City of Miramar

Final Report for Major Modification of

West Water Treatment Plant Injection Well System

153722-003-UC (125256-007-UO)

Book 1 of 2
January 2006

MWH

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LIST OF ABBREVIATIONS

API	American Petroleum Institute
ASTM	American Society of Testing Materials
bpl	Below pad level
CCP	Central control panel
CBL	Cement bond log
DZMW-1	Dual Zone Monitoring Well No. 1
Degrees F	Degrees Fahrenheit
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FRP	Fiberglass Reinforce Tubing
ft	Feet
ft/sec	Feet per second
ft/min	Feet per minute
gpm	Gallons per minute
IW-1	Injection Well No. 1
IW-2	Injection Well No. 2
LAF	Log after flush
LOP	Log out of position
MCC	Motor Control Center
MG	Million gallons
MGD	Million gallons per day
mg/L	Milligrams per liter
MMI	Man Machine Interface
MIT	Mechanical Integrity Testing
MOR	Monthly Operating Report
mS/cm	microSemens per centimeter
OD	Outside Diameter
O&M	Operation and Maintenance
P.G.	Professional Geologist
PIC	Panel Instrumentation Control
psi	Pounds per square inch
RTS	Radioactive Tracer Survey
TDH	Total dynamic head
TDS	Total dissolved solids
TIW	Texas Iron Works
TKN	Total kjeldahl nitrogen
UIC	Underground Injection Control
USDW	Underground source of drinking water
VSD	Variable speed drives
WTP	Water Treatment Plant
YBI	Youngquist Brothers, Inc
µmhos/cm	Micro ohms per centimeter
%	Percent

Section 1
Executive Summary

Mechanical integrity tests (MITs) were performed on the two concentrate injection wells (IW-1 and IW-2) at the Western Water Treatment Plant (WTP) located at 4100 South Flamingo Road, Miramar, Florida. The MIT activities are required by the Florida Department of Environmental Protection (FDEP) and include performance of a television survey, temperature log, annular pressure test and a radioactive tracer survey to evaluate external and internal mechanical integrity in each well. These tests were performed on the Miramar wells on schedule and in compliance with Chapter 62-528.300(6), Florida Administrative Code (FAC).

Both injection wells have 16-inch outside diameter (OD) final steel casings cemented in place at depths of 3,095 feet below pad level (bpl) and 3,040 feet bpl in IW-1 and IW-2, respectively. The 13.375-inch OD (12.347-inch inside diameter (ID)) steel injection tubings were set to depths of 3,049 bpl (IW-1) and 3,007 feet bpl (IW-2). At the time of the MIT the tubings were suspended inside the 16-inch casings with Texas IronWorks (TIW) liner hanger packers at the base to seal the annular space between the 16-inch and 13.375-inch casings. The annular space between casing and tubing was filled with a non-corrosive fluid mixture of Baracor 100 and water. The pressure in the annulus was maintained between 60 to 75 pounds per square inch (psi) using an annular pressure compensation system.

The internal mechanical integrity of IW-1 and IW-2 was tested between November and December 2004. Both concentrate injection wells failed the pressure test of the annular space between the final 16-inch OD casing and the 13.375-inch steel injection tubing. Video surveys conducted in both wells indicated scaling and encrustation. However, no penetrations of the 13.375-inch steel tubing were observed in either well. FDEP was notified and approval was obtained to continue the operation of IW-1 by injecting potable water into the annular space to maintain the pressure at approximately 1.5 times the normal injection pressure. The City of Miramar was issued a Major Modification Permit (No. 153722-003-UC) to replace the tubings in both injection wells based on a Work Plan detailing the repair activities.

MODIFICATION OF IW-1

Modification work on IW-1 began on June 20, 2005 and was completed on August 8, 2005. Modification of IW-1 consisted of removal of the existing 13.375-inch OD steel injection tubing, performance of a video survey and pressure test inside the 16-inch OD steel final casing, and replacement of the steel injection tubing with 10.75-inch nominal size (9.76-inch OD, 8.85-inch ID) Fiberglass Reinforced Plastic (FRP) tubing that was cemented inside the 16-inch final casing. The IW-1 FRP injection tubing was then tested for internal and external mechanical integrity. The video survey of the 10.75-inch nominal size (8.85-inch ID) FRP tubing indicated that the tubing had no observable defects and the results of a pressure test inside the FRP tubing was within the FDEP allowable pressure loss tolerance. The geophysical logging program consisted of background temperature and gamma ray logs. The temperature log was comparable to previous logs in that the temperature changes were gradual and did not indicate that the source of water in the FRP tubing was other than the injection zone or water used to flush the casing after drilling activities. The Radioactive Tracer Survey (RTS) performed August 18, 2005 showed no movement of the tracer up the outside of the 16-inch final steel casing, the external cement seal or the annular cement seal. The absence of tracer movement outside the well column indicated that the well has external mechanical integrity.

An injection test was performed in IW-1 to rate the well. A combination of concentrate from the Western WTP and raw water from the Biscayne aquifer was injected into IW-1 at an average rate of approximately 1,920 gallons per minute (gpm) for a period of 24 hours. The average wellhead pressure during injection was recorded at 66.4 psi. The average chloride concentration was 72 milligrams per liter (mg/L) with a specific conductance of 1,840 microSemens per centimeter (mS/cm). The short-term injection test in IW-1 was successfully completed at a rate of 1,920 gpm (2.76 million gallons per day (MGD) at 10 feet per second (ft/sec)). The average injection rate from the Miramar Western WTP under current normal operating conditions is approximately 1,000 gpm. It is expected that under emergency conditions, the City of Miramar could inject up to 12 ft/sec (2,300 gpm).

MODIFICATION OF IW-2

Modification work on IW-2 began on September 28, 2005 and was completed on November 1, 2005. Modification of IW-2 consisted of removal of the existing 13.375-inch OD steel injection tubing, performance of a video survey and pressure test inside the 16-inch OD steel final casing, and replacement of the steel injection tubing with 10.75-inch nominal FRP tubing cemented inside the 16-inch final casing. The FRP injection tubing was then tested for internal and external mechanical integrity.

The video survey of the 10.75-inch nominal FRP tubing indicated that the tubing had no observable defects and the results of a pressure test inside the FRP tubing was within the FDEP allowable pressure loss tolerance. The geophysical logging program consisted of background temperature and gamma ray logs. The temperature log was comparable to previous logs in that the temperature changes were gradual and did not indicate that the source of water in the FRP tubing was other than the injection zone or water used to flush the casing after drilling activities. The RTS performed November 10, 2005 showed no movement of the tracer up the outside of the 16-inch final steel casing, the external cement seal or the annular cement seal. The absence of tracer movement outside the well column indicated that the well has external mechanical integrity.

OPERATING DATA SUMMARY

Injection well flows and pressures as well as dual zone monitoring well (DZMW-1) pressures and water quality data were reviewed for the period between 1995 and 2005. Injection flows have increased since year 2000 and pressure head has increased correspondingly by 2 to 5 psi. The DZMW-1 has shown no pressure head response to the increase in injection flows and head pressures. The absence of a pressure response in the lower monitor zone of the DZMW-1 indicates that there is no apparent hydrogeologic connection between the injection zone at 3,130 feet bpl and the lower monitor zone between 1,930 to 2,005 feet bpl.

