North Collier Water Reclamation Facility

Well Completion Report for IW-2 Volume 1

Collier County

PUED 73948

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NCWRF - IW2

North Collier Water Reclamation Facility Well Completion Report for IW-2 PUED #73948

Collier County

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1.0 INTRODUCTION

This Well Completion Report for injection well 2 (IW-2) provides the drilling and construction details for the second of two recently installed injection wells at the North County Water Reclamation Facility (NCWRF) located at 10500 Goodlette-Frank Road, in the northern portion of the City of Naples (Figure 1-1). This report includes the test data, water quality information, and other construction details pertinent to the operation and regulation of this second well. This Class I injection well program has been initiated as a backup for the NCWRF treated effluent reuse system. 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 first injection well (IW-1), the dual-zone monitoring well (DZMW), and the second injection well (IW-2), are plotted on the project site map (Figure 1-2). The final site survey showing the locations of the wells and the heights to well flanges is presented in Appendix 1.1.

Construction and testing of well IW-2 meet all Underground Injection Control (UIC) program requirements specified in the Florida Administrative Code (F.A.C.), Section 62-528 and the associated Class I Injection Well Construction Permit, number 189741-002-UC, issued by the Florida Department of Environmental Protection (FDEP).

In accordance with regulatory requirements, the following items were addressed during the construction and testing of both IW-1 and IW-2:

- Confinement
- Mechanical integrity
- Well performance under operating conditions
- Background water quality in the injection zone at IW-2

The evaluation of confinement is based on the examination of drill cuttings, core samples from IW-1, and geophysical logging data. Results of this review 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, thereby protecting the groundwater resources of the Upper Floridan Aquifer above the base of the USDW.

The mechanical integrity of IW-2 was demonstrated by the satisfactory performance of a 60-minute casing pressure test of the 23-inch I.D. injection casing (starting hydrostatic pressure of 194 psi), and the successful performance of a suite of radioactive tracer surveys (RATS). A final recorded test pressure of 193.75 psi sets a maximum operating pressure during injection activities of 129 psi (2/3 of test value). Results of the RATS indicated no upward movement of the ejected tracer slug behind the 24-inch O.D. injection casing.

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 approximately 2 psi. Wellhead pressure stabilized near 39 psi over a 3-hour and 42-minute period at an average injection rate of approximately 17.2 MGD. Approximately 18 minutes were needed to adjust flow and reach a sustainable long-term rate. Maximum rates of 19.6 MGD were reached during the initial phases of this testing.

Formation water samples collected from the injection zone at IW-2 were analyzed to establish the background water quality of this zone. The sampling event followed standard chain-of-custody protocol.

The details of the pilot-hole drilling, lithologic descriptions, well construction, geophysical logging and groundwater characterization are presented in the following sections of this document.

2.0 HYDROGEOLOGY

2.1 Stratigraphy

The geologic formations penetrated during the drilling of well IW-2 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 2.1. 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 at well IW-2 consist primarily of sandy clay, shell fragments and fine-grained quartz sand. The undifferentiated surficial deposits extend from the drilling pad level (land surface), to approximately 30 feet bpl as determined by a change in lithology from a sandy clay to a predominantly greenish-gray, silty clay with minor fine-grained quartz and phosphate sand and fine-grained limestone (packstone).

Tamiami Formation (30 - 150 feet bpl) Pliocene

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, and usually micritic, 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 well IW-2 consist of approximately 20 feet of greenish-gray, silty clay interbedded with seams of fine-grained limestone (Bonita Springs Marl), underlain by approximately 100 feet of predominantly fossiliferous grainstones (Ochopee Limestone). This interpretation considers that the Pinecrest Limestone was not observed at the well location. The Tamiami Formation is determined to lie 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, coralline limestone to a greenish-gray, 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 consists predominantly of low-permeability, green, phosphatic, sandy clays and dolosilts.

Samples collected during drilling at well IW-2 consist of low-permeability, greenish-gray, silty, phosphatic clays and yellowish-gray, variably indurated, fossiliferous limestones. The formation is determined to lie from approximately 150 to 400 feet bpl at IW-2. The lower contact is disconformable with the Arcadia Formation and is marked by a change from greenish-gray, phosphatic clay and fossil packstone to the first appearance of recrystallized limestone and more prevalent moldic and sandy limestones. 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 well IW-2.

Arcadia Formation (Hawthorn Group) (400 - 794 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 well IW-2 consists of alternating beds or seams of yellowish-gray fossiliferous limestone and yellowish-gray to olive-gray clay with olive-gray dolostone and dolomitized limestone occurring towards the bottom of the formation. Phosphate is common throughout. The upper portion of the formation (400 to 640 feet bpl) consists predominantly of yellowish-gray, fossiliferous packstones and wackestones with common interbedded yellowish-gray to olive-gray clay. Predominantly well indurated, fossiliferous packstones and wackestones lie from 640 feet bpl to the base of the formation with occurrences of olive-gray dolostone, dolomitized limestone, and marl closer to the base. The contact between the Arcadia Formation and the Suwannee Limestone Formation is determined to lie at a depth of approximately 794 feet bpl, based on an attenuation of the natural gamma ray signal and a lack of phosphate below that depth.

Suwannee Limestone Formation (794 - 1,300 feet bpl)

The Oligocene-age Suwannee Limestone Formation (approximately 27 to 37 million years B.P.) is typically a fossiliferous, packstone to grainstone composed of moderately to well-sorted foraminifera, pellets, 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 (794 to 1,100 feet bpl) of the Suwannee Limestone Formation encountered during drilling at well IW-2 consists of yellowish-gray to pale-orange, poorly to moderately indurated grainstones and packstones, exhibiting fair to good porosity. Yellowish-gray clay (fine-quartz-sandy) beds are common from 980 to 1,100 feet bpl. Sediments collected from the lower portion (1,100 to 1,300 feet bpl) of the formation predominantly consist of yellowish-gray to olive-gray poorly to moderately indurated, fine to medium-grained packstones with lesser grainstones, containing variable amounts of fine to medium-grained quartz and phosphatic sand. Beds of yellowish-brown crystalline dolostone exist from 1,100 to 1,160 feet bpl. The lower portion of the formation generally exhibits fair porosity and apparent permeability. Based on a lithologic change from pale-yellowish-brown grainstone and packstone with common fine-grained quartz sand to very-pale-orange, fine to coarse-grained, fossiliferous grainstone, the base of the Suwannee Limestone is picked at a depth of approximately 1,300 feet bpl.

Ocala Formation (1,300 - 1,700 feet bpl)

The upper Eocene-age Ocala Formation (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 larger 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 formation (1,300 to 1,430 feet bpl) at well IW-2 consists of very-pale-orange, fine to coarse-grained, friable to moderately-indurated grainstones. Overall, interparticle porosity and apparent permeability of sediments collected from the upper portion of the unit at IW-2 are good to fair. Interbedded yellowish-brown, fine to medium-grained, well to moderately-indurated dolostones and yellowish-gray, fine to coarse-grained, moderate to poorly-indurated packstones occur from 1,430 to 1,500 feet bpl. Predominantly yellowish-gray to grayish-orange, moderate to poorly-indurated packstones and recrystallized limestones with lesser beds of yellowish-brown, well to moderately-indurated dolostones generally lie from 1,500 to 1,560 feet bpl. Yellowish-brown to olive-brown, fine-grained to microcrystalline, pinpoint-vuggy, well to moderately-indurated dolostones with appearances of calcareous clay and dolomitic limestone generally lie from 1,560 feet bpl to the base of the formation. These drill cuttings (from 1,560 to 1,700 feet bpl) generally exhibit fair to poor porosity and apparent permeability. Log-derived (sonic) porosity values through the upper portion (1,560 to 1,620 feet bpl) of this region decline when compared to sediments above. Ocala-specific foraminifera (Nummulites vanderstoki) were not observed in the drill cuttings collected at well IW-2, probably due to the increased dolomitization in this deeper interval as compared to IW-1. Based on a lithologic change from dolomitic limestone and finely crystalline, moderately indurated dolostone to a massive, microcrystalline, well-indurated and hard dolostone, the base of the Ocala Formation is picked at approximately 1,700 feet bpl.

Avon Park Formation (1,700 – 2,300 feet bpl)

The Avon Park Formation (approximately 43 to 48 million years B.P.) is middle Eocene in age and unconformably underlies the Ocala Formation. 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). This lithology is generally easily distinguished from the poorly indurated limestones of the Ocala Formation. 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 1,700 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 in either well IW-1 nor IW-2, possibly due to extensive dolomitization throughout the upper portion of the formation. The extensive dolomitization provides areas of very high permeability throughout the formation.

Generally, the upper portion of the formation at well IW-2 (1,700 to 2,070 feet bpl) consists of olive-brown, microcrystalline to finely crystalline, variably indurated, variably vuggy dolostones with interbedded chalky dolomitized limestone and lesser beds of mudstone appearing at the bottom of the unit. Log-derived porosity values sharply decline with the appearance of dolomitized limestone at a depth of approximately 1,970 feet bpl. Overall porosity varies significantly due to the irregular nature and occurrence of vugs and solution cavities within the dolostones. Apparent permeability of this upper portion of the formation, based on lithologic descriptions, is generally fair to poor. Sediments collected from the lower portion (2,070 to 2,300 feet bpl) of the formation consist of alternating sequences of olive-brown to olive-gray, microcrystalline to finely crystalline, well to poorly-indurated, variably vuggy dolostones and yellowish-gray, fine-grained, moderate to poorly-indurated, variably dolomitized limestones (grainstone and packstone). Generally, dolostones occur from 2,070 to 2,100 feet bpl and from 2,150 to 2,200 feet bpl. Limestone beds occur from 2,100 to 2,180 feet bpl and from 2,200 to 2,260 feet bpl. Closely interbedded dolostone and limestone (variably dolomitized) occur from 2,260 to 2,300 feet bpl. With the exception of sediments from 2,260 to 2,290 feet bpl, apparent permeability of this lower portion of the formation, based on lithologic descriptions, is generally fair to poor.

The contact between the Avon Park Formation and the Oldsmar Formation is ambiguous at this location due to the intensive dolomitization, which has altered the original structure of the limestones and destroyed formation-specific fossils. The formation contact at IW-2 is estimated at a depth of 2,300 feet bpl based on a correlation of dual induction and natural gamma ray signatures recorded from IW-1 with geophysical signatures recorded while testing injection wells drilled at the South County Regional Water Treatment Plant site. This correlation places significant amounts of lignite and carbonaceous dolostone in the upper portion of the Oldsmar Formation at both sites. These sequences of carbonaceous dolostone were identified in IW-2 immediately below 2,300 feet bpl.

Oldsmar Formation (2,300 - 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 (2,300 to 2,640 feet bpl) encountered during drilling at well IW-2, consists of greenish-black, olive-brown, and yellowish-brown, cryptocrystalline to medium-crystalline, well indurated, variably vuggy, dolostones with minor yellowish-gray, fine-grained, variably dolomitized limestone. Secondary crystal growth is common in dolostones, as noted, in and around vug openings. Areas exhibiting low log-derived (borehole compensated sonic w/ VDL) porosity values of less than 10%, lie from 2,478 to 2,500, 2,505 to 2,512, 2,524 to 2,528, 2,545 to 2,552, 2,565 to 2,580 and 2,595 to 2,612 feet bpl.

A portion of the lower Oldsmar Formation will serve as the injection zone. Drill cuttings collected from the lower portion of the formation generally consist of yellowish-brown, well-indurated, variably vuggy crystalline dolostones with intermittent fractures. Common secondary crystal growth of carbonates is noted in vug openings and along some fracture planes. Occasional carbonate clay, mudstone, lignite and rare limestone (packstone) occur within this lower unit. Areas of borehole enlargement exhibited by caliper log of the 22-inch open hole interval lie from 2,645 to 2,655; 2,770 to 2,785; 2,825 to 2,830; 2,890 to 2,895; and 2,965 to 2,970 feet bpl. The borehole size from

3,004 to 3,250 feet bpl is very close to gauge, indicating an absence or lesser degree of fractures.

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 sandy clay to approximately 30 feet bpl, underlain by approximately 20 feet of limestone and clay (Bonita Springs Marl member of the Tamiami Formation). The low-permeability material is underlain by an approximate 100-foot layer of fossiliferous grainstone (Ochopee Limestone member of the Tamiami Formation). The aquifer system terminates with the presence of phosphatic clays present in the Peace River Formation.

Intermediate Aquifer System (150 - 794 feet bpl)

The intermediate aquifer system is approximately 644 feet thick at well IW-2. 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 794 feet bpl at well IW-2. Water-bearing zones were encountered during drilling operations from approximately

250 to 387 (Mid-Hawthorn Zone I), 403 to 470 (Mid-Hawthorn Zone II), and 620 to 700 feet bpl (Lower-Hawthorn Zone II). These intervals consist of moderately permeable fossiliferous limestones (grainstone, packstone, and wackestone). Confining sediments represent approximately 60% 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 (794 - 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 is not differentiated as defined by Miller (1986).

The upper Floridan aquifer (794 - 1,700 feet bpl) consists of permeable strata in the Suwannee Limestone and the Ocala Formations. Based on lithologic descriptions (Appendix 2.1) and sonic porosity logs (Appendix 2.2.12), sediments within the upper Floridan aquifer are fairly permeable at well IW-2, although less permeable intervals are present. The aquifer system is predominantly composed of relatively clean, poorly to moderately indurated packstones and grainstones with lesser beds of variably vuggy, well to moderately indurated dolostones with appearances of calcareous clay and dolomitic limestone. Less permeable beds consisting of yellowish-gray clay (fine-quartz sandy) are common from approximately 980 to 1,100 feet bpl. Drill cuttings and decreasing sonic log porosity values indicate that carbonates exhibiting fair to poor porosity are present from approximately 1,535 to 1,620 feet bpl.

The lower Floridan aquifer (1,700 - 3,250+ feet bpl) includes all permeable strata in the Avon Park and Oldsmar Formations. Carbonates that exhibit very high porosity lie within the Avon Park Formation, particularly from a depth of 1,700 to 1,960 feet bpl, and within the upper (from 2,340 to 2,460 feet bpl) and middle (from below 2,640 feet bpl) portions of the Oldsmar Formation. These intervals are predominantly composed of vugular and fractured dolostones exhibiting very high permeability. Less permeable intervals lie in limited areas of interbedded, variably dolomitized limestones and in areas where vugs and fractures within the dolostones are rare or non-existent.

2.3 Water Quality

Water samples were collected for laboratory analyses from well IW-2 by various sampling methods that are detailed in this section. Grab samples of formation water were collected from well IW-2 while advancing the pilot hole by reverse-air drilling and immediately after the well purging/development of the injection interval, using a centrifugal pump. Results of water quality analyses are summarized in Table 2-1 and Figures 2-2 and 2-3.

2.3.1 Water Sampling and Water Quality Analyses of IW-2

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 407 to 2,939 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 after field testing, water samples were placed on ice and prepared for shipment, following standard chain-of-custody protocol, to Sanders Laboratories Environmental Testing Services (Sanders Laboratories), located in Nokomis, Florida. The laboratory analyses consisted of total dissolved solids (TDS), ammonia, and Total Kjeldahl Nitrogen (TKN). The purpose of these analyses is to determine the existence of these chemical species and an estimate of the potential background concentration of these constituents in the penetrated formation. A secondary goal was 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 at 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. Freshwater was used until the formation was penetrated and yielded ample 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 Table 2-1 and on Figures 2-2 and 2-3. Laboratory reports are presented in Appendix 2.4.1.

