Report For

MECHANICAL INTEGRITY TESTING OF INJECTION WELLS IW-1, IW-2, IW-3, AND IW-5

Prepared for the

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EXECUTIVE SUMMARY

Mechanical Integrity Tests (MITs) were conducted on Injection Wells IW-1, IW-2, IW-3, and IW-5 located at the City of Fort Lauderdale's George T. Lohmeyer Waste Water Treatment Plant. Testing was conducted by Youngquist Brothers Inc., of Fort Myers, Florida from November 29, 1990, to February 28, 1991. The results of testing performed on each injection well demonstrate that the requirements for both Part 1 (internal) and Part 2 (external) mechanical integrity have been satisfactorily met as set forth in the Florida Administrative Code (FAC) 17.28. Testing included background geophysical logs, video television surveys, radioactive tracer surveys, and casing pressure tests. A summary of the testing results for each well is provided below.

IW-1

Caliper and temperature logs were run over the entire depth of the injection well. No unusual conditions were observed on either of the logs. The base of the casing was recorded at a depth of 2,799 feet below land surface (bls) and the total depth of the well was 3,513 feet bls. A video survey performed from land surface to the total depth of the well indicated no unusual conditions and showed the casing to be in good condition.

The Radioactive Tracer Survey included a background gamma ray log, the location of the base of the casing with a casing collar locator, and static and dynamic tracer tests. The base of the casing was identified by the casing collar locator at 2,799 feet bls. The results from the static and dynamic tracer tests were conclusive and there was no evidence of leakage through the casing or around the cement seal at the base of the casing. A final gamma ray log of the well confirmed that no tracer had traveled

above 2,778 feet bls. Therefore, the well has met the requirements for demonstration of Part 2 mechanical integrity as set forth in FAC 17-28.

A casing pressure test was performed at 140 pounds per square inch (psi). Over a one-hour period, a 4.5-pounds-per-square-inch gauge (psig) loss in pressure was observed. This loss (3.2 percent) falls within the 5 percent change allowed by Florida Department of Environmental Regulation (FDER).

IW-2

Caliper and temperature logs were run over the entire depth of the injection well. No unusual conditions were observed on either of the logs. The base of the casing was recorded at a depth of 2,798 feet bls and the total depth of the well was 3,518 feet bls. A video survey performed from land surface to the total depth of the well indicated no unusual conditions and showed the casing to be in good condition.

The Radioactive Tracer Survey included a background gamma ray log, the location of the base of the casing with a casing collar locator, and static and dynamic tracer tests. The base of the casing was identified with the casing collar locator at 2,798 feet bls. The results from the static and dynamic tracer tests were conclusive and there was no evidence of leakage either through the casing or around the cement seal at the base of the casing. A final gamma ray log of the well confirmed that no tracer had traveled above 2,748 feet bls. Therefore, the well has met the requirements for demonstration of Part 2 mechanical integrity as set forth in FAC 17.28.

A casing pressure test was performed at 140 psi. Over a one-hour period, a 4 psig loss in pressure was observed. This loss (3 percent) falls within the 5 percent change allowed by FDER.

IW-3

Caliper and temperature logs were run over the entire depth of the injection well. No unusual conditions were observed on either of the logs. The base of the casing was recorded at a depth of 2,800 feet bls and the total depth of the well was 3,977 feet bls. A video survey performed from land surface to the total depth of the well indicated no unusual conditions and showed the casing to be in good condition.

The Radioactive Tracer Survey included a background gamma ray log, the location of the base of the casing with a casing collar locator, and static and dynamic tracer tests. The base of the casing was identified with the casing collar locator at 2,801 feet bls. The results from the static and dynamic tracer tests were conclusive and there was no evidence of leakage either through the casing or around the cement seal at the base of the casing. A final gamma ray log of the well confirmed that no tracer had traveled above 2,790 feet bls. Therefore, the well has met the requirements for demonstration of Part 2 mechanical integrity as set forth in FAC 17.28.

A casing pressure test was performed at 140 psi. Over a one-hour period, a 5 psig loss in pressure was observed. This loss (3.6 percent) falls within the 5 percent change allowed by FDER.

IW-5

Caliper and temperature logs were run over the entire depth of the injection well. No unusual conditions were observed on either of the logs. The base of the casing was recorded at a depth of 2,818 feet bls and the total depth of the well was

3,462 feet bls. A video survey performed from land surface to the total depth of the well indicated no unusual conditions and showed the casing to be in good condition.

The Radioactive Tracer Survey included a background gamma ray log, the location of the base of the casing with a casing collar locator, and static and dynamic tracer tests. The base of the casing was identified with the casing collar locator at 2,817 feet bls. The results from the static and dynamic tracer tests were conclusive and there was no evidence of leakage either through the casing or around the cement seal at the base of the casing. A final gamma ray log of the well confirmed that no tracer had traveled above 2,777 feet bls. Therefore, the well has met the requirements for demonstration of Part 2 mechanical integrity as set forth in FAC 17.28.

A casing pressure test was performed at 140 psi. Over a one-hour period, a 2.75 psig loss in pressure was observed. This loss (2 percent) falls within the 5 percent change allowed by FDER.

The results of Mechanical Integrity Tests (MITs) conducted on Injection Wells IW-1, IW-2, IW-3, and IW-5 located at the City of Fort Lauderdale's George T. Lohmeyer Waste Water Treatment Plant have demonstrated that the requirements for both Part 1 (internal) and Part 2 (external) mechanical integrity have been satisfactorily met as set forth in Florida Administrative Code 17.28.

INTRODUCTION

Mechanical Integrity Tests (MITs) were conducted on the Class I Municipal Injection Wells IW-1, IW-2, IW-3, and IW-5 located at the City of Fort Lauderdale's George T. Lohmeyer Waste Water Treatment Plant. Mechanical Integrity testing was performed to demonstrate the internal and external mechanical integrity of these effluent disposal wells. Each injection well is cased with a nominal 24-inch-diameter steel to an approximate depth of 2,800 feet below land surface (bls). The wells are completed with open-hole construction to an approximate depth of 3,500 feet bls. Injection Well IW-3 is completed to an approximate depth of 4,000 feet bls. Further details on well construction can be found in the engineering report prepared by Hazen and Sawyer (1983).

MITs of the injection wells were conducted in accordance with Florida Administrative Code (FAC) Section 17.28 as set forth by Florida Department of Environmental Regulation (FDER). Testing included background geophysical logs, video television surveys, radioactive tracer surveys, and casing pressure tests. CH2M HILL prepared specifications for the MITs and provided resident observation services during testing. The City awarded the testing contract to Youngquist Brothers Inc., from Fort Myers, Florida. The contractor was given notice to proceed on November 28, 1990.

Black and white television surveys were performed by Florida Geophysical Inc. to visually observe and record the condition of the 24-inch casing and open hole of each injection well to total depth. Two sets of spring-loaded centralizers were installed on the body of the camera to keep it centralized in the casing and borehole. A logging rate of approximately 20 feet per minute (fpm) was used for each survey. The television surveys were witnessed by either Mr. Ed Rahrig or Ms. Margaret Highsmith of FDER-West Palm Beach. Prior to each survey, the well was flushed with potable

water to ensure a clear picture. For confirmation purposes, uphole surveys were also conducted from the base of the casing to pad level. Reports of the video surveys are included in Appendix A.

Radioactive tracer surveys (RTS) were conducted on each injection well by Schlumberger Well Services, Inc. These surveys were used to evaluate the integrity of the steel casing and the grout seal around the base of the 24-inch final casing in each injection well. The radioactive tracer was handled by Schlumberger personnel in accordance with state and federal regulations. An FDER representative (Ms. Margaret Highsmith, FDER-West Palm Beach) was onsite for the RTS activities.

Background geiger counter site surveys, conducted by Schlumberger personnel, indicated readings of less than 0.02 millirhems per hour (mR/hr) prior to removal of the tracer material from its carrying case. Similar readings were recorded at each site after completion of the work. Background and final geiger counter surveys for each well site are contained in Appendix B. Next, a background gamma ray log was conducted from the total depth of each well to 10 feet below the top of the wellhead. This survey also delineated the base of each casing using a Casing Collar Locator (CCL). For the purposes of this report, the casing collar locator will be used to establish base of casing depths. Small discrepancies (generally 1 to 2 feet) in the casing depths may occur between the caliper log, video survey, and casing collar locator due to differences in measurement error.

The radioactive isotope used to trace the fluid during the RTS was Iodine 131, which has a half-life of approximately 8.1 days. The tracer fluid was placed in a tool equipped with upper and lower ejector ports and upper, middle, and lower gamma detectors (Figure 1). The upper detector is positioned above the upper ejector port and the middle and lower detectors are positioned below the lower ejector port.

