushed and prepared for running the final test.

The third dynamic test was conducted with the injection rate increased to 300 gpm, (14 feet/min downhole velocity) and was conducted for 15 minutes. There was no indication of tracer movement on the GRT. The time span from ejection to detection on the middle (15 seconds) and lower detectors (50 seconds) was much shorter than recorded during the previous tests. The shorter detection time is consistent with the increased down-hole fluid velocity. After the test, the hole was logged out of position upward 200 feet to 2,375 feet bpl. No increase in gamma signal was noted on the GRT at any time during the test. After the LOP, the hole was logged down to 2,675 feet bpl, noting an increased gamma signal from 2,590 to 2,605 feet bpl with a lesser increase down to 2,740 feet bpl.

At the completion of the dynamic tests, the tool was lowered into the open hole to a depth of approximately 2,760 feet bpl and the remaining 2 millicuries of Iodine-131 was released from the tool.

A final gamma ray profile of the well was conducted from 2,800 feet bpl to surface and compared with the original gamma ray profile performed prior to ejecting any tracer. Initially a slight increase in gamma activity was noted on all three detectors indicating the ejected tracer. Final gamma signals matched background gamma signals by the time the tool was raised inside the 24-inch casing (Appendix 2.1.24).

5.0 WELL TESTING

5.1 Injection Test

The injection test was performed after the well was completed and mechanical integrity was demonstrated according to FAC 62-528.410(7). A summary of the two-rate injection test data recorded in the field is included in Table 5.1. Pressure recording devices were placed 10 feet above the base of the casing and at the surface to monitor pressure responses in the injection well during injection. An injection rate of approximately 17 MGD (approximately 11,800 gpm) was sustained through the majority of the test. The designed operational rate for IW-1 is 18.65 MGD (approximately 12,950 gpm). Continuous pressure responses were recorded in both zones of DZMW to monitor pressure changes due to injection activities. The raw pressure data collected during the injection test are included in Appendix 5.1. Injection was accomplished using the plant's reclaimed water pumps. The calibration certificate for the flowmeter used during the test is provided in Appendix 5.2.

Background pressure data in each of the monitoring zones of DZMW and in IW-1 were collected for a 24-hour period prior to initiating the test and ending 24 hours after injection was stopped. Local tidal and barometric data were also collected during this period as discussed in more detail in subsections 5.2 and 5.3.

5.2 Injection Well Performance

The injection rate during the injection test is graphically presented on Figure 5-1. Pressure responses were recorded down-hole and at the wellhead during injection activities. The changes in pressure at the wellhead and at the formation are graphically presented on Figure 5-2. Local tidal data and on-site barometric data collected during the test are presented graphically on Figure 5-3.

The initial injection rate fluctuated over the first 45-minute period until it was stabilized at 17 MGD (11,800 gpm). This rate was maintained for the next 3-hour and 15-minute period. A maximum injection rate of 18.1 MGD was attained for a brief period of time during the first twenty minutes of pumping. Rates were reduced within ten minutes of reaching 18.1 MGD to prevent excessive drawdown within the reuse pump system's wet well. A down-hole pressure increase of 0.75 psi (approximately 1.7 feet) and a wellhead pressure increase of 12.5 psi (approximately 29 feet) were noted over the 4-hour period. An average injection rate of 17 MGD (11,800 gpm) was noted over the 4-hour period.

After the 4-hour test at the higher rate (near operational), the injection rate was lowered to 8.4 MGD (5,800 gpm), and maintained at a lower rate for an 8-hour period. The injection rate increased approximately 2 hours and 30 minutes into this portion of the test, from 8.4 MGD (5,800 gpm) to 10.7 MGD (7,400 gpm) due to a reduction in reuse system demand. A net down-hole pressure increase of 0.3 psi (0.7 feet) and a wellhead pressure increase of 5 psi (11.5 feet) above background were noted over the 8-hour period. An average injection rate of 9.7 MGD (6,700 gpm) was noted over the 8-hour period.

The specific injectivity of the well at the wellhead, based on the current testing, is approximately 410 gpm/ft at 11,800 gpm and approximately 640 gpm/ft at 7,400 gpm as estimated from pressure changes at the surface. Similar calculations under down-hole conditions indicate a down-hole injectivity of 6,900 gpm/ft at 11,800 gpm and 10,600 gpm/ft at 7,400 gpm. These values, based on the empirical Walton formula (Driscoll, 1986), suggest a formation transmissivity in the range of 14 to 21 MGD/ft. A summary of calculated specific injectivity and transmissivity values from the injection test is provided in Table 5-2.

The difference in specific injectivities measured at the surface and under bottom hole conditions reflects the substantial contribution to pressure response of friction due to flow in the pipe. Pressure build-up due to friction in the pipe of approximately 11.75 psi is noted at the 11,800 gpm rate, and approximately 4.7 psi recorded at the 7,400 gpm rate.

It should be recognized that pipe friction will increase as the injection casing ages, causing a decrease in specific injectivity measured at the surface over time.

Formation transmissivity, based on a multirate analysis (Mathews and Russell, 1967) of injection test data, is in the range of 10 MGD/ft. The plot used to calculate the transmissivity value is presented on Figure 5-4. The analysis method allows, in this case, for the evaluation of the two-rate flow test to determine a Kh value for the formation.

The formation storage value (S) is estimated to range between 3×10^{-4} and 7.5×10^{-4} based on an effective porosity of 20 to 50%, a compressibility factor (C) of 3.5×10^{-6} per foot, and an injection interval height (h) of 420 feet, using the following equation:

$S = \phi C h$

where,

ϕ = effective porosity

C = compressibility of the matrix and fluid

h = height of injection interval

5.3 Monitoring Well Response

Pressure transducers and recording devices were placed in both monitoring zones at DZMW prior to performing the injection test. The transducer for the lower monitoring zone was set approximately 50 feet below the top of the flange (approximately 48 feet bpl). The transducer for the upper monitoring zone was placed at surface (approximately two feet apl). Pressures were continuously recorded in both zones throughout the injection test and background periods to assess any response due to injection activities. Down-hole pressures in IW-1 and local tidal variations are presented graphically on Figure 5-5. Water level variations in the upper and lower monitoring zones are presented in Figures 5-6 and 5-7. An adjusted response in the monitoring zone water levels, based on subtracting out tidal changes, is also presented in Figures 5-6 and 5-7.

Minimal pressure responses in the range of 0.05 to 0.1 psi were recorded by the transducer in the lower monitoring zone and appear to correlate with injection activities. Similar muted anomalies in the range of 0.01 to 0.03 psi are noted in the responses recorded from the transducer in the upper monitoring zone. Similar anomalies, in the range of 0.01 to 0.08 psi, that do not appear to correlate with injection activities, are noted during the data recording period in both monitoring zones. Although the pressure responses in the dual-zone monitoring well are not considered important, it is relevant to note that IW-2 was open between 1,425 and 2,500 feet bpl during this test. The open hole in IW-2 could have provided a pressure conduit that will not exist after the longstring casing is cemented in place.

5.4 Packer Tests

5.4.1 IW-1

Packer tests were performed in well IW-1 to assess hydrologic conditions, to identify potential monitoring zones, and facilitate the collection of representative formation water samples. Test intervals (depths) for the single-packer drill-stem tests were selected prior to drilling. The primary purpose of the single-packer tests was to obtain water quality and yield-data with depth. After the drilling of the pilot hole, straddle-packer drill-stem tests were attempted to collect additional information on confinement above 1,700 feet bpl. However, hole conditions did not allow for the satisfactory straddle-packer testing of this region. In performing both types of packer tests, zones of interest were isolated, pumped at controlled rates, and the induced drawdown within the work-string (drill-stem) was recorded continuously. The packer test intervals and hydraulic test results are summarized in Table 5-3.

Single-Packer Tests

Four single-packer drill-stem tests using an inflatable packer installed on the work-string were performed inside the 12.25-inch pilot hole at specified depths throughout the drilling.

The purpose of these tests was to obtain water quality and locate target-monitoring zones for installation of DZMW. Barite was used, as needed, to control well flow before tripping in the packer string. An in-line, calibrated pressure gauge was continuously monitored throughout the duration of each packer test to assure that the packer bladder(s) pressurized within the borehole. A 3-hp or a 5-hp submersible pump was used depending upon the predicted yield of each zone. Submersible pumps were set inside the work-string at a depth of approximately 180 feet bpl to facilitate each pump test. A 250-psi pressure transducer was set within the work-string at a minimum of 10 feet above the pump intake. This transducer was connected to an In-Situ Hermit Model 3000 data logger used to continuously record changes in head. The head within the annulus was also continuously recorded with a second, 20-psi pressure transducer. An in-line propeller-type flow meter was employed during each pump test to record flow rate (discharge) and total volume pumped. Water quality of samples collected during the single-packer tests is discussed in Section 2.3.1 and summarized in Table 2-3.

Single-packer drill-stem test #1 was performed on February 12, 2003, over the interval from 1,198 to 1,357 feet bpl. An average pumping rate of 74 gpm was recorded during the 225-minute pumping phase. A total volume of 16,200 gallons of formation water was pumped during this test. Recovery-phase data was recorded for 156 minutes. Approximately 5.0 feet of drawdown was recorded in the work-string. A specific capacity value of 15 gpm/ft was calculated based on an average pumping rate of 74 gpm. Water quality analysis indicated that the TDS of this unit was 27,800 mg/l, which places the unit below the base of the USDW (see Table 2-3).

Single-packer drill-stem test #2 was performed on February 26, 2003, over the interval from 1,450 to 1,500 feet bpl. An average pumping rate of 67 gpm was recorded during the 149-minute pumping phase. A total volume of 9,889 gallons of formation water was pumped during this test. Recovery-phase data was recorded for 142 minutes. Approximately 1.1 feet of drawdown in the work-string was recorded. A specific capacity value of 61 gpm/ft was calculated based on an average pumping rate of 67 gpm.

Single-packer drill-stem test #3 was performed on March 3, 2003, over the interval from 1,875 to 1,925 feet bpl. A sustained pumping rate of 67 gpm was recorded during the 240-minute pumping phase. A total volume of 16,400 gallons of formation water was pumped during this test. Recovery-phase data was recorded for 271 minutes. Approximately 0.7 feet of drawdown in the work-string was recorded. A specific capacity value of 96 gpm/ft was calculated based on the above values.

Immediately before ending the pumping phase for the first three packer tests, a combined minimum of five drill-stem and open-hole volumes of water was evacuated. After each isolated zone was sufficiently purged, grab samples of formation water were collected and analyzed by Sanders Laboratories (see Section 2.3.1).

A fourth single-packer test was performed on March 23, 2003, over the interval from 2,539 to 3,250 feet bpl. The centerline of the packer's single bladder was set at 2,539 feet bpl. Unlike the previous three packer tests run, this test included both static and dynamic flow logs over the interval from 2,539 to 2,960 feet bpl. Downhole pressure was also recorded. The purpose for this fourth test was to estimate specific capacity of the injection zone. The testing plan was finalized based on the results of a caliper log and static flow log, performed over the test interval the previous day, March 22, 2003.

First, a 20-psi pressure transducer was set inside the work-string at approximately 7.5 feet bpl. This transducer was connected to an In-Situ Hermit Model 3000 data logger used to continuously record changes in head. A second, 20-psi pressure transducer was set inside the annulus to record head. A pressure-recording device set on the flow tool was employed to assess pressure changes in the formation without the friction loss due to flow through the work-string. A static flow log was run immediately after reaching a depth of 2,534 feet bpl. The flow tool could not be safely advanced past a depth of 2,964 feet bpl, and data recording ended at 2,960 feet bpl. The tool was then retrieved to 2,534 feet bpl and held stationary there recording data for 10 minutes. Next, a dynamic flow log was performed, logging downhole from 2,534 to 2,960 feet bpl a mission Magnum (8" x 6" x 14") centrifugal pump, was used to induce flow. The flow tool was then retrieved uphole while pumping at an average rate of 195 gpm. The tool was held stationary after reaching a depth of 2,543.5 feet bpl and data was recorded for 10 minutes. Finally, the well was shut-in and pressure data was recorded for an additional 32 minutes.

Pumping during the first 195 minutes of the pump test was continually interrupted by pump cavitation. The pumping rate ranged from 180 to 210 gpm during the 275-minute pumping phase. Approximately 6 feet of drawdown was recorded in the work-string, at surface, during continuous pumping in the final 80 minutes of the test. Downhole pressure was recorded five feet inside the base of drill pipe (2,534 feet bpl) and reached a maximum pressure decrease of less than 0.1 psi during the test. A specific capacity value of approximately 1,000 gpm/ft was calculated based on an average pumping rate of 200 gpm and a downhole pressure change of 0.2 feet (approximately 0.1 psi).

Straddle-Packer Tests

After reaching the termination depth of the pilot hole and completing the single-packer drill-stem tests, four straddle-packer tests, two within the original 12.25-inch pilot hole and two within a 20-inch reamed interval were performed (Table 5-3). Due to the nature of the borehole size and shape, the 12.25-inch pilot hole was reamed to 20 inches from 1,300 to 1,700 feet bpl to facilitate the use of sleeved straddle-packer bladders for four straddle packer tests. Due to the nature of the hole below 1,414 feet bpl, the hole was reamed-out further to 22-inches in an attempt get packer bladder sleeves to seal against the borehole wall. However, attempts at performing straddle-packer drill-stem tests inside the 22-inch reamed interval (1,300 to 1,700 feet bpl) failed as a competent seal between the packer bladder and borehole wall could not be attained. The risk of losing or rupturing the packer assembly cancelled plans for performing a fifth or further straddle-packer drill-stem tests. The same methodology employed during the pumping phase of the single-packer drill-stem tests was used for each straddle-packer drill-stem test. Due to the short pumping time for each of the straddle-packer drill-stem tests, water samples were not collected towards the end of the tests nor was recovery data recorded.

Straddle-packer drill-stem test #1 was performed on March 24, 2003, in the 12.25-inch pilot hole, from 1,347 to 1,364 feet bpl. The center of the packer's perforated pipe was set at 1,355.5 feet bpl. An average pumping rate of 9 gpm was recorded during the 23-minute pump test. A total volume of approximately 250 gallons of formation water was pumped during this test. Approximately 1.1 feet of drawdown in the work-string was recorded over the pumping period. A specific capacity value of 8.2 gpm/ft was calculated based on the average pumping rate of 9 gpm.

Straddle-packer drill-stem test #2 was performed on March 24, 2003, in the 12.25-inch pilot hole, from 1,412 to 1,429 feet bpl. The center of the packer's perforated pipe was set at 1,420 feet bpl. A sustained pumping rate of 7 gpm was recorded during the 39-minute pump test. A total volume of approximately 250 gallons of formation water was pumped during this test. Approximately 4.0 feet of drawdown in the work-string was recorded. A specific capacity value of 1.8 gpm/ft was calculated based on the sustained pumping rate of 7 gpm.

Straddle-packer drill-stem test #3 was performed on March 26, 2003, in the 20-inch reamed interval from 1,369 to 1,386 feet bpl. The center of the packer's perforated pipe was set at 1,377 feet bpl. An average pumping rate of 2.5 gpm was recorded during the 33-minute pump test. A total volume of approximately 100 gallons of formation water was pumped during this test. Approximately 1.4 feet of drawdown in the work-string was recorded. A specific capacity value of 1.8 gpm/ft was calculated based on the average pumping rate of 2.5 gpm.

Straddle-packer drill-stem test #4 was performed on March 26, 2003, in the 20-inch reamed interval from 1,397 to 1,414 feet bpl. The center of the packer's perforated pipe was set at 1,405 feet bpl. The pumping rate ranged from 1.5 to 2.75 gpm during the 58-minute pump test. A total volume of 117 gallons of formation water was pumped during this test. Approximately 12.1 feet of drawdown in the work-string was recorded during the test. A specific capacity value of 0.2 gpm/ft was calculated based on the average pumping rate of 2.1 gpm. Additional straddle-packer testing below 1,414 feet bpl could not be conducted due to the increased hole size as discussed previously.

5.4.2 DZMW

Packer tests were performed in DZMW to assess hydrologic conditions, to identify potential monitoring zones, and to facilitate the collection of representative formation water samples. In performing the packer tests, zones of interest were isolated, pumped at controlled rates, and the induced drawdowns within the work-string (drill-stem) were recorded continuously. The test intervals and hydraulic test results are summarized in Table 5-4.

Three single-packer drill-stem tests using an inflatable packer, installed on a work-string, were performed inside the 12.25-inch pilot hole throughout the drilling process. Barite was used, as needed, to control well flow before tripping in the packer string. An in-line calibrated pressure gauge was continuously monitored throughout the duration of each packer test to assure that the packer bladder pressurized within the borehole. A 3-hp or a 5-hp submersible pump was used depending upon the predicted yield of each zone. Submersible pumps were set inside the work-string at a depth of approximately 180 feet bpl to facilitate each pump test. A 250-psi pressure transducer was set within the work-string at approximately 10 feet above the pump intake. This transducer was connected to an In-Situ Hermit Model 3000 data logger used to continuously record changes in head. The head within the annulus was also continuously recorded with a second, 20-psi pressure transducer. An in-line propeller-type flow meter was employed during each pump test to record discharge flow rate and total volume pumped.

After the 12.25-inch-diameter pilot hole was advanced to 950 feet bpl, the first single-packer test was performed, with the centerline of the packer set in the borehole at 902 feet bpl. A three-rate step-drawdown test was performed at 18.5-gpm, 60-gpm, and 65-

gpm pumping rates for durations of 60-minutes, 72-minutes, and 25-minutes, respectively. An approximate 13-minute recovery phase immediately followed the third and final pumping phase. Measured drawdown based on the recovery level was 11 feet at 65 gpm. Results of this packer test (902 to 950 feet bpl) indicate a specific capacity in the range of 5 gpm/ft at 65 gpm.

After the 12.25-inch-diameter pilot hole was advanced to a target depth of 1,250 feet bpl, the second single-packer drill-stem test was performed to characterize flow conditions within the planned lower-monitoring-zone interval. The centerline of the single packer was set in the borehole at a depth of 1,202 feet bpl. A two-rate step-drawdown test was performed at pumping rates of 24.5 gpm and 60 gpm for test durations of 60-minutes and 63-minutes, respectively, with less than one foot of drawdown. Pumping was followed by a 30-minute recovery phase. Results of this packer test indicate a specific capacity in the range of 60 gpm/ft at 60 gpm for the interval from 1,202 to 1,250 feet bpl.

After setting the 14-inch casing string at 875 feet bpl, a third single-packer drill-stem test was performed to characterize flow conditions within the interval from 875 to 934 feet bpl. The centerline of the single packer was set in the borehole at a depth of 934 feet bpl. A 250-psi pressure transducer was set in the annulus and head readings were recorded continuously. Soon after air development ended, the well flowed under artesian at approximately 60 gpm. Flow was reduced to approximately 40 gpm by adjusting an in-line valve. The valve was soon opened allowing the well to again flow at approximately 60 gpm. After allowing the well to flow at 60 gpm for the next 52 minutes, formation water samples were collected to assess preliminary water quality. A specific capacity in the range of 4.6 gpm/ft was calculated based on a flowing water level of 6 feet above pad, and a static pressure of 19 feet above pad measured after shut-on. The well was allowed to flow for an additional 7 minutes before being shut-in and approximately 34 minutes of recovery data were recorded. Results of this packer test indicate ample yield for groundwater monitoring in the interval from 875 to 934 feet bpl.

Immediately before ending the pumping phase for the third packer test (875 to 934 feet bpl), grab samples of formation water were collected for analysis by Sanders Laboratories (see Section 2.3.2). A combined minimum of five drill-stem and open-hole volumes of water was evacuated prior to sampling. Water quality of the samples collected during the third single-packer test is summarized in Table 2-3.