Final Injection Zone Water Quality Sampling Analysis

From January 21st to the 22nd, a total volume of approximately 127,227 gallons of formation water was purged from well IW-2 in preparation for groundwater sampling. During the initial well purging, water was pumped to an on-site collection tank at an average rate of 270 gpm. Approximately 38,390 gallons of water was evacuated during this first-phase purging. The balance of the pumping, ranging at rates between approximately 100 and 255 gpm, was conveyed directly down well IW-1. On January 22nd, immediately following well purging water samples were collected by a representative of Sanders Laboratories. The samples were collected after field-tested values for electrical conductivity of recovered formation water indicated stabilization. The temporarily stored formation water was pumped down well IW-1 after the sampling was completed.

Laboratory analyses of 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 34,900 mg/l, a chloride concentration of 19,500 mg/l, and a pH of 7.6. Minimum criteria parameters (for sewage effluent) total Kjeldahl nitrogen (TKN), total phosphorous and orthophosphate were detected at concentrations of 0.53 mg/L, 0.071 mg/L and 0.025 mg/L, respectively. The balance of the analyses for minimum criteria parameters for sewage effluent were not detected. 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 the 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 2.4.2.

USDW Delineation

The depth to the base of the USDW in well IW-2 was conservatively set at 1,050 feet bpl based on sonic porosity and dual inductance log analyses. An R_W value (resistivity of formation water) of 0.49 ohm-meters for a 10,000 mg/l NaCl solution at 86°F, a porosity (∅) of 35% 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.

For the above input values for R_W and ∅, R_t is equal to 4.0 ohmmeters. 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 0.35 would yield a higher formation resistivity. Higher formation resistivity values are noted above 1,050 feet on the dual induction log.

2.4 Confinement Evaluation

2.4.1 Geophysical Logs and Hole Conditions

An evaluation of confinement at well IW-2 is based on the drill cuttings collected during pilot-hole drilling at IW-2, the results of geophysical logging at IW-2, and the cores collected during the construction of IW-1. Additionally, comparisons of both lithologic and geophysical logging data between the two wellbores were used in evaluating confinement at IW-2.

As discussed on page 17 of the Completions Report for IW-1 dated January 15, 2004, core samples 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. The data provided from these core samples, as discussed in the IW-1 Completions Report, indicated that the major confining units were located in the limestone above 1,690 feet bpl and in the dolostone between 2,350 feet and 2,600 feet bpl.

Although more confinement likely exists along the wellbore for IW-2 based on the lower volumes of cement and minimal need for gravel, overall confinement is still likely associated with the two previously identified units. The lowest permeable and porous dolostone section, as indicated on the Borehole Compensated Sonic Log (BHC log), extends from approximately 2,466 feet to 2,648 feet bpl in IW-2. The porosity, as interpreted from the BHC log, is less than 10% and in many intervals is less than 5% over 43% or a net 78 feet in this interval. It is also important to recognize that actual porosity values interpreted from the BHC log were often two times the actual values obtained from the core samples when correlated in IW-1. If a specific conductivity of 38,000 umhos/cm is assumed for native water below 2,000 feet, than Archie's equation would suggest that porosity levels approaching 10% are common in this region. The porosity is estimated to be less than 2% between 2,466 and 2,648 feet bpl even with a native water specific conductivity of 54,000 umhos/cm.

Thus, the geophysical logging data, drill cuttings analyses, and core data indicate that there is good confinement that exists between the injection zone and base of the USDW at 1,050 feet bpl.

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 provide 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 2,640 to 2,660, 2,750 to 2,790, 2,820 to 2,850, 2,890 to 2,895, and 2,960 to 2,990 feet bpl (Appendix 2.2.17).

The majority of the injection capacity is considered to lie from the base of the 24-inch casing at 2,582 feet bpl to approximately 3,000 feet bpl. The borehole below approximately 3,000 feet bpl shows little evidence of major wall collapse and is generally close to the gauge diameter of 22 inches. Well test data as indicated in section, provides an estimate of the transmissivity to be approximately 2,000,000 gpd/ft, which is similar to the values obtained during the testing of IW-1.

3.0 WELL CONSTRUCTION PROGRAM

3.1 Well Construction

The drilling and well construction of well IW-2 were performed by Youngquist Brothers, Inc. (Contractor), using a platform-mounted OIME-1000 top-head-driven rotary rig equipped with a blowout preventer at the wellhead used 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 well IW-2 is provided in Appendix 3.1. Weekly reports used to summarize daily site operations were sent to the Technical Advisory Committee (TAC) throughout the duration of this project and are presented in Appendix 3.2. The final construction details for IW-2 are presented on Figure 3-1 and Figure 3-2.

An approved containment pad for drilling fluids was installed prior to initiation of drilling activities (Appendix 3.3). On August 29, 2003, pad-monitoring wells were installed inside 8-inch diameter boreholes, approximately 20 feet deep, 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 each sand pack to land surface then completed with a 4-inch removable PVC cap (Figure 3-3). Each of the pad monitoring wells was completed above land surface. Well development and initial groundwater sampling for background concentrations were performed on August 31, 2003 (Appendix 3.4).

Drill cuttings were collected and described at 10-foot-depth intervals during all pilot-hole drilling (Appendix 2.1). These lithologic descriptions were verified during reaming operations. The driller on shift recorded the average rate of penetration and weight on bit data every five feet (Appendix 2.3). Formation water samples were collected at 30-foot-depth intervals throughout the reverse-air drilling and field-tested for chloride concentration and electrical conductivity (Table 2-1). Inclination surveys were performed at 90-foot-depth intervals in both pilot holes 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 prior to the placement of subsequent cement stages. Appendix 3.5 summarizes the volume of cement pumped and the annular height for each cement stage. Appendix 3.6 summarizes the volume of gravel pumped and the annular height of each stage. Specifications for the neat cement and a summary of compressive strength analysis of cement sample cubes, collected during each cementing event, are provided in Appendix 3.7. A summary of geophysical surveys completed during the construction of well IW-2 is provided in Table 3-2. Copies of all associated geophysical logging plots are provided in Appendices 2.2.1 through 2.2.21.

Drilling, reaming, cementing and all other aspects of the well construction were performed according to project specifications. Mill certificates for all casing strings are provided in Appendix 3.8. Prior to each casing installation, the FDEP verbally approved written requests for approval of associated casing setting depths (Appendix 3.9). Results of all 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

From September 1st to September 4th, 2003, a 58.5-inch-diameter flat-bottom bit was used to drill, by mud-rotary circulation, to a termination depth of 413 feet bpl. A temporary 60-inch O.D. pit casing was previously set at an approximate depth of 8 feet bpl for circulation/piping purposes. The drilling operation was performed using 40-foot-long joints of drill pipe and a 39.2-foot-long stabilizer as part of the bottom hole assembly (BHA). After reaching the target depth of the borehole, wiper runs were performed with conditioned drilling fluid. Caliper and natural gamma ray logging runs (Appendix 2.2.1) were performed in the borehole from pad level to the termination depth. Geophysical logging was performed to estimate annular volume for cementing and to confirm the total depth of the borehole for setting casing.

On September 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 at a depth of 407 feet bpl. The casing string, including the header joint, consists of eight 48-inch O.D. joints ranging in length from 38 to 50 feet and one 21-foot-long cut joint of 50-inch O.D. casing. This first joint of casing is welded to the 48-inch string by a 1-inch-wide ring of steel welded to the inside edge of the upper end of the cut joint. A tally of the 48-inch conductor casing string is presented in Table 3-3. Mill certificates of the conductor 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 in the borehole by employing the pressure grouting method, pumping 1,027 cubic feet of cement mixed with 12% bentonite at the head, followed by pumping 2,334 cubic feet of neat cement at the tail. On September 5, 2003, 185 cubic feet of neat cement, pumped by using a 2.375-inch-diameter tremie pipe, was required to fill the annulus to the surface. Cement-top temperature surveys were performed 6 to 8 hours after each cementing event (Appendix 2.2.2). The cement plug inside the 48-inch casing was tagged at 403 feet bpl.

3.1.2 42-inch Surface Casing Installation

Drilling of the 12.25-inch-diameter pilot hole, by reverse-air circulation, resumed on September 8th as the cement plug was drilled out of the 48-inch conductor casing. On September 11th, the termination depth of the pilot hole was reached at 1,690 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 September 14, 2003, required geophysical logging of the pilot hole was performed that included caliper, natural gamma ray, dual induction, BHC sonic-VDL, log-derived TDS, and temperature logs (Appendices 2.2.3 through 2.2.7). The bottom of the logged interval, a depth of 1,677 feet bpl, is approximately 13 feet short of the drilled depth, likely caused by an impassable ledge encountered in the pilot hole. Pilot-hole cementing was accomplished in 18 stages, with a total of 3,792 cubic feet of cement pumped from September 14th to September 19th. The pilot hole was cemented back from the bottom of the borehole to within approximately 60 feet of the conductor casing. Cement stages no. 2 through no. 14 consist of cement mixed with 6% calcium chloride accelerator. The first stage and stages no. 15 through no. 18 consist of cement mixed with 12% bentonite. A single lift of gravel (approximately 100 cubic feet) was emplaced in the borehole to achieve fill past an open interval centered at an approximate depth of 1,464 feet bpl.

The top of cement in the pilot hole was tagged at a depth of 455 feet bpl. From September 24th to October 6th, 2003, a nominal 47-inch-diameter flat-bottom bit was used to ream, by reverse-air circulation, to a depth of 1,500 feet bpl. The reaming operation was performed using 120-foot long stands of drill pipe and a 39-foot long stabilizer as part of the BHA. Recovery of cement chips mixed with the formation cuttings indicated that the reamed hole tracked the pilot hole closely. Immediately after performing a wiper run of the reamed hole, caliper/natural gamma logging runs (Appendix 2.2.8) were performed to 1,500 feet bpl. From October 7th to October 8th, approximately 5,000 cubic feet of gravel were emplaced in the reamed borehole. The well construction plan had been revised the previous week and the surface casing setting depth had been approved for 1,425 feet bpl. On October 9th, a final hard tag indicated the top of gravel at a depth of approximately 1,445 feet bpl. This gravel lift was stabilized with neat cement, by the tremie grouting method, in three stages. A total volume of 544 cubic feet of cement was pumped atop the gravel. On October 10, 2003, the top of cement inside the 47-inch reamed borehole was tagged at a depth of 1,435 feet bpl.

From October 12th to October 13th, 2003, a 42-inch O.D., 0.375-inch-wall spiral-welded steel surface casing with centralizers, was set at a depth of 1,425 feet bpl. The casing string consists of 28 joints (including the header joint) of casing ranging in length from 50.00 to 51.92 feet and one 27.77-foot long cut section. A tally of the 42-inch surface casing string is presented in Table 3-4. Mill certificates of the surface 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 October 13, 2003, the casing string was cemented in place by employing the pressure grouting method. A 1,122-cubic foot tail of neat cement followed a 1,633-cubic foot head of cement mixed with 12% bentonite. Cementing of the remaining annulus was accomplished by tremie grouting in fourteen additional stages, the last of which was completed on October 21st, 2003, when cement returns reached the surface. A total volume of 6,828 cubic feet of cement slurry was used in cementing the 42-inch casing to the surface. Cement-top temperature surveys were performed following each cementing event and are included in Appendix 2.2.9. Cement inside the 42-inch casing was tagged at a depth of 1,308 feet bpl.

3.1.3 24-inch Injection Casing Installation

From October 22nd to October 25th, 2003, the reaming operation to remove the cement plug inside the surface casing was accomplished by reverse-air circulation using a 40.5-inch-diameter bit. The reamed borehole was advanced to a termination depth of 1,515 feet bpl. From October 26th to November 6th, 2003, a 12.25-inch-diameter pilot hole was drilled, by reverse-air circulation, to a total depth of 2,939 feet bpl. Immediately after reaching the termination depth of the pilot hole, required geophysical logging was performed to include high-resolution temperature, caliper/natural gamma ray, dual induction, sonic, and log-derived TDS (Appendices 2.2.11 through 2.2.14). The bottom of the logged interval was recorded at a depth of 2,862 feet bpl. Additionally, a video survey (Appendix 2.2.10) of the pilot hole was performed to a depth of 2,737 feet bpl. Of note, rock obstructions were encountered in the pilot hole while performing both the geophysical logging and video survey, which ended the logging runs before reaching total depth.

On November 10th, a specially fabricated bridge plug designed to be run through drill pipe, was set inside the pilot hole at a depth of 2,621 feet bpl (base of lower cement basket). The upper end of the bridge plug assembly was positioned in the borehole at a depth of 2,603 feet bpl. The bridge plug was cemented in place using neat cement employing a stacked set of cement baskets. Gravel was then pumped atop the bridge plug to provide a platform for subsequent stages of cement. The top of the gravel lift was tagged at a depth of 2,597 feet bpl. Cementing was accomplished in 33 stages (3,312 cubic feet) using both neat cement and cement mixed with 12% bentonite with an accelerator (3 to 4% CaCl) usually added to the cement slurry. Additionally, a total volume of approximately 260 cubic feet of gravel pumped in four separate lifts, was emplaced in the cavernous intervals of the pilot hole to achieve vertical fill. On November 19, 2003, the top of cement inside the pilot hole was tagged at a depth of 1,766 feet bpl.

From November 20th to December 1, 2003, a 32.5-inch-diameter flat-bottom bit was used to ream, by reverse-air circulation, to a depth of 2,587 feet bpl. The reaming operation was performed using 120-foot long stands of drill pipe and a 33.5-foot-long stabilizer as part of the BHA. Recovery of cement chips found in with the formation cuttings indicated that the reamed hole tracked the pilot hole closely. Required geophysical logging (caliper/natural gamma ray) was performed after a satisfactory wiper run of the reamed borehole was completed (Appendix 2.2.15).

On December 2nd through the 3rd, a 24-inch O.D., 0.50-inch-wall steel (w/mill coat) injection casing with centralizers, was installed in the reamed borehole to a depth of 2,582 feet bpl. The casing string consists of 65 joints (including the header joint) of casing ranging in length from 13.62 to 43.56 feet. The original total string length measured 2,588.75 feet. A tally of the 24-inch casing string is presented in Table 3-5. Mill certificates of the longstring casing 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 December 3, 2003, the injection casing was cemented in-place by employing the pressure grouting method for this first stage, pumping 1,122 cubic feet of neat cement. The cement plug inside the casing was tagged at a depth of 2,570 feet bpl and the annular cement tagged at a depth of 2,528 feet bpl. Cementing the remaining annulus to within 182 feet of the surface was accomplished by tremie grouting in 45 additional stages, the last of which was completed on December 20, 2003. Approximately 182 feet of free casing was left to allow for a good geophysical signature when performing the cement bond log. On January 30, 2004, while demobilization operations at the site were underway, the remaining annular volume was cemented (tremie grouting) to the surface using 1,038 cubic feet of cement w/ 12% bentonite. A total volume of 17,271 cubic feet of cement slurry (neat and cement w/ 12% bentonite), in 47 stages, was used in cementing the 24-inch casing to land surface. An approximate 314-foot neat cement shoe was emplaced in the bottom of the reamed borehole before continuing annular cementing using bentonite. Cement-top temperature surveys were performed 6 to 8 hours after each cementing event (Appendix 2.2.16). Additionally, approximately 5,468 cubic feet of gravel, pumped in six separate lifts, was used to fill the cavernous intervals of the borehole. Details of the cementing and gravel-pumping operations are presented in Appendices 3.5 and 3.6, respectively.

3.1.4 Open-Hole Drilling

From December 21st, 2003 to January 1st, 2004, a nominal 22-inch-diameter tricone button bit was used to drill the open hole, by reverse-air circulation, to a termination depth of 3,250 feet bpl. A 12-foot-long cement plug was drilled out of the injection casing before penetrating the formation. Of note, sediment samples (drill cuttings) were collected at 10-foot-depth intervals and described in the field after the termination depth (2,939 feet bpl) of the previous pilot hole was reached. On January 2nd, 2004, after completing satisfactory wiper runs of the open-hole section, required geophysical logging (caliper/natural gamma ray) was performed in the open hole to total depth (Appendix 2.2.17). A satisfactory cement bond log (w/ VDL) of the longstring casing annular cement (logged interval from 100 to 2,600 feet bpl) was performed after the caliper run (Appendix 2.2.18). On January 16th, a video survey of the injection casing and the open-hole interval to a depth of 2,770 feet bpl, was performed. A complete loss of visibility in the open hole ended any further advancement of the video camera.