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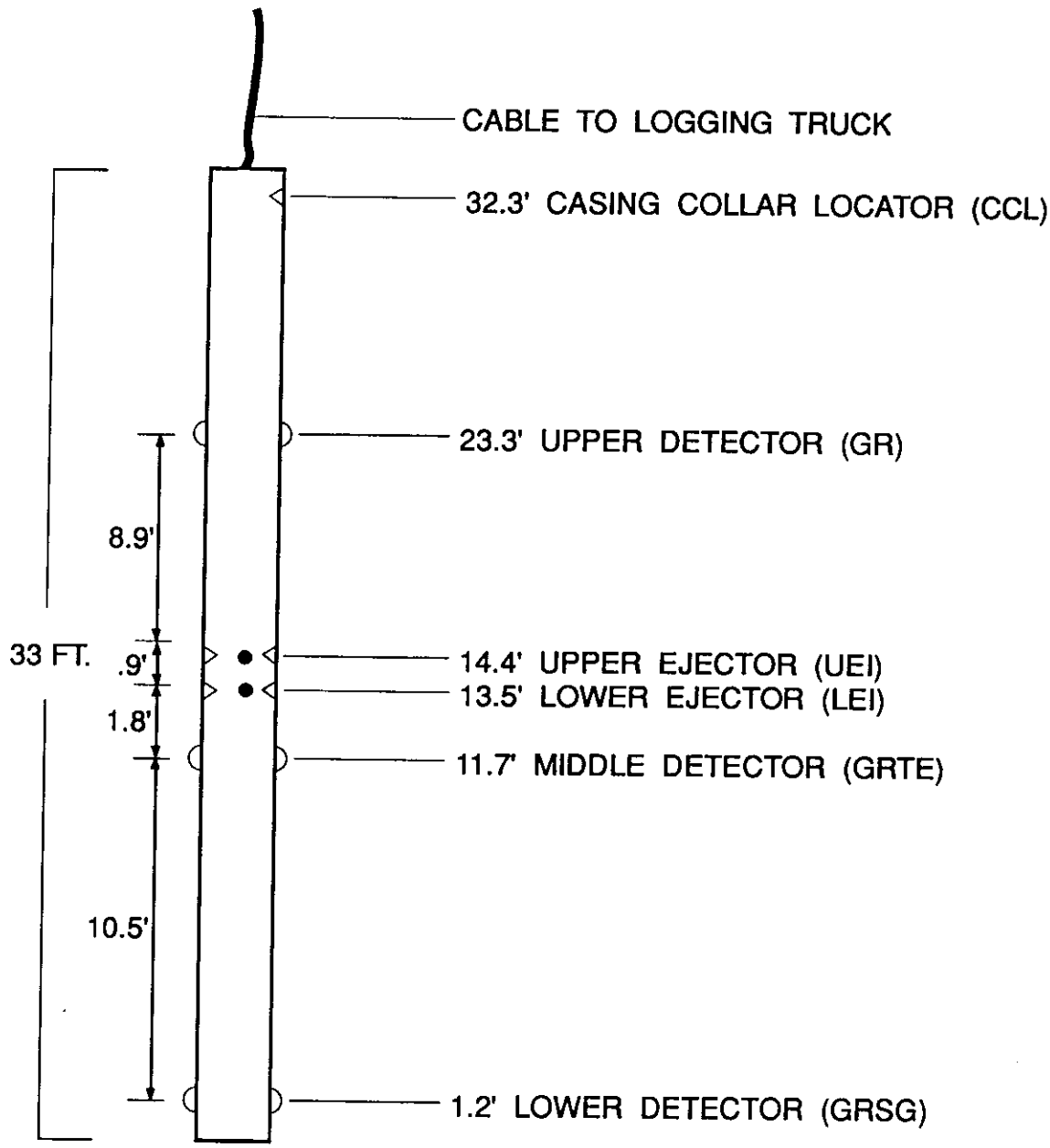

NOTE: All Measurements Referenced to Bottom of Logging Tool

FIGURE 1
Schlumberger Radioactive Tracer Tool

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Static and dynamic ejections were conducted at each well to test the integrity of the lower casing and cement seals. During the testing of each well, a total of 40 cm^3 of tracer fluid was ejected from the upper and lower ejector ports. A total radiation level of 0.5 to 2 millicuries was ejected during each static or dynamic test. Multiple ejections were made under static and flowing conditions to confirm the repeatability of the tests. To conclude the radioactive tracer surveys, a final gamma log was conducted from the base of each well to 10 feet below the top of the casing. Gamma and RTS logs are contained in Appendix C. Each of the logging activities is identified by the File number at the top and bottom of each log segment. The clock times during which the logs were run are noted for each file.

Casing pressure tests were performed on each injection well to test for internal mechanical integrity. Approximately 24,000 pounds of salt were mixed with potable water on site and pumped into each well to control artesian flow. Wellhead piping was then removed to allow access into the well for hydraulic jetting and pressure testing.

The lower 60 feet of the casing was then jetted with potable water for approximately 4 hours while slowly lowering and turning the jetting tool. After jetting was complete, the tool was removed and an inflatable packer with 2-inch-diameter tubing was lowered into the well and inflated near the base of the casing. With the wellhead sealed, the casing was pressurized to 140 psig with water for testing. A zero to 200 psig pressure gauge was used to measure pressure during the one-hour casing pressure test. The gauge was calibrated on November 29, 1990. A copy of the calibration certificate is provided in Appendix D. Pressure testing was performed in accordance with FDER regulations that require the final casing to be pressure tested at 1.5 times the expected operating pressure for one hour with a test tolerance of +/- 5 percent. Pressure readings were recorded at 5-minute intervals during the one hour test period. Each pressure test was observed by an FDER representative (Mr. Bawo

Okome or Ms. Margaret Highsmith, FDER-West Palm Beach) who was present as the casing was filled with water, pressurized, and depressurized at the completion of the test. Copies of the pressure test data sheets for each well are contained in Appendix E. After each pressure test was accepted by FDER, the packer was deflated and removed from the well. Finally, the wellhead was reassembled and the well was returned to service.

IW-1

GEOPHYSICAL LOGGING

Caliper and temperature geophysical logs were performed on injection well IW-1 on February 23, 1990. The caliper log confirmed the total depth of the well recorded by the driller (3,520 feet) at approximately 3,522 feet bls. A uniform borehole of approximately 23-inch diameter was generally observed from the bottom of the well to the base of the casing identified at 2,799 feet bls. Large cavities were apparent from 2,940 feet bls to the base of the casing at 2,799 feet bls. From the base of the casing to land surface, the log indicates smooth 23-inch-diameter pipe with no obstructions.

The temperature log (run from land surface to a total depth of 3,522 feet bls) indicated a constant temperature of 83°F to a depth of 800 feet bls. From 800 feet bls to 3,200 feet bls, the temperature gradually decreased to approximately 54°F. The temperature remained relatively constant from 3,200 feet bls to the bottom of the well.

A fluid resistivity log (run with the temperature log) indicated uniform water quality to a depth of 2,870 feet bls, where a sharp shift towards lower resistivity occurred.

Water quality below 2,930 feet bls remained fairly constant to the bottom of the well with a small shift observed at 3,000 feet bls, corresponding to the shift in temperature.

No unusual conditions were observed on either the caliper or temperature logs for IW-1. Based on the temperature and fluid resistivity logs, it appears that the formation is not taking effluent below 3,020 feet bls.

VIDEO TELEVISION SURVEYS

A video survey was begun at 09:25 on December 6, 1990, at Injection Well IW-1. A potable water flow of 90 gallons per minute (gpm) was maintained throughout the survey to ensure a clear picture. The survey indicated no inconsistencies and the casing appeared in good condition. A scale build-up (presumably of organic material) was noted throughout the casing interior of the well. The material was easily scraped loose by the camera centralizers and fell down the borehole during the survey. Several casing joints were noted throughout the survey at various depths. The base of the casing was observed at a depth of 2,799 feet bls. Medium-to-large void spaces and horizontal and vertical fractures were observed at various depths throughout the open hole portion of the well. Recorded total depth of the well was 3,513 feet bls.

RADIOACTIVE TRACER SURVEYS

Background Gamma Log

A background gamma ray log was conducted on December 12, 1990, from the total depth of the well (3,518 feet bls) to 10 feet below the top of the wellhead. This segment is listed at the bottom of the geophysical log sheet as "File 1, 12-DEC-90 08:25." The log sheet shows four logs across the page as follows: upper gamma detector (GR), casing collar locator (CCL), lower gamma detector (GRSG), and

middle gamma detector (GRTE). This survey also delineated the base of the casing at 2,799 feet bls with the CCL.

Static Ejection No. 1

After completion of the background gamma log, the tool was lowered into the well so that the upper ejector was positioned 1 foot (2,800 feet bls) below the base of the final casing. Keeping the tool stationary, background gamma readings were recorded for each gamma detector so that tracer movement could be distinguished from natural gamma variations. A 2 millicurie slug was ejected from the upper ejector to initiate the test then gamma radiation was recorded for one hour. The output of the three gamma detectors after ejection is displayed in "File 4, 12-DEC-90 10:10 - 11:12."

This segment of the log records detector output (gamma counts/sec) over time; the vertical scale is 1.5 inches per minute with each division equal to 4 seconds. Approximately 3 minutes after ejection, the middle detector (GRTE) indicated increased gamma activity. The GRTE log appears to shows a decrease in gamma response but this is actually a result of data clipping (i.e., the recording instrumentation changes scale to accommodate the limited horizontal scale on the log). The lower and upper detectors indicated tracer detection about 24 and 32 minutes after ejection as shown in the GR and GRSG logs. After recording gamma radiation for one hour, the tool was repositioned upwards approximately 200 feet showing no evidence of tracer above a depth of 2,783 feet bls. This geophysical log is shown in the segment "File 5, 12-DEC-90 11:13 - 11:20." After the tool repositioning log, the injection well was flushed with 110,000 gallons of effluent to remove any remaining tracer from the base of the casing.

The log after flushing the casing is shown in the log segment "File 6, 12-DEC-90 13:35 - 13:45." This log shows that a tracer stain is observed at a depth of

approximately 2,796 feet bls. No tracer was detected above a depth of 2,778 feet bls. The results of the first static test indicate no upward migration of radioactive tracer.