Water quality in the DZMW-1 was reviewed for the same period between 1995 and 2005. The water quality parameters, in general, have remained consistent over the review period. Chloride and sulfate have increased in the lower monitor zone since 2002; however, the associated salinity parameters of specific conductance and total dissolved solids (TDS), have not shown similar increases. The traditional wastewater indicators of ammonia and total kjeldahl nitrogen (TKN) have remained relatively consistent throughout the review period.

The absence of pressure head changes in the monitor zones and the inconsistency of increase between associated indicator parameters (salinity and wastewater) indicate that there is no apparent geohydrologic connection between the injection zone and the DZMW-1. The indication of separation between the upper and lower monitor zones and the injection zone based on water quality verifies the external mechanical integrity of both IW-1 and IW-2.

The conclusion of MIT results indicates that IW-1 and IW-2 have external and internal mechanical integrity in accordance with Chapter 62-528, FAC. The injection test in IW-1 was successfully completed and the well was rated for a flow velocity of 10 feet per second, and up to 12 feet per second in an emergency. The injection test in IW-2 is tentatively scheduled for December 15, 2005 and the results will be provided as a separate addendum to this report.

Section 2
Background

The Western WTP is located at 4100 South Flamingo Road, Miramar, Florida as shown in the location map in **Figure 2-1**. The FDEP concentrate injection well Operating Permit (No. 125256-007-UO) for the Western Water WTP requires that MITs be performed every five years and that testing should consist of the following:

1. A hydrostatic pressure test of the injection tubing and Texas Iron Works (TIW) liner hanger packer using the existing annular piping system, as required by Chapter 62-528.300(6)(b)2, and 62-528.300(6)(e), FAC.

2. A video television survey through the entire length of each well from the ground surface to the base of the injection zone, as required by Chapter 62-528.425 (1)(d), FAC.

3. A temperature log, gamma ray log, and radioactive tracer survey, as required by Chapter 62-528.300(6)(c), FAC.

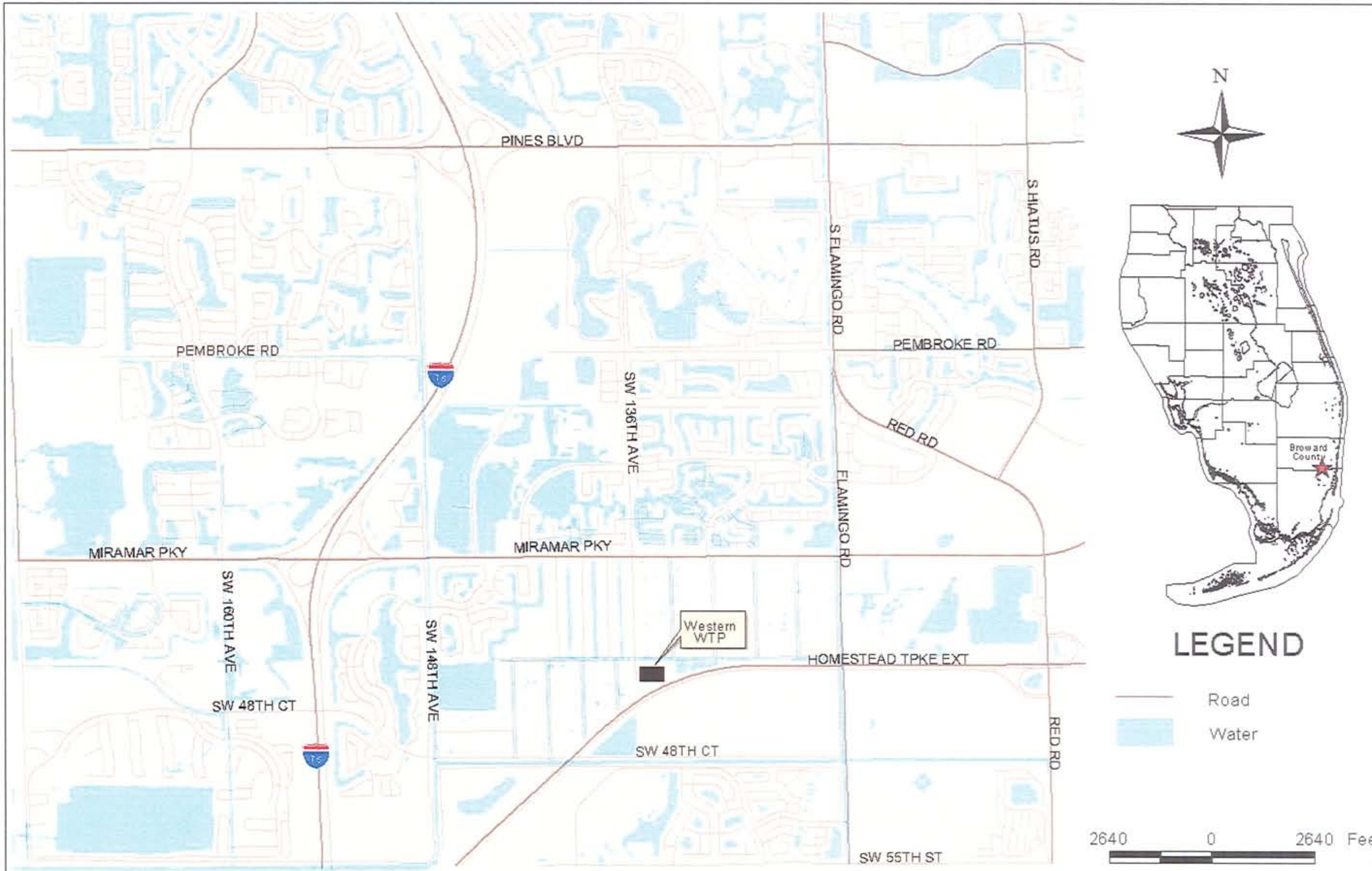
MIT activities are performed to verify the internal and external integrity of each injection well. The injection wells and the dual zone monitor well at the City of Miramar Western WTP are located on concrete pads on the east side of the property as seen on the Site Plan shown in **Figure 2-2**. The injection wells are used to inject concentrate from the treatment of surficial aquifer (Biscayne aquifer) groundwater at the Western WTP into the Floridan Aquifer below the Underground Source of Drinking Water (USDW). The USDW is demarcated by the 10,000-mg/L isochlor for Total Dissolved Solids (TDS).

INJECTION WELL SYSTEM

The injection well system consists of two concentrate disposal wells and one dual-zone monitor well. Each of the two disposal wells is a 16-inch OD Class I concentrate injection well. Prior to this modification each well was lined with a 13-inch OD removable steel injection tubing, supported by a retrievable TIW liner hanger packer. The initial operating permit (No. 125256-007-UO) authorized an injection rate of 800 gpm (1.15 MGD) per well.