6.0 REFERENCES

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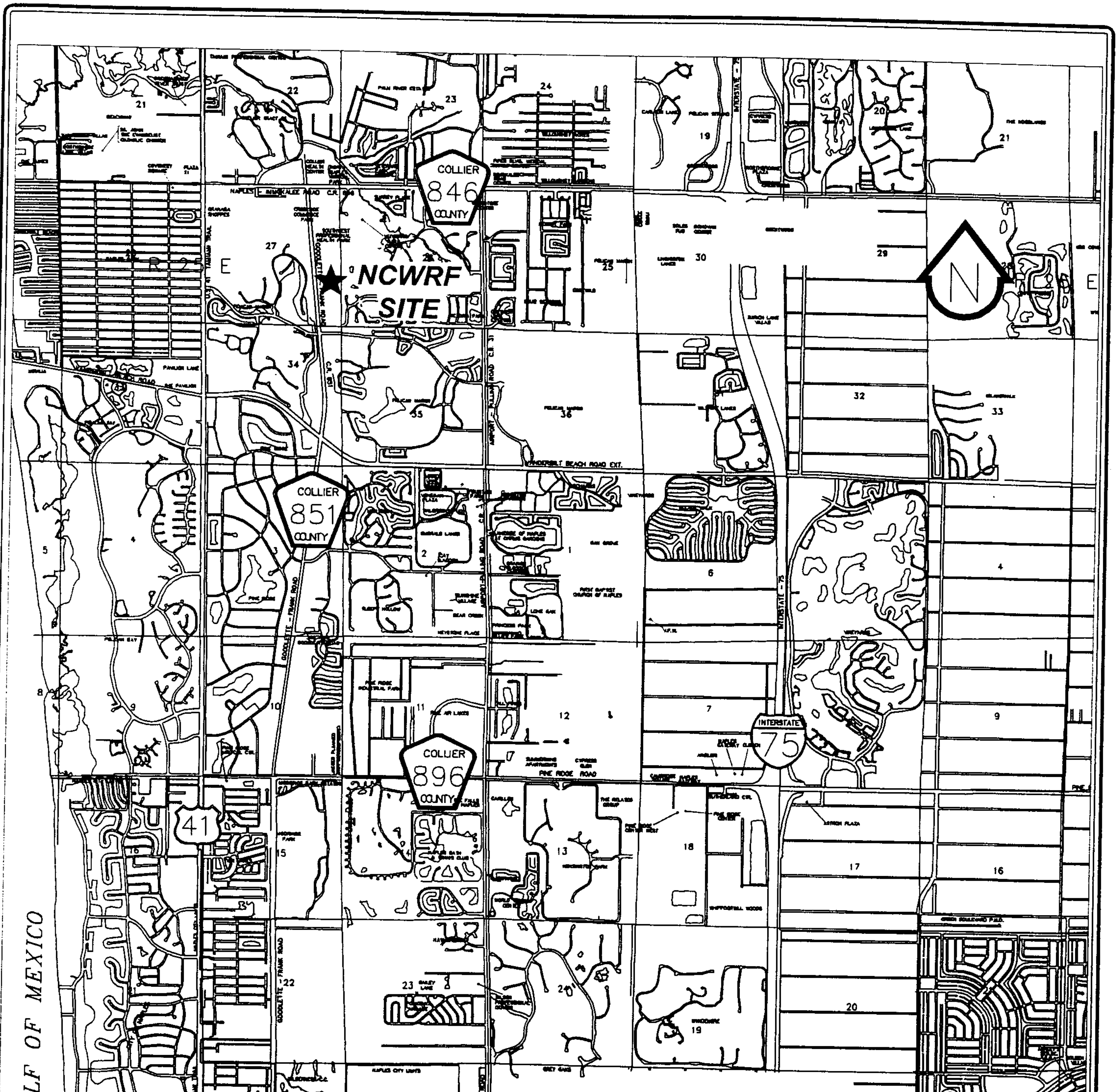
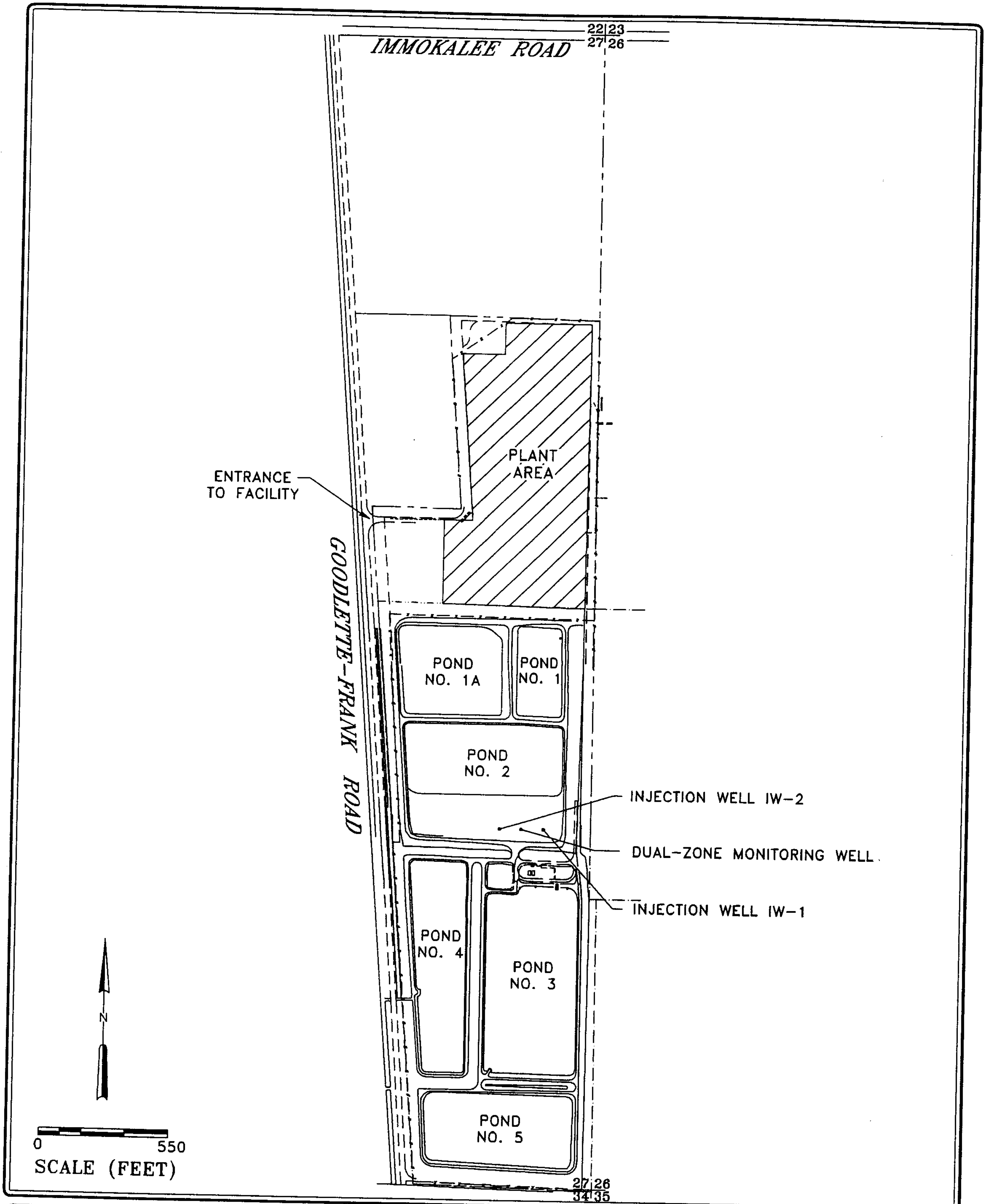


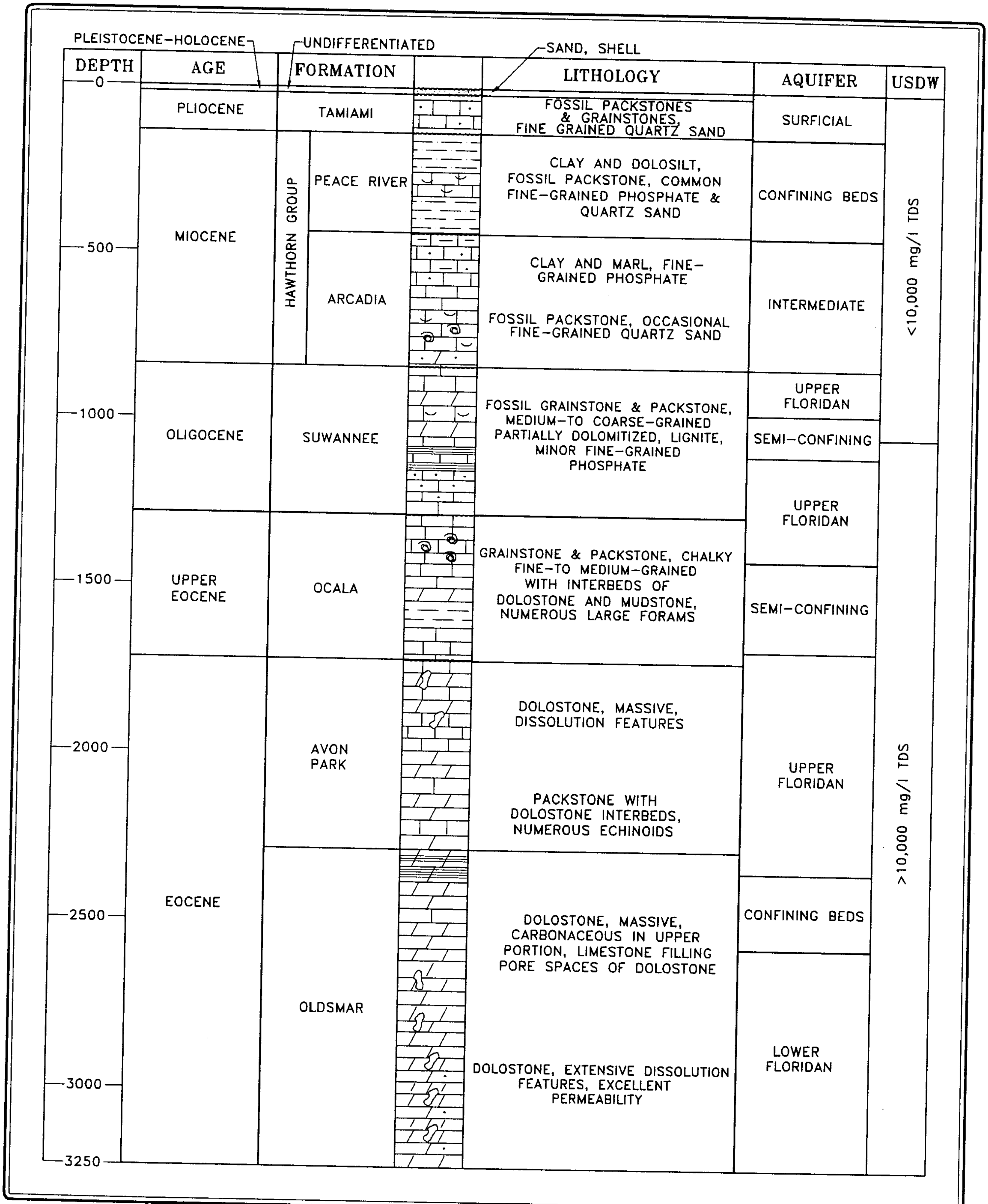
Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-013946SS-4	*Agnoli, Barber & Brundage*
	PROJECT NUMBER: 01-04254.01	DATE: 01/05/04	

FIGURE 1-1. GENERAL LOCATION MAP.



Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-014168S3-1
	PROJECT NUMBER: 01-04254.01	DATE: 01/05/04

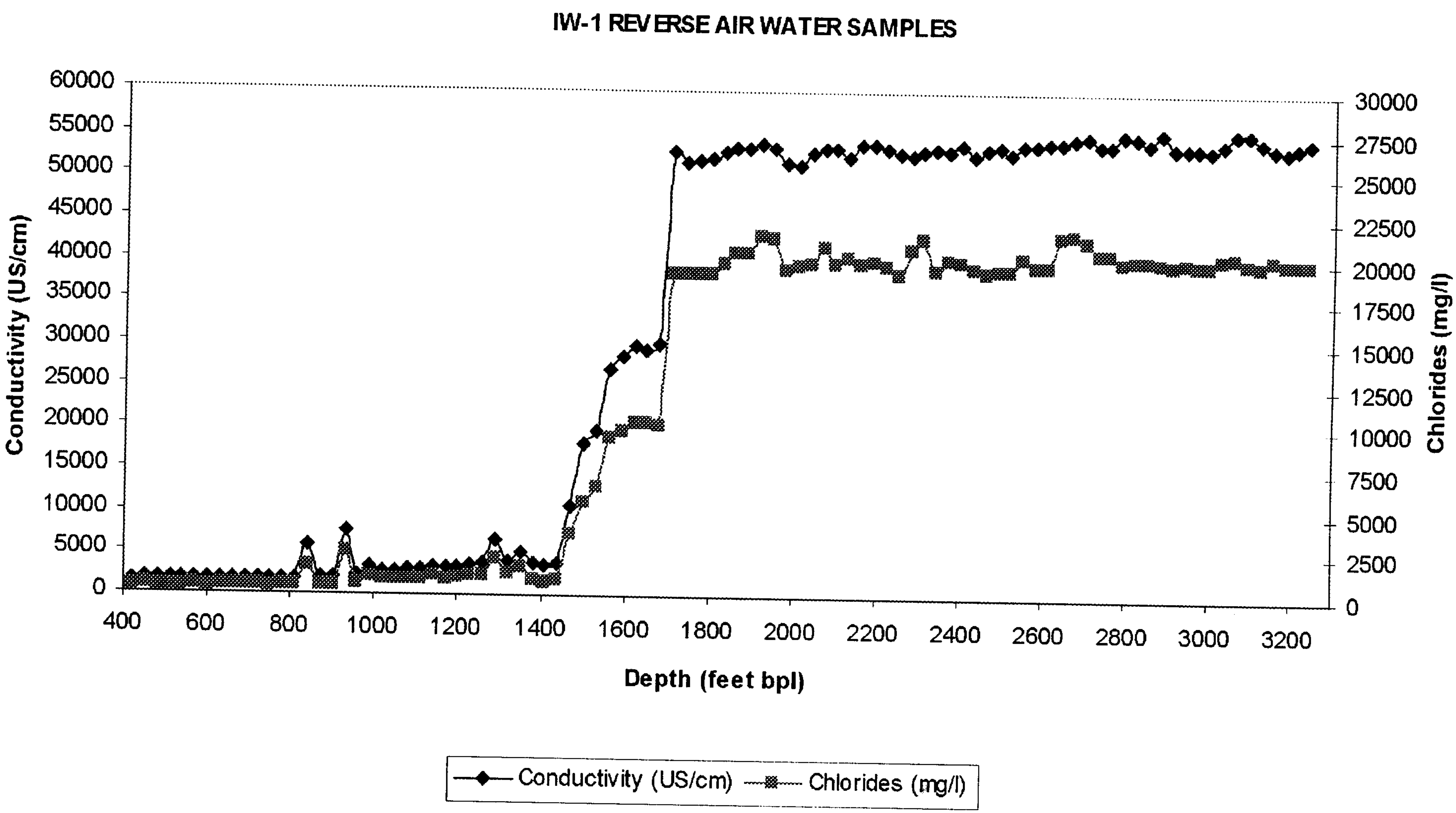
FIGURE 1-2. DETAILED SITE MAP.



Water Resource Solutions

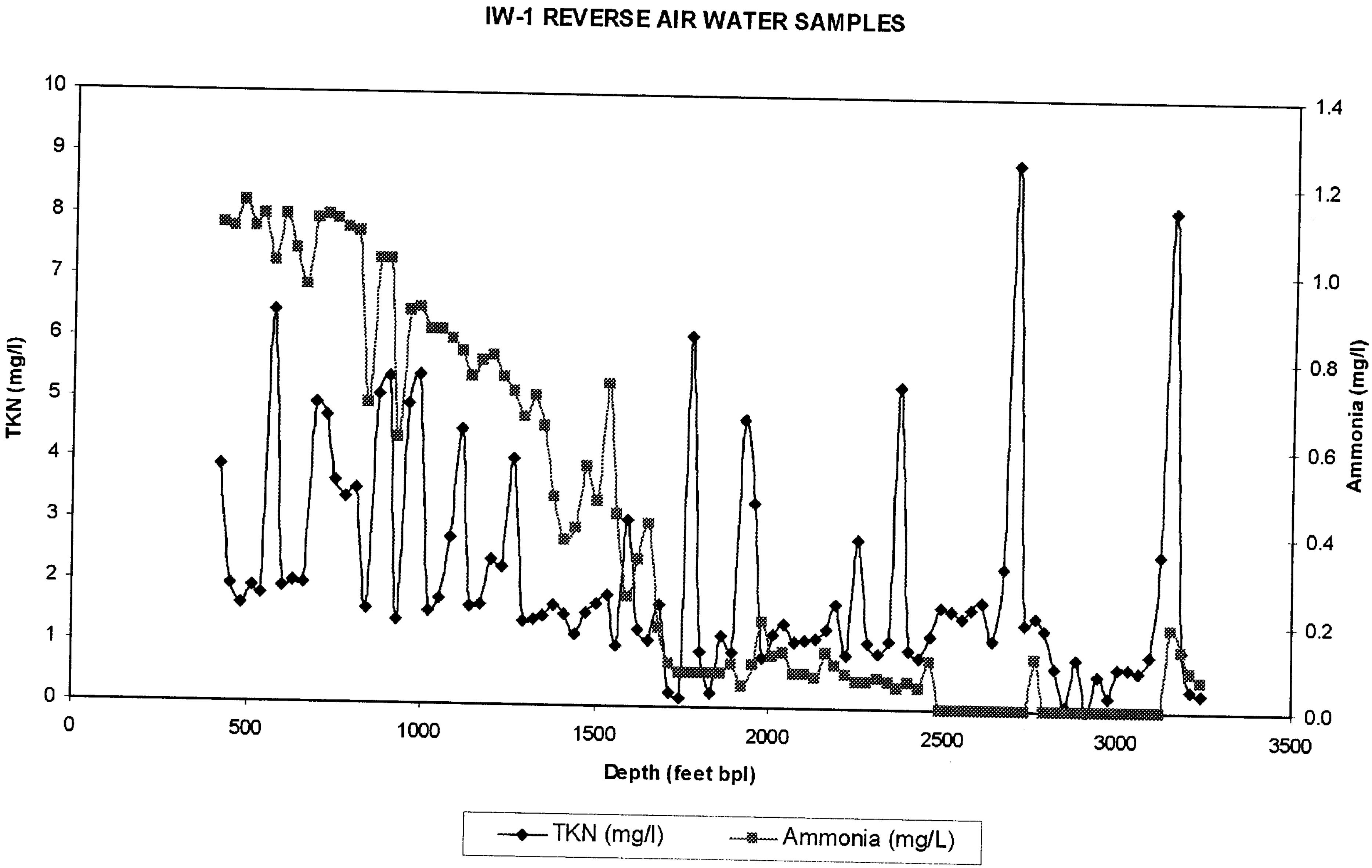
PROJECT NAME: NCWRF
PROJECT NUMBER: 01-04254.01
DWG. NUMBER: A-014254N1-1
DATE: 01/16/04

FIGURE 2-1. HYDROSTRATIGRAPHIC COLUMN FOR IW-1 AT THE NCWRF SITE.



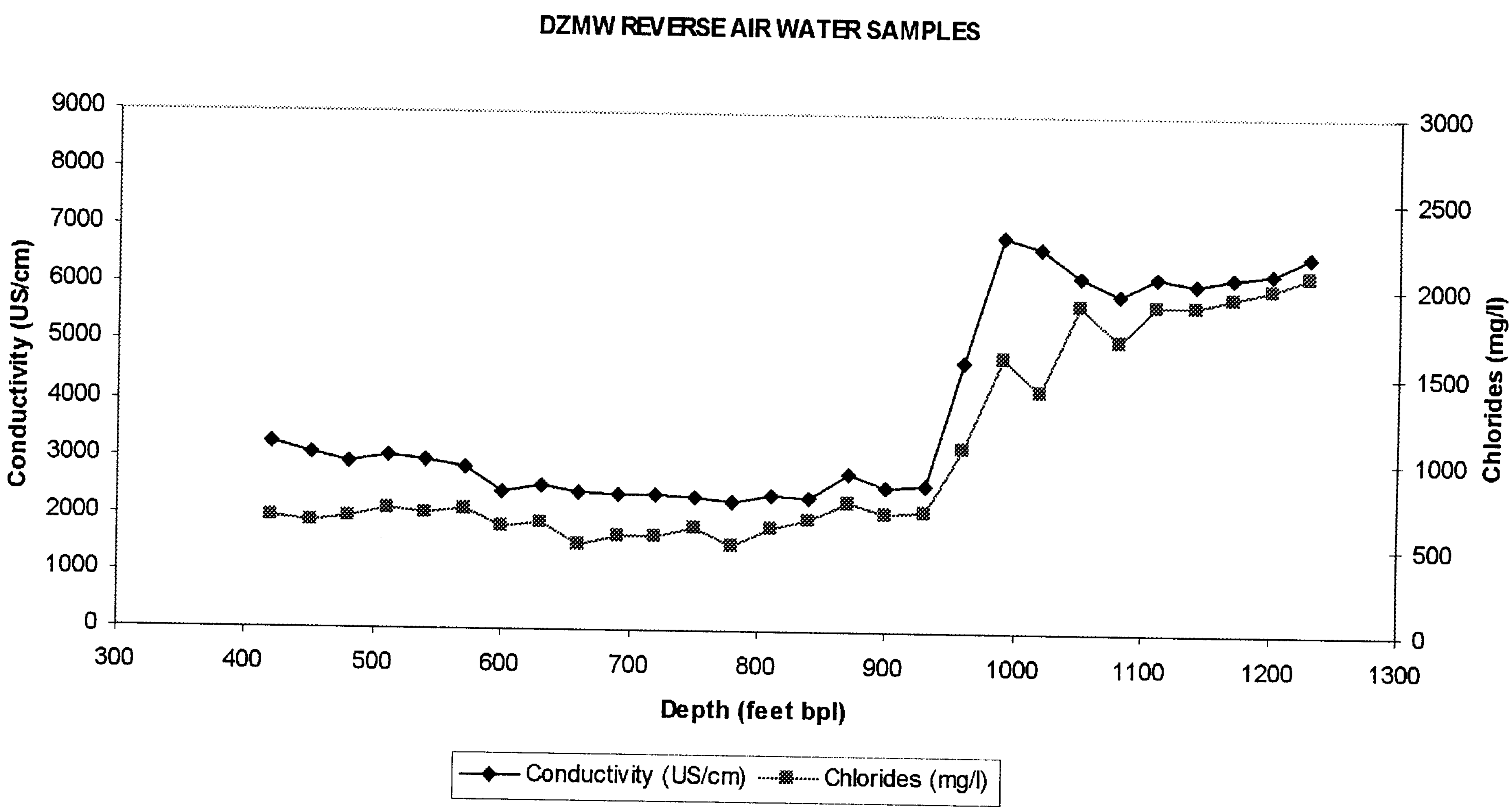
Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-014254N2_2
	PROJECT NUMBER: 01-04254.01	DATE: 01/05/04

FIGURE 2-2. REVERSE-AIR WATER QUALITY FOR IW-1 – CONDUCTIVITY AND CHLORIDES.