Static Ejection No. 2

A second static test was conducted as shown in "File 7, 12-DEC-90 13:50 - 14:51." The tool was repositioned so that the upper ejector was one foot (2,798 feet bls) above the base of the casing. Background gamma readings were obtained from each gamma detector to distinguish tracer from natural gamma variations. A 2 millicurie slug of tracer was then ejected from the upper ejector port. After 2 minutes, the middle detector showed a decrease in gamma activity indicating tracer detection with clipped data (as observed in the first static ejection). At 7 minutes after ejection, the upper detector (GR) began showing higher gamma counts and quickly became saturated with tracer. The lower detector showed an increase in gamma activity 17 minutes following ejection.

Test results for the second static ejection were somewhat different than the first test. For instance, the GR log showed much quicker detection in the second static test where ejection occurred inside the casing. This difference may be the result of dispersion in areas of different volumes (i.e. casing and formation). After readings were obtained for approximately one hour, the tool was repositioned upward to 2,586 feet bls ("File 8, 12-DEC-90 14:52 - 14:59") showing no gamma activity above a depth of 2,762 feet bls on the GR log. Slightly higher gamma counts were noted on the GRSG log versus background. This phenomenon may be due to residual tracer picked up by the detector as the tool was raised through the tracer cloud during the repositioning sequence.

After the tool was repositioned, the injection well was flushed with approximately 50,000 gallons of effluent to remove any remaining tracer in the casing. A log after

the flush ("File 18, 12-DEC-90 16:19 - 16:26") shows staining at the point of ejection but no tracer was observed above 2,778 feet bls inside the casing on the GR log.

Dynamic Ejection No. 1

After completion of the second static test, the tool was set so that the lower ejector port was 10 feet (2,789 feet bls) above the base of the casing. A potable waterline was connected to the well to enable injection at a low flow rate for dynamic testing. After establishing a constant injection rate of 56 gpm, a 1 millicurie slug of tracer fluid was ejected from the lower ejector port and gamma activity was monitored for 15 minutes. The output of the three gamma detectors after ejection for the first two dynamic tests is displayed in "File 10, 12-DEC-90 16:39 - 17:40."

This segment of the log records detector output over time; the vertical scale is 1.5 inches per minute with each division equal to 4 seconds. The middle detector (GRTE), which is 1.8 feet below the lower ejector port, indicated high gamma activity almost immediately after ejection. Three minutes later, the lower detector (GRSG), which is 12.3 feet below the lower ejector port, became saturated with tracer. Movement of the tracer past the GRTE and GRSG is consistent with a fluid velocity of approximately 2.6 ft/min, equivalent to an injection rate of approximately 56 gpm in a 24-inch casing. The upper detector showed no increased radioactivity during this first dynamic ejection.

Dynamic Ejection No. 2

A second dynamic tracer ejection was performed 15 minutes after the first dynamic test at 16:55 and is also shown in File 10. As with Dynamic Ejection No. 1, the 1 millicurie slug of tracer fluid moved downward past the middle detector almost immediately after ejection and, 3 minutes later, past the lower detector. These results

are identical to the first dynamic ejection. Radiation levels were monitored for 45 minutes but did not exceed background levels with the upper detector.

Segment "File 11, 12-DEC-90 17:41 - 17:48," is the geophysical log of the tool running upward to 2,590 feet bls. Above a depth of 2,778 feet bls, this log shows no increase in gamma activity above background. This upper limit of tracer is within a foot of that found after flushing the casing in the first static test.

After repositioning the tool, the injection well was flushed with approximately 50,000 gallons of effluent to remove any remaining tracer in the casing. A log after the flush ("File 12, 12-DEC-90 18:51 - 18:58") indicates staining at the point of ejection (2,788 feet bls) but no tracer was observed higher than 2,778 feet bls inside the casing on the GR log. Accumulation of tracer at a depth of 2,778 feet bls indicates an adequate grout seal around the casing above this depth.

Static Ejection No. 3

Following the logging sequence after the flush, a third static test was conducted as shown in "File 13, 12-DEC-90 19:02 - 20:20" to verify static conditions inside the casing. The tool was repositioned so that the lower ejector was 69 feet (2,730 feet bls) above the base of the casing and left stationary for one hour. The rationale was to eject tracer at a depth above where tracer had previously been detected. Background gamma readings were obtained so that tracer detection could be distinguished from natural gamma variations. Next, a 0.5 millicurie slug was ejected from the lower ejector port. After 0.5 minutes, the middle detector showed an increase in gamma activity indicating tracer detection. About 15 minutes after ejection, the upper detector (GR) began showing higher gamma counts and quickly became saturated with tracer. The lower detector (GRSG) showed a more gradual increase in gamma activity beginning 17 minutes after ejection.

After readings were obtained for 77 minutes, the tool was repositioned upward to 2,590 feet bls ("File 14, 12-DEC-90 20:22 - 20:26") showing no gamma activity above a depth of 2,698 feet bls on the GR log. The slightly higher gamma count on the GRSG log is again probably due to residual tracer adhering to the detector as the tool was raised through the tracer cloud.

Following the log out of position, a fourth log was conducted under static conditions by lowering the tool from 2,560 feet bls to 2,900 feet bls as shown in "File 15, 12-DEC-90 21:00 - 21:10." The purpose of this log was to determine the amount of vertical dispersion that took place from the time of ejection. Under static conditions the dispersion curve should be bell shaped, which would indicate equivalent rates of tracer movement both up and down from 2,730 feet bls. The compressed GRSG log most clearly demonstrates this bell curve occurring at 2,730 feet bls. Therefore, it appears that there was no net vertical migration of tracer inside the casing.

Final Gamma Log

After completion of the static and dynamic tracer surveys, the tool was lowered to a depth of 3,263 feet bls in the open-hole portion of the well and the tool was emptied of all remaining tracer. The well was then flushed with effluent at an injection rate of approximately 9,000 gpm for 30 minutes to clear the well and tool of any residual tracer. Following the flush, a final gamma log was conducted from a total depth of 3,518 feet bls to 10 feet bls. This log was superimposed on the background gamma log. Segment "File 16, 12-DEC-90 21:57 - 23:15" displays gamma counts above the recorded background gamma radiation from a depth of 2,800 feet bls to 2,790 feet bls. This is attributed to a tracer stain remaining on the casing from the ejections and tracer movement up around the outside of the casing to the 2,778 foot bls depth. The survey above 2,778 feet bls showed no radiation levels above background. Upon completion of the RTS testing the well was brought back online.

CASING PRESSURE TEST

On February 28, 1991, a pressure test was conducted on injection well IW-1. Due to difficulty in seating the 30-inch ball valve on the transmission line, pressure testing of IW-1 had to be delayed until arrangements could be made by the City and the contractor to direct flow from the injection well. Using the bypass pipeline, the flow leaking past the 30-inch valve was diverted back to the headworks of the Waste Water Treatment Plant. While diverting the flow, the wellhead on IW-1 was removed and a 30-inch blind flange was installed on the transmission line.

Upon isolation of the injection well, the artesian head was lowered. The contractor then performed hydraulic jetting and set the packer at a depth of 2,765 feet bls. The packer was inflated to 400 psig and the casing pressurized to 140 psig. The casing pressure was monitored for one hour and pressure readings were taken every 5 minutes. A total pressure drop of 4.25 psig was recorded. This pressure loss is less than the 5 percent allowable loss established in FAC 17.28 as set forth by FDER standards for Part 1 MIT. A copy of the Engineers Field Report of this test is included in Appendix E.

IW-2

GEOPHYSICAL LOGGING

Caliper and temperature geophysical logs were run on injection well IW-2 on February 22, 1990. The caliper log indicated the bottom of the well at 3,522 feet bls. The original total depth recorded by the driller at time of construction was 3,525 feet bls. A relatively uniform borehole of approximately 23-inch diameter was observed from the bottom of the well to the base of the casing identified at 2,798 feet bls.

Large cavities were apparent at 3,290 feet bls; 3,020 feet bls; and from 2,960 feet bls to the base of the casing. From the base of the casing to land surface, the log indicated smooth 23-inch-diameter pipe with no obstructions.

The temperature log (run from land surface to a total depth of 3,522 feet bls) indicated a fairly constant temperature of approximately 83°F to a depth of 3,010 feet bls. At 3,010 feet bls, temperature decreased to approximately 72°F and remained constant down to 3,290 feet bls. At 3,290 feet bls, the temperature decreased to approximately 56°F. Below 3,460 feet bls, the temperature gradually decreased to approximately 53°F at the bottom of the well.

A fluid resistivity log (run with the temperature log) indicated a uniform water quality to a depth of 2,780 feet bls, where a shift towards lower resistivity occurred. Water quality below 3,030 feet bls remained fairly constant to the bottom of the well with the exception of a small shift observed at 3,290 feet bls, which corresponds to a shift in temperature.

No unusual conditions were observed on either the caliper or temperature logs for IW-2. Based on the temperature and fluid resistivity logs, it appears that the base of the injection zone occurs at 3,290 feet bls.

VIDEO TELEVISION SURVEYS

The video survey at Injection Well IW-2 was performed on December 5, 1990. A fresh water flow of 100 gpm was maintained throughout the survey to ensure a clear picture. The survey indicated no inconsistencies and the casing appeared in good condition. Mottled coloring and a scale build-up (presumably of organic material) were noted throughout the casing interior of the well. Casing joints were observed at various depths. The base of the casing was observed at a depth of 2,800 feet bls.

Medium-to-large void spaces and horizontal and vertical fractures were evident at various depths throughout the open hole portion of the well. The borehole varied between a smooth, uniform surface to one with large cavities and vugs. Total depth of the well was recorded as 3,518 feet bls.