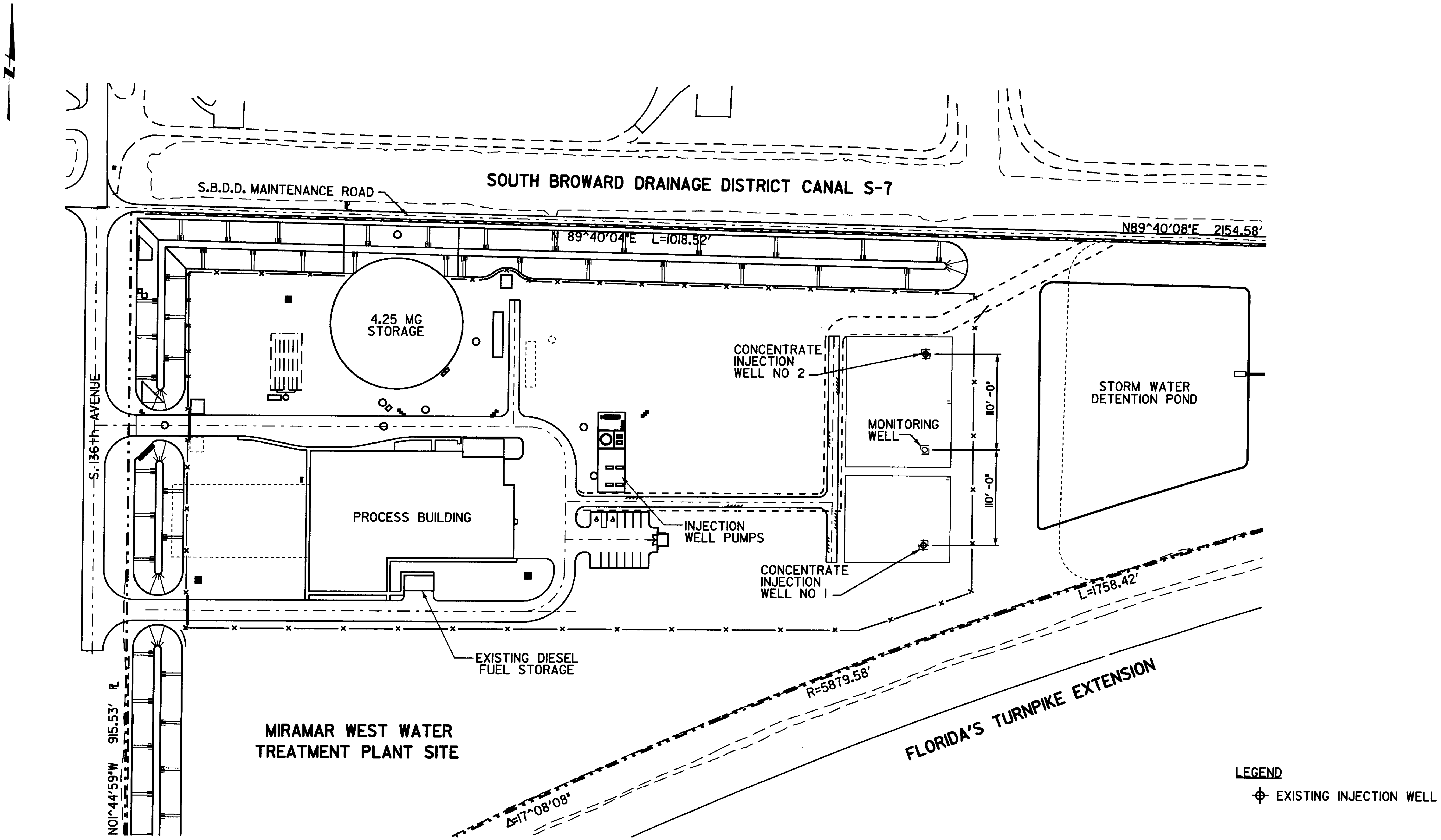
Description of Wells

Injection Well 1. Construction and initial mechanical integrity testing of IW-1 was completed on March 20, 1995. Injection well IW-1 has a final casing cemented to a total depth of 3,095 feet bpl. The initial injection tubing was set to a total depth of 3,049 feet bpl. The well was completed with a nominal 16-inch diameter open borehole extending



City of Miramar
Western Water Treatment Plant Location

Figure 1



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SCALE				FIGURE
NOT TO SCALE	MWH Sunrise Florida	City of Miramar, Florida	CITY OF MIRAMAR CONCENTRATE DISPOSAL WELLS AND MONITORING WELL LOCATIONS	2

from the bottom of the final casing to approximately 3,500 feet bpl, as shown in **Figure 2-3**. However, during the initial injection tubing installation, the steel tubing was dropped causing the borehole to collapse below 3,179 feet. Based upon information obtained during construction, the injection zone in IW-1 was determined to be above the location of the lost tubing between 3,100 feet bpl and 3,179 feet bpl, therefore the tubing was left in place, and the borehole below 3,179 feet was not re-drilled.

Injection Well 2. Construction of IW-2 was completed on February 27, 1995, and initial mechanical integrity testing was completed on February 28, 1995. Injection well IW-2 has a final casing cemented to a total depth of 3,040 feet bpl. The initial injection steel tubing was set to a total depth of 3,007 feet bpl. The well was completed with a nominal 16-inch diameter open borehole extending from the bottom of the final casing to approximately 3,508 feet bpl. Based on information obtained during construction, the injection zone in IW-2 appears to be between 3,125 feet bpl and 3,180 feet bpl as shown in **Figure 2-4**.

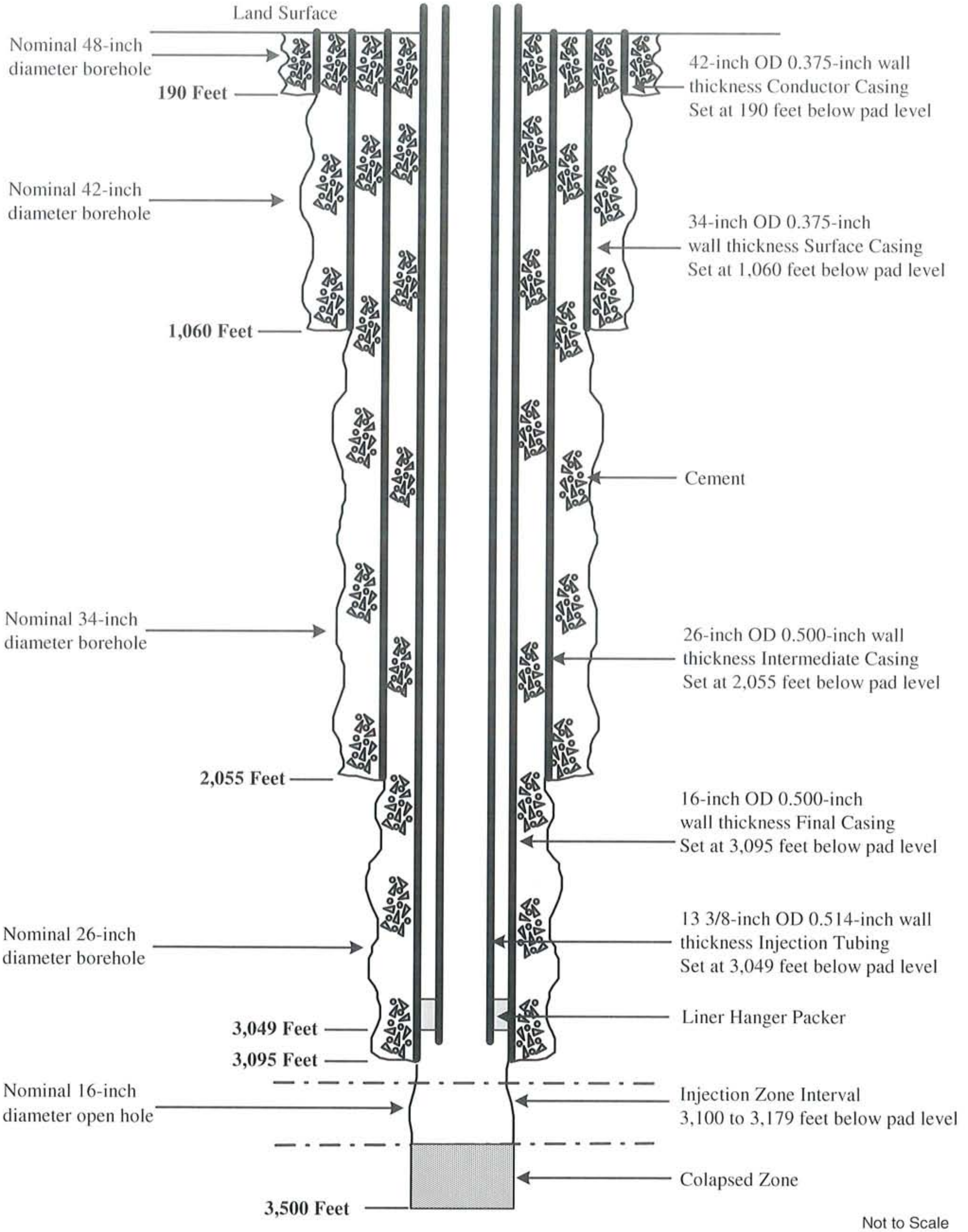
Dual Zone Monitor Well. Dual Zone Monitor Well 1 (DZMW-1) is located 110 feet north of IW-1 and 110 feet south of IW-2. The upper monitor zone taps the interval between 1,639 feet bpl and 1,738 feet bpl. The lower monitor zone taps the interval between 1,930 feet bpl and 2,005 feet bpl as shown in **Figure 2-5**. The DZMW-1 was designed and constructed to monitor both IW-1 and IW-2.