3.1.5 Cement Bond Log Evaluation

On January 2, 2004, a cement bond (w/VDL) log was performed over the length of the 24-inch O.D. injection casing from 2,600 feet bpl (bottom-logged interval) to 100 feet bpl (Appendix 2.2.18). A review of the cement bond log indicates a strong casing signal over the interval of free casing from the top-logged interval (100 feet bpl) to a depth of 182 feet bpl, as this portion of the casing is not supported by cement. A comparison of the log along the free casing with the cemented sections below 182 feet bpl, indicates that casing signals are generally weak and formation signals are weak to moderate

(0.70 to 24 mV) along the casing. The cement bond log indicates that annular cement has been placed along the length of the injection casing to 182 feet bpl, and that there is bonding between the cement and casing and between the cement and formation. As indicated by the radioactive tracer survey (RATS) survey (Section 4.4), the seal provided by the cement is sufficient to prevent migration of fluids behind the casing.

Because the cement-bond tool was designed for considerably smaller casing than 24-inch, the contractor used the single 5-foot receiver, instead of dual receivers, to record both amplitude and VDL signals.

3.1.6 Wellhead and Pad Completion

The final wellhead completion of IW-2 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 2-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° 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 (Appendix 3.10).

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-2, which is a tubingless type completion, that included:

- A video survey of the casing and open hole to a depth of 2,770 feet bpl
- A successful pressure test of the injection casing conducted at an initial pressure of 194 psi
- A background temperature survey
- A successful set of radioactive tracer surveys (RATS), including background and final (post-test) gamma ray surveys

Prior to the performance of the pressure test and RATS tests, potable water was pumped into IW-2 to increase visual clarity for the video survey and to form a uniform density column of freshwater near the base of the injection casing in preparation for the RATS. A pressure test of the injection casing was performed after the video survey and before the RATS tests. A background temperature survey was performed with the background gamma ray logging immediately before starting the first of three RATS tests. A final gamma ray survey was performed after completing the RATS and dumping the ejector chamber of its remaining tracer then logging uphole to the surface.

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

- Analysis of the video survey indicates that the overall condition of the steel casing was good. The open-hole section of the well was video surveyed to 2,770 feet bpl and appeared in good condition.
- Hydrostatic pressure in the casing decreased from 194 to 193.75 psi during the pressure test, which meets test requirements. Based on a test pressure of 194 psi, the

maximum permittable operating pressure for IW-2 is 129 psi (2/3 of the maintained test pressure value).

- Results of the dynamic (low-flow rate) and operational dynamic (high-flow rate) RATS tests did not indicate any upward movement of ejected tracer behind the injection casing.

Based on the information gathered during the MIT, it is concluded that IW-2 has mechanical integrity.

4.1 Video Survey

On January 16, 2004, a satisfactory video survey (Appendix 2.2.19) was performed from pad level to a depth of 2,770 feet bpl. The video survey run ended at 2,770 feet bpl as visibility at this depth was reduced to zero and the logger did not want to risk damaging the camera.

Data recording started from a depth of approximately 46 feet bpl logging downhole at an average logging speed of 20 feet/minute. Water clarity was good throughout the cased interval and well into the open-hole section of the well. Visibility rapidly deteriorated at a depth of 2,760 feet bpl and was completely lost at 2,770 feet bpl (bottom-logged interval). Data was recorded in side-view mode uphole from a depth of 2,768 feet bpl.

Results of the video survey indicate that the overall condition of the steel injection casing was good with casing welds clearly visible. The casing seat was confirmed at a depth of 2,582 feet bpl. The cement shoe at the base of the casing appeared intact and in good condition. No defects in the casing string or welded joints were apparent in the video survey. Numerous fractures, vugs, and voids were observed throughout the open-hole interval.

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 day. On January 27, 2004, a pressure of 194 psi was applied to the inside of the casing string at the start of the test. A 0.25-psi loss (0.13%) of pressure was recorded over the duration of the 60-minute test. Test data is summarized in WRS's Casing Pressure Test Log form presented as Table 4-1. Mr. Jack Myers, 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. Myers, is presented as Appendix 4.1. The calibration record for the pressure gauge used in the official test is provided in Appendix 4.2. 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 45 gallons of water were removed before the pressure gauge returned to 0 psi. The following equation was used to calculate the compressibility of fluid:

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

Given a total water volume of 55,154 gallons, a change in water volume of 45 gallons, and an associated pressure change of 194 psi, the calculated value for the compressibility of the water in the casing is estimated to be 4.2×10^{-6} psi. Since the measured compressibility of water is representative of the values associated with water, it is concluded that there was no trapped air in the system and therefore, the test is considered valid.

4.3 Background Temperature Survey

A background temperature survey (Appendix 2.2.20) was performed over the entire cased portion of the well and part of the open-hole interval to a depth of 2,776 feet bpl. A rock obstruction ended the logging run at 2,776 feet bpl. The open-hole portion of the well exhibited a range in temperature of 82.0 to 92.2 °F, from below the injection casing at a depth of 2,590 to 2,620 feet bpl. Below a depth of 2,620 feet bpl, the temperature remains constant at approximately 92 °F. A maximum open-hole temperature of 92.2 °F was recorded at a depth of 2,620 feet bpl.

4.4 Radioactive Tracer Survey

Prior to initiating the RATS, high-resolution temperature and background gamma ray logs were completed over the entire cased interval and in the open-hole section to a depth of 2,776 feet bpl. A rock obstruction in the open hole limited the bottom-logged interval to 2,776 feet bpl. Water in the cased part of the well registered absolute temperatures ranging between 73.9 and 82.5°F. A sharp increase in the temperature from 82 to 92°F occurred between 2,600 and 2,614 feet bpl where cooler, lower-density injected water appears to be sitting on top of warmer formation water flowing out from a major flow zone located at an approximate depth of 2,600 feet bpl.

The radioactive tracer survey (RATS) consists of a background gamma ray survey with casing collar locator, two low-flow rate dynamic RATS at 116 gpm and 108 gpm (5-feet/minute downhole velocity), one high-flow rate or operational dynamic RATS at 510 gpm (23.64-feet/minute downhole velocity), and a final background gamma ray survey. The results of these tests are provided in Appendix 2.2.21. The radioactive material used during these tests was iodine-131 supplied by Medtech Diagnostic Services. The source used had an assayed strength of 1.0 millicurie per milliliter and an assay date of January 27, 2004. The source was two days into its 8-day half-life on the day of the tests. A 5.0-millicurie sample of iodine-131 was loaded into the tool. A 6-second time span is required to empty one-fifth of the ejector chamber. A copy of the source data sheet/invoice is included in Appendix 4.3.

The tool used for the RATS consists of a radioactive source ejector and three gamma ray detectors. The ejector is located 3.5 feet above the detector designated the middle detector (GRM), 12.3 feet above the bottom detector (GRB), and 10.5 feet below the designated top detector (GRT). A diagram of the tool with distances and locations of the ejector and detectors is presented at the beginning of the RATS log provided in Appendix 2.2.21. The casing collar locator detected the bottom of the casing at a depth of 2,582 feet bpl, which was used as the reference point for positioning the ejection port.

Dynamic RATS

The first dynamic RATS was run with the ejector port set at a depth of 2,577 feet bpl, five feet above the base of the injection casing. Water held in an on-site frac tank was pumped into the well using a centrifugal pump at a sustained rate of 116 gpm to induce a downhole velocity of slightly over 5-feet/minute. Source water was pumped from a 6-inch on-site production well, using a submersible pump, then conveyed to the frac tank using a trash pump. Once water flowed into the well for five minutes and the ejector port was set stationary and at the correct depth, time-drive monitoring (data recording) was started and one minute later, a 1-millicurie slug of iodine-131 was ejected. Gamma-ray responses on the three detectors were monitored for 60 minutes while keeping the tool stationary and pumping freshwater downhole at a sustained rate of 116 gpm.

Within seconds after ejection, the middle detector registered an increased gamma signal. The entire tracer plume moved by the GRM approximately 10 minutes later. The signal recorded from the bottom detector increased sharply 100 seconds after ejection, beyond the plotted scale (above 100 GAPI). The entire tracer plume moved by the GRB approximately 15.5 minutes after ejection. The gamma ray signal returned to background levels 8.0 minutes thereafter and remained at background for the remainder of the test. There was no increase in the gamma ray signal registered by the top detector (GRT) during the entire 60-minute test.

After recording gamma ray levels for 60 minutes, the hole was logged out-of-position (LOP) to approximately 200 feet above the original point of ejection. Results of the LOP indicated no increase in gamma ray activity from any of the detectors as each of the three plots (GRT, GRM, and GRB) matched their background curves.

Upon completion of the LOP upward pass, a down-pass was performed in the interval from approximately 2,540 to 2,660 feet bpl. Results of the LOP (down-pass) indicated no increase in gamma ray activity from the middle or bottom detectors. The top detector (GRT) indicated sharply-increased gamma ray activity from a depth of 2,630 to 2,660 feet bpl, the end of the run. This interval of increased gamma ray activity is within an identified flow zone. The cause of the top detector receiving a strong signal while the other detectors indicated nothing may be due to the orientation of the tool as it passed stained areas of the borehole wall during the down-pass run.

Immediately following the LOP down-pass, a log-after-flush (LAF) was performed within the same interval as the first LOP (upward pass to 200 feet above original position). Results of the LAF indicated no increase in gamma ray activity from any of the detectors as each of the three plots (GRT, GRM, and GRB) matched their background curves.

Repeat Dynamic RATS

A second dynamic test (repeat dynamic RATS) was performed after repositioning the ejector port five feet above the base of the casing and flowing water at a downhole velocity of 5 feet per minute (108 gpm). Once water flowed into the well for five minutes, time-drive monitoring was started and one minute later, a 1-millicurie slug of iodine-131 was ejected. Gamma-ray responses on the three detectors were monitored for 30 minutes while keeping the tool stationary and pumping freshwater downhole at a sustained rate of 108 gpm.

Within seconds after ejection, the middle detector registered an increased gamma signal. The entire tracer plume moved by the GRM approximately 6.5 minutes later. The signal recorded from the bottom detector increased sharply 95 seconds after ejection, beyond the plotted scale (above 100 GAPI). The entire tracer plume moved by the GRB approximately 14 minutes after ejection. The gamma ray signal returned to background levels 9.0 minutes thereafter and remained at background for the remainder of the test. There was no increase in the gamma ray signal registered by the top detector (GRT) during the entire 30-minute test.

After recording gamma ray levels for 30 minutes, the hole was logged out-of-position to approximately 200 feet above the original point of ejection. Results of the LOP indicated no increase in gamma ray activity from any of the detectors as each of the three plots (GRT, GRM, and GRB) matched their background curves.

Immediately after completing the LOP upward pass, a down-pass was performed in the interval from approximately 2,550 to 2,700 feet bpl. Results of the LOP (down-pass) indicated increased gamma ray activity from each of the three detectors in the interval from approximately 2,650 2,680 feet bpl. Additionally, the top detector indicated an increased signal at a slightly shallower depth in the open hole, recorded at 2,635 feet bpl. Signals close to background levels were recorded from each of the detectors above 2,635 feet bpl.

Immediately following the LOP down-pass, a log-after-flush was performed from approximately 2,390 to 2,700 feet bpl. Results of the LAF indicated increased gamma ray activity from the middle and bottom detectors in the open-hole interval from the bottom of the casing (2,582 feet bpl) to 2,695 feet bpl. The signals peaked (250 GAPI) at a depth of 2,689 feet bpl. The top detector indicated increased gamma ray activity from 2,644 feet bpl to the limit of the tool's bottom-logged interval (GRT ends at 2,680 feet bpl).

Operational Dynamic RATS

A third dynamic test (operational dynamic RATS) was performed after repositioning the ejector port five feet above the base of the casing and flowing water at an increased rate of 510 gpm (downhole velocity of 23.64 feet per minute). Once water flowed into the well for five minutes, time-drive monitoring was started and one minute later, a 2-millicurie slug of iodine-131 was ejected. Gamma-ray responses on the three detectors were monitored for 15 minutes while keeping the tool stationary and pumping freshwater downhole at a sustained rate of 510 gpm.

Within seconds after ejection, the middle detector registered an increased gamma signal. The entire tracer plume moved by the GRM approximately one minute later. The signal recorded from the bottom detector increased sharply 26 seconds after ejection, beyond the plotted scale (above 100 GAPI). The entire tracer plume moved by the GRB approximately two minutes after ejection. The gamma ray signal returned to background levels two minutes thereafter and remained at background for the remainder of the test. There was no increase in the gamma ray signal registered by the top detector (GRT) during the entire 15-minute test.

After recording gamma ray levels for 15 minutes, the hole was logged out-of-position to approximately 200 feet above the original point of ejection. The flow rate was reduced to approximately 90 gpm during this phase of the test. Results of the LOP indicated no increase in gamma ray activity from any of the detectors as each of the three plots (GRT, GRM, and GRB) matched their background curves.

Immediately after completing the LOP upward pass, a down-pass was performed in the interval from approximately 2,550 to 2,760 feet bpl. The flow rate was maintained at approximately 90 gpm during the down-pass run. Results of the LOP (down-pass) indicated increased gamma ray activity from the middle and bottom detectors in the interval from approximately 2,650 to 2,710 feet bpl. Additionally, the top detector indicated an increased signal at a shallower depth in the open hole, recorded at approximately 2,600 feet bpl. Signals recorded from each of the detectors above 2,600 feet bpl were at background values.

At the completion of the third dynamic test, the tool was lowered into the open hole with the ejector port positioned at a depth of 2,762 feet bpl and the remaining iodine-131 was released from the ejector chamber while continuing to pump water downhole at a rate of approximately 90 gpm.

A final gamma ray logging run of the well was performed from a depth of approximately 2,750 feet bpl to within ten feet of pad level (land surface). The final gamma ray plot was compared to the original background gamma ray profile performed prior to tracer ejection. The two curves matched between the interval from approximately 200 feet bpl to the bottom of the injection casing at 2,582 feet bpl. An increase in gamma activity was noted from the middle detector and the bottom detector in the open hole from below the casing to the bottom-logged interval at 2,750 feet bpl. The top detector indicated a higher gamma ray count during the final run as compared to the original background run in the interval from approximately 2,640 to 2,750 feet bpl. The increased gamma ray activity indicated during the final background run is caused from staining of tracer on the formation surface (Appendix 2.2.21).

Results of each of the three dynamic RATS do not indicate upward fluid movement behind the casing near the base of the cased hole.

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 IW-2 during injection. An injection rate of approximately 17.1 MGD (approximately 11,875 gpm) was sustained through the high-rate portion of the test. The designed and permitted operational rate for IW-2 is 18.65 MGD (approximately 12,950 gpm). Continuous pressure responses were also recorded in both zones of DZMW to monitor pressure changes in the monitoring wells due to injection activities and in IW-1. 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 flow meter used during the test is provided in Appendix 5.2.

Background pressure data in each of the monitoring zones of DZMW, IW-1, and in IW-2 were collected for a 24-hour period prior to initiating the test and ending 14 hours after injection was stopped due to the impending hurricane, Frances. Local barometric data were also collected during this period.

5.2 Injection Well Performance

The injection rate during the injection test is graphically represented on Figure 5-1. Pressure responses were recorded down-hole and at the wellhead during injection activities. The changes in pressure at the formation is graphically represented on Figure 5-2 and the pressures monitored at the surface for IW-1 and IW-2 are presented on Figure 5-3. Local on-site barometric data collected during the test are presented graphically on Figure 5-4.