RADIOACTIVE TRACER SURVEYS

Background Gamma Log

A background gamma ray log was conducted from the total depth of the well to 10 feet below the top of the wellhead on December 11, 1990. This segment is listed at the bottom of the geophysical log sheet as "File 1, 11-DEC-90 07:56 - 09:15." The log sheet shows four logs across the page as follows: upper gamma detector (GR), casing collar locator (CCL), lower gamma detector (GRSG), and middle gamma detector (GRTE). This survey also delineated the base of the casing at 2,798 feet bls with the GRTE.

Static Ejection No. 1

After completion of the background gamma log, the tool was lowered into the well and the upper ejector was positioned 1 foot (2,799 feet bls) below the base of the casing. Background gamma readings were recorded and a 2 millicurie slug was ejected from the upper ejector. The tool was left stationary for one hour while recording gamma output. The output of the three gamma detectors after ejection is displayed in "File 3, 11-DEC-90 09:33 - 10:38."

This segment of the log records detector output over time; the vertical scale is 1.5 inches per minute with each division equal to 4 seconds. Approximately 1 minute into the ejection, the middle detector (GRTE) indicated increased gamma activity.

The upper and lower detectors indicated increased gamma activity from the slug about 6 and 5 minutes after ejection, respectively. Detection by the upper and lower detectors at almost the same time indicates natural dispersion of tracer within the well. The lower detector quickly became saturated with tracer as shown in the GRSG log. After recording gamma radiation for one hour, the tool was repositioned upwards about 200 feet. This log indicates no evidence of tracer above a depth of 2,758 feet bls and is shown in the segment "File 4, 11-DEC-90 10:39 - 10:43." After the tool repositioning sequence, the injection well was flushed for 15 minutes with approximately 50,000 gallons of effluent to remove any tracer remaining in the casing.

The log after flushing the casing is shown in the log segment "File 5, 11-DEC-90 11:00 - 11:09." This log shows a tracer stain just above the base of the casing at 2,798 feet bls. No other indications of tracer were noted above this depth.

Static Ejection No. 2

Following the logging sequence after the flush, a second static test was conducted as shown in "File 6, 10-DEC-90 11:17 - 12:19." The tool was lowered so that the upper ejector was positioned one foot (2,797 feet bls) above the base of the casing and left stationary for one hour. Once again, background gamma readings were obtained from each gamma detector so that tracer movement could be distinguished from natural gamma variations. Next, a 2 millicurie slug was ejected from the upper ejector port. After 3 minutes, the middle detector indicated increasing gamma activity. At 12.5 minutes and 14 minutes, respectively, the lower and upper detectors began showing higher gamma counts. Both the upper and lower detectors became saturated with tracer fairly rapidly. After readings were obtained for approximately one hour, the tool was repositioned upward 200 feet. "File 7, 11-DEC-90 12:19 - 12:25" shows no tracer above the depth of 2,749 feet bls.

After repositioning the tool, the injection well was flushed for 15 minutes at a flow rate of approximately 9,000 gpm to remove any tracer remaining in the casing. A log after the flush ("File 8, 11-DEC-90 12:42 - 12:50") indicates staining near the point of ejection (2,797 feet bls) but no tracer was observed inside the casing above this depth.

Dynamic Ejection No. 1

Following the static tests, dynamic tests were conducted to verify integrity of the grout seal around the 24-inch casing. A potable waterline was connected to the injection well and an injection rate of 30 gpm was established. The tool was repositioned so that the lower ejector port was 10 feet above the bottom of the casing at a depth of 2,788 feet bls. Next, a 1 millicurie slug of tracer was ejected at 13:25 from the lower ejector port and gamma activity was monitored for 15 minutes. The output of the three gamma detectors after ejection is displayed in "File 9, 11-DEC-90 13:22 - 14:20."

This segment of the log records detector output over time; the vertical scale is 1.5 inches per minute with each division equal to 4 seconds. The middle detector (GRTE), which is 1.8 feet below the lower ejector port, indicated high gamma activity almost immediately after ejection. Five minutes later, the lower detector (GRSG), which is 12.3 feet below the lower ejector port, became saturated with tracer. Movement of the tracer past the GRTE and GRSG detectors below the lower ejector port is consistent with a fluid velocity of approximately 25 ft/min, equivalent to an injection rate of 33 gpm in a 24-inch casing. The upper detector showed no increased radioactivity during this first dynamic ejection, indicating no upward movement of tracer.

Dynamic Ejection No. 2

A second dynamic tracer (33 gpm) ejection was performed 18 minutes after the first flowing test at 13:40 and is also shown in File 9. As with Dynamic Ejection No. 1, the 1 millicurie slug of tracer fluid moved downward past the middle detector almost immediately after ejection and, 6 minutes later, past the lower detector. Radiation levels were monitored for 18 minutes but none higher than background were detected by the upper detector. This result indicates there has been no upward movement of tracer.

Dynamic Ejection No. 3

A third dynamic tracer ejection was conducted at 13:58 and is also shown in File 9. This final dynamic ejection was conducted at a flow rate of approximately 115 gpm with a 2 millicurie slug, effectively emptying the ejectors of tracer fluid. As with Dynamic Ejection No.'s 1 and 2, the tracer fluid moved downward past the middle detector almost immediately after ejection and, 2.3 minutes later, past the lower detector. No radiation levels higher than background were detected by the upper detector for the 30 minute monitoring period. Thus, no upward movement of tracer inside or outside the casing was implied.

Segment "File 10, 11-DEC-90 14:28-14:35," is the geophysical log of the tool running upward. Above the depth of 2,749 feet bls, the log showed no increased gamma activity above background. Accumulation of tracer at a depth of 2,749 feet bls indicates an adequate grout seal around the casing above this depth.

Final Gamma Log

After completion of the five tracer surveys, effluent was injected into the well at a rate of approximately 9,000 gpm for 16 minutes. Following the flush, a final gamma log was conducted from a total depth of 3,508 feet bls to 10 feet bls. This log was superimposed on the background gamma log. Segment "File 11, 11-DEC-90 14:58 - 16:14" shows gamma counts exceeding background from a depth of 2,800 feet bls to 2,784 feet bls. This is attributed to tracer stain remaining on the casing from the ejections. The survey above 2,748 feet bls showed no radiation levels above background.

Upon completion of the RTS, the well was brought back online and any remaining tracer was dispersed into the formation.

CASING PRESSURE TEST

On January 11, 1991, a casing pressure test was performed on injection well IW-2. The packer was set at a depth of 2,765 feet bls and inflated to 515 psi. The casing was then pressurized to 140 psig and monitored for one hour with pressure readings recorded at 5-minute intervals. Results of this pressure test indicated a pressure loss of 4 psig after one hour, representing a 3 percent change in pressure. This pressure drop is within the 5 percent change allowed by FAC 17-28 for Part 1 MIT. A copy of the Engineers Field Report of this test is included in Appendix E.

IW-3

GEOPHYSICAL LOGGING

Caliper and temperature geophysical logs were performed on injection well IW-3 on February 20, 1990. While running the caliper into the well, the tool hit an obstruction at 2,926 feet bls and could not proceed past this depth. The original total depth recorded by the driller at time of construction was 4,010 feet bls. A relatively uniform borehole of approximately 19-inch diameter was observed from the bottom of the well to 3,500 feet bls. At 3,500 feet bls, the diameter of the borehole increased to approximately 23 inches and remained relatively constant to the base of the casing identified at 2,800 feet bls. Two intervals of large cavities were apparent from 3,170 feet bls to 3,110 feet bls, and from 2,955 feet bls to the base of the casing. The log indicated smooth 23-inch-diameter pipe with no obstructions from the base of the casing to land surface.

The temperature log (run from land surface to a total depth of 3,940 feet bls) indicated a fairly constant temperature of approximately 83°F to a depth of 3,000 feet bls. From 3,000 feet bls to 3,135 feet bls, the temperature decreased to approximately 62°F and remained constant down to 3,285 feet bls. At 3,285 feet bls, the temperature decreased to approximately 61°F and remained constant to a depth of 3,480 feet bls. At 3,480 feet bls, the temperature decreased to approximately 54°F and gradually increased to 59°F at the bottom of the well.

A fluid resistivity log (run with the temperature log) indicated constant water quality to a depth of 2,890 feet bls, where a shift towards lower resistivity occured. At 3,130 feet bls, a sharp decrease in resistivity is observed. Below 3,130 feet bls, water quality remains fairly constant to the bottom of the well.

No unusual conditions were observed on either the caliper or temperature logs for IW-2. Based on the temperature and fluid resistivity logs, it appears that the base of the injection zone occurs at 3,130 feet bls.

VIDEO TELEVISION SURVEYS

The video survey was begun at 11:02 on December 4, 1990, at Injection Well IW-3. A potable water flow of 100 gpm was maintained throughout the survey to ensure a clear picture. The survey indicated no inconsistencies and the casing appeared in good condition. Mottled coloring and a scale build-up (presumably of organic material) were noted throughout the cased interior of the well. The base of the casing was observed at a depth of 2,798 feet bls compared to a 2,800 foot bls depth shown on construction details. A subsequent log (casing collar locator) identified the base of the casing at 2,801 feet bls. Medium-to-large void spaces and horizontal and vertical fractures were observed at various depths throughout the open hole portion of the well. The borehole varied between a smooth, uniform surface to one with large cavities and vugs capable of receiving significant effluent flows. Total depth of the well was observed to be 3,977 feet bls.

RADIOACTIVE TRACER SURVEYS

Background Gamma Log

A background gamma ray log was conducted from the total depth of the well (3,994 feet bls) to 10 feet below the top of the wellhead on December 10, 1990. This segment is listed at the bottom of the geophysical log sheet as "File 1, 10-DEC-90 12:02." The log sheet shows four logs across the page as follows: upper gamma detector (GR), casing collar locator (CCL), lower gamma detector (GRSG), and middle gamma detector (GRTE). This survey also delineated the base of the casing

at 2,801 feet bls with the CCL. The total depth differences between the caliper and the gamma ray log resulted from the caliper hitting an obstruction at that depth and not being able to proceed deeper.