INITIAL MECHANICAL INTEGRITY TESTING (MIT) WORK

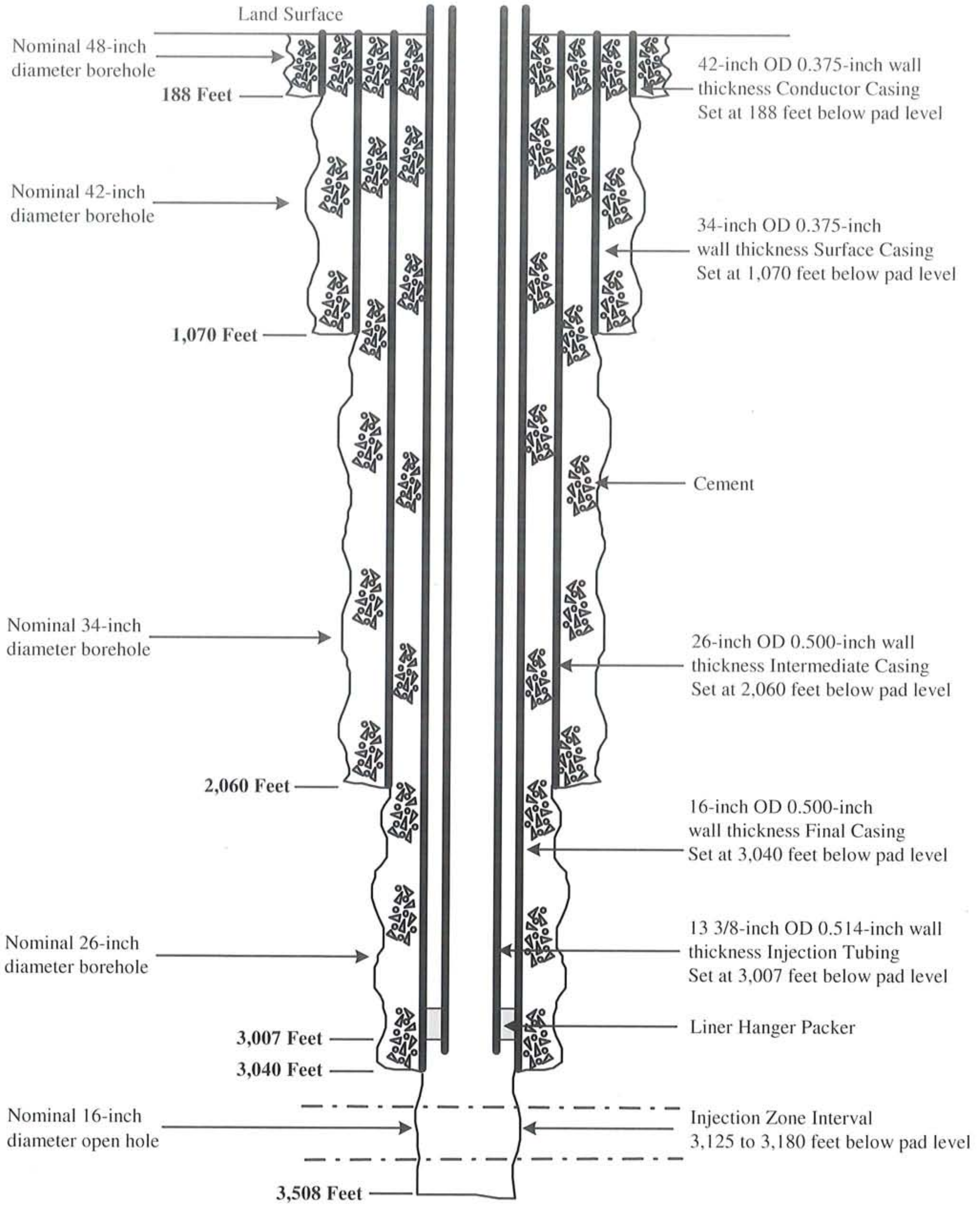
The first MIT activities were performed between December 1999 and January 2000 (five years after well construction) in accordance with Chapter 62-528, FAC and the City's FDEP Operation Permit. At that time, the mechanical integrity of injection wells IW-1 and IW-2 was verified. The second MIT work plan (2004) for the City of Miramar western WTP was approved by FDEP on September 15, 2004. The MIT work plan included a description of the 13.375-inch OD tubing, video survey, and pressure test of the annular space between the 16-inch OD final steel casing and the 13.375-inch OD steel tubing, and the RTS of the external cement seal. A copy of the approved MIT work Plan is provided in **Appendix A**.

Condition of IW-1

A video survey of the IW-1 13.375-inch OD steel injection tubing and a preliminary pressure test of the annular space between the steel injection tubing and the final 16-inch OD steel casing was performed on Tuesday, December 14, 2004. The video survey was unsuccessful due to contractor equipment failures and was rescheduled for Friday December 17, 2004. The video was re-run and showed pitting and encrustation of the liner, but no visible penetrations. A copy of the video survey of the IW-1, 13.375-inch