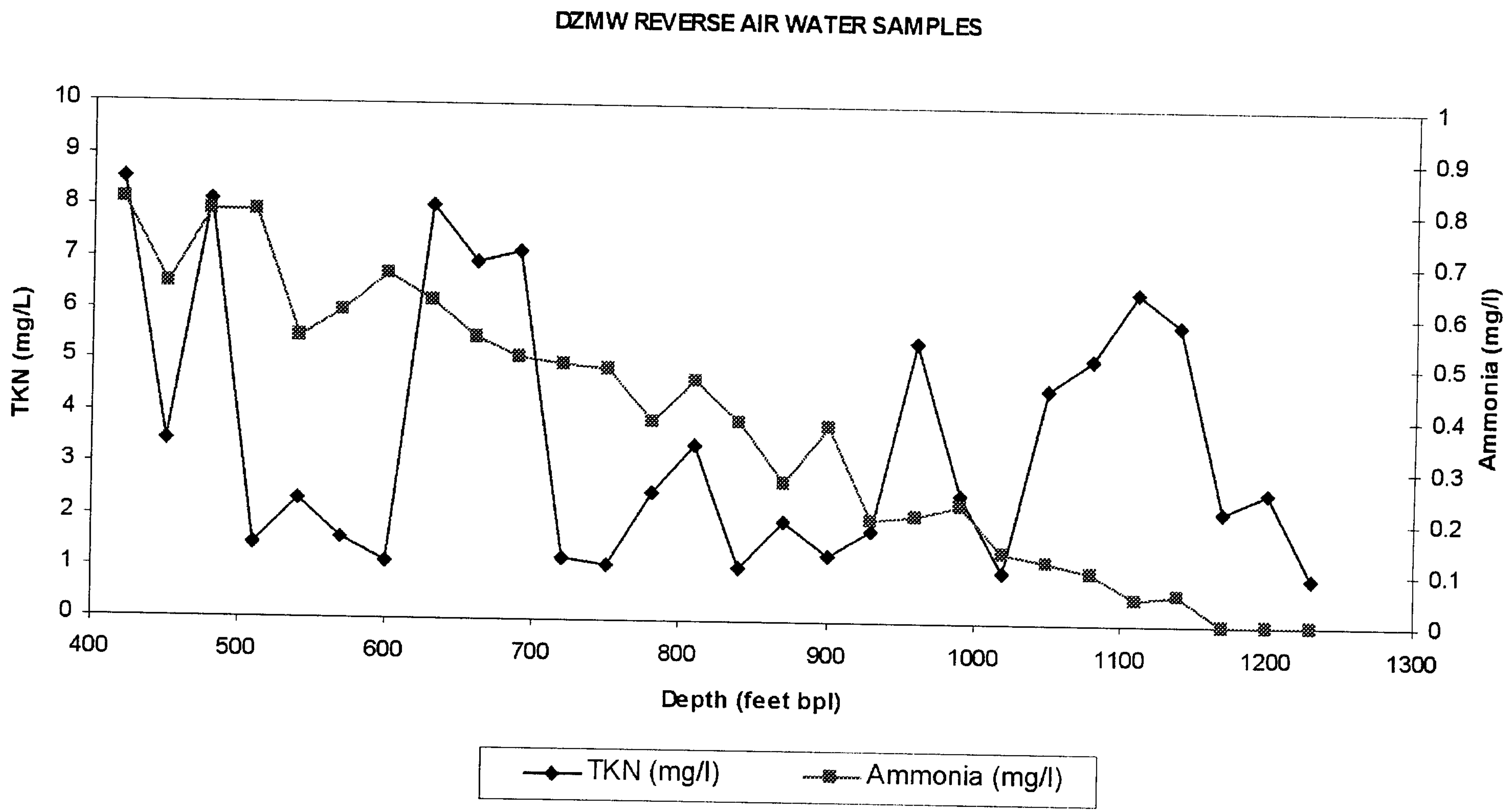
Water Resource Solutions	PROJECT NAME: NCWRF PROJECT NUMBER: 01-04254.01	DWG. NUMBER: A-014254N2_3 DATE: 01/05/04

FIGURE 2-3. REVERSE-AIR WATER QUALITY FOR IW-1 – TKN AND AMMONIA.



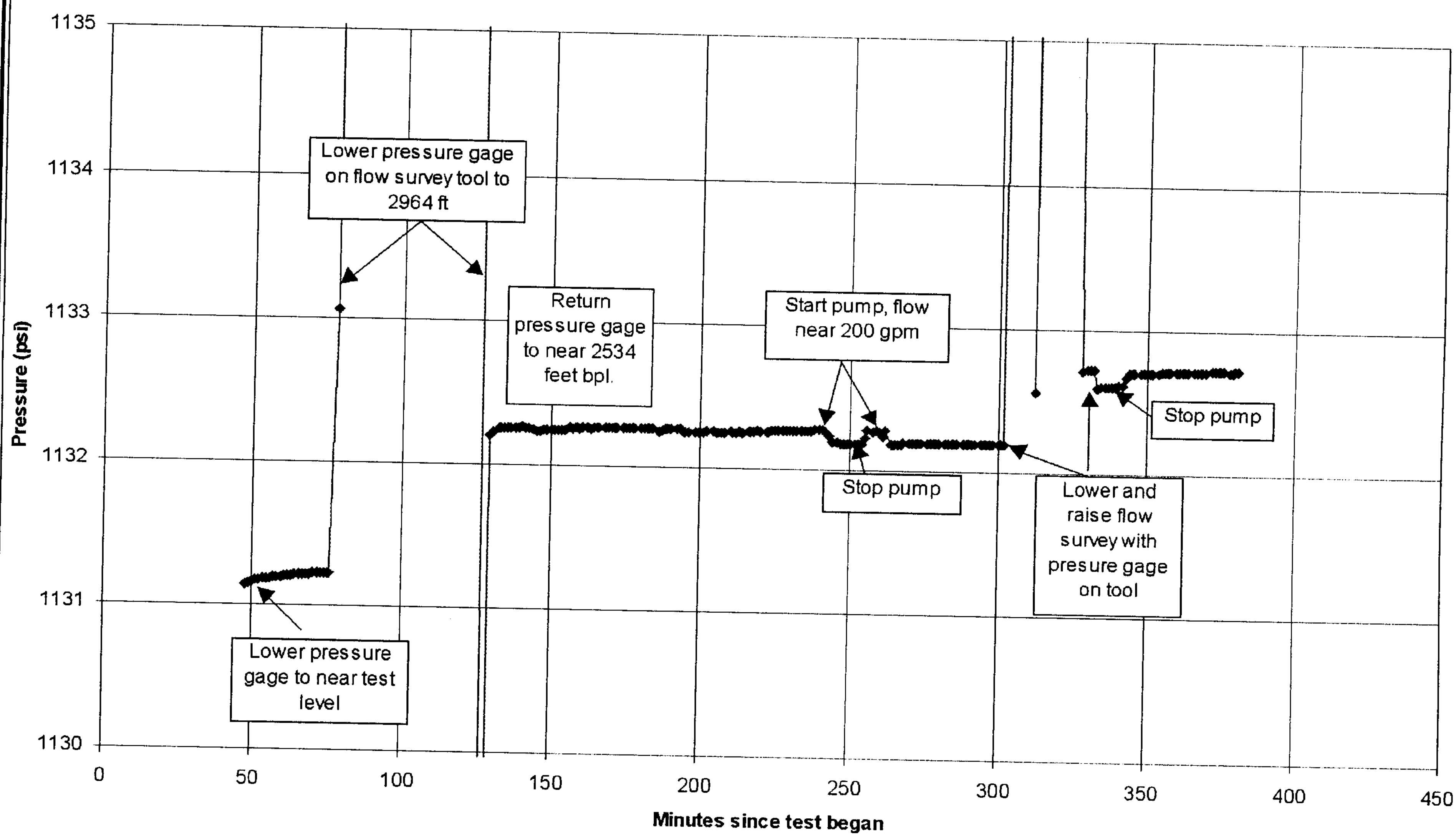
Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-014254N2_4
	PROJECT NUMBER: 01-04254.01	DATE: 01/05/04

FIGURE 2-4. REVERSE-AIR WATER QUALITY FOR DZMW – CONDUCTIVITY AND CHLORIDES.



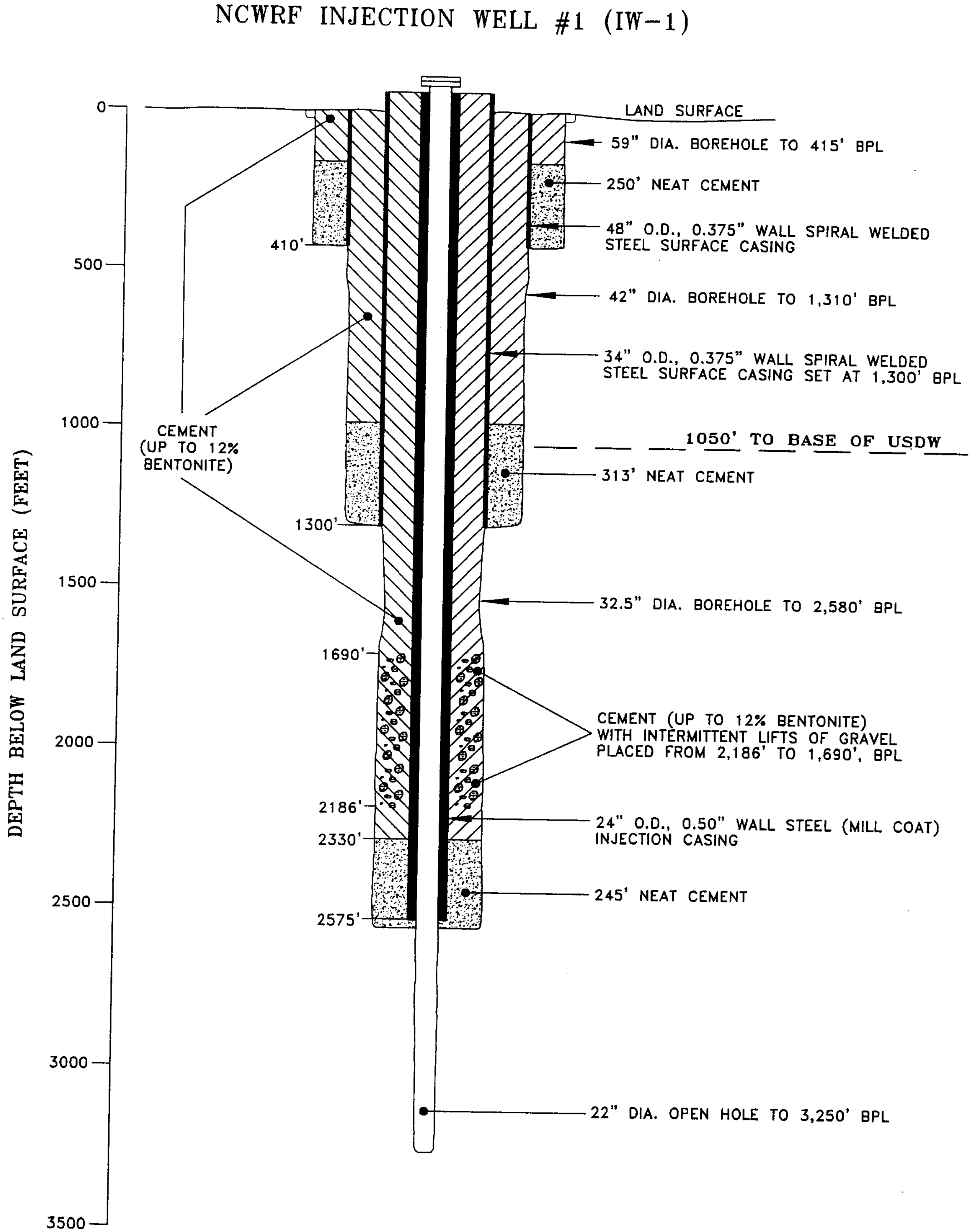
Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-014254N2_5
	PROJECT NUMBER: 01-04254.01	DATE: 01/05/04

FIGURE 2-5. REVERSE-AIR WATER QUALITY FOR DZMW – TKN AND AMMONIA.



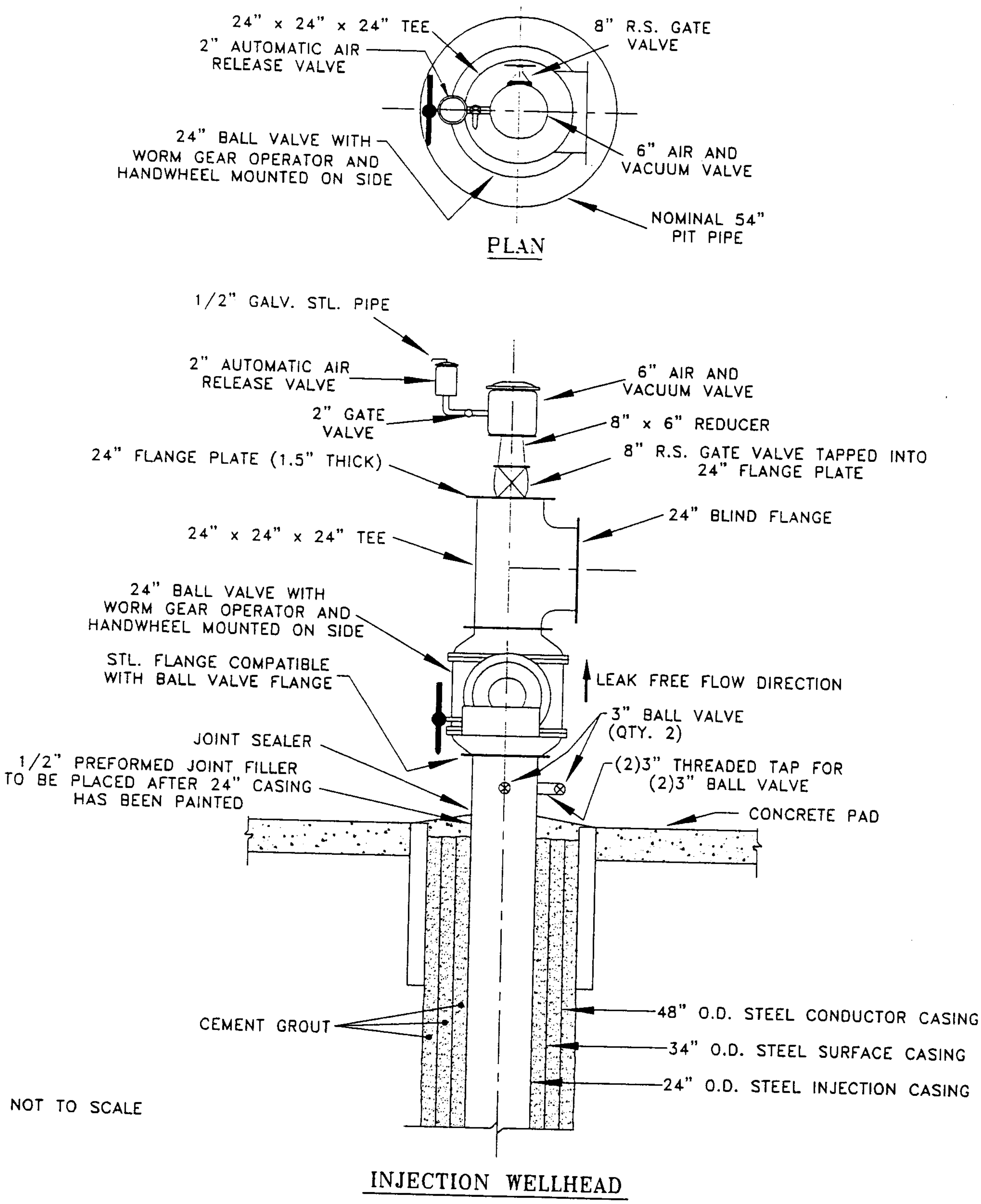
Water Resource Solutions	PROJECT NAME: NCWRF PROJECT NUMBER: 01-04254.01	DWG. NUMBER: A-014254N2_6 DATE: 01/05/04

FIGURE 2-6. DOWNHOLE PRESSURE PROFILE DURING FLOW SURVEY AT IW-1.



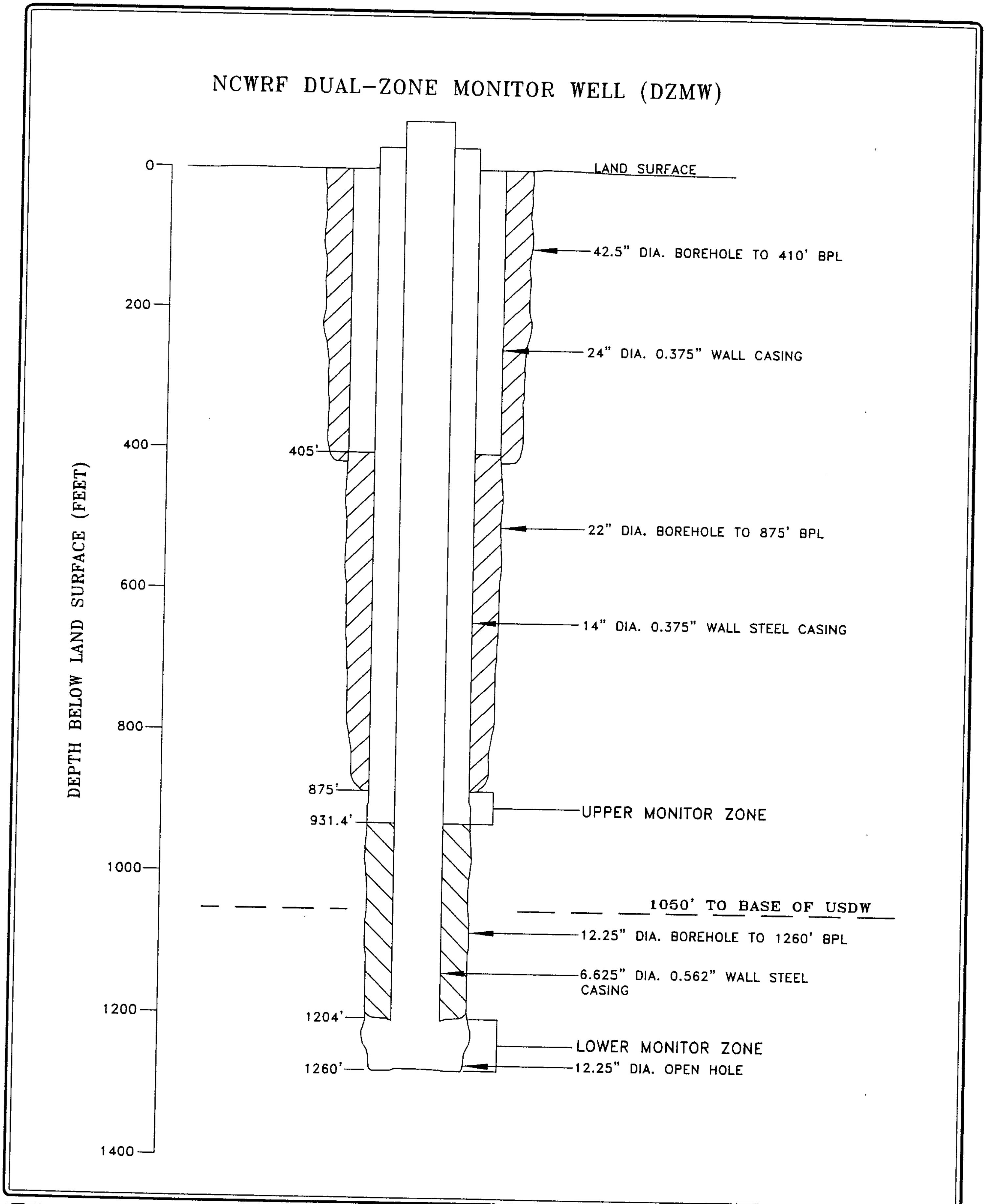
Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-014254F3_1-1
	PROJECT NUMBER: 01-04254.01	DATE: 01/05/04

FIGURE 3-1. IW-1 WELL CONSTRUCTION DETAILS.