The background and tracer log horizontal scales for the upper GR range from zero to 100 gamma API (GAPI) units and the vertical scale is 5 inches equal to 100 feet. The horizontal scales for the GRTE and GRSG detectors range from zero to 2,000 GAPI with a vertical scale of 5 inches equal to 100 feet.

Static Ejection No. 1

After completion of the background gamma log, the tool bottom was lowered into the well so that the upper ejector was positioned one foot (2,802 feet bls) below the base of the final casing. Next, background gamma readings were recorded from each gamma detector so that tracer movement could be distinguished from natural gamma variations. A 2 millicurie slug was ejected from the upper detector to conduct the test and the tool was left stationary for one hour. The output of the three gamma detectors after ejection is displayed in "File 2, 10-DEC-90 13:00 - 14:04."

This segment of the log records detector output over time; the vertical scale is 1.5 inches per minute with each division equal to 4 seconds. Approximately 2 minutes after ejection, the middle detector (GRTE) indicated increased gamma activity. The upper and lower detectors indicated increased gamma activity from the slug about 12 minutes after ejection and the detectors quickly became saturated with tracer as shown in the GR and GRSG logs. After recording gamma radiation for one hour, the tool was repositioned upwards approximately 200 feet. There was no evidence of tracer above a depth of 2,762 feet bls. This geophysical log is shown in the segment "File 3, 10-DEC-90 14:04 - 14:11." After repositioning the tool, the injection well was

flushed for 15 minutes at a flow rate of approximately 9,000 gpm to displace any tracer into the formation.

The log after flushing the casing is shown in the log segment "File 4, 10-DEC-90 14:33 - 14:41." This log shows a tracer stain at a depth of 2,802 feet bls. No other tracer was detected inside the casing above this depth. The results of the first static test indicate no upward migration of radioactive tracer.

Static Ejection No. 2

Following the logging sequence after the flush, a second static test was conducted as shown in "File 5, 10-DEC-90 14:53 - 15:06." The tool was repositioned so that the upper ejector was one foot (2,800 feet bls) above the base of the casing and left stationary for one hour. Once again, background gamma readings were obtained from each gamma detector so that tracer movement could be distinguished from natural gamma variations. Next, a 2 millicurie slug was ejected from the upper ejector port. After 1 minute, the middle detector indicated increasing gamma activity. At approximately 10 minutes, the lower and upper detector began showing higher gamma counts. The increase in counts did not occur as quickly as during the first static release. Instead, a gradual increase in gamma radiation was noted. After readings were recorded for about one hour, the tool was repositioned upward ("File 6, 10-DEC-90 15:57 - 16:03") showing no gamma activity above a depth of 2,788 feet bls, which confirmed the previous test results.

The injection well was then flushed for 15 minutes at an injection rate of approximately 9,000 gpm to remove any tracer remaining in the casing. A log after the flush ("File 7, 10-DEC-90 16:24-16:32") indicates staining at the point of ejection (2,800 feet bls) but no tracer was observed inside the casing above this depth.

Dynamic Ejection No. 1

After completion of the second static test, the tool position was adjusted so that the lower ejector port was 10 feet (2,791 feet bls) above the bottom of the casing. A fresh waterline was connected to the well to enable injection at a low flow rate for dynamic testing. After establishing a constant flow rate of 30 gpm, a 1 millicurie slug of tracer fluid was ejected from the lower ejector port and gamma activity was monitored for 15 minutes. The output of the gamma detectors after ejection for the three dynamic tests is displayed in "File 8, 10-DEC-90 16:41 - 17:50."

This segment of the log records detector output over time; the vertical scale is 1.5 inches per minute with each division equal to 4 seconds. The middle detector (GRTE), which is 1.8 feet below the lower ejector port, indicated high gamma activity almost immediately after ejection. Four minutes later, the lower detector (GRSG), which is 12.3 feet below the lower ejector port, became saturated with tracer. Movement of the tracer past the GRTE and GRSG is consistent with an injection rate of approximately 35 gpm in a 24-inch casing. The upper detector showed no increase in gamma counts during this first ejection.

Dynamic Ejection No. 2

A second dynamic tracer (35 gpm) ejection was performed 15 minutes after the first low rate injection test at 16:59 and is also shown in File 8. As with Dynamic Ejection No. 1, the 1 millicurie slug of tracer fluid moved downward past the middle detector almost immediately after ejection and, 5 minutes later, past the lower detector. Radiation levels were monitored for 20 minutes but none higher than background were detected by the upper detector.

Dynamic Ejection No. 3

A third dynamic tracer ejection was conducted after the second low rate injection test at 17:20 and is also shown in File 8. This final dynamic ejection was conducted at a flow rate of 125 gpm with a 2 millicurie slug, effectively emptying the ejectors of tracer fluid. As with Dynamic Ejection No.'s 1 and 2, the tracer moved downward past the middle detector almost immediately after ejection and, one minute later, past the lower detector. No radiation levels higher than background were detected by the upper detector during the 30 minute monitoring period.

Segment "File 9, 10-DEC-90 17:51-17:56," is the geophysical log of the tool running upward. This log shows no gamma activity greater than background above the depth of 2,782 feet bls. Accumulation of tracer at a depth of 2,782 feet bls indicates an adequate grout seal around the casing above this depth.

Final Gamma Log

After completion of the static and dynamic tracer surveys, the well was flushed with effluent at a flow rate of approximately 9,000 gpm for 16 minutes. Following the flush, a final gamma log was conducted from a total depth of 3,994 feet bls to 10 feet bls. This log was superimposed on the background gamma log. Segment "File 10, 10-DEC-90 18:12 - 19:37" shows gamma counts exceeding background from a depth of 2,800 feet bls to 2,788 feet bls. This is attributed to tracer stain remaining on the casing from the ejections and tracer movement around the outside of the casing to 2,788 feet bls. The survey above 2,788 feet bls showed no radiation levels above background.

Upon completion of the RTS, the well was brought back online and any remaining tracer was allowed to disperse into the formation.

CASING PRESSURE TEST

A casing pressure test was conducted at injection well IW-3 on January 4, 1991. The packer was set at a depth of 2,794 feet bls and pressurized to 480 psig. With the packer inflated to 140 psig, pressure readings were recorded at 5-minute intervals for one hour. At the end of the test, a 5 psig decrease in pressure was observed. This represents an acceptable loss as set forth by FAC, Section 17-28 for a successful determination of Part 1 MIT.

IW-5

GEOPHYSICAL LOGGING

Caliper and temperature geophysical logs were performed on injection well IW-5 on February 20, 1990. The caliper log identified the bottom of the well at 3,472 feet bls. The original total depth recorded by the driller at the time of construction was 2,480 feet bls. A uniform borehole of approximately 23-inch diameter was observed from the bottom of the well to the base of the casing identified at 2,818 feet bls. Large cavities were apparent from 3,200 feet bls to 3,100 feet bls and from 2,930 feet bls to the base of the casing at 2,818 feet bls. From the base of the casing to land surface, the log indicates smooth 23-inch-diameter pipe with no obstructions.

The temperature log (run from land surface to a total depth of 3,470 feet bls) indicated a constant temperature of 83°F to a depth of 2,925 feet bls. From 2,925 feet bls to 2,975 feet bls, the temperature gradually decreased to approximately 71.5°F. The temperature below 2,975 feet bls remained relatively constant to a depth of 3,300 feet bls, where it decreased sharply to 55°F. Below 3,300 feet bls, the temperature gradually decreased to 53°F at the bottom of the well.

A fluid resistivity log (run with the temperature log) indicated constant water quality to a depth of 2,930 feet bls, where a shift towards less resistivity occurred. This shift corresponds to the shift observed on the temperature log. Water quality below 2,930 feet bls remained fairly constant to the bottom of the well with a small shift observed at 3,300 feet bls, again corresponding to a shift in temperature.

No unusual conditions were observed on either the caliper or temperature logs for IW-5. Based on the temperature and fluid resistivity logs, it appears that the base of the injection zone occurs at 3,300 feet bls.

VIDEO TELEVISION SURVEYS

The video survey was performed on December 3, 1990, at Injection Well IW-5. A potable water flow of 65 gpm was maintained throughout the survey to ensure a clear picture. The survey indicated no inconsistencies and the casing appeared in good condition. Mottled coloring and a scale buildup (presumably of organic material) were noted throughout the casing interior of the well. The base of the casing was observed at a depth of 2,815 feet bls. Medium-to-large void spaces and horizontal and vertical fractures were observed at various depths throughout the open hole portion of the well. Total depth of the well was observed to be 3,462 feet bls.

RADIOACTIVE TRACER SURVEYS

Background Gamma Log

A background gamma ray log was conducted from the total depth of the well to 10 feet below the top of the wellhead on December 7, 1990. This segment is listed at the bottom of the geophysical log sheet as "File 1, 07-DEC-90 11:00 - 12:20." The log sheet shows four logs across the page, as follows: upper gamma detector (GR),

casing collar locator (CCL), lower gamma detector (GRSG), and middle gamma detector (GRTE) as described previously. This survey also delineated the base of the casing with the CCL and GRTE at 2,817 feet bls.