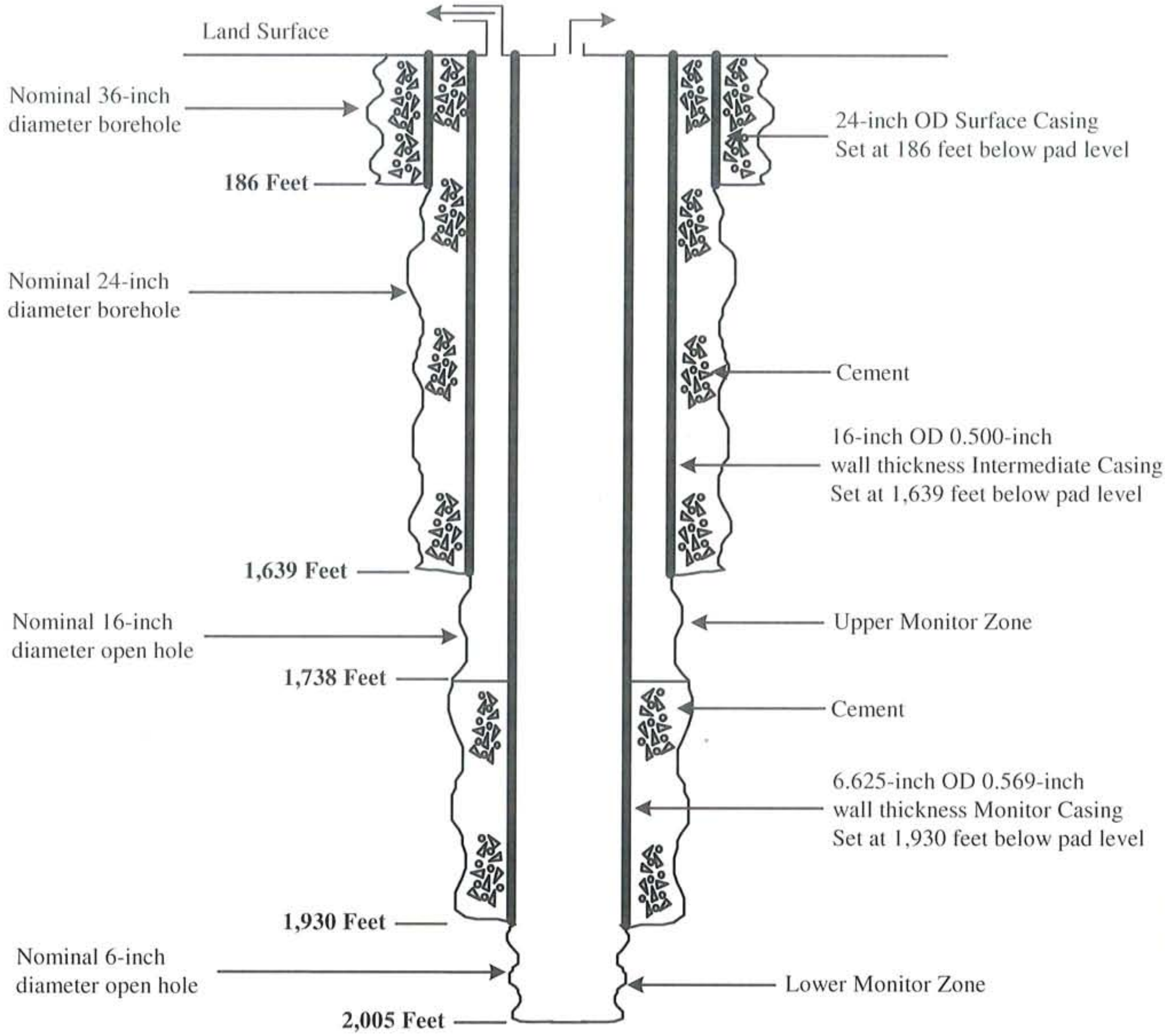


MWH	Miramar — Beauty and Progress	**City of Miramar WTP Injection Well - IW-1 Initial Construction**	**Figure 2-3**



Not to Scale

MWH	Miramar — Beauty and Progress	City of Miramar WTP Injection Well - IW-2 Initial Construction	Figure 2-4



MWH	Miramar Beauty and Progress	**City of Miramar WTP Dual Zone Monitor Well DZMW-1**	**Figure 2-5**

OD steel injection tubing is included in **Appendix B**. The preliminary pressure test of the IW-1 annular space indicated that pressure could not be maintained for the required time. The flow from the annular space into the tubing was estimated at approximately 4 to 5 gallons per minute. The FDEP was notified of the preliminary pressure test results.

Condition of IW-2

A video survey of the 13.375-inch OD steel injection tubing and a preliminary pressure test of the annular space between the tubing and the final 16-inch OD steel casing was performed in IW-2 on Tuesday, November 30, 2004. The video survey showed various areas of pitting, scaling and encrustation. There were no visible penetrations of the injection tubing in IW-2. A copy of the video survey of the IW-2, 13.375-inch OD steel injection tubing is included in **Appendix B**.

The IW-2 annular space was pressurized to approximately 150 percent of the rated capacity, approximately 150 psi as specified under Chapter 62-528(6)(e). The initial attempt to pressurize the tubing using the on-site annular pressure system was not successful. The annular pressure system was then isolated and a compressor was connected directly to the annular space. The annular pressure was increased to 150 psi and shut in. Several attempts to hold the 150 psi pressure were made, however, the pressure dissipated at a rate that exceeded the allowable pressure change of 5% under Chapter 62-528(6)(e).

Amendment No. 1 to the original MIT Plan was prepared and submitted to FDEP on December 8, 2004. The amendment requested approval to maintain the annular pressure in IW-2 using potable water at a rate of 0.1 gpm to maintain an annular pressure of approximately 55 psi (approximately 50 percent greater than the injection pressure of 33 psi). The FDEP was notified of the preliminary pressure test results.

ALTERNATIVE DESIGN

On January 9, 2005 at a meeting between FDEP and the representative of the City of Miramar, it was decided that the City would pursue an alternative design to correct the annular pressure maintenance issues in the injection wells. A letter requesting Major Modification of the Miramar injection wells was submitted to FDEP on January 24, 2005. This letter proposed the removal of the 13.375-inch OD steel tubing and TIW packer and installation of 10.75-inch nominal FRP tubing that would be cemented inside the existing 16-inch OD steel final casing in both injection wells. Comments were received from FDEP and where addressed in subsequent correspondence on March 11, 2005. A final FDEP Underground Injection Control (UIC) Construction Permit was issued on July 18, 2005. A copy of the Major Modification letter request, the March 2005 response to FDEP comments and the final FDEP UIC permit are provided in **Appendix A**.

Youngquist Brothers, Inc. (YBI) was selected by the City of Miramar to perform the modification of IW-1 and IW-2. YBI began site work on June 14, 2005. Site work consisted of preparation of the IW-1 containment pad for equipment access, routing of a potable water supply line to the work location and the establishment of electrical power for site use. IW-1 was stopped from flowing or "killed" on June 20, 2005 to prepare the wellhead for removal of the existing 13.375-inch OD steel tubing. Removal of the existing tubing took place between June 29, 2005 and June 30, 2005. The removed tubing was placed in sequence on the site and was examined for visible defects. Some of the casing pieces showed a definite thinning of the casing wall but there were no visible holes in the casing. The 16-inch OD steel final casing was brushed to remove accumulated debris. The interior of the casing was brushed from the top to the bottom of the well at approximately 3,100 feet bpl and then the well was flushed. The IW-2 containment pad was used to collect the discharge from the IW-1 casing cleaning operation by setting up hay bail baffles and directing the discharge towards the IW-2 clearwell.

Visible thinning of the steel tubing wall removed from IW-1

VIDEO SURVEY OF THE 16-INCH OD STEEL FINAL CASING

On July 14, 2005, a video of the interior of the 16-inch OD casing was conducted that showed no visible signs of defects or encrustation on the inside of the casing. The liner hanger packer assembly was visible in the video and appeared to be in good condition. The video survey is included along with the corresponding video log in **Appendix B**.