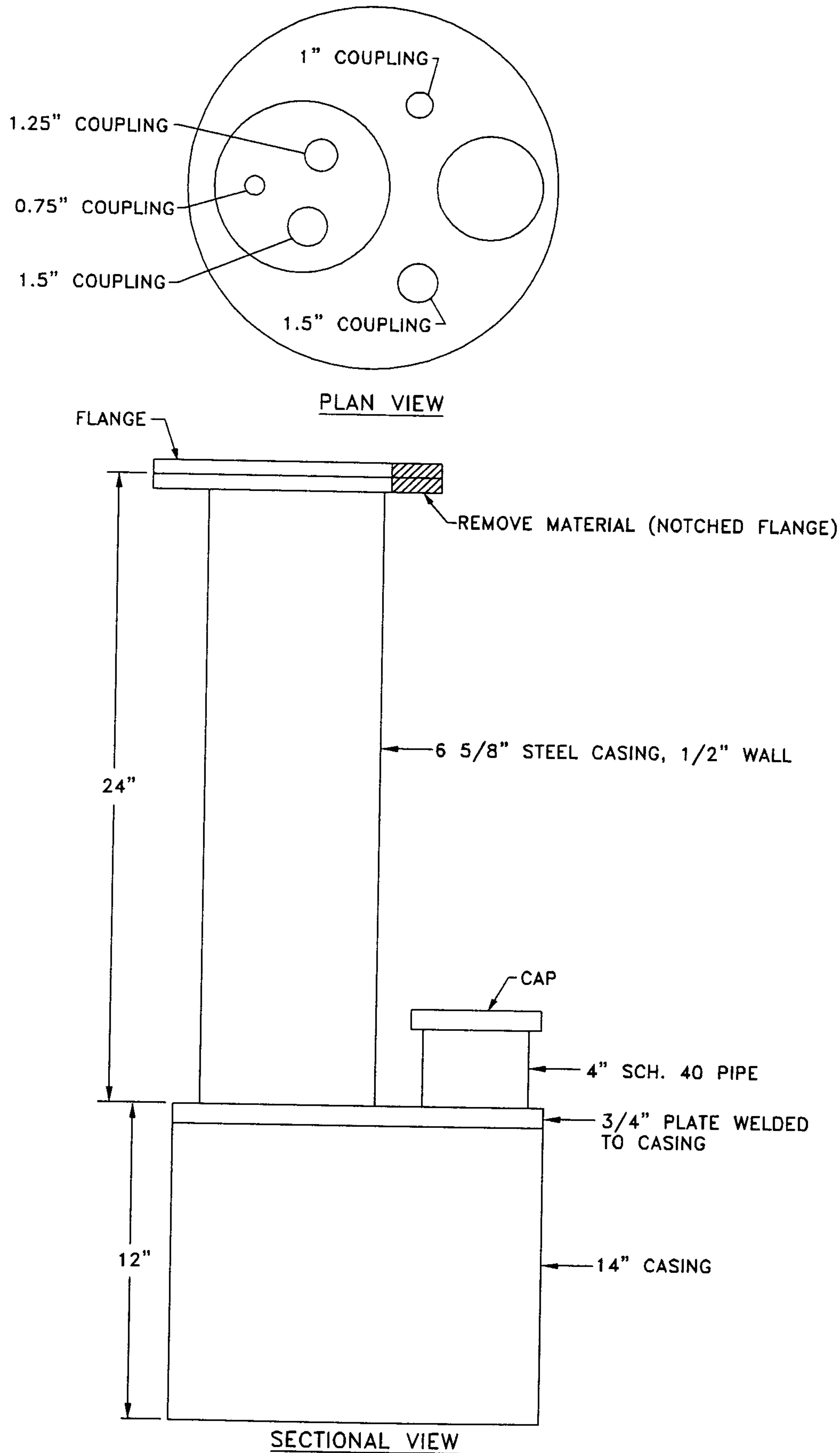
Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-014254F3_2-1
	PROJECT NUMBER: 01-04254.01	DATE: 01/14/04

FIGURE 3-2. WELLHEAD DIAGRAM OF IW-1.



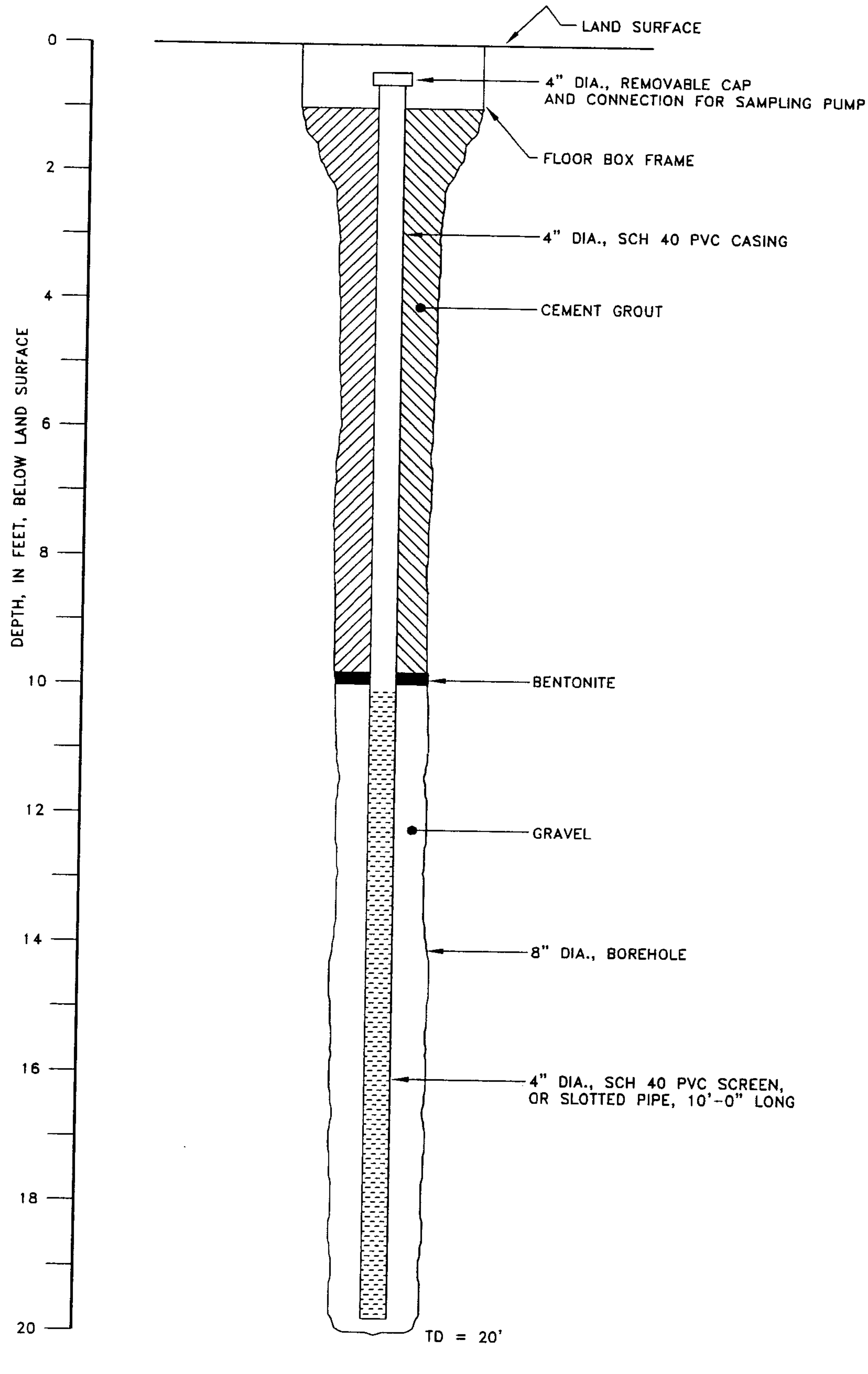
Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-014254F3_3-1
	PROJECT NUMBER: 01-04254.01	DATE: 01/16/04

FIGURE 3-3. DZMW WELL CONSTRUCTION DETAILS.



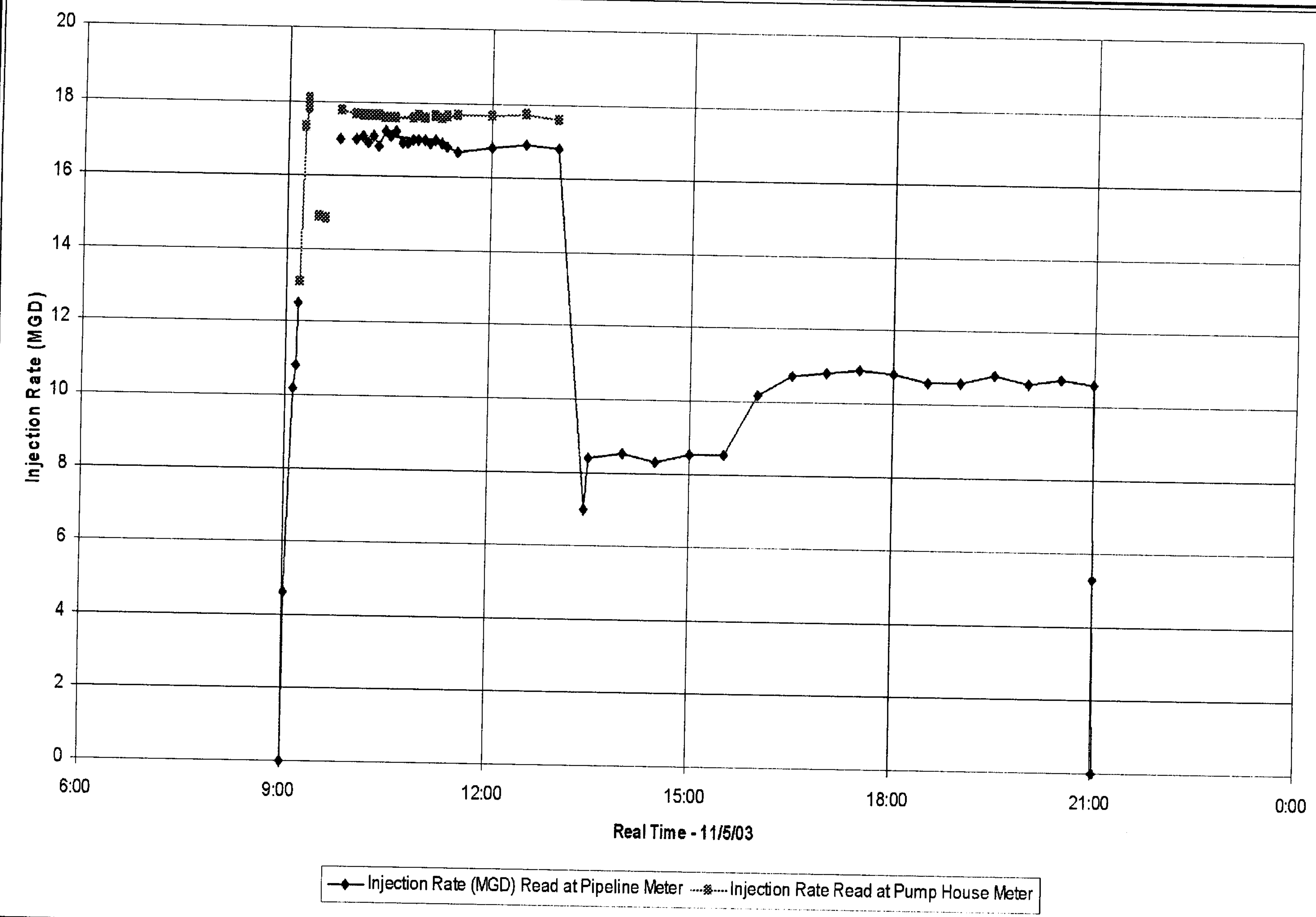
Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-014254F3_4-1
	PROJECT NUMBER: 01-04254.01	DATE: 01/05/04

FIGURE 3-4. WELLHEAD DIAGRAM OF DZMW.



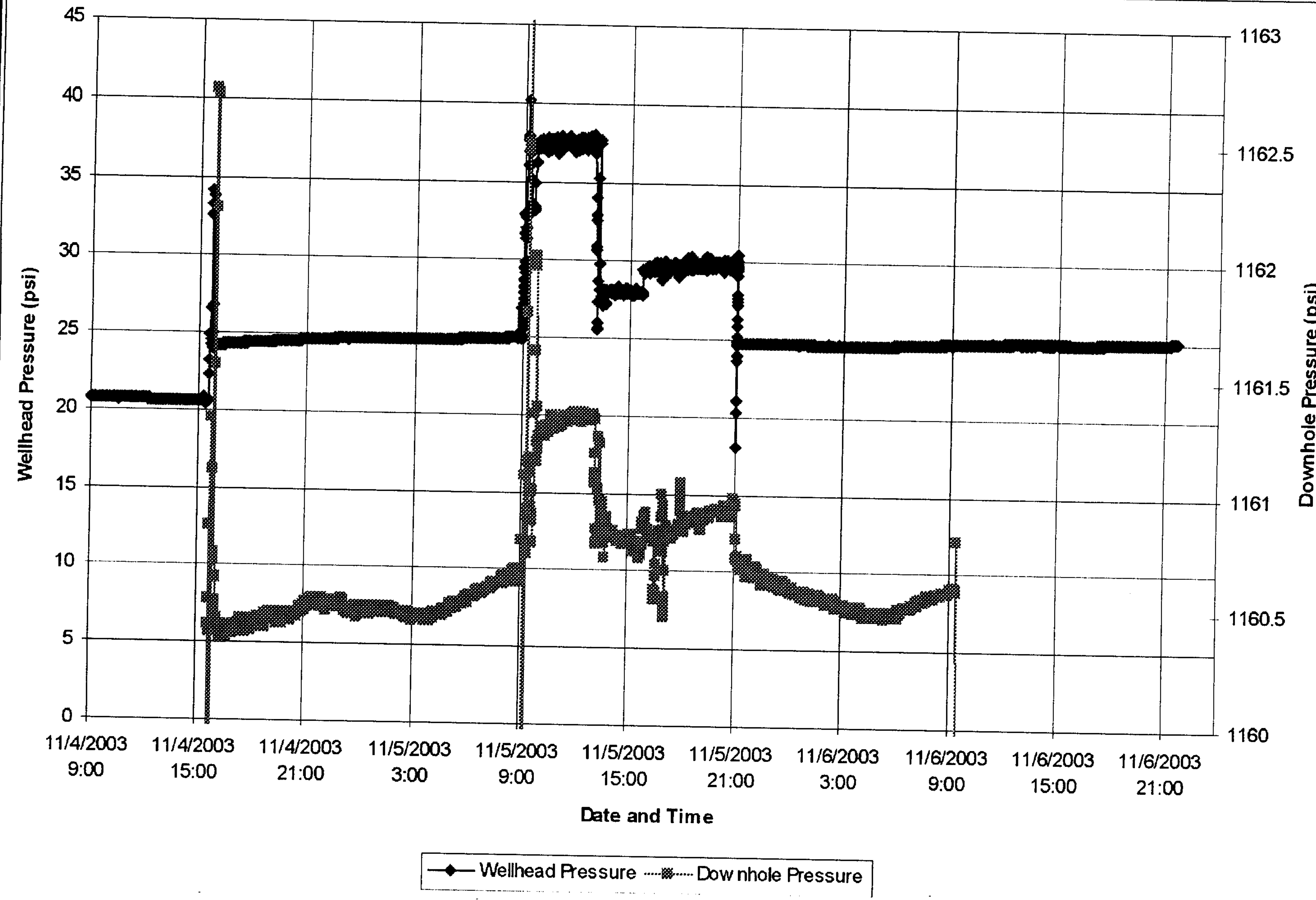
Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-014254F3_5-1
	PROJECT NUMBER: 01-04254.01	DATE: 01/16/04

FIGURE 3-5. PAD MONITORING WELL CONSTRUCTION SCHEMATIC.



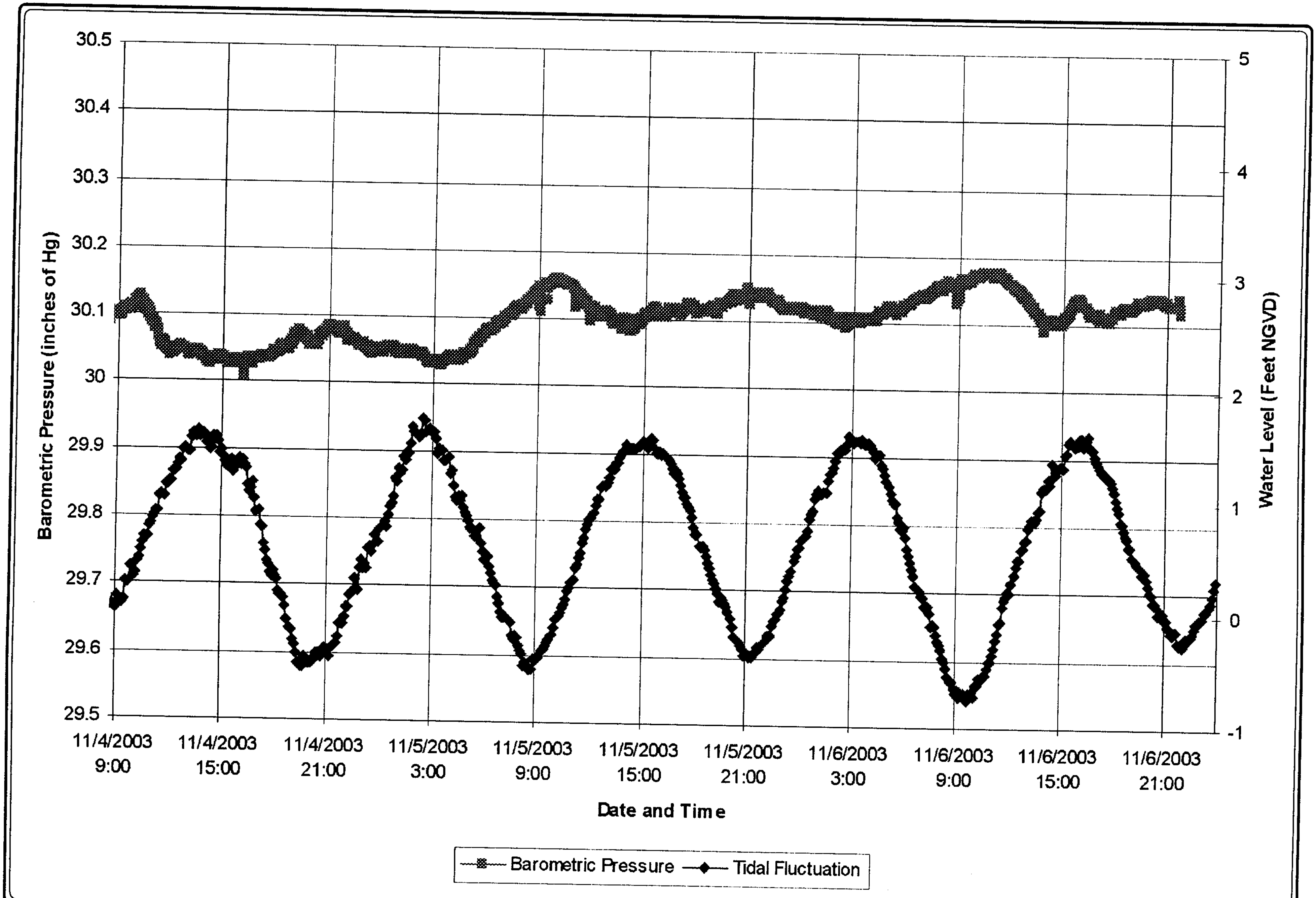
Water Resource Solutions	PROJECT NAME: NCWRF PROJECT NUMBER: 01-04254.01	DWG. NUMBER: A-014254N5_1 DATE: 01/05/04

FIGURE 5-1. INJECTION RATE DURING INJECTION TEST.