Static Ejection No. 1

After completion of the background gamma log, the tool was lowered into the well to a depth of 2,832.4 feet bls so that the upper ejector was one foot (2,818 feet bls) below the base of the final casing. The tool was left stationary for approximately one hour. Next, background gamma readings were determined from each gamma detector so that tracer movement could be distinguished from natural gamma variations. A 2 millicurie slug was ejected from the upper ejector to begin the test. The output of the three gamma detectors after ejection is displayed in "File 2, 07-DEC-90 13:02 - 14:07."

This segment of the log records detector output over time; the vertical scale is 1.5 inches per minute with each division equal to 4 seconds. Approximately 2 minutes after ejection, the middle detector (GRTE) indicated increased gamma activity. The upper and lower detectors indicated increased gamma activity from the slug at approximately 9 and 11 minutes, respectively, after ejection. Detection at the upper detector may be due to natural dispersion while the bulk of the slug appeared to move downward as the detector became saturated. After recording radiation levels for one hour, the tool was repositioned upwards about 200 feet but showed no evidence of tracer above a depth of 2,787 feet bls on the GR log. This log is shown in the segment "File 3, 07-DEC-90 14:10 - 14:19." The lower detector, however, showed some gamma peaks that were inconsistent with the background log within this interval. This discrepancy indicates that some residual tracer may have adhered to the tool as the lower detector was raised through the tracer ejection point.

After the tool repositioning sequence, the injection well was flushed with fresh water for 15 minutes at a flow rate of approximately 100 gpm. The 30-inch valve on the injection well system was then opened for 10 minutes for additional flushing at a flow rate of 9,000 gpm to remove any tracer remaining in the casing. Seating this valve had been difficult in the past. A small ejection (50-millisecond shot) was performed at a depth of 2,850 feet bls in the open hole and monitored. Results of this test indicated no tracer movement and, therefore, the valve was considered properly closed.

As shown in the log segment "File 4, 07-DEC-90 15:39 - 15:48," the log indicates staining at a depth of 2,800 feet. Because tracer was not observed above a depth of 2,778 feet bls, the results of the first static test indicate no upward migration of radioactive tracer.

Static Ejection No. 2

Following the logging sequence after the flush, a second static test was conducted as shown in "File 6, 07-DEC-90 16:14 - 17:15." The tool was lowered so that the upper ejector was positioned one foot (2,816 feet bls) above the base of the casing. The tool was left stationary for one hour. Background gamma readings were recorded for each gamma detector so that tracer movement could be distinguished from natural gamma variations. A 2 millicurie slug was then ejected from the upper ejector port. After 4 minutes, the middle detector indicated increasing gamma activity. At 7 minutes and 8 minutes, respectively, the lower and upper detectors began showing higher gamma counts. Both detectors show gradual increases in gamma radiation initially, but as noted in the first static ejection, the lower detector became saturated with tracer much sooner. Because the upper and lower detectors show similar response times, the movement of tracer is attributed to natural dispersion within the well.

After monitoring gamma activity for approximately one hour, the tool was repositioned upward approximately 200 feet. Output from this log is contained in "File 7, 07-DEC-90 17:16 - 17:22." This log shows no tracer above 2,778 feet bls with the upper detector, confirming that there were no leaks in the casing. However, the lower detector again showed some gamma peaks that were inconsistent with the background log over this interval. These peaks, also observed during the first static ejection, may indicate that some residual tracer adhered to the tool as the lower detector was raised through the tracer ejection point.

The casing was then flushed with effluent for 15 minutes at a flow rate of approximately 9,000 gpm. The log segment "File 8, 07-DEC-90 17:40 - 17:46," indicates staining of the casing at a depth of 2,800 feet bls. Tracer was not observed above a depth of 2,778 feet bls. The results of the second static test indicate no upward migration of radioactive tracer.

Dynamic Ejection No. 1

After completion of the second static test, three dynamic high and low rate injection tests were conducted to verify integrity of the grout seal around the base of the 24-inch casing. The tool was positioned so that the lower ejector port was 10 feet (2,807 feet bls) above the bottom of the casing. A potable waterline was connected to the injection well and a flow rate of approximately 28 gpm was established for dynamic testing. Background gamma readings were obtained and a 1 millicurie slug of tracer fluid was ejected from the lower ejector port. The log of the three dynamic tests is displayed in "File 9, 07-DEC-90 18:01 - 19:00."

The log of the three dynamic tests records detector output over time; the vertical scale is 1.5 inches per minute with each division equal to 4 seconds. The middle detector (GRTE), which is 1.8 feet below the lower ejector port, indicated high

gamma activity almost immediately after ejection. Six minutes later, the lower detector (GRSG), which is 12.3 feet below the lower ejector port, indicated high gamma activity (i.e., the detector became saturated with tracer). Movement of the tracer past the GRTE and GRSG detectors below the lower ejector port is consistent with an injection rate of 38 gpm in a 24-inch casing. The upper detector showed an increase in radioactivity over time, but this increase may be due to accumulation of tracer outside the casing.

Dynamic Ejection No. 2

A second dynamic tracer ejection was conducted 14 minutes after the first dynamic test. Both the tool position and injection rate were the same as in the first dynamic test. As with Dynamic Ejection No. 1, a 1 millicurie slug of tracer fluid was ejected. The slug moved downward past the middle detector almost immediately after ejection and, 6 minutes later, past the lower detector. Because the lower detector showed residual high gamma counts from the first test, detection appears on the log as a relative increase in gamma activity. No radiation levels higher than background were detected by the upper detector. This result was consistent with the lack of upward movement around the outside of the casing.

Dynamic Ejection No. 3

A third dynamic tracer test was performed 15.5 minutes after Dynamic Ejection No. 2. This final dynamic ejection was conducted at a flow rate of 120 gpm with a 2 millicurie slug, effectively emptying the tool of tracer fluid. The tool was stationary throughout this test and radiation levels were monitored for 30 minutes. As with Dynamic Ejection No.'s 1 and 2, the tracer fluid moved downward past the middle detector almost immediately. Because the lower detector was saturated with tracer from the first two tests, the exact time of detection could not be determined. The

upper detector showed an increase in radioactivity after about 7 minutes, but like the first dynamic test, this is may be due to accumulation of tracer outside the casing.

Segment "File 10, 07-DEC-90 19:07 - 19:41," is the geophysical log after the tool has been run upward approximately 200 feet. Above the depth of 2,777 feet bls, this log shows no gamma activity above background with the upper gamma detector (GR). This test confirms an adequate cement seal around the casing above a depth of 2,777 feet bls. This is consistent with the upward limit of tracer movement noted in the previous logs.

Final Gamma Log

After completing the tracer surveys, the tool was lowered to the open-hole portion of the well and the 30-inch valve opened so that any remaining tracer would be flushed from the tool. Following the flush, a final gamma log was conducted from a total depth of 3,473 feet bls to 10 feet bls. Segment "File 11, 07-DEC-90 19:41 - 21:05" displays gamma levels above background from a depth of 2,800 feet bls to 2,777 feet bls. This is attributed to tracer stain on the casing. Also, the final gamma log shows normal background gamma radiation above 2,777 feet bls, which corresponds to the depth where tracer accumulated around the outside of the casing. Residual traces of ejected tracer were observed in the open hole from 2,850 to 2,900 feet bls; 3,020 feet bls; and below 3,200 feet bls.

Upon completion of the RTS the well was brought back on line and any tracer remaining in the well was dispersed into the formation.

CASING PRESSURE TEST

The casing pressure test was conducted at injection well IW-5 on December 19, 1990. The packer was set at a depth of 2,794 feet bls and inflated to 430 psig. The casing was then pressurized to 140 psig. Pressure readings were recorded at 5-minute intervals for one hour. At the end of the test, a pressure decrease of 2.75 psi was observed. This represents a decrease in casing pressure of less than 2 percent and, therefore, was within the requirements set forth in the FAC, Section 17-28 for a successful determination of Part 1 MIT.

Results of each pressure test indicated that the casings have internal mechanical integrity.

SUMMARY AND CONCLUSIONS

The results of Mechanical Integrity Tests (MITs) conducted on Injection Wells IW-1, IW-2, IW-3, and IW-5 located at the City of Fort Lauderdale's George T. Lohmeyer Waste Water Treatment Plant have demonstrated that the requirements for both Part 1 (internal) and Part 2 (external) mechanical integrity have been satisfactorily met as set forth in Florida Administrative Code 17.28. Testing included background geophysical logs, video television surveys, radioactive tracer surveys, and casing pressure tests.

This report can be submitted to the Florida Department of Environmental Regulation as part of the City's application to operate its Class I Injection Well System. Under current operational requirements, testing will not be necessary for 5 years following the conclusion of testing (February 28, 1991) performed under this contract.

Appendix A

VIDEO SURVEY REPORTS

IW - 1
VIDEO SURVEY REPORT
VIDEO TAPES ARE PRESENTED UNDER SEPARATE COVER

RECORD OF UNDERWATER TV SURVEY

Project: Mechanical Integrity Testing of IW-1, IW-2, IW-3 and IW-5 for the City of Ft. Lauderdale
Well: IW-1
Survey By: Florida Geophysical Inc.