PRESSURE TEST OF THE 16-INCH OD STEEL FINAL CASING

On Friday July 15, 2005 a packer was set at approximately 3,045 feet bpl and inflated to approximately 420 psi in preparation for a pressure test of the 16-inch OD final casing. Len Fishkin, FDEP, Bill Knee, City of Miramar, and Susan Bodmann P.G., MWH were present to record the results of the pressure test. The contractor provided the MWH observer and FDEP with a Certificate of Calibration for the pressure gauge used during the test. A copy of the pressure gauge certificate is provided in **Appendix C**. During the preliminary pressure test, a leak was discovered at a weld on the pressure header fabricated for this test. The leak was determined by the contractor to be minimal and the bottom hole packer was not deflated to re-weld the pressure header. The contractor applied silicon gel to the area of the leak and applied a compression wrapping over the area. The test was restarted at a pressure of 130 psi and pressures were recorded every 5 minutes for one hour. Five percent variation from the initial 130 psi would be +/- 6.5 psi. Over the one-hour period the pressure in the well dropped to a final reading of approximately 123.5 psi, a 6.5 psi decrease from the starting pressure. The consensus of the observers was that the well passed the pressure test and that the small drop in pressure was due to the leak at the weld. The calculated bleed down volume was approximately 15 gallons. The actual bleed down volume was 14 gallons. The pressure test log is provided in **Appendix C**.

INSTALLATION OF 10.75-INCH NOMINAL FRP TUBING

A request was submitted to FDEP on July 19, 2005 that proposed to set the 10.75-inch nominal FRP tubing at a depth of 3,035 feet bpl. This depth was selected based on the video survey and the TIW liner hanger packer assembly location. The request included the results of the video survey and pressure test on the 16-inch OD steel final casing, the specifications for the 10.75-inch nominal FRP tubing and a tubing cementing plan. A copy of the letter, the FRP tubing specifications and the cementing plan are provided in **Appendix D**.

Liner Hanger Packer removed from IW-1 to be filled with cement and used as a bridge plug.

The contractor fashioned a bridge plug from the TIW liner hanger packer that was removed from IW-1 by filling the packer with cement. The packer was then set back into the existing hanger brackets at the base of the well (approximately 3,045 feet bpl). Approximately 5 feet of cement was placed by tremie pipe on top of the cement filled packer at the base of the 16-inch casing to completely seal the bottom of the casing. The seal was verified by running a short duration pressure test in the 16-inch casing.

On July 28, 2005 after verification that the 16-inch casing was sealed, a specialty crew from Future Pipe Industries, Inc., Houston, Texas, began running the 10.75-inch nominal FRP tubing inside the existing 16-inch casing. A background cement bond log (CBL) was recorded inside the un-cemented FRP tubing as a baseline. Clear definite return signals appear on the log of the free hanging FRP tubing. Cementing operations began at approximately 1 PM on August 3, 2005. Cementing of the FRP was performed by pressure grouting in a single stage from 3,035 feet bpl to land surface as stated in the Injection Well System Work Plan approved by FDEP. Based on a calculation of the annular space to be cemented, approximately 384 barrels (2,155 cubic feet) of cement would be needed. Cementing was completed at 3 PM and approximately 399 barrels of cement had been pumped. Cement returns were seen in the annular space between the 16-inch casing and the FRP tubing at pad level. The final CBL was performed on Thursday August 4, 2005. The signal reflections shown on the CBL performed after cementing indicate a dampening of the signal. Comparison of the before and after CBL show that a cement seal was obtained around the FRP Tubing. A copy of the CBL is provided in **Appendix H**. The cement bridge plug was drilled out by the contractor on August 8, 2005 to prepare for MIT activities. IW-1 modification was completed as shown in **Figure 3-1**. The certification of completion is provided in **Appendix I**.

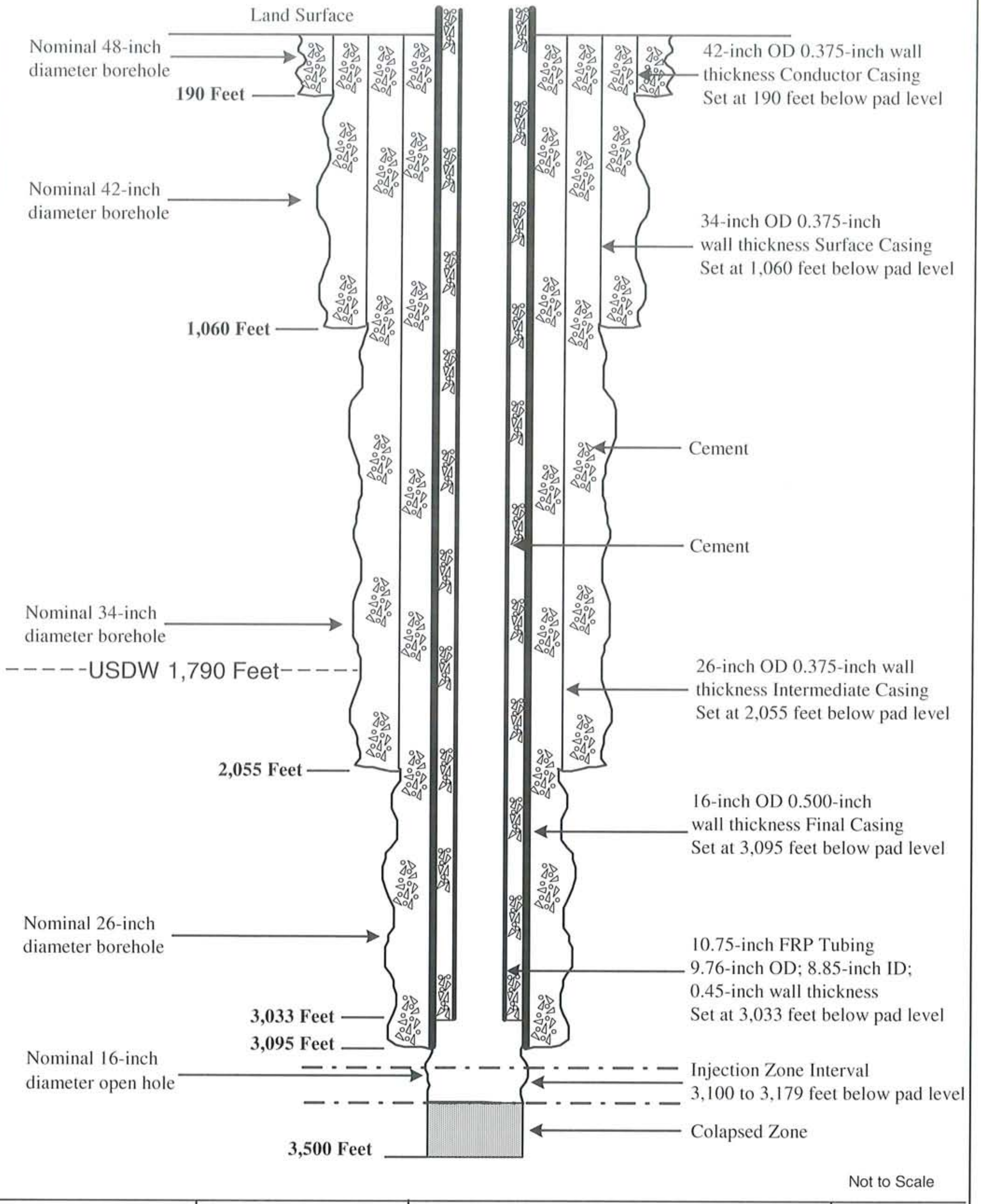
IW-1 MECHANICAL INTEGRITY TESTING

In accordance with the approved Work Plan for the Major Modification of IW-1 the following MIT activities were performed in IW-1 to verify the internal and external mechanical integrity of the well following modification.