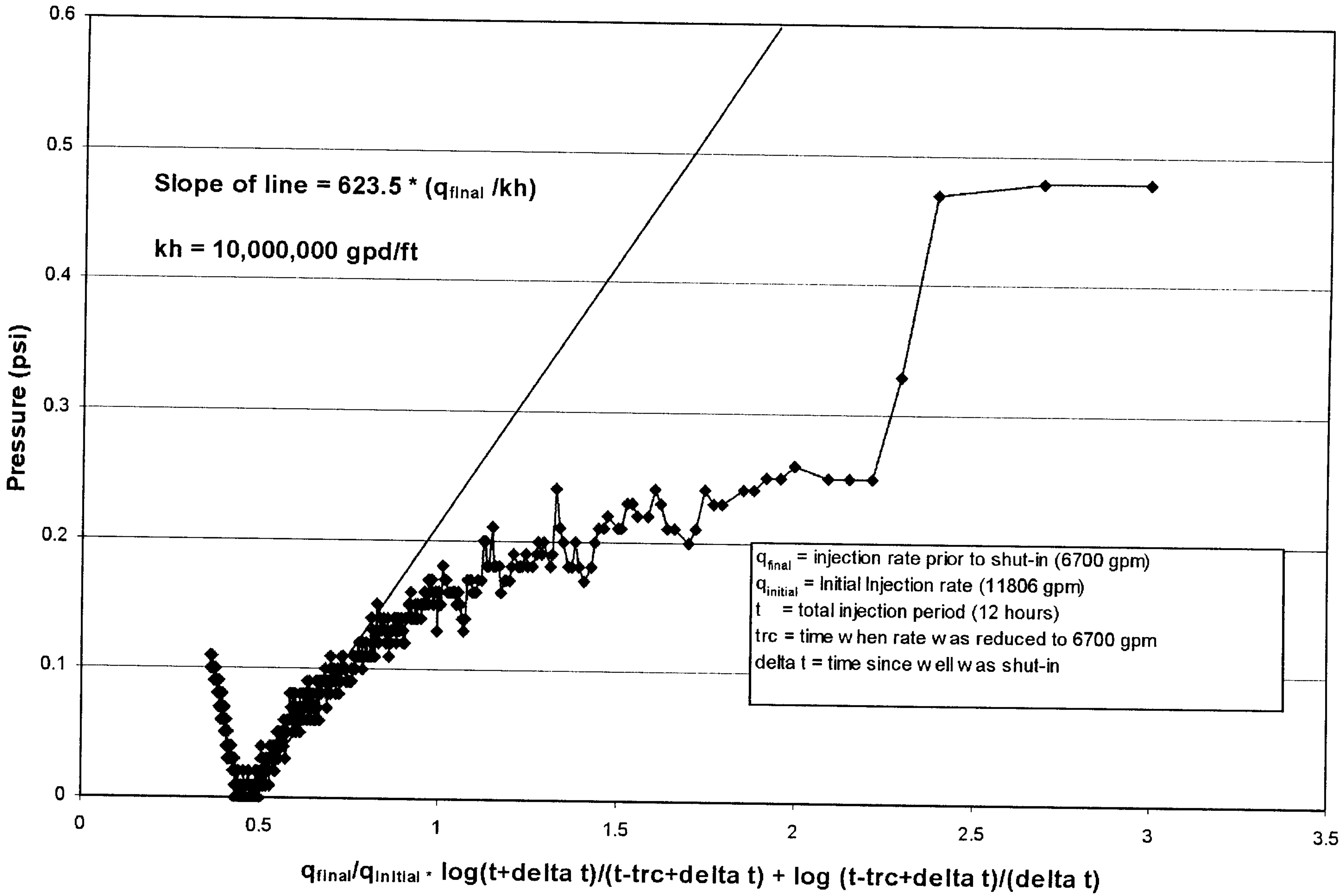
Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-014254N5-2
	PROJECT NUMBER: 01-04254.01	DATE: 01/05/04

FIGURE 5-2. CHANGES IN BOTTOM-HOLE AND WELLHEAD PRESSURE DURING THE INJECTION TEST.



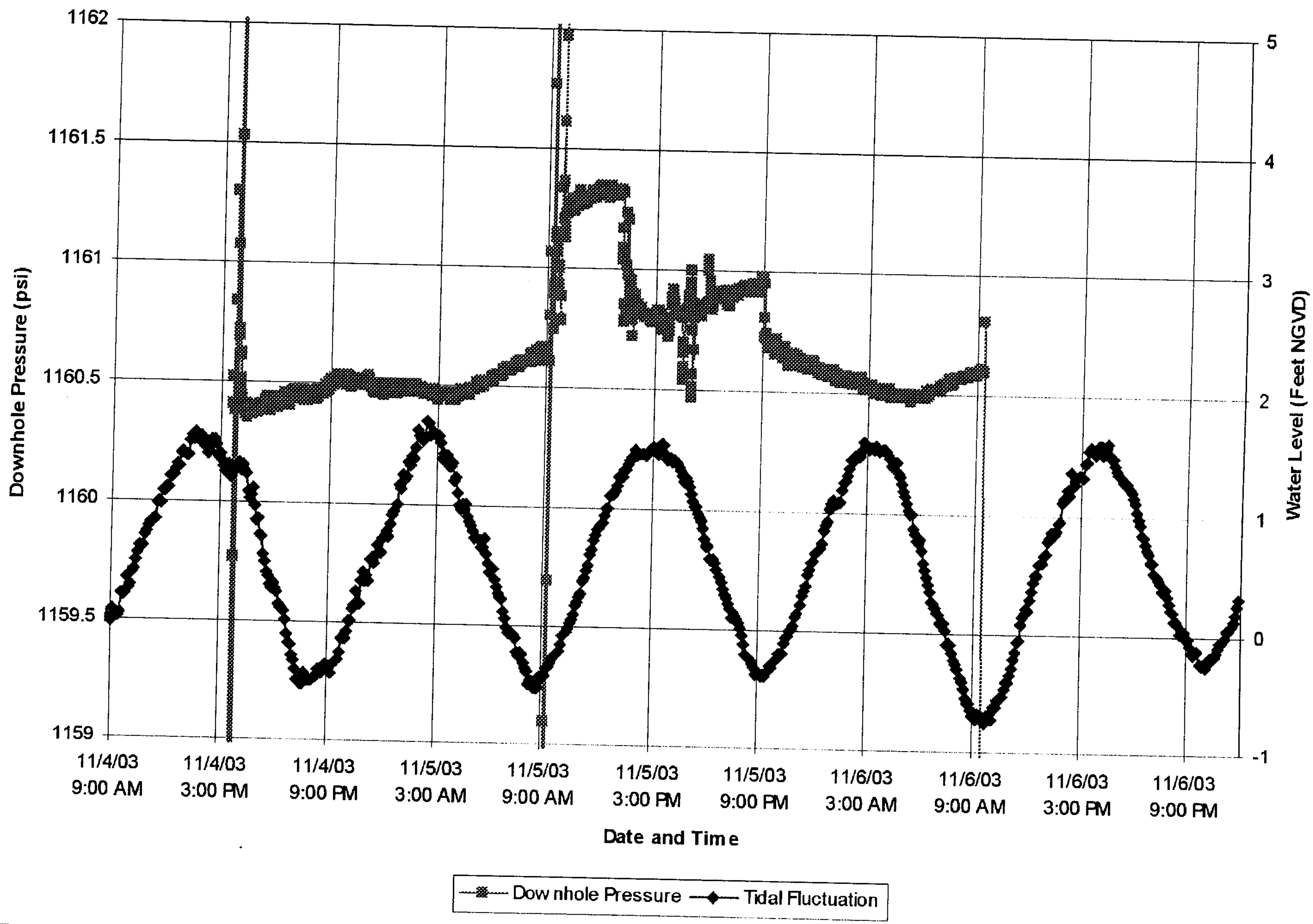
Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-014254N5-3
	PROJECT NUMBER: 01-04254.01	DATE: 01/05/04

FIGURE 5-3. LOCAL TIDAL AND BAROMETRIC CONDITIONS DURING THE PERIOD OF THE INJECTION TEST.



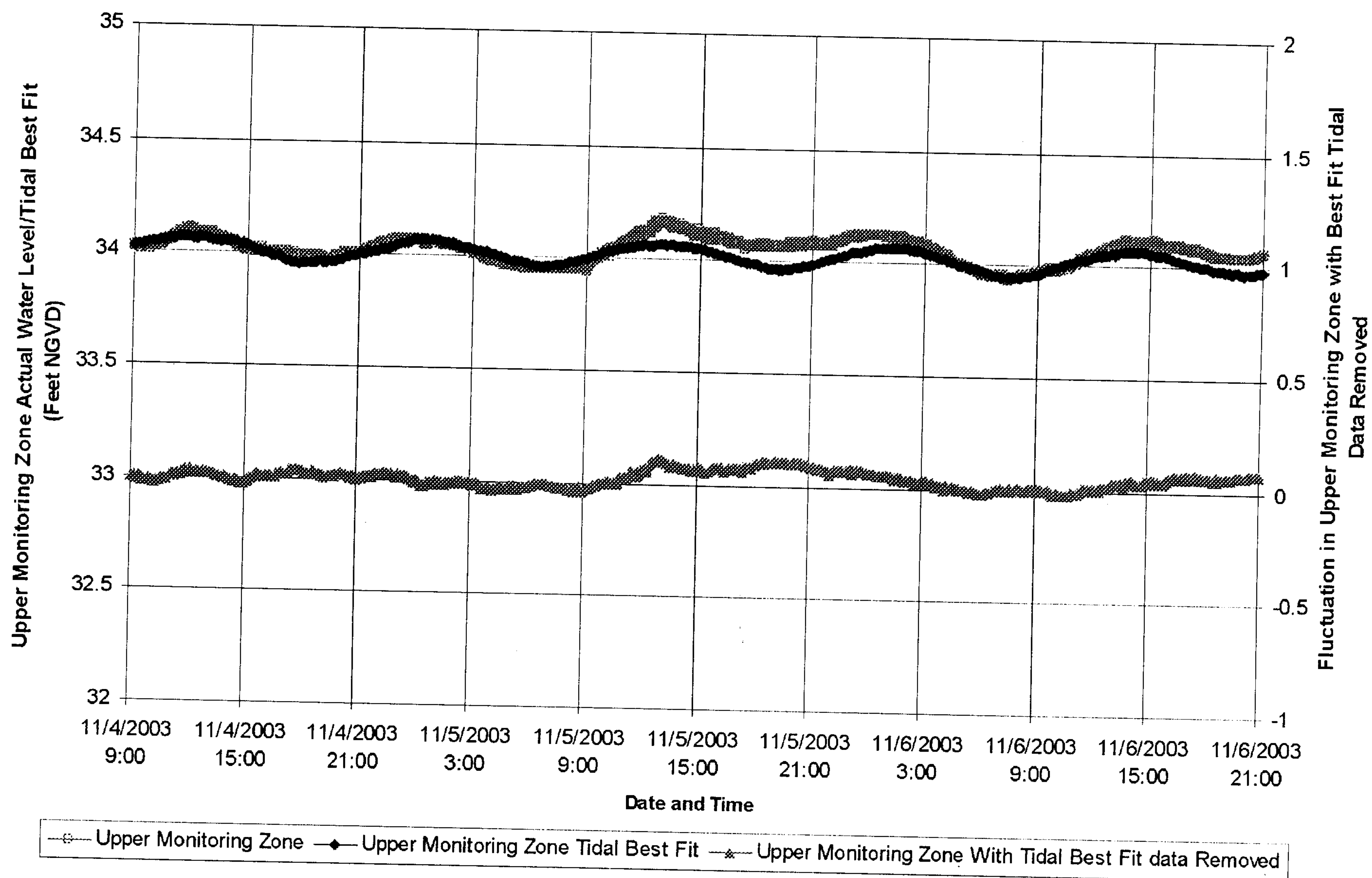
Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-014254N5-4
	PROJECT NUMBER: 01-04254.01	DATE: 01/16/04

FIGURE 5-4. MULTIRATE ANALYSIS OF THE INJECTION TEST DATA TO DETERMINE TRANSMISSIVITY OF THE INJECTION ZONE.



Water Resource Solutions	PROJECT NAME: NCWRF	
	PROJECT NUMBER: 01-04254.01	DWG. NUMBER: A-014254N5-5 DATE: 01/05/04

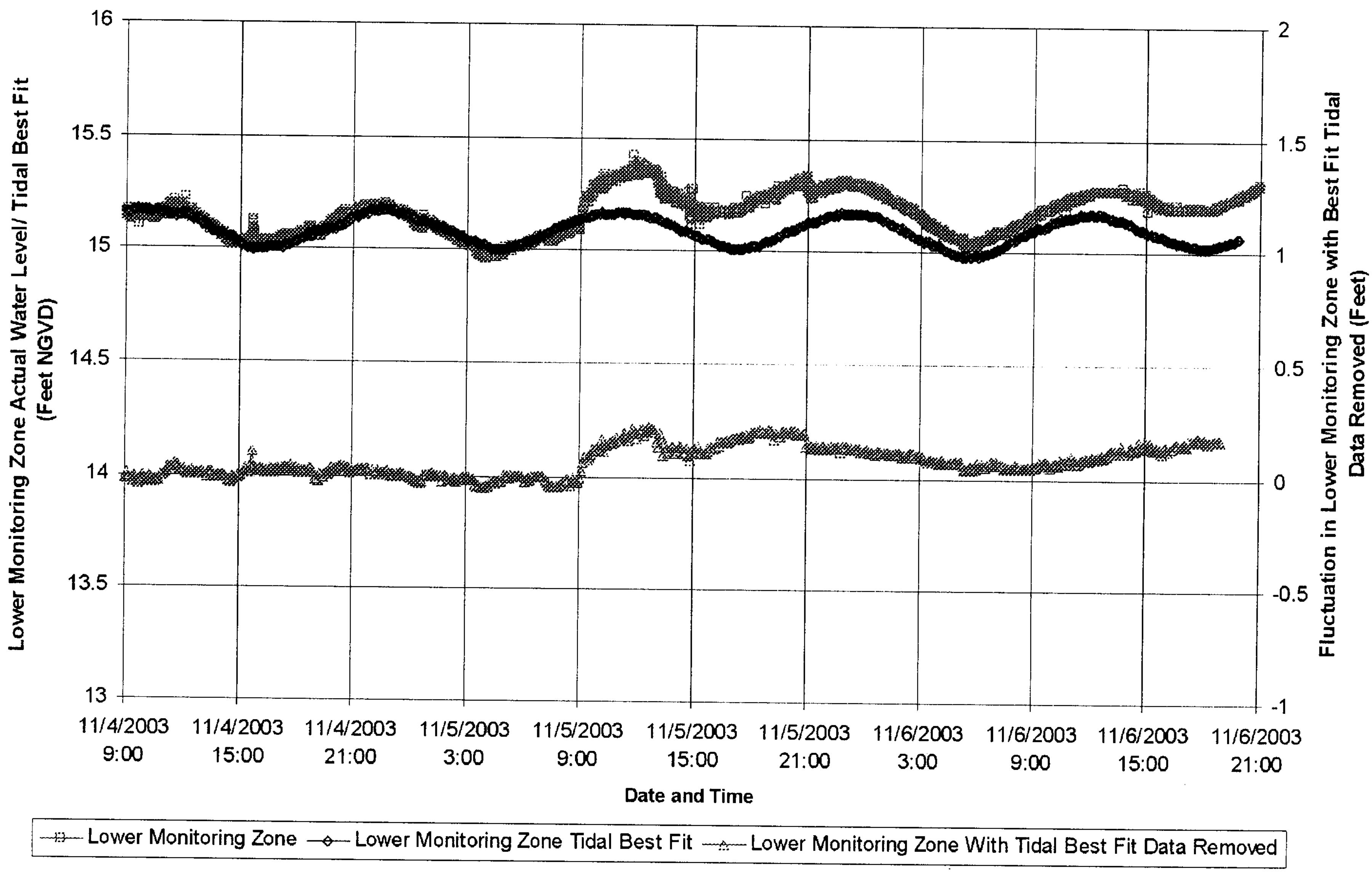
FIGURE 5-5. BOTTOM-HOLE PRESSURE CHANGE IN IW-1, WITH TIDAL DATA, DURING THE INJECTION TEST.



Water Resource Solutions

PROJECT NAME: NCWRF
PROJECT NUMBER: 01-04254.01
DWG. NUMBER: A-014254N5-6
DATE: 01/15/04

FIGURE 5-6. WATER LEVELS IN THE UPPER MONITORING ZONE OF DZMW, WITH TIDAL BEST FIT DATA REMOVED, THROUGH THE PERIOD OF INJECTION.



Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-014254N5-7
	PROJECT NUMBER: 01-04254.01	DATE: 01/15/04

FIGURE 5-7. WATER LEVELS IN THE LOWER MONITORING ZONE OF DZMW, WITH TIDAL BEST FIT DATA REMOVED, THROUGH THE PERIOD OF INJECTION.

TABLE 2-1
IW-1
REVERSE-AIR
WATER QUALITY
SUMMARY

SAMPLING DEPTH (feet bpl)	SAMPLING DATE	FIELD TESTING		LABORATORY ANALYSES		
		Conductivity (uS/cm)	Chloride (mg/L)	Total Dissolved Solids (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Ammonia (mg/L)
420	2/6/2003	1639	440	896	3.90	1.10
450	2/6/2003	1713	450	860	1.96	1.09
480	2/6/2003	1659	440	900	1.63	1.15
510	2/6/2003	1670	420	856	1.93	1.09
540	2/6/2003	1706	440	944	1.81	1.12
570	2/6/2003	1672	445	884	6.43	1.01
600	2/6/2003	1699	440	916	1.92	1.12
630	2/6/2003	1720	445	988	2.00	1.04
660	2/6/2003	1710	445	952	1.98	0.96
690	2/7/2003	1699	445	992	4.94	1.11
720	2/7/2003	1752	455	908	4.72	1.12
750	2/7/2003	1655	435	868	3.67	1.11
780	2/7/2003	1770	450	956	3.40	1.09
810	2/7/2003	1828	465	984	3.54	1.08
840	2/7/2003	5970	1650	3290	1.55	0.69
870	2/7/2003	1970	485	1020	5.06	1.02
900	2/7/2003	2060	565	1050	5.38	1.02
930	2/7/2003	7620	2500	5050	1.38	0.61
960	2/7/2003	2190	600	1100	4.92	0.90
990	2/7/2003	3280	1000	1820	5.39	0.91
1020	2/7/2003	2880	870	1640	1.54	0.86
1050	2/7/2003	2900	875	1590	1.74	0.86
1080	2/7/2003	3100	950	1720	2.74	0.84
1110	2/7/2003	3000	900	1680	4.52	0.81
1140	2/7/2003	3400	1100	1980	1.62	0.75
1170	2/7/2003	3200	950	1860	1.65	0.79
1200	2/7/2003	3400	1050	1920	2.39	0.80
1230	2/8/2003	3500	1150	2000	2.28	0.75
1260	2/8/2003	3800	1200	2080	4.05	0.72
1290	2/8/2003	6600	2150	3630	1.39	0.66
1320	2/8/2003	4000	1300	2170	1.42	0.71
1350	2/8/2003	5100	1650	2870	1.48	0.64
1380	2/24/2003	3710	840	2450	1.64	0.48
1410	2/24/2003	3680	825	2420	1.50	0.38
1440	2/24/2003	3740	865	2470	1.19	0.41
1470	2/24/2003	10700	3750	7240	1.54	0.55
1500	2/24/2003	18100	5600	11700	1.69	0.47
1530	2/26/2003	19600	6500	11500	1.82	0.74
1560	2/26/2003	27000	9450	16500	1.01	0.44
1590	2/27/2003	28400	9750	17600	3.08	0.25
1620	2/27/2003	29800	10300	20600	1.27	0.34
1650	2/27/2003	29200	10300	17700	1.08	0.42
1680	2/27/2003	30000	10200	19000	1.67	0.18
1710	2/28/2003	52800	19200	33200	0.24	0.10
1740	2/28/2003	51500	19200	32100	0.14	0.08
1770	2/28/2003	51900	19200	37800	6.08	0.08
1800	2/28/2003	52200	19200	32000	0.91	0.08