Survey Date: 12/6/90 Total Depth: 3513 Feet

Witnessed By: Mr. Rahrig/FDER- West Palm Beach, B. Ziegler, P. Kwiatkowski/CH2M Hill
Reviewed By: Sean T. Skehan Date:
Remarks: 24-inch diameter casing; Survey rate set at 20 ft per hour
Centralizers set to 24 inch casing

Depth in Feet From	To	Observations
0	100	No unusual conditions noted, some scale on casing
100	200	As Above
200	300	As Above
300	400	As Above
400	500	As Above
500	600	As Above
600	700	As Above
700	800	As Above
800	900	As Above
900	1000	As Above
1000	1100	As Above
1100	1200	As Above
1200	1300	As Above
1300	1400	As Above
1400	1500	As Above
1500	1600	As Above
1600	1700	As Above
1700	1800	As Above
1800	1900	As Above
1900	2000	As Above
2000	2100	As Above
2100	2200	As Above
2200	2300	As Above with increased buildup of percipitate
2300	2400	As Above
2400	2500	As Above
2500	2600	As Above
2600	2700	As Above
2700	2800	As above, cement ports at 2794
2800	2900	Base of casing at 2800', smooth borehole
2900	3000	Small vugs and fractures, uphole flow observed at 2925, very silty
3000	3100	Large cavities at 3019', picture clears, source of flow.
3100	3200	Mostly uniform 23" diameter borehole, some large vugs

Depth in Feet		
From	To	Observations
3200	3300	As Above, some uphole flow at 3275
3300	3400	As Above, low rate flow still observed.
3400	3500	As Above
3500	3513	Total depth observed at 3513, previously recorded depth was 3520', FDER verified that no unusual conditions were observed on the survey.

IW - 2
VIDEO SURVEY REPORT
VIDEO TAPES ARE PRESENTED UNDER SEPARATE COVER

RECORD OF UNDERWATER TV SURVEY

Project: Mechanical Integrity Testing of IW-1, IW-2, IW-3 and IW-5 for the City of Ft. Lauderdale
Well: IW-2
Survey By: Florida Geophysical Inc.

Survey Date: 12/5/90 Total Depth: 3518 Feet

Witnessed By: Ms. Highsmith/FDER- West Palm Beach, Sean T. Skehan and E. Pomar/CH2M Hill
Reviewed By: Sean T. Skehan Date:
Remarks: 24-inch diameter casing; Survey rate set at 25 ft per hour
Centralizers set to 24 inch casing

Depth in Feet From	To	Observations
0	100	Some apparent growth on casing, mottled appearance; no unusual conditions noted.
100	200	As Above, no unusual conditions noted, verified condition with Ms. Highsmith
200	300	As Above
300	400	As Above
400	500	As Above
500	600	As Above
600	700	As Above
700	800	As Above
800	900	As Above
900	1000	As Above
1000	1100	As Above
1100	1200	As Above
1200	1300	As Above
1300	1400	As Above
1400	1500	As Above
1500	1600	As Above
1600	1700	As Above
1700	1800	As Above
1800	1900	As Above
1900	2000	As Above
2000	2100	Increased suspended solids from ~ 2200'
2100	2200	As Above
2200	2300	As Above
2300	2400	As Above
2400	2500	As Above
2500	2600	As Above
2600	2700	As Above
2700	2800	As Above, observed base of casing at 2800'
2800	2900	Cemented sheath to ~ 2820', "chicken wire" appearance, consistent gauge borehole
2900	3000	At ~ 2920' becomes cloudy, poor visibility, uphole flow, suspended material
3000	3100	3012 large cavity, poor visibility, observed some small cavities and vugs
3100	3200	Poor visibility, some small cavities and vugs

Depth in Feet		
From	To	Observations
3200	3300	3241'- large cavity, 3275-down hole flow, 3290 large cavity, clear picture with uphole flow
3300	3400	Uniform borehole w/vugs and cavities, uphole flow > 1'/sec
3400	3500	3400-3410 large cavity, considerable flow, 3469 large cavity w/flow, 3486 large fractures, good clear picture
3500	3518	3518 tag bottom
3295	2600	Relog well for verification at FDER request, no unusual conditions noted, FDER verified that no unusual conditions were observed on survey.

IW - 3
VIDEO SURVEY REPORT
VIDEO TAPES ARE PRESENTED UNDER
SEPARATE COVER

RECORD OF UNDERWATER TV SURVEY

Project: Mechanical Integrity Testing of IW-1, IW-2, IW-3 and IW-5 for the City of Ft. Lauderdale
Well: IW-3
Survey By: Florida Geophysical Inc.

Survey Date: 12/4/90 Total Depth: 3977 Feet

Witnessed By: Ms. Highsmith/FDER- West Palm Beach, Sean T. Skehan/CH2M Hill
Reviewed By: Sean T. Skehan Date:
Remarks: 24-inch diameter casing; Survey rate set at 25 ft per hour
Centralizers set to 24 inch casing

Depth in Feet From	To	Observations
0	100	Spots on casing, clear picture
100	200	No unusual conditions observed
200	300	As Above
300	400	As Above
400	500	As Above
500	600	As Above
600	700	As Above
700	800	As Above
800	900	As Above
900	1000	As Above
1000	1100	As Above.
1100	1200	As Above
1200	1300	As Above
1300	1400	As Above.
1400	1500	As Above, casing appears smooth in some areas
1500	1600	As Above
1600	1700	As Above
1700	1800	As Above
1800	1900	As Above
1900	2000	As Above
2000	2100	As Above
2100	2200	As Above
2200	2300	As Above
2300	2400	As Above, replace videotape at 2350'
2400	2500	As Above, suspended solids gradually increasing
2500	2600	As Above
2600	2700	As Above
2700	2800	As Above, cement appears to be on casing at 2770, 2798 base of casing
2800	2900	Large diameter hole, camera hangs to one side
2900	3000	2940 uphole flow, 3020' picture becomes obscure, very dark
3000	3100	Stop at 3156', observe uphole flow, low visibility, 3070 some claring
3100	3200	3120 large cavity, 3125 picture becomes clear, generally gauge hole with factures and cavities.
3200	3300	Very uniform borehole, few cavities, 3273 up hole flow, 3279 base of flow

Depth in Feet		
From	To	Observations
3300	3400	3309 color change of formation, some mottling, 3322 formation more broken
		3344' uniform borehole, w some factures and small cavities
3400	3500	3470 up hole flow, 3482' large cavity from which flow originated
3500	3600	Uniform borehole as large fractures, 3513 large cavity, 3590 formation very white
3600	3700	Uniform borehole, few fractures
3700	3800	As Above
3800	3900	As Above
3900	3977	3914 becoming cloudy, 3927 large cavity, 3977-TD
2600	2700	At request of FDER this section of the well was resurveyed for background on RTS logs, no
		unusual conditions were observed, FDER verified that no unusual conditions were observed on survey

IW - 5
VIDEO SURVEY REPORT
VIDEO TAPES ARE PRESENTED UNDER SEPARATE COVER

RECORD OF UNDERWATER TV SURVEY

Project: Mechanical Integrity Testing of IW-1, IW-2, IW-3 and IW-5 for the City of Ft. Lauderdale
Well: IW-5
Survey By: Florida Geophysical Inc.

Survey Date: 12/3/90 Total Depth: 3472 Feet

Witnessed By: Ms. Highsmith/FDER- West Palm Beach, Bart Ziegler/CH2M Hill
Reviewed By: Sean T. Skehan Date:
Remarks: 24-inch diameter casing; Survey rate set at 20 ft per hour
Centralizers set to 24 inch casing

Depth in Feet From	To	Observations
0	100	No unusual conditions noted, some scale on casing
100	200	As Above
200	300	As Above
300	400	As Above
400	500	As Above
500	600	As Above
600	700	As Above
700	800	As Above
800	900	As Above
900	1000	As Above
1000	1100	As Above
1100	1200	As Above
1200	1300	As Above
1300	1400	As Above
1400	1500	As Above
1500	1600	As Above
1600	1700	As Above
1700	1800	As Above
1800	1900	As Above
1900	2000	As Above
2000	2100	As Above
2100	2200	As Above with increased buildup of scale
2200	2300	As Above
2300	2400	As Above
2400	2500	As Above
2500	2600	As Above
2600	2700	As Above
2700	2800	As above with some cement on casing
2800	2900	Cement ports at 2810' base of casing at 2815', uphole flow at 2896'
2900	3000	High rate of uphole flow, poor visibility
3000	3100	Flow decreases at 3040', visibility improved
3100	3200	Increased uphole flow 3108', large cavity at 3168'

Depth in Feet		
From	To	Observations
3200	3300	Continued uphole flow to 3280'
3300	3400	Large cavity at 3301, flow stops below cavity, smooth borehole with vugs
3400	3472	Borehole with small vugs, base of well at 3472', 8 feet less than recorded depth
2820	2104	Verified condition through different intervals of casing, FDER verified that no unusual conditions were observed on survey.

Appendix B
SCHLUMBERGER GEIGER COUNTER SURVEY REPORTS

WELL RECORD

Company: Youngquist Brothers Drilling

Well: G.T.Lohmeyer IW No.1

Location: G.T.Lohmeyer Plant - Port Everglades, Florida

Date: 12 Dec 90

Isotope: I^{131} Assay Date: 6 Dec 90

Total mci brought to site: 7

Total mci used at site: 7

Total volume tracer mixed (cc): 50

Area survey before job (mrem/hr): < .015

Area survey after job (mrem/hr): < .015

Schlumberger personnel: 1. Miller

2. Kuhn

3.

Survey meter no.: 290

Calibration date: 9 Nov 90

Surveyed by: Miller

Remarks: Area Clean - Nothing Unusual

WELL RECORD

Company: Youngquist Brothers Drilling

Well: G.T.Lohmeyer IW No.2

Location: G.T.Lohmeyer Plant - Port Everglades, Florida

Date: 11 Dec 90

Isotope: I^{131} Assay Date: 6 Dec 90

Total mci brought to site: 14

Total mci used at site: 7

Total volume tracer mixed (cc): 50

Area survey before job (mrem/hr): < .02

Area survey after job (mrem/hr): < .02

Schlumberger personnel: 1. Miller

2. Kuhn

3.