- Pressure test - for internal mechanical integrity
- Downhole video survey
- Radioactive tracer survey - for external mechanical integrity
- Temperature log

Video Survey of the FRP Tubing

A video survey of the inside of the 10.75-inch nominal FRP tubing in IW-1 was performed on August 9, 2005. The video showed that the FRP tubing interior is in good condition over the entire length. The bottom of the tubing was observed at approximately 3,028 feet bpl and the base of the 16-inch final casing was observed at approximately 3,088 feet bpl. The active injection zone appeared to begin at a depth of approximately 3,123 feet bpl, based on the increased cloudiness of the water. All of the joints were visible and there were no observable defects in the casing wall. The condition of the IW-1 tubing indicates apparent internal mechanical integrity. A copy of the video survey and video log are provided in **Appendix B**.



MWH

Miramar Beauty and Progress

City of Miramar WTP Injection Well - IW-1 Modified

Figure 3-1

Pressure Test of FRP Tubing

The pressure test on IW-1 was conducted on the morning of August 11, 2005 in the presence of Ms. Heidi Vandor, P. G. of FDEP. The wellhead was sealed with a pressure head equipped with a calibrated pressure gauge and a valve. The pressure in the casing was increased to 130.5 psi representing approximately 1.5 times an injection pressure of 86 psi. The valve was closed and the pressure was monitored every 5 minutes for a period of one hour. The pressure at the end of the one-hour period measured 129.5 psi, which is a 1 psi decrease in pressure from the start of the test. Chapter 62-528, FAC allows a 5 percent change in pressure over one hour to account for environmental influences (heating and cooling of the wellhead and gauges). The detailed pressure test results are provided in **Appendix C**. The newly installed FRP tubing demonstrated internal mechanical integrity based on the results of the video survey and the pressure test performed in the well.

Geophysical Logging

The geophysical logging program consisted of a background temperature and gamma ray log. The background temperature and gamma ray logs were run on August 17, 2005 prior to the performance of the RTS. Temperature logs recorded the temperature continuously from land surface to the base of the injection zone. Gamma ray logs were run to record the naturally occurring background gamma radiation. Background gamma ray readings are compared as a baseline to the RTS responses during testing. Copies of the geophysical logs can be found in **Appendix H**, the certifications for the flow meter and Iodine-131 used during the RTS can be found in **Appendix E**.

Temperature Log in IW-1. The temperature log charts the changes in fluid temperature in the tubing. A sudden or radical change in temperature would indicate a fluid source outside the tubing (a potential breach or opening in the tubing).

The temperature recorded during the well completion MIT in 1995 showed a constant temperature ranging between 68 - 60 degrees Fahrenheit (F) with gradual fluctuations over the entire length of the injection tubing. During the 2000 MIT, the temperature showed a similar trend with a temperature range of between 85 to 74 degrees F (representing the approximate temperature of the injectate). The temperature log of the newly installed and cemented 10.75-inch nominal FRP injection tubing decreased from 81 degrees F at 100 feet bpl to 70 degrees F at 2,370 feet bpl, then increased between 2,370 and 2,700 feet bpl to approximately 79 degrees F. The temperature remained stable from 2,700 feet bpl to the base of the log at approximately 3,100 feet bpl (injection zone depth). The absence of abrupt temperature changes is an indication that the source of fluid in the tubing is either injection zone water or the water used to flush the well after cementing. The temperature log results provide an indication of internal mechanical integrity.

Gamma Ray Log. The background gamma ray log was run on August 17, 2005 as a basis of comparison with the RTS on August 18, 2005. The background and real time logs were compared simultaneously during the RTS run so that changes in the gamma ray counts could be directly observed.

Radioactive Tracer Survey

On August 18, 2005 the RTS tool was configured with detectors arranged above and below the ejector as shown on the log provided in **Appendix H**: GR#3-RTST (the Top detector), the Ejector, GR#2-RTSM (the Middle detector), and GR-RTSB (the Bottom detector). The detector names (i.e. GR#2-RTSM) that appear on the log will be used in the following discussions for clarity. Two low-flow (5 feet per minute (ft/min)) tests were performed consistent with the approved Work Plan.

Low Flow Test No. 1. A 2 milliCurie slug of Iodine-131 was ejected into the well at 9:56 AM under pumping conditions at 3,083 feet bpl, 5 feet above the bottom of the casing. A flow rate of 46 gpm was used to maintain an Iodine-131 slug movement of approximately 5 ft/min. The movement of this slug was monitored for one hour with detectors GR#3-RTST at 3,073 feet bpl, GR#2-RTSM at 3,086 feet bpl and GR-RTSB at 3,095 feet bpl. The slug of tracer was detected by GR#2-RTSM approximately 26 seconds after ejection and GR-RTSB 120 seconds after detection due to the rate of fluid movement. GR#3-RTST did not detect any additional gamma ray activity throughout the entire one hour monitoring period, indicating an absence of an upward migration path immediately behind the casing. A summary of the Low Flow Test No. 1 one-hour monitoring results is presented in **Table 3-1**.

Table 3-1
Summarized Results of IW-1 Low Flow Test No. 1 - One Hour Monitoring

RTS Tool Specifics		Sequence of Events During Test			
Tool Detector/ Ejector	Depth (feet bpl)	Test Start	Response Time Since Start of Test		
		Tracer released @ 09:56 hours	26 sec.	120 sec.	None detected
GR#3-RTST	3,073				X
Ejector	3,083	X			
GR#2-RTSM	3,086		X		
GR-RTSB	3,095			X	

Following the one-hour monitoring period, a log-out-of-position (LOP) was performed by moving the tool from its monitoring position at 3,083 feet bpl up to 2,900 feet bpl.

The well was then flushed with potable water at a rate of approximately 204 gpm for approximately 20 minutes and a log-after-flush (LAF) was performed to verify the removal of tracer from the well. A minimal amount of radioactive staining was present on the inside of the 16-inch casing at the point of ejection of the tracer. A summary of the Low Flow Test No. 1 log-out of position and log-after-flush results are presented in **Table 3-2** and **Table 3-3,** respectively.

Table 3-2
Summarized Results of IW-1 Low Flow Test No. 1 - Log Out-of-Position

Tool Detector	Initial Measuring Depth (feet bpl)	Upper Detectable Limit of Tracer (feet bpl)	Final Measuring Depth (feet bpl)
GR#3-RTST	3,073	None	2,900
GR#2-RTSM	3,086	None	2,900
GR-RTSB	3,095	3,074	2,900

Table 3-3
Summarized Results of IW-1 Post Low Flow Test No. 1 – Log After-Flush

Tool Detector	Initial Measuring Depth (feet bpl)	Upper Detectable Limit of Tracer (feet bpl)	Final Measuring Depth (feet bpl)
GR#3-RTST	3,073	None	2,900
GR#2-RTSM	3,086	None	2,900
GR-RTSB	3,095	3,084	2,900

Following the flushing of the casing, the stain remained on the casing wall at the point of ejection but had diminished in intensity. The upper detector GR#3-RTST measured gamma readings that matched background values indicating no upward movement of tracer material.

Low Flow Test No. 2. A second test was performed to verify the repeatability of the first low flow test. A second slug of Iodine-131 was ejected into the well at 11:38 AM under pumping conditions at 3,083 feet bpl, 5 feet above the bottom of the casing. The pumping rate into the well was approximately 46 gpm creating an Iodine slug velocity of approximately 5 ft/min. The responses of the detectors were similar to those of the first low flow test demonstrating repeatability and are shown in **Table 3-4**.