The initial injection rate fluctuated over the first 22-minute period until it was stabilized near 17 MGD (11,800 gpm). A maximum injection rate of 19.6 MGD was attained for a brief period of time during the first twenty minutes of pumping. Rates were reduced to prevent excessive drawdown within the reuse pump-system's wet well. A down-hole pressure increase of 1.22 psi (approximately 2.82 feet) and a wellhead pressure increase of 14.3 psi (approximately 33 feet) were noted over the 4-hour period based on the final shut-in pressure. The final wellhead pressure was used since the initial wellhead pressure indicated a higher-density fluid in the wellbore.

After the 4-hour test at the higher rate, the injection rate was reduced to 8.0 MGD (5,552 gpm), and maintained at a lower rate for an 8-hour period. A net down-hole pressure increase of 0.4 psi (0.9 feet) above background and a wellhead pressure increase of 4.7 psi (10.9 feet) above background were noted over the 8-hour period.

The specific injectivity of the well at the wellhead, based on the current testing, is approximately 349 gpm/ft at 11,875 gpm and approximately 511 gpm/ft at 5,552 gpm as estimated from pressure changes at the surface. Similar calculations under down-hole conditions indicate a down-hole injectivity of 4,211 gpm/ft at 11,875 gpm and 6,009 gpm/ft at 5,552 gpm. These down-hole values, based on the empirical Walton formula (Driscoll, 1986), suggest a formation transmissivity in the range of 8.4 MGD/ft.

The difference in specific injectivities measured at the surface and bottom-hole conditions reflects the substantial contribution of friction to the injection pressure associated with flow in the pipe. Pressure build-up, due to friction in the pipe, of approximately 13.1 psi is noted at the 11,875 gpm rate and approximately 4.3 psi at the 5,552 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 an average injection rate analysis of injection test data (Mathews and Russell, 1967), is in the range of 2,000,000 gpd/ft. The plot used to calculate the transmissivity value is presented on Figure 5-5. Storage, based on the analysis performed for IW-1, is estimated to be $3x10^{-4}$.

5.3 Monitoring Well Response

Pressure transducers and recording devices were placed in both monitoring zones prior to performing the injection test. Both transducers for the upper and lower monitoring zones were set at the surface. Pressures were recorded in both zones continuously throughout the injection test and background periods to assess any response due to injection activities. Surface pressures in both zones of the monitoring well are provided graphically on Figure 5-6.

As can be seen by the data presented on Figure 5-6, there are no pressure changes that reflect a response in the monitoring zones due to injection into IW-2.

6.0 REFERENCES

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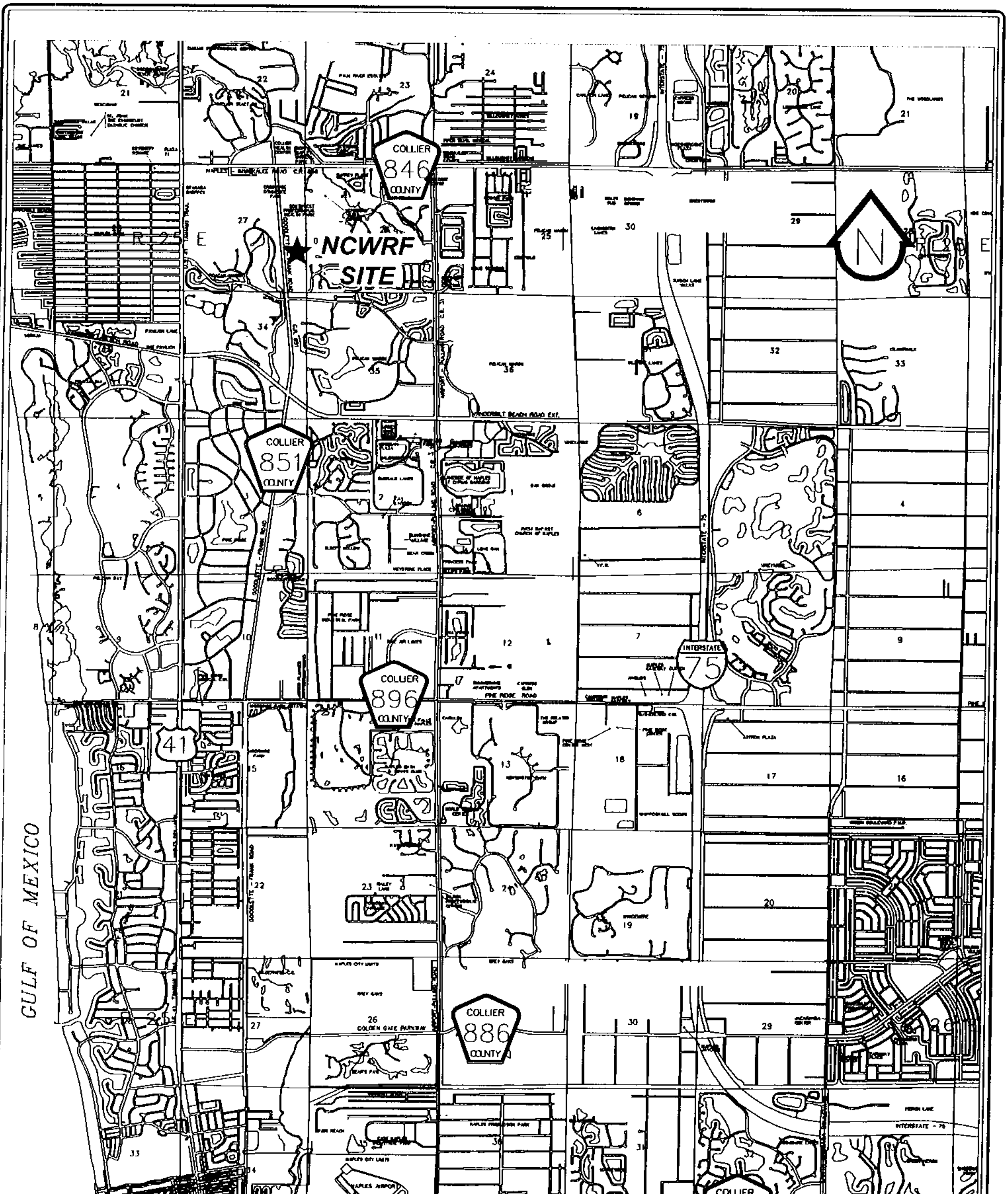
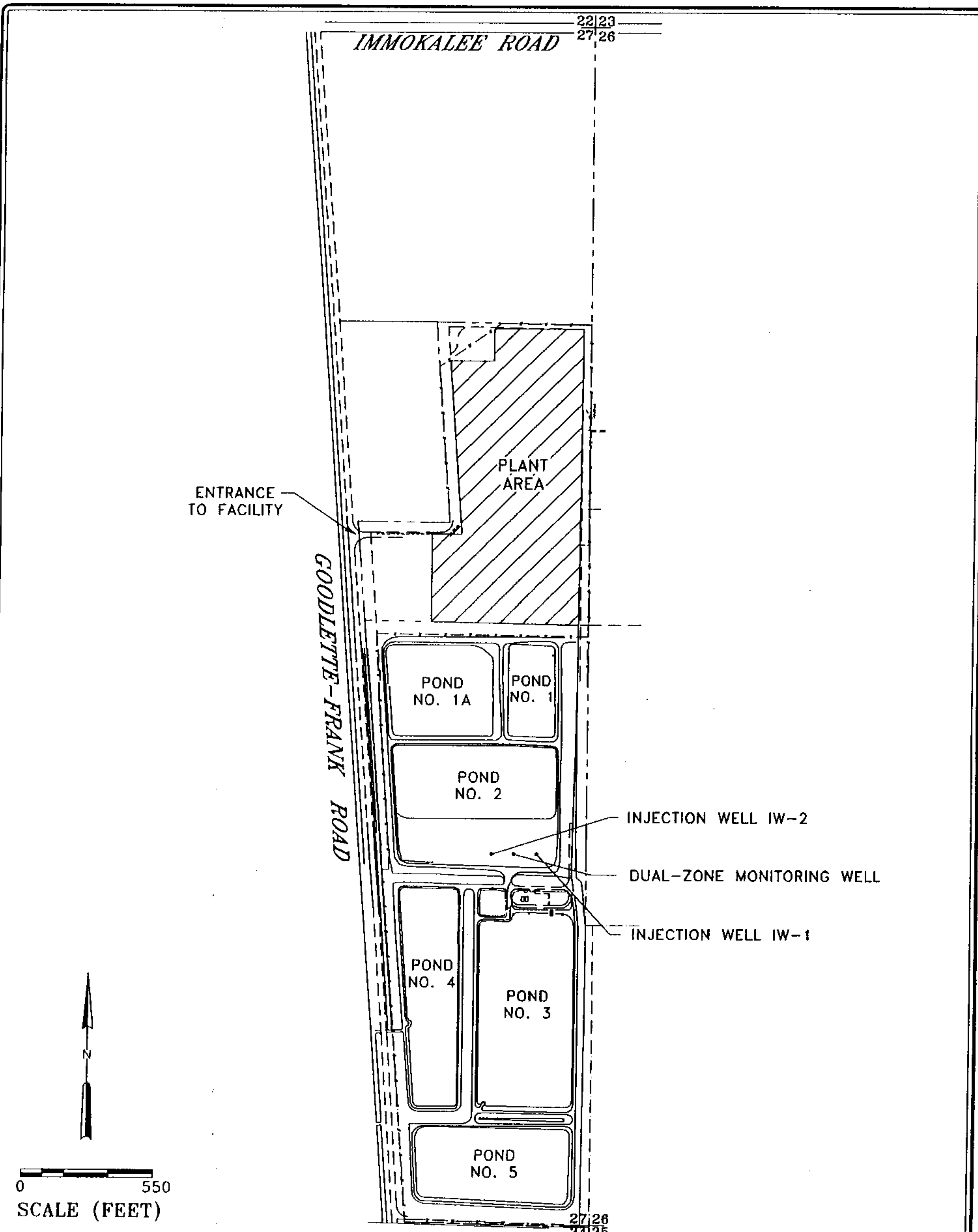


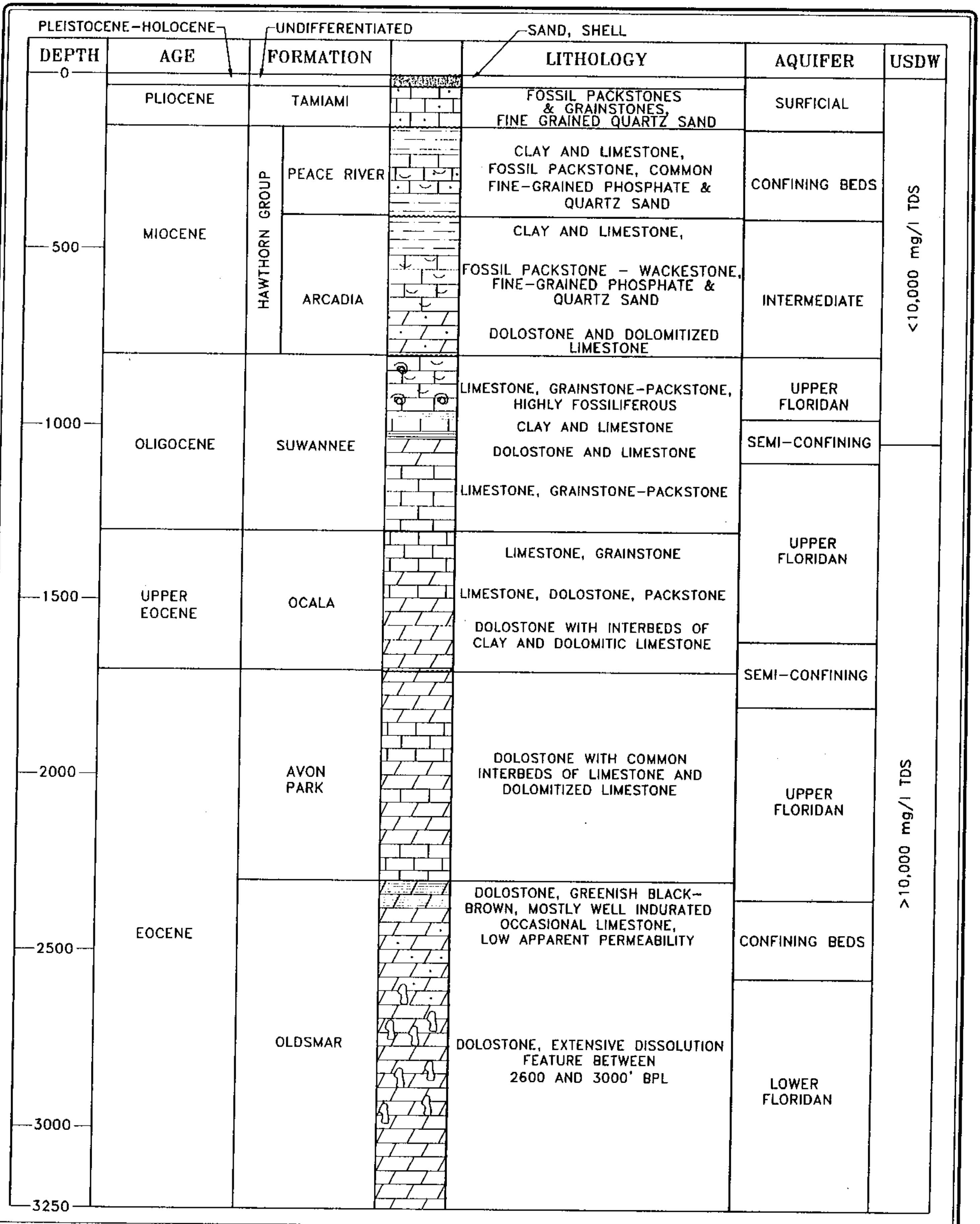
Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-013946SS-4	*Agnoli, Barber & Brundage*
	PROJECT NUMBER: 01-04254.01	DATE: 02/10/04	

FIGURE 1-1. GENERAL LOCATION MAP.