TABLE 2-1
IW-1
REVERSE-AIR
WATER QUALITY
SUMMARY

SAMPLING DEPTH (feet bpl)	SAMPLING DATE	FIELD TESTING		LABORATORY ANALYSES		
		Conductivity (uS/cm)	Chloride (mg/L)	Total Dissolved Solids (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Ammonia (mg/L)
1830	3/1/2003	53000	19800	31500	0.24	0.08
1860	3/1/2003	53300	20500	36300	1.19	0.08
1890	3/1/2003	53500	20500	35100	0.91	0.10
1920	3/1/2003	53900	21500	41100	4.72	0.05
1950	3/3/2003	53300	21300	34300	3.36	0.10
1980	3/4/2003	51500	19500	36800	0.83	0.20
2010	3/5/2003	51300	19750	37600	1.21	0.12
2040	3/6/2003	52900	19850	36300	1.40	0.13
2070	3/6/2003	53400	20900	38500	1.09	0.08
2100	3/6/2003	53300	19800	41700	1.13	0.08
2130	3/6/2003	52500	20200	38000	1.15	0.07
2160	3/7/2003	53900	19850	36700	1.29	0.13
2190	3/7/2003	53800	19900	37000	1.71	0.10
2220	3/8/2003	53500	19750	37700	0.88	0.08
2250	3/8/2003	52800	19250	34800	2.76	0.06
2280	3/8/2003	52700	20750	31500	1.08	0.06
2310	3/9/2003	53200	21400	37900	0.92	0.07
2340	3/9/2003	53400	19500	52500	1.12	0.06
2370	3/10/2003	53100	20100	36000	5.28	0.05
2400	3/10/2003	53900	19900	40300	0.98	0.06
2430	3/10/2003	52700	19550	34800	0.86	0.05
2460	3/10/2003	53500	19350	36500	1.21	0.11
2490	3/12/2003	53700	19500	36000	1.67	<0.05
2520	3/14/2003	53000	19500	36700	1.62	<0.05
2550	3/14/2003	53900	20250	32500	1.51	<0.05
2580	3/14/2003	53800	19750	37400	1.65	<0.05
2610	3/14/2003	54100	19750	37500	1.76	<0.05
2640	3/15/2003	54200	21500	33700	1.14	<0.05
2670	3/15/2003	54700	21650	36300	2.33	<0.05
2700	3/15/2003	54800	21200	38100	8.93	<0.05
2730	3/15/2003	53900	20500	35500	1.42	<0.05
2760	3/16/2003	53900	20500	37400	1.53	0.12
2790	3/16/2003	55100	19900	37700	1.33	<0.05
2820	3/16/2003	54900	20050	38300	0.72	<0.05
2850	3/16/2003	54200	20100	38600	0.09	<0.05
2880	3/16/2003	55300	19900	37300	0.85	<0.05
2910	3/17/2003	53700	19850	36200	<0.05	<0.05
2940	3/17/2003	53600	19900	35400	0.60	<0.05
2970	3/17/2003	53600	19850	39800	0.23	<0.05
3000	3/17/2003	53500	19800	37500	0.70	<0.05
3030	3/18/2003	54200	20200	39000	0.70	<0.05
3060	3/18/2003	55300	20350	38500	0.64	<0.05
3090	3/18/2003	55300	20000	40000	0.92	<0.05
3120	3/18/2003	54400	19850	32600	2.56	<0.05
3150	3/19/2003	53600	20250	37300	8.20	0.19
3180	3/20/2003	53500	20000	37300	0.99	0.14
3210	3/20/2003	54000	20000	39900	0.35	0.09
3240	3/20/2003	54400	20000	32300	0.29	0.07

TABLE 2-2
DZMW
REVERSE-AIR
WATER QUALITY
SUMMARY

SAMPLING DEPTH (feet bpl)	SAMPLING DATE	FIELD TESTING		LABORATORY ANALYSES		
		Conductivity (uS/cm)	Chloride (mg/L)	Total Dissolved Solids (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Ammonia (mg/L)
390-makeup water	8/14/2003	2230	570	NM	NM	NM
420	8/14/2003	3260	650	1570	8.53	0.81
450	8/14/2003	3070	620	1520	3.48	0.65
480	8/14/2003	2900	650	1520	8.12	0.79
510	8/14/2003	3040	700	1530	1.46	0.79
540	8/14/2003	2930	675	1440	2.34	0.55
570	8/14/2003	2840	700	1440	1.59	0.6
600	8/14/2003	2420	600	1360	1.11	0.67
630	8/14/2003	2520	625	1290	8.05	0.62
660	8/14/2003	2420	500	1300	6.93	0.55
690	8/15/2003	2380	550	1410	7.16	0.51
720	8/15/2003	2370	550	1160	1.22	0.5
750	8/15/2003	2320	600	1360	1.10	0.49
780	8/15/2003	2270	500	1370	2.52	0.39
810	8/15/2003	2380	600	1400	3.44	0.47
840	8/15/2003	2320	650	1400	1.05	0.39
870	8/15/2003	2750	750	1620	1.96	0.27
900	8/15/2003	2530	690	1480	1.29	0.38
930	8/15/2003	2550	700	1520	1.82	0.20
960	8/16/2003	4700	1075	2580	5.42	0.21
990	8/16/2003	6900	1600	3900	2.52	0.23
1020	8/16/2003	6700	1400	3640	1.01	0.14
1050	8/16/2003	6200	1900	3790	4.58	0.12
1080	8/16/2003	5900	1700	3700	5.14	0.1
1110	8/16/2003	6200	1900	3500	6.44	0.05
1140	8/16/2003	6100	1900	3500	5.8	0.06
1170	8/16/2003	6200	1950	3540	2.2	<0.05
1200	8/16/2003	6300	2000	3670	2.59	<0.05
1230	8/16/2003	6600	2075	3940	0.9	<0.05

TABLE 2-3
PACKER TEST WATER QUALITY SUMMARY FOR IW-1 AND DZMW

INTERVAL DESIGNATION	INTERVAL DEPTH (feet bpl)	CHLORIDE (mg/L)	SULFATE (mg/L)	TOTAL DISSOLVED SOLIDS (mg/L)	CONDUCTIVITY (umhos/cm)
IW-1					
Single Packer #1	1,198 - 1,357	15500	2220	27800	42300
Single Packer #2	1,450 - 1,500	17500	2400	31500	49900
Single Packer #3	1875 - 1925	18500	2620	35000	53900
Single Packer #4	2539 - 3250	nm	nm	nm	nm
DZMW					
Single Packer #1	875 - 934	2850	737	5920	10600
Single Packer #2	902 - 950	nm	nm	nm	nm
Single Packer #3	1202 - 1250	nm	nm	nm	nm

TABLE 2-4
ROCK-CORE ANALYSIS SUMMARY

CORE #	SAMPLE DEPTH (feet bpl)	LITHOLOGIC DESCRIPTION	*VERTICAL HYDRAULIC CONDUCTIVITY (ft/day)	*HORIZONTAL HYDRAULIC CONDUCTIVITY (ft/day)	TOTAL POROSITY (Ø)	YOUNG'S MODULUS E(lb/in^2)	UNCONFINED COMPRESSIVE STRENGTH σ_a(ult)(lb/in^2)
1	1,600	Slightly dolomitic fossiliferous limestone (wackestone)	1.9×10^{-2}	2.2×10^{-2}	0.31	NM	NM
1	1,604	Slightly dolomitic fossiliferous limestone (wackestone)	2.2×10^{-3}	-	0.29	NM	NM
1	1,605	Slightly dolomitic fossiliferous limestone (wackestone)	1.5×10^{-2}	1.8×10^{-2}	0.32	NM	NM
1	1,608	Coarsely-crystalline dolomitic limestone	1.1×10^{-2}	1.1×10^{-2}	0.31	NM	NM
2	1,713	Fine-medium crystalline dolostone	2.1	1.8	0.31	NM	NM
3a	2,019	Finely to coarsely-crystalline dolostone w/ abundant cavities	2.2×10^{-2}	1.4×10^{-5}	0.10	NM	NM
4	2,206.5	Finely to coarsely-crystalline dolostone w/occasional vugs and fractures	4.0×10^{-6}	na	0.06	NM	NM
4	2,209	Finely to coarsely-crystalline dolostone w/occasional vugs and fractures	1.0×10^{-1}	1.9×10^{-5}	0.06	NM	NM
4	2,210	Finely to coarsely-crystalline dolostone w/ abundant vugs and cavities	2.1×10^{-2}	na	0.05	NM	NM
5	2,356	Microcrystalline dolostone w/ abundant vugs and cavities	1.8×10^{-2}	2.8×10^{-5}	0.01	NM	NM
5	2,357	Microcrystalline dolostone w/ abundant vugs and cavities	3.4×10^{-6}	na	0.09	NM	NM
6	2,483	Microcrystalline dolostone w/ common isolated partially open and mended small fractures	1.1×10^{-2}	9.9×10^{-3}	0.03	8.0×10^{5}	13,410

*Laboratory reported values were converted from units of centimeters/second to feet/day for consistency of hydrologic discussion.

TABLE 2-5
DOWNHOLE PRESSURE DATA DURING FLOW SURVEY

Date	Time	Total Time (min)	Downhole Pressure (psi)	Annular Pressure (psi)	Comments
3/22/2003	6:13:10	0	14.04	73.1	
3/22/2003	6:14:10	1	13.85	73.37	
3/22/2003	6:15:10	2	13.91	73.63	
3/22/2003	6:16:10	3	14	73.9	
3/22/2003	6:17:10	4	14.03	74.16	
3/22/2003	6:19:10	6	14.07	74.45	
3/22/2003	6:20:10	7	14.06	74.47	
3/22/2003	6:21:10	8	14.05	74.48	
3/22/2003	6:22:10	9	14.05	74.5	
3/22/2003	6:23:10	10	14.05	74.52	
3/22/2003	6:25:10	12	14.05	74.52	
3/22/2003	6:26:10	13	14.04	74.51	
3/22/2003	6:27:10	14	14.04	74.49	
3/22/2003	6:28:10	15	14.04	74.48	
3/22/2003	6:29:10	16	14.03	74.46	
3/22/2003	6:31:10	18	14.23	74.96	
3/22/2003	6:32:10	19	14.22	75.47	
3/22/2003	6:33:10	20	14.33	75.98	Run tool into hole
3/22/2003	6:34:10	21	14.51	76.5	
3/22/2003	6:35:10	22	20.65	77.01	
3/22/2003	6:37:10	24	20.42	79.13	
3/22/2003	6:38:10	25	23.68	80.74	
3/22/2003	6:39:10	26	51.48	82.35	
3/22/2003	6:40:10	27	96.47	83.96	
3/22/2003	6:41:10	28	155.41	85.56	
3/22/2003	6:43:10	30	274.09	87.81	
3/22/2003	6:44:10	31	332.92	88.44	
3/22/2003	6:45:10	32	390.83	89.07	
3/22/2003	6:46:10	33	447.69	89.71	
3/22/2003	6:47:10	34	503.46	90.34	
3/22/2003	6:49:10	36	614.44	91.6	
3/22/2003	6:50:10	37	682.19	92.22	
3/22/2003	6:51:10	38	750.95	92.85	
3/22/2003	6:52:10	39	817.84	93.47	
3/22/2003	6:53:10	40	883.56	94.09	
3/22/2003	6:55:10	42	1011.22	94.83	
3/22/2003	6:56:10	43	1072.82	94.94	
3/22/2003	6:57:10	44	1129.19	95.04	
3/22/2003	6:58:10	45	1133.83	95.15	
3/22/2003	6:59:10	46	1131.08	95.26	
3/22/2003	7:01:10	48	1131.14	95.38	
3/22/2003	7:02:10	49	1131.15	95.39	
3/22/2003	7:03:10	50	1131.16	95.4	
3/22/2003	7:04:10	51	1131.17	95.42	
3/22/2003	7:05:10	52	1131.17	95.43	
3/22/2003	7:07:10	54	1131.18	95.45	
3/22/2003	7:08:10	55	1131.19	95.45	
3/22/2003	7:09:10	56	1131.19	95.46	
3/22/2003	7:10:10	57	1131.2	95.46	

TABLE 2-5
DOWNHOLE PRESSURE DATA DURING FLOW SURVEY

Date	Time	Total Time (min)	Downhole Pressure (psi)	Annular Pressure (psi)	Comments
3/22/2003	7:11:10	58	1131.2	95.47	
3/22/2003	7:13:10	60	1131.2	95.47	
3/22/2003	7:14:10	61	1131.21	95.48	
3/22/2003	7:15:10	62	1131.21	95.48	
3/22/2003	7:16:10	63	1131.21	95.48	
3/22/2003	7:17:10	64	1131.22	95.49	
3/22/2003	7:19:10	66	1131.22	95.49	
3/22/2003	7:20:10	67	1131.22	95.49	
3/22/2003	7:21:10	68	1131.22	95.49	
3/22/2003	7:22:10	69	1131.22	95.49	
3/22/2003	7:23:10	70	1131.23	95.49	
3/22/2003	7:25:10	72	1131.23	95.49	
3/22/2003	7:26:10	73	1131.23	95.49	
3/22/2003	7:27:10	74	1131.23	95.49	
3/22/2003	7:28:10	75	1131.23	95.49	
3/22/2003	7:29:10	76	1131.23	95.49	Start static flow log run
3/22/2003	7:31:10	78	1133.07	95.44	
3/22/2003	7:32:10	79	1154.81	95.38	
3/22/2003	7:33:10	80	1181.45	95.32	
3/22/2003	7:34:10	81	1208.01	95.26	
3/22/2003	7:35:10	82	1234.59	95.2	
3/22/2003	7:37:10	84	1287.38	95.04	
3/22/2003	7:38:10	85	1313.33	94.94	
3/22/2003	7:39:10	86	1323.75	94.84	
3/22/2003	7:40:10	87	1316.71	94.75	
3/22/2003	7:41:10	88	1294.72	94.65	
3/22/2003	7:43:10	90	1323.22	94.55	
3/22/2003	7:44:10	91	1321.41	94.56	
3/22/2003	7:45:10	92	1323.6	94.56	
3/22/2003	7:46:10	93	1317.94	94.56	
3/22/2003	7:47:10	94	1316.89	94.56	
3/22/2003	7:49:10	96	1316.98	94.59	
3/22/2003	7:50:10	97	1316.99	94.61	
3/22/2003	7:51:10	98	1321.77	94.63	
3/22/2003	7:52:10	99	1321.19	94.66	
3/22/2003	7:53:10	100	1320.65	94.68	
3/22/2003	7:55:10	102	1323.78	94.69	
3/22/2003	7:56:10	103	1323.73	94.69	
3/22/2003	7:57:10	104	1323.72	94.68	
3/22/2003	7:58:10	105	1321.21	94.67	
3/22/2003	7:59:10	106	1295.96	94.66	
3/22/2003	8:01:10	108	1278.74	94.62	
3/22/2003	8:02:10	109	1296.26	94.59	
3/22/2003	8:03:10	110	1312.09	94.56	
3/22/2003	8:04:10	111	1299.96	94.53	
3/22/2003	8:05:10	112	1278.2	94.5	
3/22/2003	8:07:10	114	1304.35	94.48	
3/22/2003	8:08:10	115	1311.91	94.48	
3/22/2003	8:09:10	116	1287.19	94.49	

TABLE 2-5
DOWNHOLE PRESSURE DATA DURING FLOW SURVEY

Date	Time	Total Time (min)	Downhole Pressure (psi)	Annular Pressure (psi)	Comments
3/22/2003	8:10:10	117	1270.07	94.49	
3/22/2003	8:11:10	118	1298.3	94.49	
3/22/2003	8:13:10	120	1306.47	94.58	
3/22/2003	8:14:10	121	1288.16	94.66	
3/22/2003	8:15:10	122	1261.79	94.74	
3/22/2003	8:16:10	123	1229.58	94.82	
3/22/2003	8:17:10	124	1195.64	94.91	
3/22/2003	8:19:10	126	1153.23	95.06	
3/22/2003	8:20:10	127	1118.01	95.14	
3/22/2003	8:21:10	128	1122.93	95.22	
3/22/2003	8:22:10	129	1132.21	95.29	
3/22/2003	8:23:10	130	1132.23	95.37	
3/22/2003	8:25:10	132	1132.26	95.45	End static flow survey, reset tool at approx. 2534
3/22/2003	8:26:10	133	1132.26	95.46	
3/22/2003	8:27:10	134	1132.26	95.47	
3/22/2003	8:28:10	135	1132.26	95.47	
3/22/2003	8:29:10	136	1132.26	95.48	
3/22/2003	8:31:10	138	1132.26	95.49	
3/22/2003	8:32:10	139	1132.26	95.5	
3/22/2003	8:33:10	140	1132.27	95.5	
3/22/2003	8:34:10	141	1132.26	95.5	
3/22/2003	8:35:10	142	1132.26	95.51	
3/22/2003	8:37:10	144	1132.25	95.51	
3/22/2003	8:38:10	145	1132.24	95.51	
3/22/2003	8:39:10	146	1132.24	95.51	
3/22/2003	8:40:10	147	1132.25	95.51	
3/22/2003	8:41:10	148	1132.25	95.51	
3/22/2003	8:43:10	150	1132.25	95.51	
3/22/2003	8:44:10	151	1132.25	95.51	
3/22/2003	8:45:10	152	1132.25	95.51	
3/22/2003	8:46:10	153	1132.25	95.51	
3/22/2003	8:47:10	154	1132.25	95.51	
3/22/2003	8:49:10	156	1132.27	95.51	
3/22/2003	8:50:10	157	1132.26	95.51	
3/22/2003	8:51:10	158	1132.27	95.51	
3/22/2003	8:52:10	159	1132.26	95.51	
3/22/2003	8:53:10	160	1132.27	95.51	
3/22/2003	8:55:10	162	1132.27	95.51	
3/22/2003	8:56:10	163	1132.26	95.51	
3/22/2003	8:57:10	164	1132.27	95.51	
3/22/2003	8:58:10	165	1132.27	95.52	
3/22/2003	8:59:10	166	1132.27	95.52	
3/22/2003	9:01:10	168	1132.27	95.52	
3/22/2003	9:02:10	169	1132.27	95.52	
3/22/2003	9:03:10	170	1132.27	95.53	
3/22/2003	9:04:10	171	1132.27	95.53	
3/22/2003	9:05:10	172	1132.27	95.53	
3/22/2003	9:07:10	174	1132.27	95.53	
3/22/2003	9:08:10	175	1132.27	95.53	

TABLE 2-5
DOWNHOLE PRESSURE DATA DURING FLOW SURVEY

Date	Time	Total Time (min)	Downhole Pressure (psi)	Annular Pressure (psi)	Comments
3/22/2003	9:09:10	176	1132.27	95.54	
3/22/2003	9:10:10	177	1132.27	95.54	
3/22/2003	9:11:10	178	1132.27	95.54	
3/22/2003	9:13:10	180	1132.27	95.54	
3/22/2003	9:14:10	181	1132.27	95.54	
3/22/2003	9:15:10	182	1132.27	95.54	
3/22/2003	9:16:10	183	1132.27	95.54	
3/22/2003	9:17:10	184	1132.27	95.54	
3/22/2003	9:19:10	186	1132.25	95.53	
3/22/2003	9:20:10	187	1132.26	95.53	
3/22/2003	9:21:10	188	1132.27	95.53	
3/22/2003	9:22:10	189	1132.27	95.52	
3/22/2003	9:23:10	190	1132.27	95.52	
3/22/2003	9:25:10	192	1132.27	95.51	
3/22/2003	9:26:10	193	1132.27	95.51	
3/22/2003	9:27:10	194	1132.25	95.51	
3/22/2003	9:28:10	195	1132.25	95.51	
3/22/2003	9:29:10	196	1132.25	95.51	
3/22/2003	9:31:10	198	1132.25	95.51	
3/22/2003	9:32:10	199	1132.25	95.51	
3/22/2003	9:33:10	200	1132.25	95.51	
3/22/2003	9:34:10	201	1132.25	95.51	
3/22/2003	9:35:10	202	1132.26	95.51	
3/22/2003	9:37:10	204	1132.26	95.51	
3/22/2003	9:38:10	205	1132.25	95.51	
3/22/2003	9:39:10	206	1132.25	95.51	
3/22/2003	9:40:10	207	1132.25	95.51	
3/22/2003	9:41:10	208	1132.25	95.51	
3/22/2003	9:43:10	210	1132.26	95.51	
3/22/2003	9:44:10	211	1132.25	95.51	
3/22/2003	9:45:10	212	1132.25	95.51	
3/22/2003	9:46:10	213	1132.26	95.51	
3/22/2003	9:47:10	214	1132.25	95.51	
3/22/2003	9:49:10	216	1132.26	95.51	
3/22/2003	9:50:10	217	1132.26	95.51	
3/22/2003	9:51:10	218	1132.26	95.51	
3/22/2003	9:52:10	219	1132.27	95.51	
3/22/2003	9:53:10	220	1132.26	95.51	
3/22/2003	9:55:10	222	1132.26	95.51	
3/22/2003	9:56:10	223	1132.26	95.51	
3/22/2003	9:57:10	224	1132.27	95.51	
3/22/2003	9:58:10	225	1132.27	95.51	
3/22/2003	9:59:10	226	1132.27	95.51	
3/22/2003	10:01:10	228	1132.27	95.51	
3/22/2003	10:02:10	229	1132.27	95.51	
3/22/2003	10:03:10	230	1132.27	95.51	
3/22/2003	10:04:10	231	1132.27	95.51	
3/22/2003	10:05:10	232	1132.27	95.51	
3/22/2003	10:07:10	234	1132.27	95.51	