Survey meter no.: 290

Calibration date: 9 Nov 90

Surveyed by: Miller

Remarks: Area Clean - Nothing Unusual

WELL RECORD

Company: Youngquist Brothers Drilling

Well: G.T.Lohmeyer IW No.3

Location: G.T.Lohmeyer Plant - Port Everglades, Florida

Date: 1Ø Dec 9Ø

Isotope: I^{131} Assay Date: 6 Dec 9Ø

Total mci brought to site: 22

Total mci used at site: 8

Total volume tracer mixed (cc): 5Ø

Area survey before job (mrem/hr): < .Ø2

Area survey after job (mrem/hr): < .Ø2

Schlumberger personnel: 1. Miller

2. Kuhn

3.

Survey meter no.: 29Ø

Calibration date: 9 Nov 9Ø

Surveyed by: Miller

Remarks: Area Clean - Nothing Unusual

WELL RECORD

Company: Youngquist Brothers Drilling

Well: G.T.Lohmeyer IW No.5

Location: G.T.Lohmeyer Plant - Port Everglades, Florida

Date: 7 Dec 90

Isotope: I^{131} Assay Date: 6 Dec 90

Total mci brought to site: 30

Total mci used at site: 8

Total volume tracer mixed (cc): 50

Area survey before job (mrem/hr): .01/.02

Area survey after job (mrem/hr): .01/.02

Schlumberger personnel: 1. Schuler

2. Kuhn

3.

Survey meter no.: 290

Calibration date: 9 Nov 90

Surveyed by: Schuler

Remarks: Area Clean.....

Appendix C

RADIOACTIVE TRACER SURVEY LOGS

Appendix D

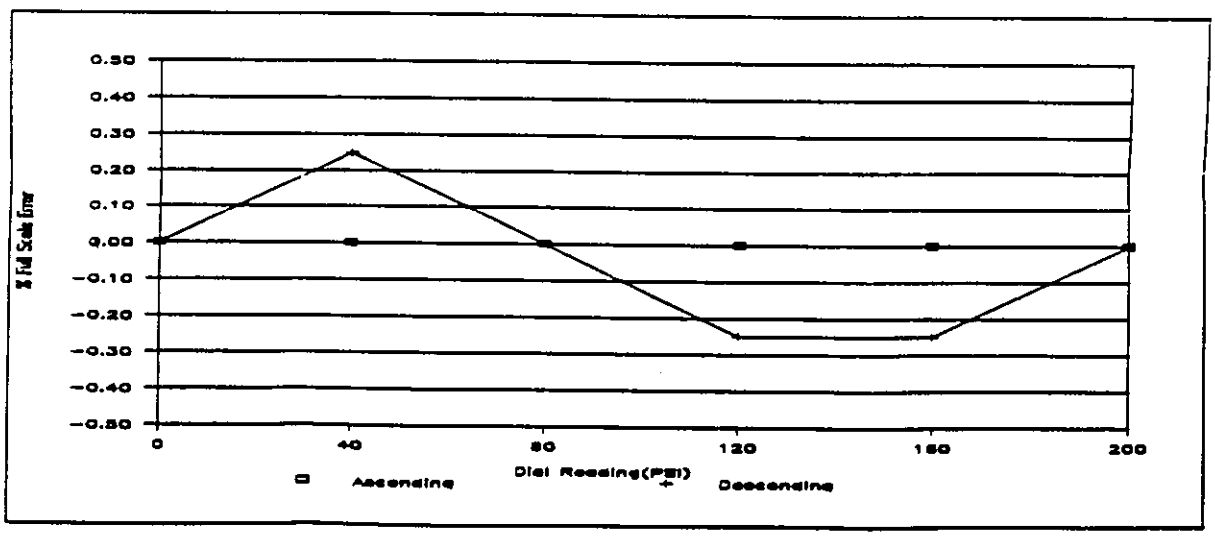
PRESSURE GAUGE CALIBRATION CERTIFICATE

CALIBRATION CHART

Date: 11/29/90
Client: CH2MHILL
P.O. No: GNV6172-AO

Instrument: 60-1082AS-02L
Manufacturer: Ashcroft
Range: 0/200 PSI
Accuracy: ±.25% F.S.

Pressure Input	*Output*	*% F.S. Error*
0.0	0.0	0.00
40.0	40.0	0.00
80.0	80.0	0.00
120.0	120.0	0.00
160.0	160.0	0.00
200.0	200.0	0.00
160.0	160.5	0.25
120.0	120.0	0.00
80.0	79.5	-0.25
40.0	39.5	-0.25
0.0	0.0	0.00



SOLARES FLORIDA CORPORATION
Tampa, Florida

Appendix E

CASING PRESSURE TEST DATA SHEETS

IW - 1
CASING PRESSURE TEST DATA

IW-1
Casing Pressure Test
Data Sheet

Client: City of Fort Lauderdale

Injection Well: IW-1

Date: February 28, 1991

Resident Observers: Sean Skehan/CH2M HILL

FDER Representative: Ms. Margaret Highsmith/West Palm Beach

Packer Setting: 2,765 feet below pad level

Bottom of Casing: 2,799 feet below pad level

Casing Pressure: 140 psi

Packer Pressure: 515 psi

Time	Lapse Time Minutes	Casing Pressure (psi)	Packer Pressure (psi)	Comment
21:00				Bolt up header assembly, flange to flange.
21:06	0	140.0	476	Pressurize.
21:11	5	139.5		Start test.
21:16	10	139.0		
21:21	15	138.5	476	
21:26	20	138.0		
21:31	25	137.75		
21:36	30	137.5	475	
21:41	35	137.0		
21:46	40	136.75		
21:51	45	136.5	474	
21:56	50	136.25		
22:01	55	136.0		
22:06	60	135.75	473	Test complete. Bleed off pressure.

IW - 2
CASING PRESSURE TEST DATA

IW-2
Casing Pressure Test
Data Sheet

Client: City of Fort Lauderdale

Injection Well: IW-2

Date: January 11, 1991

Resident Observers: Sean Skehan/CH2M HILL

FDER Representative: Mr. Bawo Okome/West Palm Beach

Packer Setting: 2,798 feet below pad level

Bottom of Casing: 2,799 feet below pad level

Casing Pressure: 140 psi

Packer Pressure: 515 psi

Time	Lapse Time Minutes	Casing Pressure (psi)	Packer Pressure (psi)	Comment
11:00				Bolt up header assembly, flange to flange.
11:45				Pressurize casing.
11:51	0	140.0	515	Start test.
11:56	5	139.5	515	
12:01	10	139.0		
12:06	15	138.5	510	
12:11	20	138.0	510	
12:16	25	138.0	509	
12:21	30	137.5	509	
12:26	35	137.5	507	
12:31	40	137.0	506	
12:36	45	136.5	504	
12:41	50	136.5		
12:46	55	136.5	502	
12:51	60	136.05	502	Test complete. Bleed off pressure.

IW - 3
CASING PRESSURE TEST DATA

IW-3
Casing Pressure Test
Data Sheet

Client: City of Fort Lauderdale

Injection Well: IW-3

Date: January 4, 1991

Resident Observers: Sean Skehan/CH2M HILL

FDER Representative: Mr. Bawo Okome/West Palm Beach

Packer Setting: 2,794 feet below pad level

Bottom of Casing: 2,800 feet below pad level

Casing Pressure: 140 psi

Packer Pressure: 480 psi

Time	Lapse Time Minutes	Casing Pressure (psi)	Packer Pressure (psi)	Comment
07:00				Bolt up header assembly, flange to flange.
07:16				Pressurize casing.
07:20	0	140.0	480	Start of Test.
07:25	5	139.5	478	Occasional drip in gauge fitting.
07:30	10	138.5	478	Hand tightened.
07:35	15	138.0	476	
07:40	20	137.5	474	
07:45	25	137.0	470	
07:50	30	136.75	470	
07:55	35	136.5	469	
08:00	40	136.0	467	
08:05	45	135.75	467	
08:10	50	135.5		
08:15	55	135.0	465	Test complete.
08:20	60	135.0		Bleed Off pressure.

IW - 5
CASING PRESSURE TEST DATA

IW-5
Casing Pressure Test
Data Sheet

Client: City of Fort Lauderdale

Injection Well: IW-5

Date: December 19, 1990

Resident Observers: Sean Skehan, Peter Kwiatkowski/CH2M HILL

FDER Representative: Mr.Bawo Okome/West Palm Beach

Packer Setting: 2,794 feet below pad level

Bottom of Casing: 2,818 feet below pad level

Casing Pressure: 140 psi

Packer Pressure: 431 psi

Time	Lapse Time Minutes	Casing Pressure (psi)	Packer Pressure (psi)	Comment
15:00				Weld temporary steel plate onto wellhead.
15:25				Pressure casing.
15:30	0	140.0	431	Start of Test.
15:35	5	139.5	431	
15:40	10	139.0	431	
15:45	15	138.75	431	
15:50	20	138.5	430	
15:55	25	138.5	429	
16:00	30	138.25	429	
16:05	35	138.0	429	
16:10	40	138.0	429	
16:15	45	137.75	428	
16:20	50	137.5	424	
16:25	55	137.5	422	
16:30	60	137.25	422	Test Complete. Bleed off pressure.

Appendix F
GEOPHYSICAL LOGS

IW - 1
GEOPHYSICAL LOGS
CALIPER
TEMPERATURE

IW - 2
GEOPHYSICAL LOGS
CALIPER
TEMPERATURE

IW - 3
GEOPHYSICAL LOGS
CALIPER
TEMPERATURE

IW - 5
GEOPHYSICAL LOGS
CALIPER
TEMPERATURE