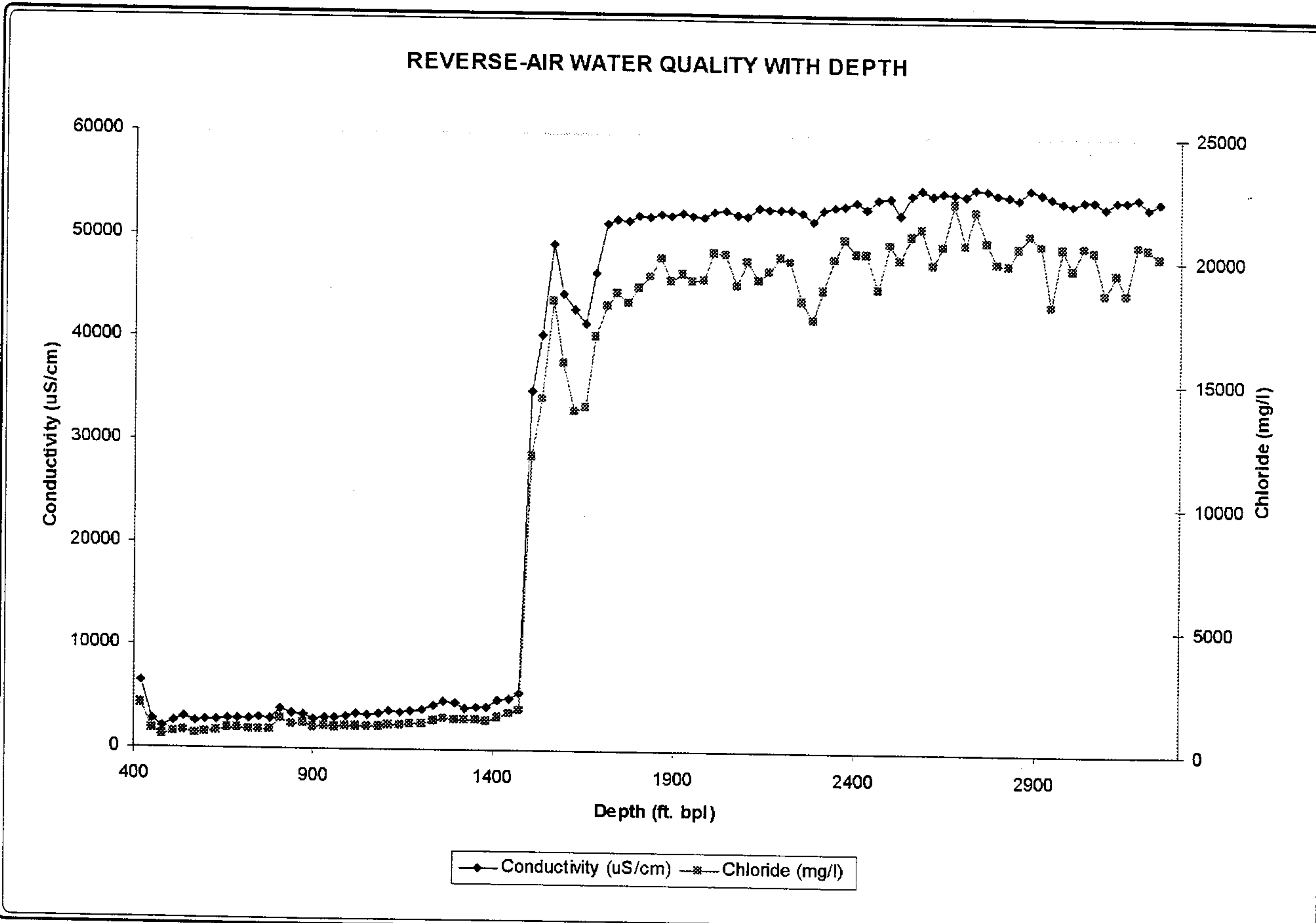
Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-01416853-1
	PROJECT NUMBER: 01-04254.01	DATE: 02/10/04

FIGURE 1-2. DETAILED SITE MAP.



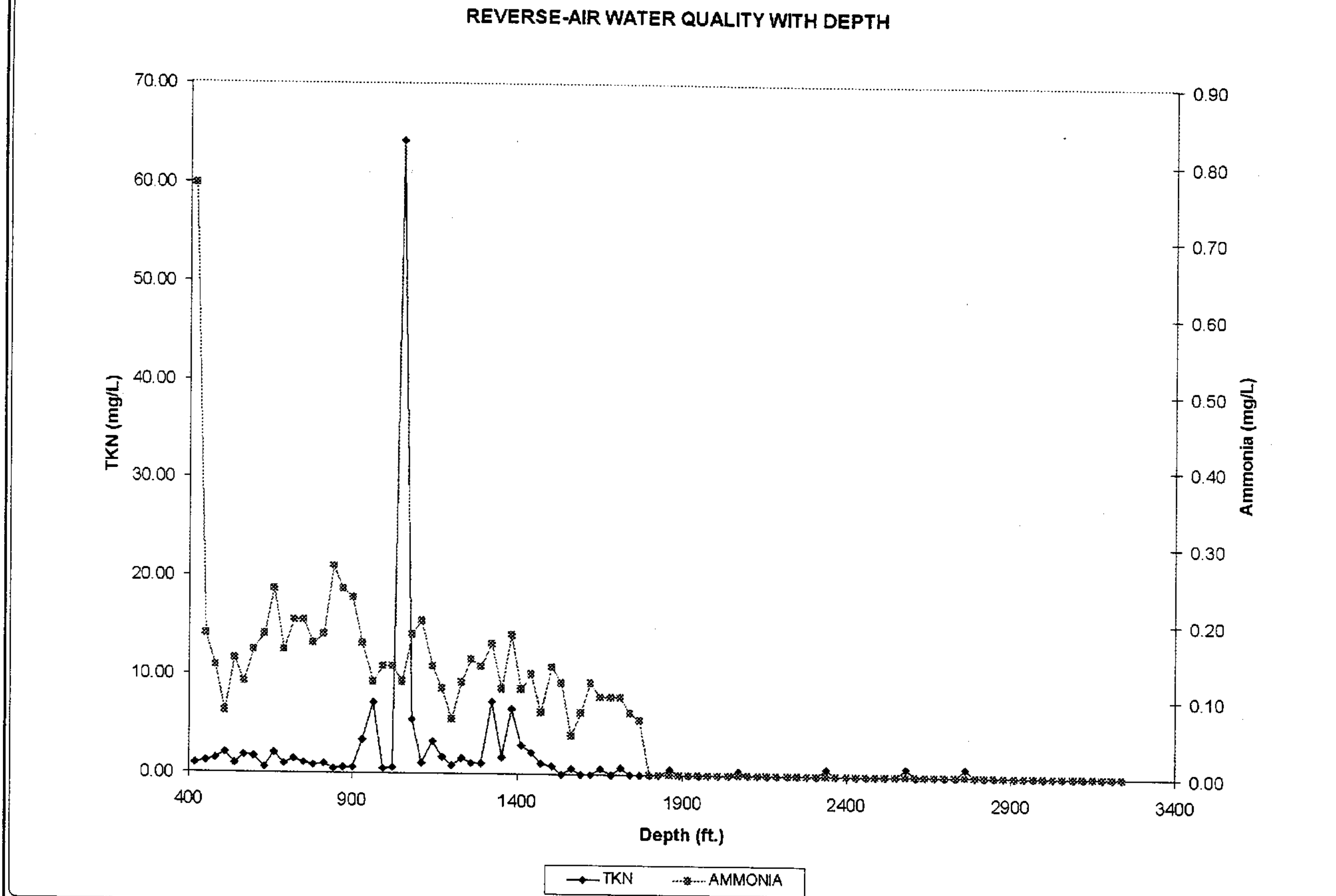
Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A–014254N1–2
	PROJECT NUMBER: 01–04254.01	DATE: 06/11/04

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



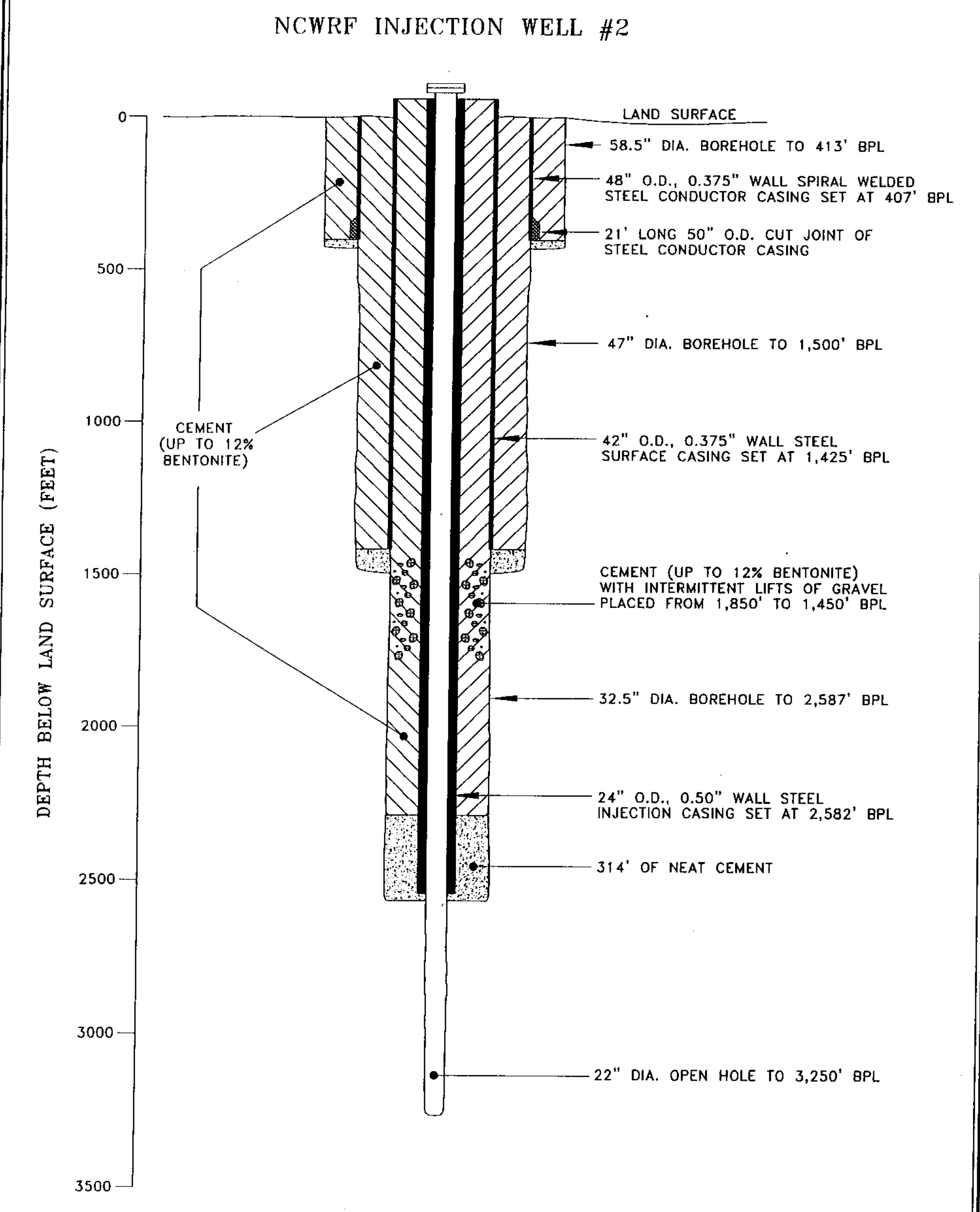
Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-014254F3_6-1
	PROJECT NUMBER: 01-04254.01	DATE: 02/13/04

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



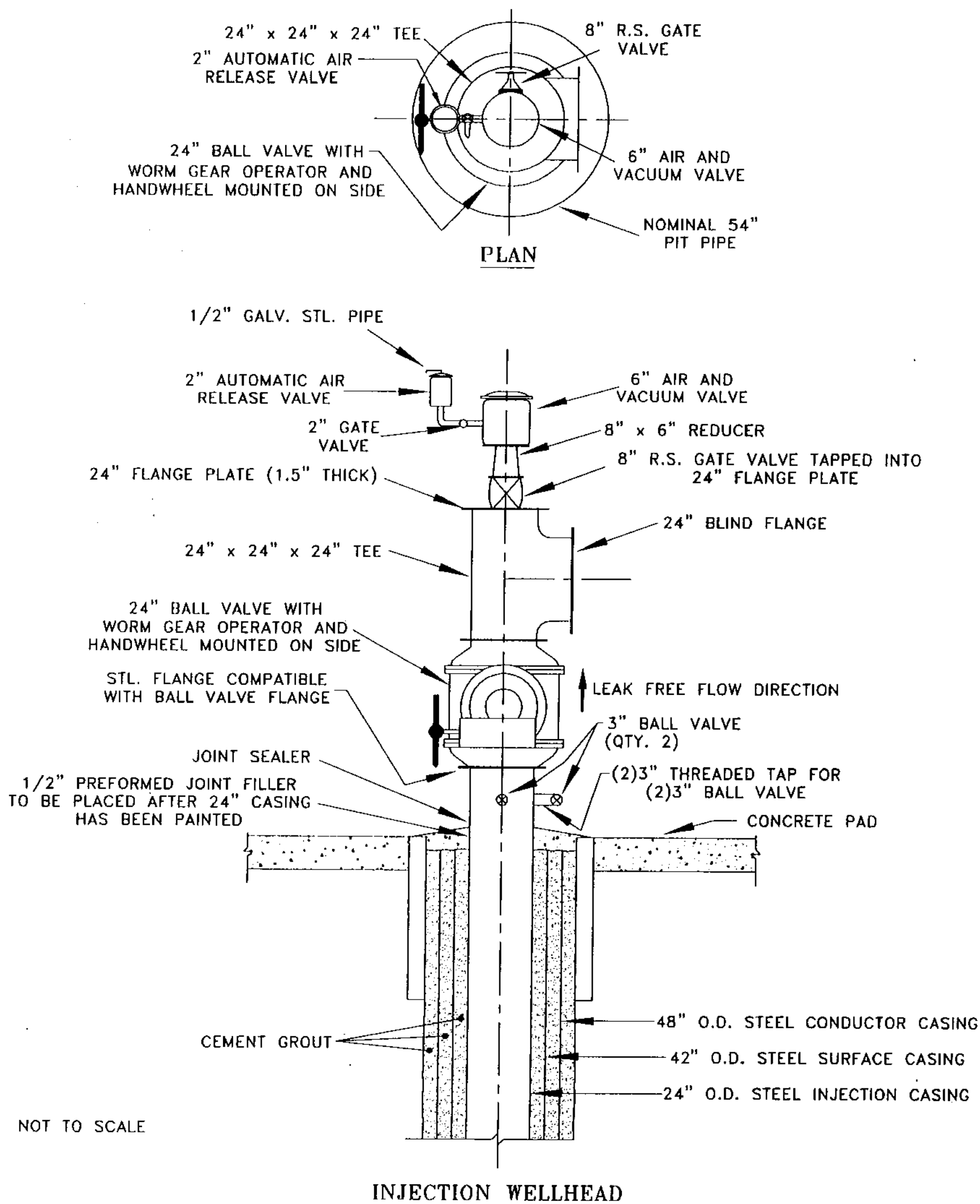
Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-014254N2_7
	PROJECT NUMBER: 01-04254.01	DATE: 03/05/04

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



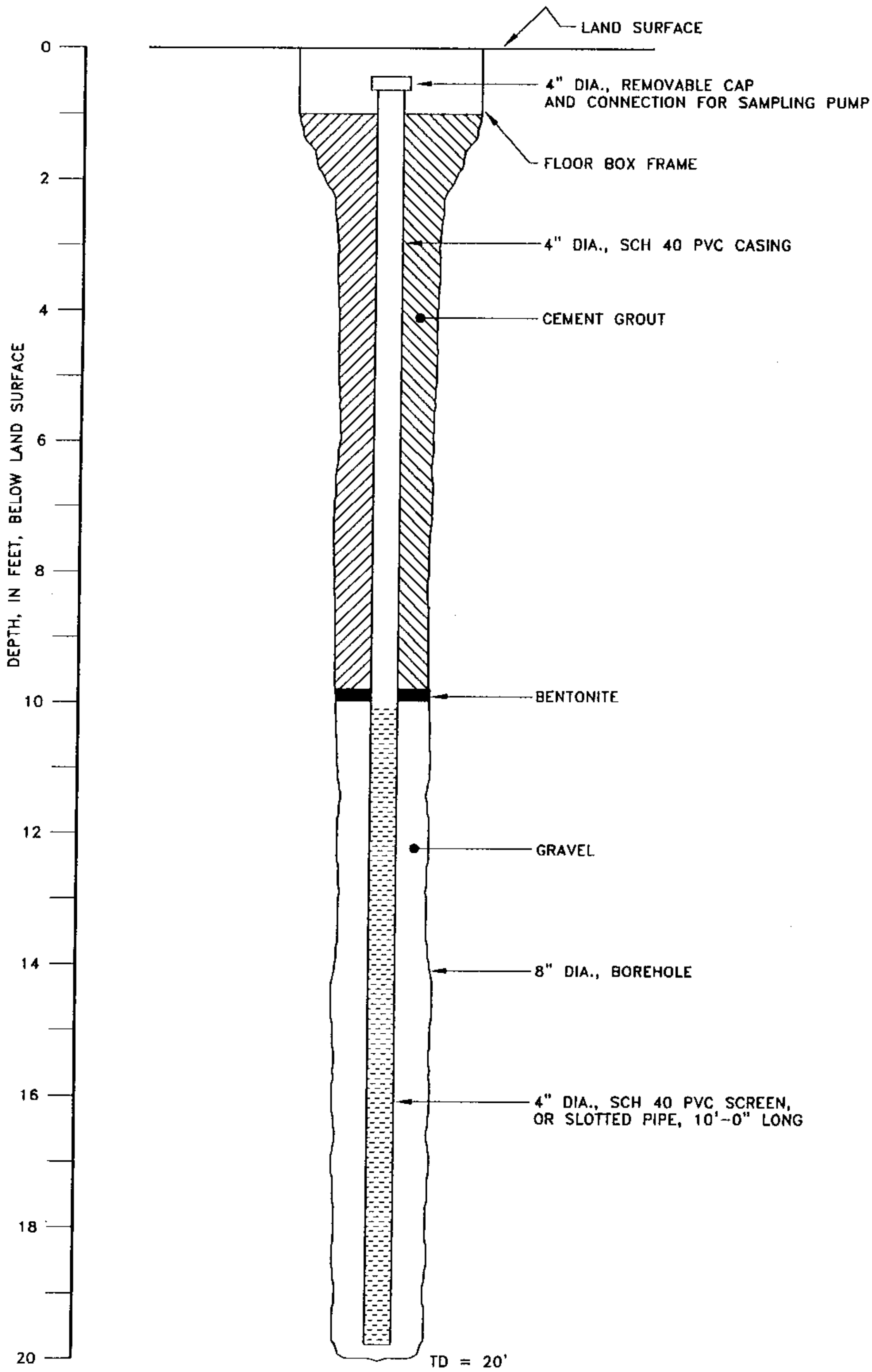
Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-014254F4
	PROJECT NUMBER: 01-04254.01	DATE: 03/19/04

FIGURE 3-1. WELL CONSTRUCTION DETAILS FOR IW-2.



Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-014254F4
	PROJECT NUMBER: 01-04254.01	DATE: 04/23/04

FIGURE 3-2. WELLHEAD SCHEMATIC OF IW-2.



Water Resource Solutions	PROJECT NAME: NCWRF	DWG. NUMBER: A-014254F3_5-1
	PROJECT NUMBER: 01-04254.01	DATE: 02/10/04

FIGURE 3-3. PAD MONITORING WELL CONSTRUCTION SCHEMATIC.

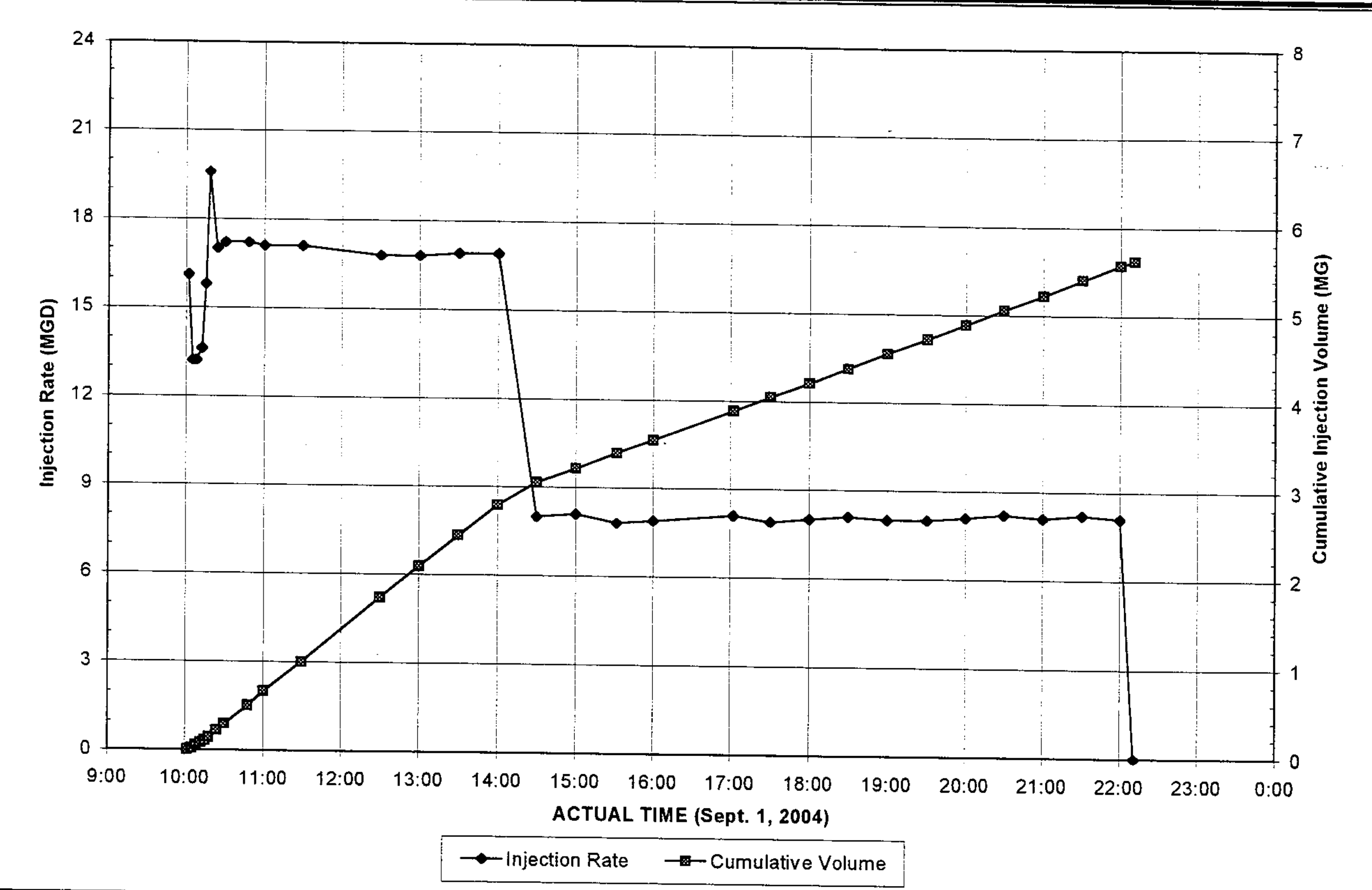


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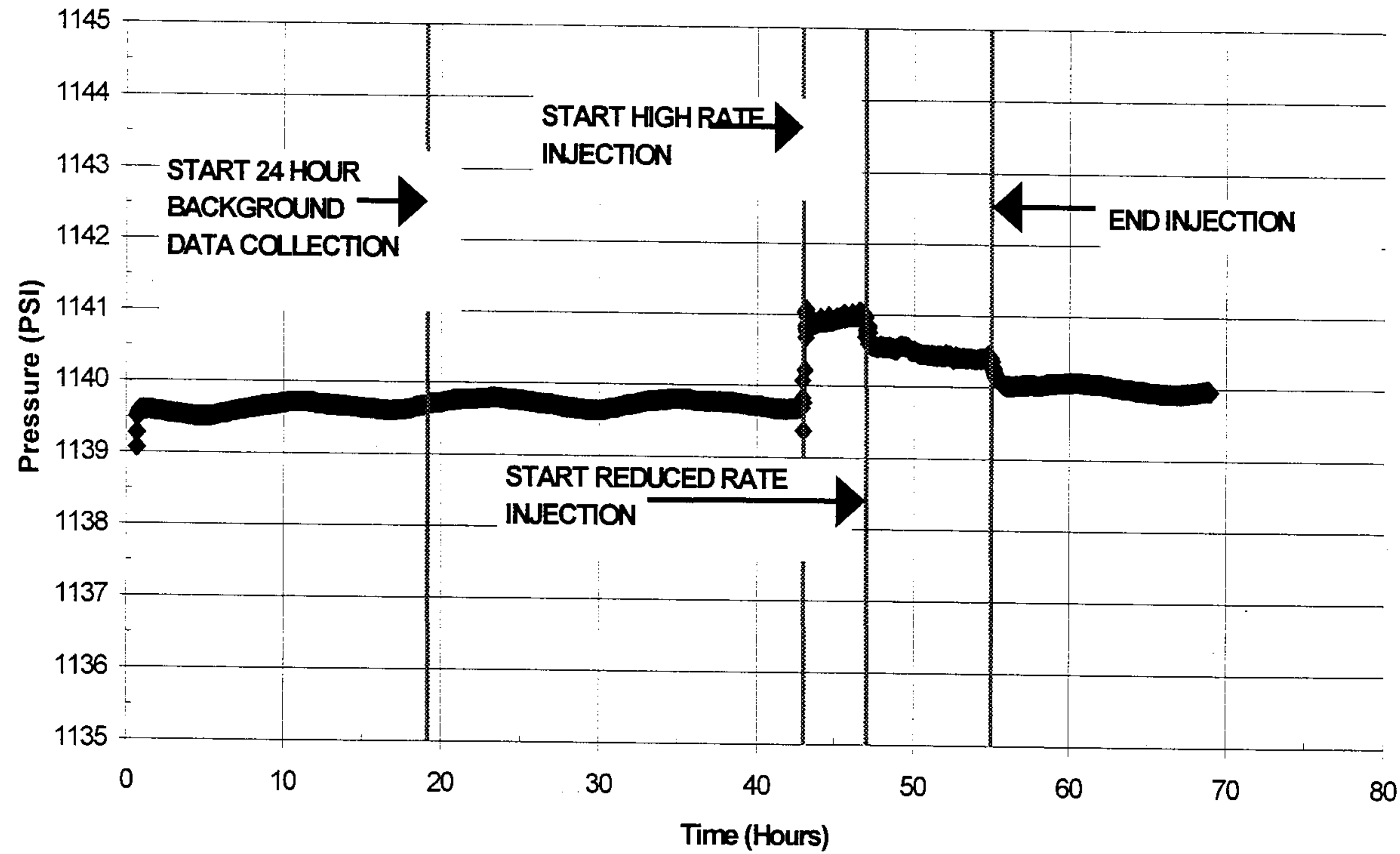
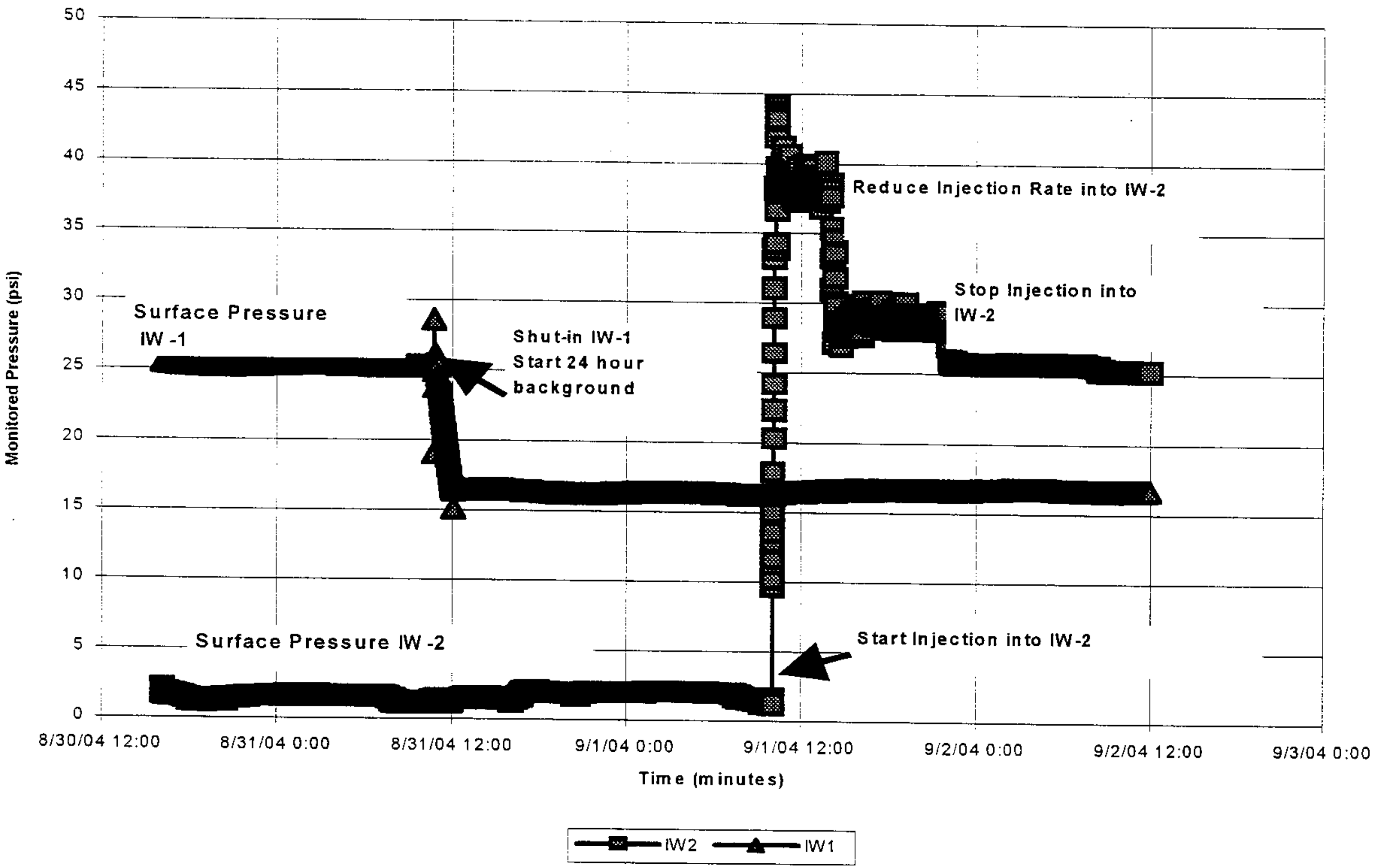
FIGURE 5.1 INJECTION RATE AND CUMULATIVE INJECTION VOLUME DURING THE INJECTION TEST.



Water Resource Solutions

Project : NCWRF IW-2 COMPLETION REPORT
Project Number: 01- 4254 Date: 9/17/04

FIGURE 5.2 CHANGES IN DOWNHOLE PRESSURE MEASURED IN IW-2 DURING THE INJECTION TEST.



Water Resource Solutions

Project : NCWRF IW-2 COMPLETION REPORT
Project Number: 01- 4254 Date: 9/17/04

FIGURE 5.3 SURFACE INJECTION PRESSURES MEASURED IN IW-2 DURING THE INJECTION TEST.