TABLE 2-5
DOWNHOLE PRESSURE DATA DURING FLOW SURVEY

Date	Time	Total Time (min)	Downhole Pressure (psi)	Annular Pressure (psi)	Comments
3/22/2003	10:08:10	235	1132.27	95.51	
3/22/2003	10:09:10	236	1132.27	95.51	
3/22/2003	10:10:10	237	1132.27	95.51	
3/22/2003	10:11:10	238	1132.28	95.51	
3/22/2003	10:13:10	240	1132.28	95.51	
3/22/2003	10:14:10	241	1132.28	95.51	Start pump test
3/22/2003	10:15:10	242	1132.26	95.51	
3/22/2003	10:16:10	243	1132.24	95.51	
3/22/2003	10:17:10	244	1132.2	95.51	
3/22/2003	10:19:10	246	1132.2	95.51	
3/22/2003	10:20:10	247	1132.19	95.51	
3/22/2003	10:21:10	248	1132.19	95.51	
3/22/2003	10:22:10	249	1132.19	95.51	
3/22/2003	10:23:10	250	1132.19	95.5	
3/22/2003	10:25:10	252	1132.19	95.5	
3/22/2003	10:26:10	253	1132.19	95.51	
3/22/2003	10:27:10	254	1132.19	95.51	
3/22/2003	10:28:10	255	1132.23	95.51	Shut pump off
3/22/2003	10:29:10	256	1132.28	95.51	
3/22/2003	10:31:10	258	1132.27	95.51	
3/22/2003	10:32:10	259	1132.28	95.51	
3/22/2003	10:33:10	260	1132.27	95.51	
3/22/2003	10:34:10	261	1132.24	95.51	
3/22/2003	10:35:10	262	1132.28	95.51	Restart pump
3/22/2003	10:37:10	264	1132.19	95.51	
3/22/2003	10:38:10	265	1132.19	95.51	
3/22/2003	10:39:10	266	1132.19	95.51	
3/22/2003	10:40:10	267	1132.19	95.51	
3/22/2003	10:41:10	268	1132.2	95.51	
3/22/2003	10:43:10	270	1132.2	95.51	
3/22/2003	10:44:10	271	1132.2	95.51	
3/22/2003	10:45:10	272	1132.2	95.51	
3/22/2003	10:46:10	273	1132.2	95.51	
3/22/2003	10:47:10	274	1132.2	95.51	
3/22/2003	10:49:10	276	1132.2	95.5	
3/22/2003	10:50:10	277	1132.2	95.5	
3/22/2003	10:51:10	278	1132.2	95.5	
3/22/2003	10:52:10	279	1132.2	95.5	
3/22/2003	10:53:10	280	1132.2	95.5	
3/22/2003	10:55:10	282	1132.2	95.5	
3/22/2003	10:56:10	283	1132.2	95.5	
3/22/2003	10:57:10	284	1132.2	95.5	
3/22/2003	10:58:10	285	1132.2	95.5	
3/22/2003	10:59:10	286	1132.2	95.5	
3/22/2003	11:01:10	288	1132.2	95.5	
3/22/2003	11:02:10	289	1132.2	95.5	
3/22/2003	11:03:10	290	1132.2	95.5	
3/22/2003	11:04:10	291	1132.2	95.5	
3/22/2003	11:05:10	292	1132.2	95.5	

TABLE 2-5
DOWNHOLE PRESSURE DATA DURING FLOW SURVEY

Date	Time	Total Time (min)	Downhole Pressure (psi)	Annular Pressure (psi)	Comments
3/22/2003	11:07:10	294	1132.2	95.5	
3/22/2003	11:08:10	295	1132.2	95.5	
3/22/2003	11:09:10	296	1132.2	95.5	
3/22/2003	11:10:10	297	1132.2	95.5	
3/22/2003	11:11:10	298	1132.2	95.5	
3/22/2003	11:13:10	300	1132.2	95.5	
3/22/2003	11:14:10	301	1132.2	95.49	
3/22/2003	11:15:10	302	1132.2	95.49	Start flow log run - lower pressure gage
3/22/2003	11:16:10	303	1142.72	95.48	
3/22/2003	11:17:10	304	1169.67	95.48	
3/22/2003	11:19:10	306	1223.54	95.45	
3/22/2003	11:20:10	307	1248.3	95.43	
3/22/2003	11:21:10	308	1235.07	95.41	
3/22/2003	11:22:10	309	1194.48	95.39	
3/22/2003	11:23:10	310	1180.73	95.37	
3/22/2003	11:25:10	312	1132.56	95.31	
3/22/2003	11:26:10	313	1148.91	95.27	
3/22/2003	11:27:10	314	1176.03	95.24	
3/22/2003	11:28:10	315	1202.87	95.2	
3/22/2003	11:29:10	316	1229.17	95.17	
3/22/2003	11:31:10	318	1281.7	95.04	
3/22/2003	11:32:10	319	1307.52	94.95	
3/22/2003	11:33:10	320	1322.2	94.86	
3/22/2003	11:34:10	321	1310.33	94.77	
3/22/2003	11:35:10	322	1289.07	94.68	
3/22/2003	11:37:10	324	1215.87	94.72	
3/22/2003	11:38:10	325	1190.26	94.86	
3/22/2003	11:39:10	326	1167.19	94.99	
3/22/2003	11:40:10	327	1135.6	95.13	Reset pressure guage at approximately 2534 feet
3/22/2003	11:41:10	328	1132.72	95.27	
3/22/2003	11:43:10	330	1132.73	95.42	
3/22/2003	11:44:10	331	1132.73	95.43	
3/22/2003	11:45:10	332	1132.73	95.45	
3/22/2003	11:46:10	333	1132.6	95.46	
3/22/2003	11:47:10	334	1132.61	95.48	
3/22/2003	11:49:10	336	1132.61	95.49	
3/22/2003	11:50:10	337	1132.61	95.5	
3/22/2003	11:51:10	338	1132.61	95.5	
3/22/2003	11:52:10	339	1132.61	95.5	
3/22/2003	11:53:10	340	1132.62	95.5	
3/22/2003	11:55:10	342	1132.62	95.51	
3/22/2003	11:56:10	343	1132.67	95.51	
3/22/2003	11:57:10	344	1132.71	95.51	Shut pump down.
3/22/2003	11:58:10	345	1132.71	95.51	
3/22/2003	11:59:10	346	1132.71	95.51	
3/22/2003	12:01:10	348	1132.71	95.51	
3/22/2003	12:02:10	349	1132.71	95.51	
3/22/2003	12:03:10	350	1132.71	95.51	
3/22/2003	12:04:10	351	1132.71	95.52	

TABLE 2-5
DOWNHOLE PRESSURE DATA DURING FLOW SURVEY

Date	Time	Total Time (min)	Downhole Pressure (psi)	Annular Pressure (psi)	Comments
3/22/2003	12:05:10	352	1132.71	95.52	
3/22/2003	12:07:10	354	1132.71	95.52	
3/22/2003	12:08:10	355	1132.72	95.52	
3/22/2003	12:09:10	356	1132.72	95.53	
3/22/2003	12:10:10	357	1132.72	95.53	
3/22/2003	12:11:10	358	1132.72	95.53	
3/22/2003	12:13:10	360	1132.72	95.53	
3/22/2003	12:14:10	361	1132.72	95.53	
3/22/2003	12:15:10	362	1132.72	95.53	
3/22/2003	12:16:10	363	1132.72	95.53	
3/22/2003	12:17:10	364	1132.72	95.54	
3/22/2003	12:19:10	366	1132.72	95.54	
3/22/2003	12:20:10	367	1132.72	95.54	
3/22/2003	12:21:10	368	1132.72	95.53	
3/22/2003	12:22:10	369	1132.72	95.53	
3/22/2003	12:23:10	370	1132.72	95.53	
3/22/2003	12:25:10	372	1132.73	95.53	
3/22/2003	12:26:10	373	1132.73	95.53	
3/22/2003	12:27:10	374	1132.73	95.53	
3/22/2003	12:28:10	375	1132.73	95.53	
3/22/2003	12:29:10	376	1132.73	95.53	
3/22/2003	12:31:10	378	1132.72	95.53	
3/22/2003	12:32:10	379	1132.72	95.52	
3/22/2003	12:33:10	380	1132.73	95.52	
3/22/2003	12:34:10	381	1132.73	95.52	End Test
3/22/2003	12:35:10	382	1116.49	95.51	
3/22/2003	12:37:10	384	1017.57	95.32	
3/22/2003	12:38:10	385	909.14	95.14	
3/22/2003	12:39:10	386	831.74	94.95	
3/22/2003	12:40:10	387	728.72	94.76	
3/22/2003	12:41:10	388	605.54	94.58	
3/22/2003	12:43:10	390	345.56	93.7	
3/22/2003	12:44:10	391	208.53	93	
3/22/2003	12:45:10	392	72.93	92.31	
3/22/2003	12:46:10	393	19.07	91.61	
3/22/2003	12:47:10	394	14.59	90.92	
3/22/2003	12:49:10	396	13.38	88.6	
3/22/2003	12:50:10	397	13.78	86.97	
3/22/2003	12:51:10	398	14.48	85.35	
3/22/2003	12:52:10	399	14.83	83.72	
3/22/2003	12:53:10	400	14.84	82.09	
3/22/2003	12:55:10	402	14.88	80.47	
3/22/2003	12:56:10	403	15.13	80.47	

TABLE 3-1
INCLINATION SURVEY SUMMARY FOR IW-1

Date	Bit Diameter (inches)	Depth (feet bpl)	Inclination (degrees)
1/31/2003	12.25	90	0.5
1/31/2003	12.25	180	0.25
1/31/2003	12.25	270	0.5
1/31/2003	12.25	360	0.5
2/1/2003	59.0	90	0.25
2/2/2003	59.0	180	<0.25
2/2/2003	59.0	270	0.65
2/3/2003	59.0	360	0.5
2/6/2003	12.25	450	0.1
2/6/2003	12.25	540	0.1
2/6/2003	12.25	630	0.1
2/7/2003	12.25	720	0.5
2/7/2003	12.25	810	0.5
2/7/2003	12.25	900	0.5
2/7/2003	12.25	990	0.5
2/7/2003	12.25	1080	0.5
2/8/2003	12.25	1170	0.5
2/8/2003	12.25	1260	0.5
2/8/2003	12.25	1350	0.25
2/14/2003	42.5	500	0.5
2/14/2003	42.5	590	0.25
2/15/2003	42.5	680	0.5
2/16/2003	42.5	770	0.5
2/16/2003	42.5	860	0.8
2/17/2003	42.5	950	0.25
2/17/2003	42.5	1040	0.5
2/18/2003	42.5	1130	0.1
2/18/2003	42.5	1220	0.4
2/24/2003	42.5	1310	0.4
2/24/2003	12.25	1400	0.75
2/26/2003	12.25	1490	0.6
2/28/2003	12.25	1580	0.25
2/28/2003	12.25	1670	0.25
2/28/2003	12.25	1760	0.45
3/1/2003	12.25	1850	0.25
3/6/2003	12.25	1940	0.1
3/6/2003	12.25	2030	0.25
3/7/2003	12.25	2120	0.4

TABLE 3-1
INCLINATION SURVEY SUMMARY FOR IW-1

Date	Bit Diameter (inches)	Depth (feet bpl)	Inclination (degrees)
3/8/2003	12.25	2210	0.55
3/10/2003	12.25	2300	0.6
3/10/2003	12.25	2390	0.6
3/14/2003	12.25	2480	0.55
3/15/2003	12.25	2570	0.75
3/15/2003	12.25	2660	0.5
3/16/2003	12.25	2750	0.25
3/16/2003	12.25	2840	0.5
3/17/2003	12.25	2930	0.75
3/18/2003	12.25	3020	0.25
3/18/2003	12.25	3110	0.5
3/20/2003	12.25	3200	0.5
4/29/2003	32.5	1390	0.25
4/29/2003	32.5	1480	0.65
4/29/2003	32.5	1570	0.25
5/3/2003	32.5	1660	0.4
5/8/2003	32.5	1750	0.25
5/8/2003	32.5	1840	0.4
5/10/2003	32.5	1930	0.25
5/15/2003	32.5	2020	0.3
5/20/2003	32.5	2110	0.5
5/20/2003	32.5	2200	0.25
5/22/2003	32.5	2290	0.4
5/24/2003	32.5	2380	0.25
5/28/2003	32.5	2470	0.25
5/28/2003	32.5	2560	0.25
7/16/2003	22.0	2650	0.25
7/16/2003	22.0	2740	0.3
7/21/2003	22.0	2830	0.5
7/24/2003	22.0	2920	0.5
NA	22.0	3010	NOTE: These surveys were not run. Survey equipment was being repaired.
NA	22.0	3100	
NA	22.0	3190	

TABLE 3-2
INCLINATION SURVEY SUMMARY FOR DZMW

Date	Bit Diameter (inches)	Depth (feet bpl)	Inclination (degrees)
8/11/2003	42.5	90	0.5
8/11/2003	42.5	180	0.5
8/11/2003	42.5	270	0.25
8/11/2003	42.5	360	0.4
8/14/2003	12.25	450	0.25
8/14/2003	12.25	540	0.25
8/14/2003	12.25	630	0.55
8/14/2003	12.25	720	0.5
8/14/2003	12.25	810	0.55
8/16/2003	12.25	900	0.4
8/16/2003	12.25	990	0.3
8/16/2003	12.25	1080	0.3
8/16/2003	12.25	1170	0.25
8/17/2003	17.5	520	0.25
8/17/2003	17.5	640	0.25
8/18/2003	17.5	760	0.3
8/19/2003	22	450	0.25
8/19/2003	22	540	0.25
8/19/2003	22	630	0.5
8/19/2003	22	720	0.5
8/19/2003	22	810	0.25
8/23/2003	12.25	1240	0.5

TABLE 3-3
GEOPHYSICAL LOGGING SUMMARY FOR IW-1

DATE	LOG RUN	DEPTH INTERVAL OF LOG (FT. BPL)	INTERVAL DESCRIPTION
2/4/2003	Caliper/ Natural Gamma	Surface to 414	59.5-inch pilot hole
2/5/2003	Temperature	Surface to 410	48-inch conductor casing
2/10/2003	Caliper/ Natural Gamma	410 -1456	12.25-inch pilot hole
2/10/2003	Dual Induction	410 -1456	12.25-inch pilot hole
2/10/2003	BHC Sonic-VDL	410 -1456	12.25-inch pilot hole
2/10/2003	Flowmeter	410 -1457	12.25-inch pilot hole
2/10/2003	Log Derived TDS	410 -1456	12.25-inch pilot hole
2/10/2003	Temperature	410 -1456	12.25-inch pilot hole
2/20/2003	Caliper/Natural Gamma	410 -1308	42.5-inch reamed borehole
2/21/2003	Temperature	Surface to 1308	34-inch surface casing
3/13/2003	Caliper/Natural Gamma	1300 - 2500	12.25-inch pilot hole
3/14/2003	Flowmeter	1300 - 2230	12.25-inch pilot hole
3/15/2003	Temperature	1300 - 2500	12.25-inch pilot hole
3/21/2003	Caliper/Natural Gamma	1300 - 3250	12.25-inch pilot hole
3/21/2003	BHC Sonic-VDL	1300 - 3250	12.25-inch pilot hole
3/21/2003	Dual Induction	1300 - 3250	12.25-inch pilot hole
3/21/2003	High Resolution Temperature	1300 - 3250	12.25-inch pilot hole
3/23/2003	Flowmeter	2534 - 2964	12.25-inch pilot hole
5/30/2003	Caliper/Natural Gamma	1300 - 2582	32.5-inch reamed borehole
6/1/03 - 7/9/03	Cement Top Temperature (merged)	Surface to 2580	24-inch longstring casing
7/30/2003	Caliper/Natural Gamma	2450 - 3250	22-inch reamed borehole
7/30/2003	Cement Bond-VDL	100 - 2600	24-inch longstring casing
8/29/2003	High Resolution Temperature	Surface to 2820	24-inch longstring casing
8/29/2003	Radio Active Tracer Survey	Surface to 2820	Injection Casing/Open hole
3/23/2003	Video Log	1300 - 2363	12.25-inch pilot hole
8/29/2003	Video Log	Surface to 3239	Injection Casing/Open hole

TABLE 3-4
GEOPHYSICAL LOGGING SUMMARY FOR DZMW

DATE	LOG RUN	DEPTH INTERVAL OF LOG (FT. BPL)	INTERVAL DESCRIPTION
8/11/2003	Caliper/Natural Gamma	Surface to 410	42.5-inch pilot hole
8/12/2003	Temperature	Surface to 410	24-inch intermediate casing
8/15/2003	Caliper/Natural Gamma	300 - 950	12.25-inch pilot hole
8/16/2003	Log Derived TDS	396 -1250	12.25-inch pilot hole
8/16/2003	Borehole Compensated Sonic w/VDL	350 -1250	12.25-inch pilot hole
8/16/2003	Dual Induction	350 -1250	12.25-inch pilot hole
8/16/2003	Temperature Log	350 -1250	12.25-inch pilot hole
8/16/2003	Caliper/Natural Gamma	350 -1250	12.25-inch pilot hole
8/20/2003	Caliper/Natural Gamma	Surface to 885	22-inch reamed borehole
8/21/2003	Temperature	550 - 875	14-inch casing
8/21/2003	Temperature	Surface to 875	14-inch casing
8/23/2003	Caliper/Natural Gamma	Surface to 1265	12.25-inch pilot hole
8/24/2003	Cement Bond w/VDL	100 - 890	14-inch casing
8/25/2003	Temperature	900 -1204	6.625" casing
8/25/2003	Temperature	Surface to1204	6.625" casing
11/11/2003	Sector Cement Bond w/ VDL	800 - 1204	6.625" casing

TABLE 3-5
48-INCH CONDUCTOR CASING SUMMARY FOR IW-1

Pipe No. and Install Order	Time of Install (pipe down)	Heat Number	Length (ft)	String Length (ft)	Run Depth (ft bpl)
1	8:30	HT.C22024	12.00	12.00	9.50
2	9:25	HT.1005330	50.10	62.10	59.60
3	10:18	HT.C22024	50.17	112.27	109.77
4	11:12	HT.A23173	50.10	162.37	159.87
5	12:02	HT.C21941	50.17	212.54	210.04
6	12:48	HT.1005330	50.00	262.54	260.04
7	13:31	HT.1005330	50.11	312.65	310.15
8	14:19	HT.C22024	50.07	362.72	360.22
9 (header joint)	15:13	HT.C21941	50.17	412.89	410.39

TABLE 3-6
34-INCH SURFACE CASING SUMMARY FOR IW-1

Pipe No. and Install Order	Time of Install (pipe down)	Heat Number	Length (ft)	String Length (ft)	Run Depth (ft bpl)
1	15:05	HT.TO23045	12.08	12.08	6.58
2	15:59	HT.TO23203	50.03	62.11	56.61
3	16:25	HT.20204	50.04	112.15	106.65
4	16:59	HT.20204	49.97	162.12	156.62
5	17:20	HT.20204	50.10	212.22	206.72
6	17:55	HT.20204	50.02	262.24	256.74
7	18:25	HT.81906	50.08	312.32	306.82
8	18:50	HT.81906	50.08	362.40	356.90
9	19:20	HT.20204	50.00	412.40	406.90
10	19:41	HT.20204	50.00	462.40	456.90
11	20:11	HT.369992Z	50.05	512.45	506.95
12	20:40	HT.20204	50.05	562.50	557.00
13	21:07	HT.20204	50.05	612.55	607.05
14	21:31	HT.20149	49.95	662.50	657.00
15	21:55	HT.20204	49.98	712.48	706.98
16	22:23	HT.369992Z	50.10	762.58	757.08
17	22:52	HT.81893	50.07	812.65	807.15
18	23:14	HT.CO9188	50.04	862.69	857.19
19	23:45	HT.81893	50.05	912.74	907.24
20	0:19	HT.20204	50.03	962.77	957.27
21	0:53	HT.20204	50.10	1012.87	1007.37
22	1:18	HT.81906	50.05	1062.92	1057.42
23	1:40	HT.20149	49.98	1112.90	1107.40
24	2:18	HT.20204	50.15	1163.05	1157.55
25	2:48	HT.2844T	45.00	1208.05	1202.55
26	3:15	HT.20204	50.00	1258.05	1252.55
27 (Header joint)	3:58	HT.20204	47.45	1305.50	1300.00