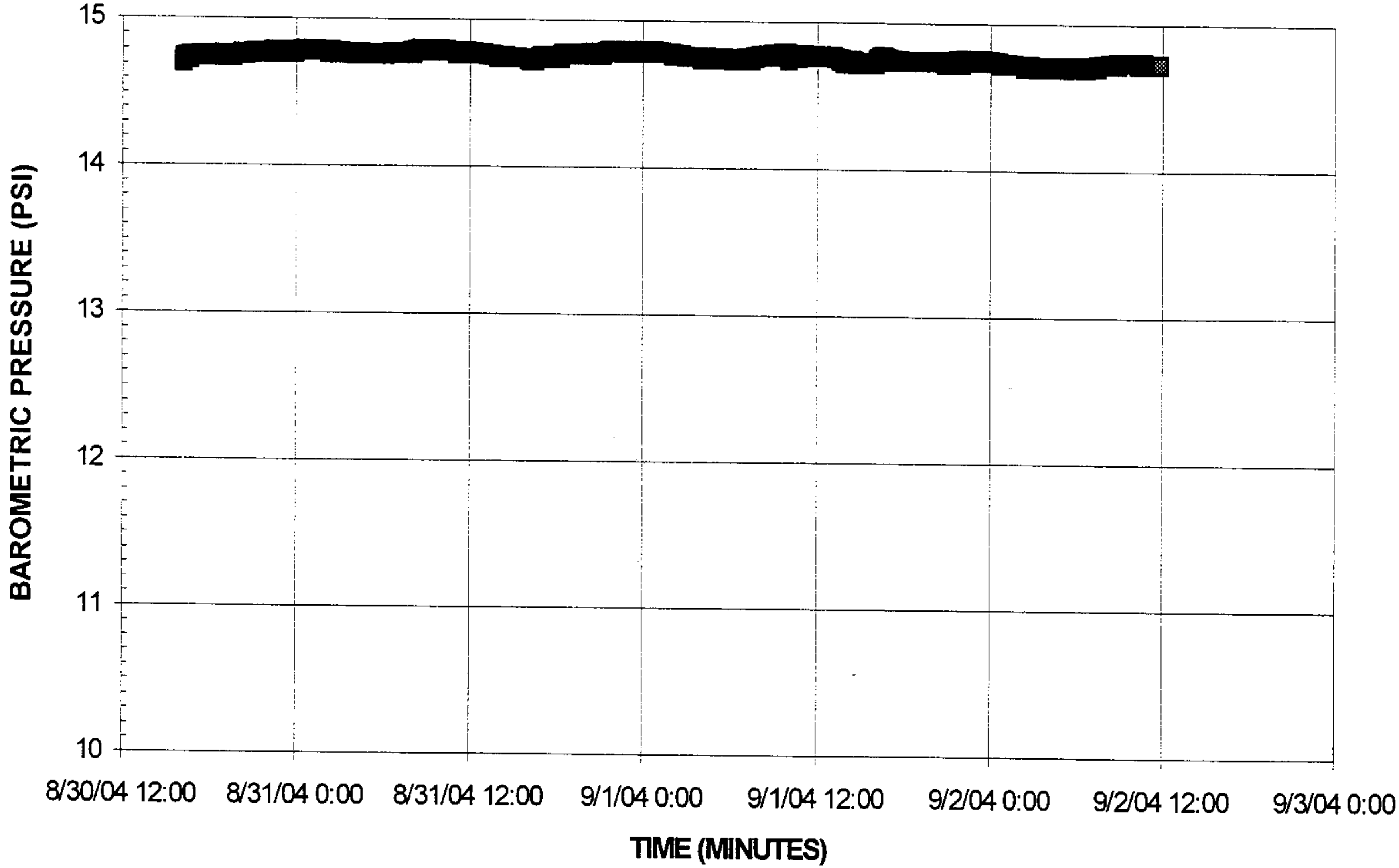


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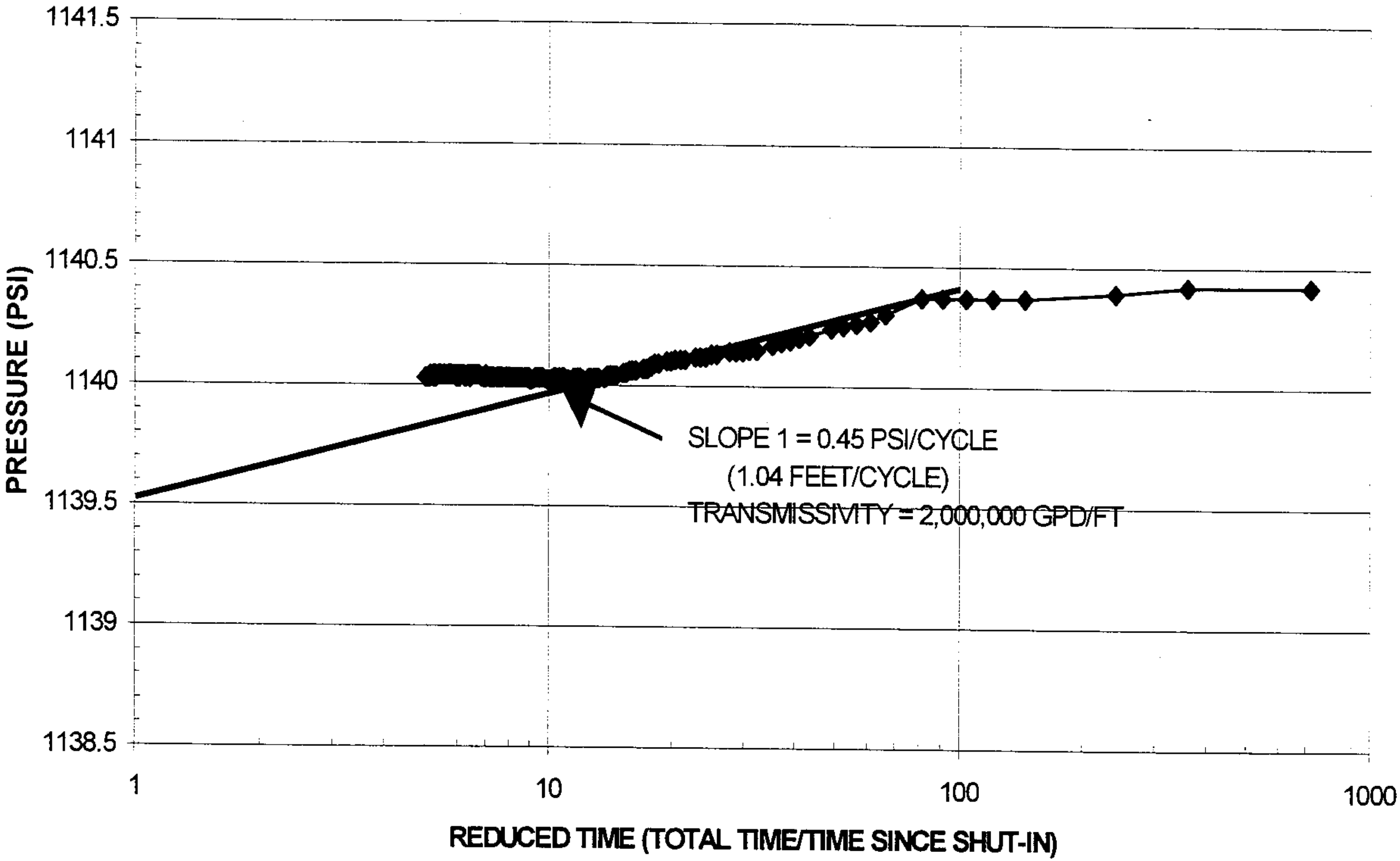
FIGURE 5.4 CHANGES IN BAROMETRIC PRESSURE DURING THE INJECTION TEST.



Water Resource Solutions

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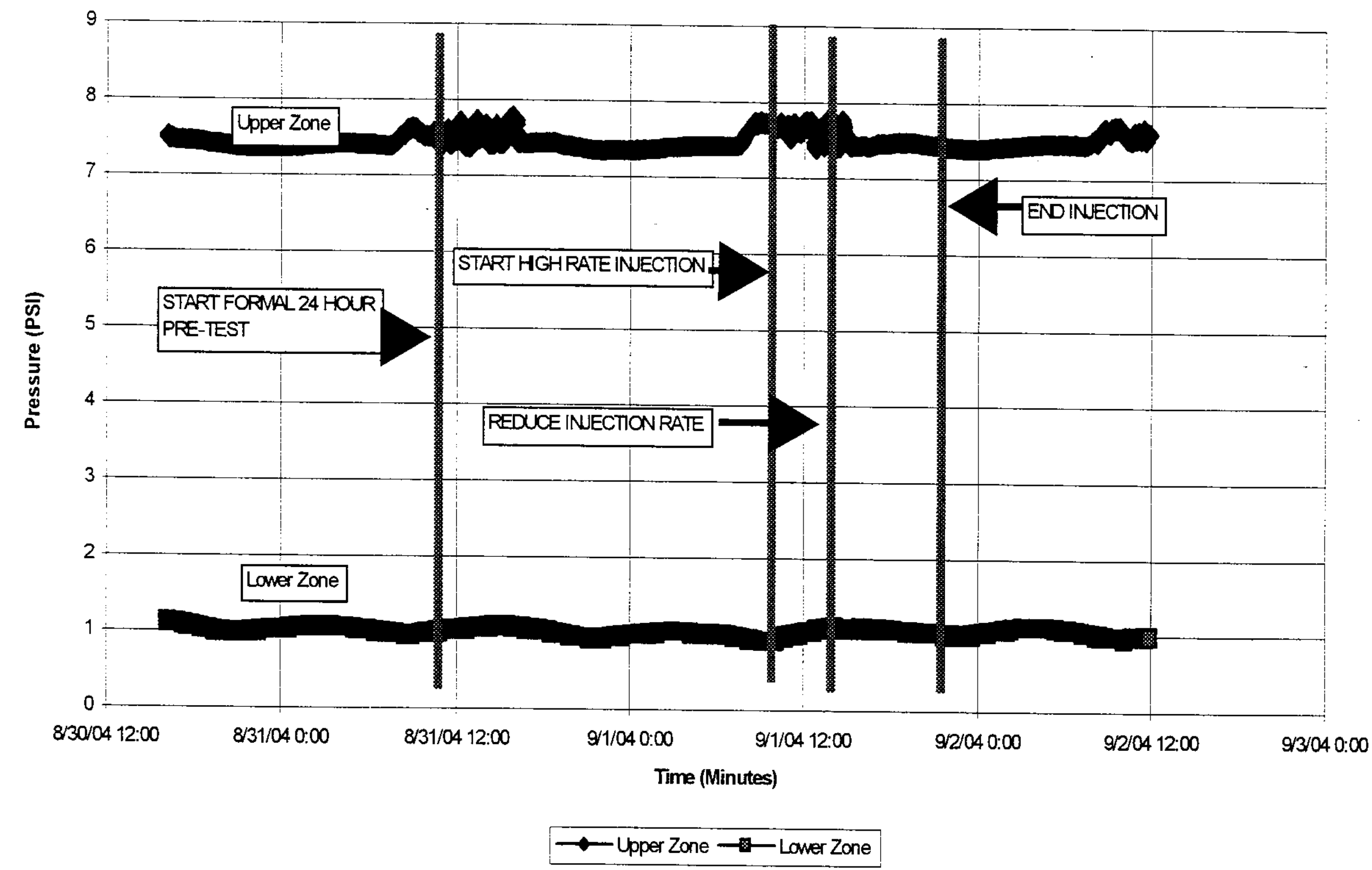
Project Number: 01- 4254 Date: 9/17/04

FIGURE 5.5 PRESSURE RESPONSE IN IW-2 DURING RECOVERY USING REDUCED TIME.



Water Resource Solutions

Project : NCWRF IW-2 COMPLETION REPORT
Project Number: 01- 4254 Date: 9/17/04

FIGURE 5.6 UPPER AND LOWER-ZONE PRESSURE CHANGES MONITORED DURING THE INJECTION TEST.

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

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	9/8/03	6470	1780	3440	1.03	0.77
450	9/8/03	2760	720	1630	1.25	0.18
480	9/8/03	2050	520	1100	1.46	0.14
510	9/8/03	2550	650	1510	2.04	0.08
540	9/8/03	2960	690	1670	0.96	0.15
570	9/8/03	2600	600	1560	1.84	0.12
600	9/8/03	2800	650	1680	1.68	0.16
630	9/9/03	2800	675	1590	0.65	0.18
660	9/9/03	2900	775	1720	2.13	0.24
690	9/9/03	2900	775	1780	0.99	0.16
720	9/9/03	2900	750	1610	1.42	0.20
750	9/9/03	3000	750	1720	1.04	0.20
780	9/9/03	2900	750	1680	0.85	0.17
810	9/9/03	3800	1200	2300	1.03	0.18
840	9/9/03	3500	975	2120	0.54	0.27
870	9/9/03	3300	1050	2300	0.66	0.24
900	9/9/03	2900	850	1830	0.63	0.23
930	9/9/03	3000	900	2100	3.39	0.17
960	9/9/03	3000	875	1840	7.26	0.12
990	9/9/03	3200	900	2060	0.53	0.14
1020	9/9/03	3440	900	2090	0.58	0.14
1050	9/9/03	3370	900	2130	64.2	0.12
1080	9/9/03	3430	900	2120	5.55	0.18
1110	9/9/03	3690	980	2220	1.05	0.20
1140	9/9/03	3540	960	2230	3.28	0.14
1170	9/9/03	3760	1020	2330	1.73	0.11
1200	9/10/03	3900	1050	2340	0.81	0.07
1230	9/10/03	4200	1150	2420	1.56	0.12
1260	9/10/03	4700	1275	2770	1.06	0.15
1290	9/10/03	4500	1225	2610	1.07	0.14
1320	9/10/03	3960	1200	2640	7.34	0.17
1350	9/10/03	4150	1200	2560	1.66	0.11
1380	9/10/03	4060	1150	2630	6.62	0.18
1410	9/10/03	4750	1325	2730	2.97	0.11
1440	9/10/03	5000	1500	2970	2.18	0.13
1470	9/10/03	5530	1600	3410	1.05	0.08
1500	9/10/03	35000	11900	22500	0.83	0.14
1530	9/10/03	40400	14250	23900	0.00	0.12
1560	9/11/03	49300	18250	31800	0.58	0.05
1590	9/11/03	44500	15700	30500	0.00	0.08
1620	9/11/03	42900	13750	25800	0.00	0.12
1650	9/11/03	41600	13950	26700	0.57	0.10
1680	9/11/03	46500	16800	35400	0.00	0.10
1710	10/26/03	51300	18050	35800	0.73	0.10
1740	10/27/03	51700	18600	36100	0.00	0.08
1770	10/27/03	51600	18150	34500	0.00	0.07

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

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)
1800	10/27/03	52200	18800	37200	0.00	0.00
1830	10/27/03	52000	19250	34000	0.00	0.00
1860	10/27/03	52300	20000	37100	0.55	0.00
1890	10/27/03	52200	19100	35700	0.00	0.00
1920	10/28/03	52400	19400	35000	0.00	0.00
1950	10/28/03	52100	19100	31600	0.00	0.00
1980	10/28/03	52000	19125	32000	0.00	0.00
2010	10/28/03	52600	20250	34600	0.00	0.00
2040	10/28/03	52700	20200	34500	0.00	0.00
2070	10/29/03	52300	18900	34600	0.50	0.00
2100	10/29/03	52100	19900	36500	0.00	0.00
2130	10/29/03	53000	19150	38700	0.00	0.00
2160	10/29/03	52900	19500	35900	0.00	0.00
2190	10/29/03	52800	20050	32000	0.00	0.00
2220	10/29/03	52900	19900	36400	0.00	0.00
2250	10/30/03	52600	18300	32900	0.00	0.00
2280	10/30/03	51800	17550	35900	0.00	0.00
2310	10/30/03	52800	18750	37400	0.00	0.00
2340	10/30/03	53100	20000	33500	0.69	0.00
2370	10/30/03	53300	20800	35900	0.00	0.00
2400	10/30/03	53700	20250	40600	0.00	0.00
2430	10/30/03	53000	20250	35600	0.00	0.00
2460	10/31/03	53900	18800	32900	0.00	0.00
2490	10/31/03	54100	20650	35800	0.00	0.00
2520	11/1/03	52500	20000	36700	0.00	0.00
2550	11/1/03	54400	21000	40500	0.00	0.00
2580	11/1/03	54900	21250	40100	0.89	0.00
2610	11/2/03	54400	19850	36300	0.00	0.00
2640	11/2/03	54600	20600	38400	0.00	0.00
2670	11/2/03	54500	22300	38000	0.00	0.00
2700	11/3/03	54400	20650	41600	0.00	0.00
2730	11/3/03	55100	22000	38000	0.00	0.00
2760	11/4/03	54900	20750	34600	0.87	0.00
2790	11/4/03	54500	19900	37700	0.00	0.00
2820	11/4/03	54400	19850	37400	0.00	0.00
2850	11/4/03	54100	20550	36000	0.00	0.00
2880	11/5/03	55100	21050	38500	0.00	0.00
2910	11/5/03	54700	20650	36000	0.00	0.00
2940	12/28/03	54200	18150	NM	0.00	0.00
2970	12/28/03	53800	20500	NM	NM	NM
3000	12/28/03	53500	19650	NM	NM	NM
3030	12/30/03	54000	20600	NM	0.00	0.00
3060	12/30/03	54000	20400	NM	0.00	0.00
3090	12/30/03	53300	18700	NM	0.00	0.00
3120	12/31/03	54000	19500	NM	NM	NM
3150	12/31/03	54000	18700	NM	0.00	0.00
3180	12/31/03	54200	20650	NM	0.00	0.00
3210	1/1/04	53200	20500	NM	0.00	0.00
3240	1/1/04	53800	20200	NM	NM	NM

TABLE 3-1
INCLINATION SURVEY SUMMARY FOR IW-2

Date	Bit Diameter (inches)	Depth (feet bpl)	Inclination (degrees)
9/1/03	58.5	90	0.15
9/3/03	58.5	180	0.20
9/3/03	58.5	270	0.25
9/4/03	58.5	360	0.25
9/8/03	12.25	450	0.25
9/8/03	12.25	540	0.25
9/9/03	12.25	630	0.50
9/9/03	12.25	720	0.50
9/9/03	12.25	810	0.50
9/9/03	12.25	900	0.25
9/9/03	12.25	990	0.25
9/9/03	12.25	1080	0.20
9/9/03	12.25	1170	0.10
9/10/03	12.25	1260	0.40
9/10/03	12.25	1350	0.20
9/10/03	12.25	1440	0.25
9/10/03	12.25	1530	0.25
9/10/03	12.25	1620	0.25
9/25/03	47	450	0.25
9/27/03	47	540	0.35
9/27/03	47	630	0.50
9/28/03	47	720	0.10
9/28/03	47	810	0.25
9/29/03	47	990	0.25
10/1/03	47	900	0.30
10/1/03	47	1080	0.30
10/2/03	47	1170	0.25
10/2/03	47	1260	0.10
10/2/03	47	1350	0.10
10/6/03	47	1440	0.10
10/26/03	40.5	1500	0.25
10/26/03	12.25	1590	0.25
10/26/03	12.25	1680	0.25
10/27/03	12.25	1770	0.25

TABLE 3-1
INCLINATION SURVEY SUMMARY FOR IW-2

Date	Bit Diameter (inches)	Depth (feet bpl)	Inclination (degrees)
10/28/03	12.25	1860	0.10
10/28/03	12.25	1950	0.25
10/28/03	12.25	2040	0.25
10/28/03	12.25	2130	0.25
10/30/03	12.25	2220	0.10
10/30/03	12.25	2310	0.25
10/30/03	12.25	2400	0.20
10/31/03	12.25	2490	0.20
10/31/03	12.25	2580	0.25
11/4/03	12.25	2670	0.20
11/4/03	12.25	2760	0.20
11/5/03	12.25	2850	0.20
11/6/03	12.25	2939	0.25
11/21/03	32.5	1515	0.25
11/21/03	32.5	1605	0.25
11/22/03	32.5	1695	0.25
11/23/03	32.5	1785	0.25
11/24/03	32.5	1875	0.25
11/24/03	32.5	1965	0.25
11/25/03	32.5	2055	0.25
11/26/03	32.5	2145	0.25
11/27/03	32.5	2235	0.25
11/27/03	32.5	2325	0.30
11/28/03	32.5	2415	0.30
12/1/03	32.5	2505	0.25
12/24/03	22	2600	0.25
12/26/03	22	2690	0.25
12/26/03	22	2780	0.25
12/27/03	22	2870	0.30
12/30/03	22	2960	0.30
12/31/03	22	3050	0.25
12/31/03	22	3140	0.25

TABLE 3-2
GEOPHYSICAL LOGGING SUMMARY FOR IW-2

DATE	LOG RUN	DEPTH OF LOGGED INTERVAL (FT. BPL)	INTERVAL DESCRIPTION
9/4/03	Caliper/ Natural Gamma	Surface to 413	58.5-inch reamed borehole
9/5/03	Temperature	Surface to 413	48-inch conductor casing
9/14/03	Caliper/ Natural Gamma	410 -1677	12.25-inch pilot hole
9/14/03	Dual Induction	410 -1677	12.25-inch pilot hole
9/14/03	BHC Sonic-VDL	410 -1677	12.25-inch pilot hole
9/14/03	Log-Derived TDS	410 -1677	12.25-inch pilot hole
9/14/03	Temperature	410 -1677	12.25-inch pilot hole
10/7/03	Caliper/Natural Gamma	410 -1500	47-inch reamed borehole
10/14/03 - 10/21/03	Cement Top Temperature (merged)	Surface to 1425	42-inch surface casing
11/6/03	Video Log	1425 -2737	12.25-inch pilot hole
11/6/03	Caliper/Natural Gamma	1425 - 2872	12.25-inch pilot hole
11/6/03	BHC Sonic-VDL	1425 -2862	12.25-inch pilot hole
11/6/03	Dual Induction	1425 -2862	12.25-inch pilot hole
11/6/03	High Resolution Temperature	1360 -2939	12.25-inch pilot hole
12/2/03	Caliper/Natural Gamma	1300 - 2590	32.5-inch reamed borehole
12/4/03 - 12/21/03	Cement Top Temperature (merged)	Surface to 2582	24-inch longstring casing
1/2/04	Caliper/Natural Gamma	2450 - 3250	22-inch open hole
1/2/04	Cement Bond-VDL	100 - 2600	24-inch longstring casing
1/16/04	Video Log	Surface to 2768	Injection casing/open hole
1/29/04	High Resolution Temperature	Surface to 2776	Injection casing/open hole
1/29/04	Radioactive Tracer Survey	Surface to 2776	Injection casing/open hole

TABLE 3-3
48-INCH CONDUCTOR CASING SUMMARY FOR IW-2

Pipe No. and Install Order	Time of Install (pipe down)	Heat Number	Length (ft)	String Length (ft)	Run Depth (ft bpl)
1 (50-inch cut joint)	14:20	-	21.06	21.06	19.46
2	15:29	HT.C22024	38.07	59.13	57.53
3	15:59	HT.A23173	49.98	109.11	107.51
4	16:19	HT.A23173	50.02	159.13	157.53
5	16:40	HT.A23173	50.07	209.20	207.60
6	17:01	HT.021941	50.05	259.25	257.65
7	17:22	HT.C22024	50.05	309.30	307.70
8	17:50	HT.A23173	50.06	359.36	357.76
9 (header joint)	18:12	HT.021941	50.00	409.36	407.76

Note: Set casing at 407 feet bpl. First joint in (50-inch) welded to 48-inch casing string using a 1-inch ring of steel welded inside upper end of this 50-inch joint.

TABLE 3-4
42-INCH SURFACE CASING SUMMARY FOR IW-2

Pipe No. and Install Order	Time of Install (pipe down)	Heat Number	Length (ft)	String Length (ft)	Run Depth (ft bpl)
1	9:04	HT.225100	27.77	27.77	20.77
2	10:14	HT225100/HTJ51135	50.12	77.89	70.89
3	10:54	HT20204	50.10	127.99	120.99
4	11:38	HT20204/HT2732P	50.13	178.12	171.12
5	12:29	HT225001	50.13	228.25	221.25
6	13:10	HT225001	50.13	278.38	271.38
7	13:50	HT225089	50.13	328.51	321.51
8	14:52	HT225100	50.10	378.61	371.61
9	15:30	HTJ51135	50.11	428.72	421.72
10	16:11	HT20204	50.13	478.85	471.85
11	16:50	HT20204	50.13	528.98	521.98
12	17:25	HTJ51135	50.08	579.06	572.06
13	18:04	HT225089/HT225001	50.08	629.14	622.14
14	18:38	HT225001	50.09	679.23	672.23
15	19:59	HTJ51135	50.09	729.32	722.32
16	20:38	HTJ51135	50.02	779.34	772.34
17	21:25	HT225089	50.08	829.42	822.42
18	22:05	HT225089	50.09	879.51	872.51
19	22:51	HTJ51135	50.00	929.51	922.51
20	23:35	HTJ51135	50.08	979.59	972.59
21	0:10	HTJ51135	50.10	1029.69	1022.69
22	0:56	HTJ51135	50.09	1079.78	1072.78
23	1:42	HT225001/HT225100	50.10	1129.88	1122.88
24	2:10	HT4177339	50.16	1180.04	1173.04
25	2:45	HT225089	50.08	1230.12	1223.12
26	3:35	HT417733	50.10	1280.22	1273.22
27	4:38	HT4177389	50.10	1330.32	1323.32
28	5:08	HT225100	50.08	1380.40	1373.40
29(header joint)	6:00	HT20204	51.92	1432.32	1425.32
Note: Surface casing set at 1,425 feet bpl.					

TABLE 3-5
24-INCH INJECTION CASING SUMMARY FOR IW-2

Pipe No. and Install Order	Time of Install (pipe down)	Heat Number	Length (ft)	String Length (ft)	Run Depth (ft bpl)
1	9:12	**illegible**	39.30	39.30	32.55
2	9:53	A60588	40.67	79.97	73.22
3	10:18	A60593	37.81	117.78	111.03
4	10:41	A60588	35.05	152.83	146.08
5	11:14	A60588	42.79	195.62	188.87
6	11:36	A60593	36.32	231.94	225.19
7	12:02	A60593	38.76	270.70	263.95
8	12:23	A60593	37.70	308.40	301.65
9	12:45	A60588	40.10	348.50	341.75
10	13:10	A60588	41.96	390.46	383.71
11	13:34	A60593	43.56	434.02	427.27
12	13:56	A60588	41.33	475.35	468.60
13	14:30	A60588	42.60	517.95	511.20
14	14:50	A60593	41.54	559.49	552.74
15	15:18	A60588	39.70	599.19	592.44
16	15:39	A60588	40.05	639.24	632.49
17	16:05	A60588	38.88	678.12	671.37
18	16:31	A60588	40.61	718.73	711.98
19	16:50	A60593	40.94	759.67	752.92
20	17:12	A60593	40.58	800.25	793.50
21	17:34	A60588	40.32	840.57	833.82
22	17:53	A60588	35.58	876.15	869.40
23	18:18	A60588	37.02	913.17	906.42
24	19:10	A60588	41.94	955.11	948.36
25	19:44	A60588	41.66	996.77	990.02
26	20:10	A46076	43.52	1040.29	1033.54
27	20:33	A60588	43.34	1083.63	1076.88
28	21:00	A60588	41.31	1124.94	1118.19
29	21:30	A60588	39.11	1164.05	1157.30
30	22:02	A60588	37.20	1201.25	1194.50
31	22:28	A60593	42.28	1243.53	1236.78
32	22:58	A60588	36.76	1280.29	1273.54
33	23:32	A60588	42.14	1322.43	1315.68
34	0:02	A46076	42.67	1365.10	1358.35

TABLE 3-5
24-INCH INJECTION CASING SUMMARY FOR IW-2

35	0:30	A60593	35.63	1400.73	1393.98
36	0:58	A46076	38.65	1439.38	1432.63
37	1:24	A60588	40.11	1479.49	1472.74
38	1:49	A60593	40.21	1519.70	1512.95
39	2:15	A60588	41.65	1561.35	1554.60
40	2:40	A46076	42.63	1603.98	1597.23
41	3:09	A46076	38.25	1642.23	1635.48
42	3:37	A60588	42.65	1684.88	1678.13
43	4:02	A46076	42.69	1727.57	1720.82
44	4:29	A60588	43.28	1770.85	1764.10
45	4:58	A60588	43.54	1814.39	1807.64
46	5:25	A60593	39.46	1853.85	1847.10
47	5:47	A60588	37.58	1891.43	1884.68
48	6:17	A60588	34.97	1926.40	1919.65
49	6:45	A60588	41.63	1968.03	1961.28
50	7:15	A60588	40.46	2008.49	2001.74
51	7:51	A60588	41.43	2049.92	2043.17
52	8:17	A46076	41.00	2090.92	2084.17
53	8:42	A46076	42.93	2133.85	2127.10
54	9:16	A60588	38.94	2172.79	2166.04
55	9:39	A46076	40.67	2213.46	2206.71
56	10:01	A60588	39.98	2253.44	2246.69
57	10:27	A60593	42.18	2295.62	2288.87
58	10:50	A60588	35.51	2331.13	2324.38
59	11:12	A60588	40.96	2372.09	2365.34
60	11:35	A60588	43.34	2415.43	2408.68
61	12:02	A60588	41.20	2456.63	2449.88
62	12:28	A60593	37.39	2494.02	2487.27
63	13:02	A46076	39.07	2533.09	2526.34
64	16:18	A60588	13.62	2546.71	2539.96
65 (header)	16:18	A60593	42.04	2588.75	2582.00

NOTE: A short joint (#64) was pre-welded to the header joint (#65) prior to running these joints into the well. Injection casing set at 2,582 feet bpl. There was 6.75 feet of stickup above pad level for cementing purposes.

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

WATER RESOURCE SOLUTIONS

Date: 1/27/04
Project Name: NCWRF
Job No.: 01-04254.A8
IW-2

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
10:05	0	194	490	Begin the test at 194 psi.
10:10	5	194	490	
10:15	10	194	490	
10:20	15	194	490	
10:25	20	194	490	
10:30	25	194	490	
10:35	30	194	490	
10:40	35	194	490	
10:45	40	194	490	
10:50	45	194	490	
10:55	50	194	490	
11:00	55	194	490	
11:05	60	193.75	490	End the test.

Casing Diameter: 24-inch O.D.
Casing Type: 0.5-inch wall steel

Witnesses: Jack Myers (FDEP), Frank Procta (WRS)

Center Line of Packer: 2,557 ft bpl
Packer Length: 23.25 feet
Guage SN/ID #: 9160
Calibration Date: 12/11/03

5% of Initial Casing Pressure: 9.7 psi
Total Pressure Change: 0.25-psi loss or 0.13%

TABLE 5-1
INJECTION TESTING SUMMARY FOR IW-2

DATE	ACTUAL TIME	INJECTION RATE (MGD)	INJECTION WELLHEAD PRESSURE (PSI)	CUMULATIVE INJECTION VOLUME (MG)
9/1/04	10:02	16.1	NR	NR
9/1/04	10:05	13.2	8.0	0.023
9/1/04	10:08	13.2	20.0	0.056
9/1/04	10:12	13.6	32.0	0.081
9/1/04	10:15	15.8	36.0	0.110
9/1/04	10:18	19.6	42.0	0.147
9/1/04	10:24	17.0	39.0	0.220
9/1/04	10:30	17.2	39.0	0.296
9/1/04	10:48	17.2	39.0	0.509
9/1/04	11:00	17.1	39.0	0.668
9/1/04	11:20	17.6	NR	NR
9/1/04	11:30	17.1	39.0	1.002
9/1/04	12:00	16.9	37.0	NR
9/1/04	12:30	16.8	38.0	1.739
9/1/04	13:00	16.8	38.0	2.096
9/1/04	13:30	16.9	38.0	2.448
9/1/04	14:00	16.9	38.0	2.794
END HIGH-RATE PHASE, BEGIN REDUCED-RATE PUMPING				
9/1/04	14:30	8.0	27.8	3.054
9/1/04	15:00	8.1	28.0	3.215
9/1/04	15:32	7.8	28.3	3.391
9/1/04	16:00	7.9	27.7	3.541
9/1/04	17:02	8.1	27.8	3.882
9/1/04	17:30	7.9	27.5	4.042
9/1/04	18:00	8.0	27.6	4.203
9/1/04	18:30	8.1	27.0	4.377
9/1/04	19:00	8.0	27.4	4.551
9/1/04	19:30	8.0	27.8	4.718
9/1/04	20:00	8.1	27.6	4.885
9/1/04	20:30	8.2	27.8	5.060
9/1/04	21:00	8.1	27.6	5.223
9/1/04	21:30	8.2	27.7	5.404
9/1/04	22:00	8.1	27.8	5.571
9/1/04	22:11	0.0	24.7	5.621

NOTE: The start of the official injection test was recorded at 10:02, flow is reduced at 14:05, and the well is shut in at 22:11.
NR = Not reported.