TABLE 3-7
24-INCH INJECTION CASING SUMMARY FOR IW-1

Pipe No. and Install Order	Time of Install (weld complete/ pipe down)	Time Start Weld	Heat Number	Length (ft)	String Length (ft)	Run Depth (ft bpl)
1	12:45		B45662	42.15		**Subtract 8.16 ft**
2	13:15	13:19	B45660	42.47	84.62	76.46
3	13:42	13:45	A24375	39.73	124.35	116.19
4	14:11	14:18	A41440	40.42	164.77	156.61
5	14:40	14:46	B45661	42.13	206.90	198.74
6	15:10	15:17	A41440	41.76	248.66	240.50
7	15:38	15:44	B45660	40.62	289.28	281.12
8	16:05	16:12	A41440	38.62	327.90	319.74
9	16:35	16:42	A41440	41.05	368.95	360.79
10	17:02	17:09	A24375	38.67	407.62	399.46
11	17:29	17:35	A24375	41.06	448.68	440.52
12	17:57	18:04	A45276	40.58	489.26	481.10
13	18:25	18:32	B45660	42.00	531.26	523.10
14	19:11	19:23	A83676	41.68	572.94	564.78
15	19:57	20:05	A24375	40.55	613.49	605.33
16	20:29	20:37	B45662	37.00	650.49	642.33
17	20:58	21:09	A41440	38.78	689.27	681.11
18	21:34	21:43	A41440	41.33	730.60	722.44
19	22:06	22:19	A24375	42.00	772.60	764.44
20	22:42	22:53	B45660	36.15	808.75	800.59
21	23:23	23:30	A41440	41.57	850.32	842.16
22	23:54	0:04	A41440	41.65	891.97	883.81
23	0:24	0:30	A41440	40.10	932.07	923.91
24	0:55	2:01	B45660	42.46	974.53	966.37
25	2:18	2:28	B45660	42.80	1017.33	1009.17
26	2:50	3:00	B45662	42.84	1060.17	1052.01
27	3:23	3:30	B45662	43.70	1103.87	1095.71
28	3:55	4:25	A41440	41.59	1145.46	1137.30
29	4:55	5:11	B45662	41.17	1186.63	1178.47
30	5:30	5:39	B45660	42.12	1228.75	1220.59
31	6:05	6:12	B45662	42.78	1271.53	1263.37
32	6:39	7:23	B45660	41.92	1313.45	1305.29
33	7:44	7:51	A24375	38.26	1351.71	1343.55
34	8:16	8:25	B45660	43.17	1394.88	1386.72
35	8:43	8:51	A24375	40.20	1435.08	1426.92
36	9:10	9:19	A41440	42.33	1477.41	1469.25
37	9:38	9:45	A41440	39.77	1517.18	1509.02
38	10:07	10:14	A41440	39.64	1556.82	1548.66
39	10:50	10:59	A41440	39.46	1596.28	1588.12
40	11:20	11:28	A24375	40.39	1636.67	1628.51
41	11:53	12:02	B45661	40.94	1677.61	1669.45
42	12:47	12:57	A41440	40.30	1717.91	1709.75

TABLE 3-7
24-INCH INJECTION CASING SUMMARY FOR IW-1

Pipe No. and Install Order	Time of Install (weld complete/ pipe down)	Time Start Weld	Heat Number	Length (ft)	String Length (ft)	Run Depth (ft bpl)
43	13:15	13:24	A24375	37.90	1755.81	1747.65
44	13:45	13:52	A41440	41.71	1797.52	1789.36
45	14:17	14:27	A41440	41.90	1839.42	1831.26
46	14:45	14:55	A45276	42.72	1882.14	1873.98
47	15:14	15:21	B45660	41.07	1923.21	1915.05
48	15:42	15:52	A45276	40.52	1963.73	1955.57
49	16:12	16:20	B45660	43.28	2007.01	1998.85
50	16:38	16:45	B45660	42.96	2049.97	2041.81
51	17:05	17:13	B45660	41.63	2091.60	2083.44
52	17:33	17:42	B45660	42.43	2134.03	2125.87
53	18:03	18:13	A45276	36.54	2170.57	2162.41
54	19:50	20:00	B45662	41.07	2211.64	2203.48
55	20:30	20:40	B45660	43.05	2254.69	2246.53
56	21:10	21:19	B45660	43.14	2297.83	2289.67
57	21:50	21:56	B45660	42.92	2340.75	2332.59
58	22:28	22:39	B45660	42.57	2383.32	2375.16
59	22:59	23:08	B45660	42.30	2425.62	2417.46
60	23:35	23:46	B45660	38.17	2463.79	2455.63
61	0:15	0:51	A41440	36.80	2500.59	2492.43
62	1:25	1:50	A83676	41.15	2541.74	2533.58
Header - 63	2:23	NA	A41440	41.42	2583.16	2575.00

Casing will be lugged 8.16 feet above pad prior to cementing.

TABLE 3-8
24-INCH INTERMEDIATE CASING SUMMARY FOR DZMW

Pipe No. and Install Order	Time of Install (weld complete/ pipe down)	Time Start Weld	Heat Number	Length (ft)	String Length (ft)	Run Depth (ft bpl)
1	8:45 (lower 1st)	8:49	HTA39153	26.49	26.49	25.99
2	9:16	9:21	HTA39709	42.10	68.59	68.09
3	9:46	9:53	HTA39711	42.08	110.67	110.17
4	10:15	10:21	HTA39153	42.08	152.75	152.25
5	10:37	10:40	HTA39707	42.11	194.86	194.36
6	10:56	10:59	HTA39802	42.14	237.00	236.50
7	11:14	11:16	HTA39153	42.16	279.16	278.66
8	11:32	11:35	HTA39802	42.12	321.28	320.78
9	11:52	11:56	HTA39802	42.12	363.40	362.90
10 (header)	12:12	-	HTA39709	42.10	405.50	405.00

Casing set at 405 feet bpl with 0.5 feet of stickup above pad prior to cementing.
Cut header joint to 26.49 feet prior to run.

TABLE 3-9
14-INCH UPPER ZONE CASING SUMMARY FOR DZMW

Pipe No. and Install Order	Time of Install (pipe down)	Heat Number	Length (ft)	String Length (ft)	Run Depth (ft bpl)
Exterior hole plug		220681	4.00	4.00	-4.22
1	19:12	220681	39.41	43.41	35.19
2	19:45	220681	35.84	79.25	71.03
3	20:08	220677	39.40	118.65	110.43
4	20:32	220677	40.42	159.07	150.85
5	20:51	220675	40.41	199.48	191.26
6	21:14	220675	40.53	240.01	231.79
7	21:30	220681	40.14	280.15	271.93
8	21:50	220675	40.55	320.70	312.48
9	22:10	220681	40.50	361.20	352.98
10	22:31	220677	39.47	400.67	392.45
11	22:53	220681	40.12	440.79	432.57
12	23:12	220677	40.54	481.33	473.11
13	23:34	220675	40.35	521.68	513.46
14	0:42	220677	40.54	562.22	554.00
15	0:58	220675	40.24	602.46	594.24
16	1:16	220681	40.56	643.02	634.80
17	1:36	220675	39.86	682.88	674.66
18	1:55	220675	40.10	722.98	714.76
19	2:10	220681	40.52	763.50	755.28
20	2:30	220677	40.31	803.81	795.59
21	2:49	220681	38.92	842.73	834.51
22 - header	3:12	220677	40.49	883.22	875.00

TABLE 3-10
6.625-INCH LOWER ZONE CASING SUMMARY FOR DZMW

Pipe No. and Install Order	Time of Install (pipe down)	Heat Number	Length (ft)	String Length (ft)	Run Depth (ft bpl)
1	9:21	682547	40.43	40.43	34.04
2	9:55	682545	39.45	79.88	73.49
3	10:12	682542	40.54	120.42	114.03
4	10:29	682576	40.49	160.91	154.52
5	10:49	682545	40.72	201.63	195.24
6	11:05	682557	40.32	241.95	235.56
7	11:25	682545	40.58	282.53	276.14
8	11:42	682541	40.45	322.98	316.59
9	12:00	682546	40.26	363.24	356.85
10	12:20	682555	40.45	403.69	397.30
11	12:38	682545	40.45	444.14	437.75
12	12:54	682541	40.52	484.66	478.27
13	13:47	682544	40.45	525.11	518.72
14	14:03	682547	40.45	565.56	559.17
15	14:20	682558	40.26	605.82	599.43
16	14:38	682545	40.44	646.26	639.87
17	14:56	682542	40.38	686.64	680.25
18	15:14	682539	40.32	726.96	720.57
19	15:31	682559	40.45	767.41	761.02
20	15:47	682541	40.56	807.97	801.58
21	16:02	682541	40.25	848.22	841.83
22	16:20	682541	40.50	888.72	882.33
23	16:37	682541	40.21	928.93	922.54
24	16:52	682541	40.56	969.49	963.10
25	17:10	682554	39.82	1009.31	1002.92
26	17:29	682547	40.27	1049.58	1043.19
27	17:45	682559	39.79	1089.37	1082.98
28	18:00	682556	40.55	1129.92	1123.53
29	18:22	682544	40.41	1170.33	1163.94
30	20:05	682544	40.06	1210.39	1204.00

Note: Casing set at 1204 feet bpl. JOINT #1 fitted with tandem set of cement baskets positioned at 1 foot and 4 feet above bottom end of joint. There are no cut joints in the casing string as 6.39 feet of JOINT #30 rises above pad level when initially set.

TABLE 4-1
24-INCH INJECTION CASING PRESSURE TEST SUMMARY

WATER RESOURCE SOLUTIONS

Date:	7/11/2003
Project Name:	NCWRF
Job No.:	01-04254.A8
Well :	IW-1

Casing Pressure Test Log

North Collier County Water Reclamation Facility
Class I Injection Well System

Time	Delta T	Casing Pressure (psi)	Packer Pressure (psi)	Comments
10:02	0	200	NA	Begin the test at 200 psi.
10:07	5	200	NA	
10:12	10	200	NA	
10:17	15	200	NA	
10:22	20	199	NA	
10:27	25	199	NA	NOTE: Packer was not needed
10:32	30	198.5	NA	since bridge plug was set.
10:37	35	198.5	NA	
10:42	40	198	NA	
10:47	45	198	NA	
10:52	50	197.5	NA	
10:57	55	197	NA	
11:02	60	197	NA	End the test.

Casing Diameter: 24 inches
Casing Type: 0.5-inch wall steel

Witnesses: Richard Orth (FDEP), Frank Procta (WRS)

Center Line of Packer: NA
Packer Length: NA
Guage SN/ID #: IC119
Calibration Date: 7/10/2003

5% of Initial Casing Pressure: 10 psi
Total Pressure Change: 3 psi loss or 1.5%

TABLE 5-1
INJECTION TESTING SUMMARY FOR IW-1

DATE	ACTUAL TIME	INJECTION RATE (MGD) at pipeline meter	INJECTION RATE (MGD) at pump station meter	INJECTION WELLHEAD PRESSURE (psi)	* UPPER-ZONE MONITORING WELLHEAD PRESSURE (psi)
11/5/03	9:01	4.6		26.0	
11/5/03	9:07	10.2		29.5	
11/5/03	9:09	10.8		30.0	
11/5/03	9:10	12.5		31.5	
11/5/03	9:12		13.08		
11/5/03	9:15		17.32		
11/5/03	9:17		17.80		
11/5/03	9:18		18.07		
11/5/03	9:19			37.0	
11/5/03	9:28		14.87		
11/5/03	9:30			33.0	5.8
11/5/03	9:34		14.86		
11/5/03	9:46	17.0		37.0	
11/5/03	9:47		17.76		
11/5/03	10:00	17.0	17.67		5.8
11/5/03	10:05	17.1	17.64	37.0	5.8
11/5/03	10:10	16.9	17.64	37.0	5.8
11/5/03	10:15	17.1	17.63	37.0	5.8
11/5/03	10:20	16.8	17.63	37.0	5.8
11/5/03	10:25	17.2	17.59	37.5	5.8
11/5/03	10:30	17.1	17.60	37.0	5.8
11/5/03	10:35	17.2	17.59	37.0	5.5
11/5/03	10:40	16.9			
11/5/03	10:45	16.9		37.0	
11/5/03	10:50	17.0	17.60	37.0	5.5
11/5/03	10:55	17.0	17.63	37.5	5.5
11/5/03	10:30	17.1	17.60	37.0	5.8
11/5/03	11:00	17.0	17.60	37.5	5.5
11/5/03	11:05	16.9		37.0	5.6
11/5/03	11:10	17.0	17.63	37.5	
11/5/03	11:15	16.9	17.60		5.7
11/5/03	11:20	16.8	17.63	37.4	5.7
11/5/03	11:30	16.7	17.65	37.0	5.7
11/5/03	12:00	16.8	17.68	37.0	5.7
11/5/03	12:30	16.9	17.71	37.0	5.7
11/5/03	13:00	16.8	17.59	38.0	6.6
REDUCED FLOW RATE					
11/5/03	13:26	7.0		27.0	7.0
11/5/03	13:30	8.4		28.0	
11/5/03	14:00	8.5		28.0	6.9
11/5/03	14:30	8.3		28.0	6.5
11/5/03	15:00	8.5		28.0	6.5
11/5/03	15:30	8.5		28.5	7.1
11/5/03	16:00	10.2		30.0	7.1
11/5/03	16:30	10.7		30.5	7.2
11/5/03	17:00	10.8		30.5	7.2
11/5/03	17:30	10.9		30.5	7.2

TABLE 5-1
INJECTION TESTING SUMMARY FOR IW-1

DATE	ACTUAL TIME	INJECTION RATE (MGD) at pipeline meter	INJECTION RATE (MGD) at pump station meter	INJECTION WELLHEAD PRESSURE (psi)	* UPPER-ZONE MONITORING WELLHEAD PRESSURE (psi)
11/5/03	18:00	10.8		30.5	7.2
11/5/03	18:30	10.6		30.5	7.2
11/5/03	19:00	10.6		30.5	7.3
11/5/03	19:30	10.8		30.5	7.2
11/5/03	20:00	10.6		30.5	7.3
11/5/03	20:30	10.7		30.5	7.3
11/5/03	20:59	10.6		30.5	7.2
11/5/03	21:00	falling		falling	
POST SHUT-IN MONITORING					
11/5/03	21:01	0		25.0	7.3
11/5/03	21:05	0		25.0	7.3
11/5/03	21:30	0		25.0	7.3
11/5/03	22:00	0		25.0	7.3
11/5/03	22:30	0		25.0	7.2
11/5/03	23:00	0		25.0	7.2
11/5/03	23:30	0		25.0	7.3
11/6/03	0:00	0		25.0	7.3
11/6/03	0:30	0		25.0	7.3
11/6/03	1:00	0		25.5	7.3
11/6/03	1:30	0		25.5	7.3
11/6/03	2:00	0		25.5	7.3
11/6/03	2:30	0		25.5	7.2
11/6/03	3:00	0		25.5	7.3
11/6/03	3:30	0		25.5	7.3
11/6/03	4:00	0		25.5	7.3
11/6/03	4:30	0		25.5	7.3
11/6/03	5:00	0		25.5	7.3
11/6/03	5:30	0		25.5	7.2
11/6/03	6:00	0		25.0	7.3
11/6/03	6:30	0		25.0	7.3
11/6/03	7:00	0		25.0	7.3
11/6/03	7:30	0		25.0	7.3
11/6/03	8:00	0		25.0	7.3
11/6/03	8:30	0		25.0	7.3
11/6/03	9:00	0		25.0	7.3
11/6/03	9:30	0		25.0	7.0
11/6/03	10:00	0		25.9	6.3
11/6/03	10:30	0		25.9	6.3
11/6/03	11:00	0		25.9	6.3
11/6/03	12:15	0		25.0	6.2
11/6/03	12:35	0		25.0	6.0
11/6/03	14:00	0		25.0	6.1
11/6/03	14:35	0		25.0	5.9
11/6/03	15:50	0		25.5	7.2
11/6/03	16:30	0		25.5	7.2
11/6/03	17:00	0		25.5	7.2
11/6/03	17:30	0		25.5	7.2

TABLE 5-1
INJECTION TESTING SUMMARY FOR IW-1

DATE	ACTUAL TIME	INJECTION RATE (MGD) at pipeline meter	INJECTION RATE (MGD) at pump station meter	INJECTION WELLHEAD PRESSURE (psi)	* UPPER-ZONE MONITORING WELLHEAD PRESSURE (psi)
11/6/03	18:00	0		25.5	7.3
11/6/03	18:30	0		25.5	7.3
11/6/03	19:00	0		25.5	7.3
11/6/03	19:30	0		25.5	7.3
11/6/03	20:00	0		25.5	7.3
11/6/03	20:30	0		25.5	7.3
11/6/03	21:00	0		25.5	7.3

Note: The official start of the injection test is recorded at 9:01, as on-going data collection (background data) is stepped on the data logger at the same time water injection is initiated down the well.

* Pressure readings were manually recorded at the wellhead for the upper monitoring zone of DZMW. Manual pressure readings were not recorded at the wellhead for the lower monitoring zone of DZMW because water levels were below land surface during the test.

Pressure data that was recorded by submerged transducers, in the upper and lower monitoring zones at DZMW as well as IW-1, is presented separately.

TABLE 5-2
INJECTION TESTING RESULTS FOR IW-1

ANALYSIS	INJECTION RATE (MGD)	INJECTION RATE (gpm)	PRESSURE INCREASE DOWNHOLE (psi/ft)	PRESSURE INCREASE AT WELLHEAD (psi/ft)	PUMP TIME (min)	SPECIFIC INJECTIVITY AT WELLHEAD (gpm/psi)	SPECIFIC INJECTIVITY AT WELLHEAD (gpm/ft)	SPECIFIC INJECTIVITY AT FORMATION (gpm/ft)	CALCULATED TRANSMISSIVITY (gpd/ft)
High-Rate Specific Injectivity	*17.0	*11,800	0.75/1.7	12.5/29	480	950	410	6,900	***14,000,000
Low-Rate Specific Injectivity	*10.7	*7,400	0.3/0.7	5.0/11.5	240	1,500	640	10,600	***21,000,000
Multi-Rate Pressure Analysis	**17.0 reduced to 9.7	**11,800 reduced to 6,700	0.75/1.7 to 0.3/0.7	12.5/29 to 5.0/11.5	720	NA	NA	NA	****10,000,000

* Highest sustained injection rate throughout pumping period.

** Average injection rate throughout pumping period.

*** Using downhole pressure data and highest sustained rate during injection operations to calculate specific capacity and thereby estimate formation transmissivity by Walton's Method (Driscoll, 1986).

**** Using downhole pressure data and average injection rates during injection operations to perform a multi-rate analysis to estimate formation transmissivity (Mathews and Russell, 1967).

TABLE 5-3
PACKER TESTING FLOW SUMMARY FOR IW-1

SINGLE-PACKER DRILL STEM TESTS

TEST #	INTERVAL DEPTH (ft bpl)	OPEN INTERVAL (ft)	AVERAGE PUMP RATE (gpm)	DRAWDOWN (ft)	PUMP TIME (min)	SPECIFIC CAPACITY (gpm/ft)	**CALCULATED TRANSMISSIVITY (gpm/ft)
1	1,198-1,357	159	74	5.0	225	15	30,000
2	1,450-1,500	50	67	1.1	149	61	120,000
3	1,875-1,925	50	67	0.7	240	96	190,000
4	2,539-3,250	711	200	* 0.2	275	1000	2,000,000

* Pressure change measured at base of drillstring

STRADDLE-PACKER DRILL STEM TESTS

TEST #	INTERVAL DEPTH (ft bpl)	OPEN INTERVAL (ft)	AVERAGE PUMP RATE (gpm)	DRAWDOWN (ft)	PUMP TIME (min)	SPECIFIC CAPACITY (gpm/ft)	**CALCULATED TRANSMISSIVITY (gpm/ft)
1	1,347-1,364	17	9.0	1.1	23	8.2	16,000
2	1,412-1,429	17	7.0	4.0	39	1.8	3,600
3	1,369-1,386	17	2.5	1.4	33	1.8	3,600
4	1,397-1,414	17	2.1	12.1	58	0.17	340

** Based on the empirical equation: $Q/s = T/2000$ used to calculate the approximate value of transmissivity in a confined aquifer.

TABLE 5-4
PACKER TESTING FLOW SUMMARY FOR DZMW

SINGLE-PACKER DRILL STEM TESTS

TEST #	INTERVAL DEPTH (ft bpl)	OPEN INTERVAL (ft)	AVERAGE PUMP RATE (gpm)	DRAWDOWN (ft)	PUMP TIME (min)	SPECIFIC CAPACITY (gpm/ft)	* CALCULATED TRANSMISSIVITY (gpm/ft)
1	902-950	48	65	11	157	5	10,000
2	1,202-1,250	48	60	< 1	149	> 60	> 120,000
3	875-934	59	60	13	59	4.6	9,200

* Based on the empirical equation: Q/s = T/2000 used to calculate the approximate value of transmissivity in a confined aquifer.