Table 3-4
Summarized Results of IW-1 Low Flow Test No. 2 - One Hour Monitoring

RTS Tool Specifics		Sequence of Events During Test			
Tool Detector/ Ejector	Depth (feet bpl)	Test Start	Response Time Since Start of Test		
		Tracer released @ 11:38 hours	24 sec.	127 sec.	None detected
GR#3-RTST	3,073				X
Ejector	3,083	X			
GR#2-RTSM	3,086		X		
GR-RTSB	3,095			X	

A log-out-of-position was performed following Low Flow Test No. 2 and the well was flushed again. The tool was positioned in the injection zone and the remainder of the tracer fluid was ejected during the flushing stage. A final background pass was logged over the same interval as the initial background pass to inspect the entire injection casing. No apparent indication of upward migration of concentrate was observed during this test. A summary of the Low Flow Test No. 2 log-out of position and log-after-flush results are presented in **Table 3-5** and **Table 3-6,** respectively.

Table 3-5
Summarized Results of IW-1 Low Flow Test No. 2 - Log Out-of-Position

Tool Detector	Initial Measuring Depth (feet bpl)	Upper Detectable Limit of Tracer (feet bpl)	Final Measuring Depth (feet bpl)
GR#3-RTST	3,073	None	2,800
GR#2-RTSM	3,086	None	2,800
GR-RTSB	3,095	3,084	2,800

Table 3-6
Summarized Results of the IW-1 Low Flow Test No. 2 - Log After-Flush

Tool Detector	Initial Measuring Depth (feet bpl)	Upper Detectable Limit of Tracer (feet bpl)	Final Measuring Depth (feet bpl)
GRT	3,150	3,082	0
GRM	3,163	3,082	0
GRB	3,172.5	3,082	0

The RTS showed no fluid migrating upwards behind the 16-inch final steel casing, cement or the annular cement between the 16-inch casing and FRP tubing due to channeling or inadequate cement seal. The initial and final background passes showed responses that were similar. This similarity in the initial background and post-test gamma ray log passes indicates the injection well has external mechanical integrity.

INJECTION TEST

A short-term injection test was performed in IW-1 to establish the flow rating for the well. The test began on September 16, 2005 with 72 hours of background static pressure monitoring. Pressures were recorded at the IW-1 wellhead and the upper and lower zones of DZMW-1. Injection began on September 19, 2005 at 10:40 AM. A combination of concentrate from the western WTP and raw water from the Biscayne aquifer was injected into IW-1 at an average rate of approximately 1,920 gpm. The average wellhead pressure during the injection was recorded at 66.4 psi. The chloride concentration and specific conductance of the injectate was measured at the beginning, middle and end of the injection period and is summarized in **Table 3-7**. The average chloride concentration was 72 mg/L with a specific conductance of 1,840 mS/cm. On September 19, 2005 at approximately 7:54 PM the raw water supply wellfield pumps lost power due to winds from passing tropical storm Katrina. Injection Pressure at the wellhead dropped from 68.6 psi to 15.4 psi. Injection flow decreased from 1,920 gpm to approximately 1,655 gpm. Power was out for approximately one hour and fifteen minutes. At 9:14 PM power to the wellfield was restored and pressures increased from 53.6 psi to approximately 72.0 psi with a corresponding flow increase from an average of 1,655 gpm to 1,967 gpm. Injection was followed by approximately 32 hours of recovery monitoring under no injection conditions. Pressures were monitored at the IW-1 wellhead and the upper and lower zones of DZMW-1 throughout the recovery.

Table 3-7
Injectate Water Quality Monitoring
September 19-20, 2005

Time (Hours)	Chloride (mg/L)	Conductance (mS/cm)
1230	74	1,855
1830	74	1,816
0030	67	1,840

Pressure, tidal and water quality data collected throughout the testing period is presented in graphic and tabular form in **Appendix F**.

TEST RESULTS

The short-term injection test in IW-1 was successfully completed on September 21, 2005 at an approximate flow rate of 1,920 gpm (2.76 MGD). The current average injection rate at the Miramar Western WTP under normal operating conditions is approximately 1,000 gpm. Under emergency conditions, the City of Miramar may inject up to 12 ft/sec (2,300 gpm).

Section 4 Modification of IW-2

Following the completion of IW-1 modifications Youngquist Brothers, Inc began the modification of IW-2. IW-2 was taken out of service on September 21, 2005 in preparation for modification activities. On September 28, 2005 the well was stopped from flowing or "killed" and work to unseat the liner hanger packer and pull the 13.375-inch OD steel injection tubing was initiated. The TIW liner hanger packer and steel liner were removed from the well by September 29, 2005. The removed tubing was placed in sequence on the site and was examined for visible defects. MWH inspected the casing and observed the original grease marker numbers written on the casing that were used to keep track of the casing joints during installation. Heat numbers were also still legible on the outside of some of the tubing lengths. The TIW packer and a small amount of tubing were modified by YBI and used as a bridge plug. According to the Contractor, a pin-hole leak was observed within the upper 15 feet of tubing removed.

Original grease marker numbers on steel tubing removed from IW-2.

VIDEO SURVEY OF THE 16-INCH OD STEEL FINAL CASING

The 16-inch OD final steel casing in IW-2 was brushed on October 3, 2005. The well was brought to artesian conditions or "alive" and flushed to clear the 16-inch OD casing for the video survey. The video survey was performed on October 5, 2005 by Florida Geophysical Logging Division. The video was observed by Cameron Webster, YBI and Susan Bodmann, P.G., MWH. The casing from 50 feet bpl to the base of the top of the packer hanger at 2,991 feet bpl was free of any incrustation. No pitting of the interior of the casing was observed and casing joints were easily identifiable. The top of the packer hanger assembly is observed at approximately 2,991 feet bpl and the base of the packer hanger assembly appears to be at 3,007 feet bpl. The base of the 16-inch OD casing is observed at 3,044 feet bpl. The video was stopped at a depth of approximately 3,100 feet when the camera encountered sediment. Two days of drilling were conducted to clear the bridged debris from the open hole section of the well. The open hole was cleared to an approximate depth of 3,154 feet bls. A copy of the Video and the Video Log are included in **Appendix B**.

PRESSURE TEST OF THE 16-INCH OD STEEL FINAL CASING

A bridge plug was placed in the liner hanger packer assembly of IW-2 at approximately 2,991 feet bpl on October 10, 2005. Three barrels of cement (approximately 15 feet) were set on top of the packer to seal the base of the 16-inch OD final steel casing. The top of the cement above the bridge plug was tagged at approximately 2,974 feet bpl. A preliminary pressure test was run to ensure that the bridge plug had sealed the base of the steel casing.

The pressure test of the 16-inch OD was performed on October 13, 2005 and observed by Len Fishken, P.G., FDEP and Susan Bodmann, P.G., MWH. The wellhead was shut in and the pressure in the well was increased to approximately 138.5 psi. The selected pressure is in excess of 1.5 times the maximum annular space pressure (86 psi as documented in the FDEP approved Injection Well System Work Plan) that was maintained during normal injection well operation. Pressures were recorded every 5 minutes for one hour. Over the one-hour period the pressure in the well dropped to a final reading of 137.0 psi. The 1.5-psi change in pressure constitutes a 1 percent change from the initial pressure. The observed pressure change is well below the 5 percent variation allowed by FDEP. The bleed-down volume was equal to approximately 15 gallons. A copy of the pressure test log is included in **Appendix C**.

INSTALLATION OF 10.75-INCH NOMINAL FRP TUBING

A request was submitted to FDEP on October 13 2005 to set the 10.75-inch nominal FRP tubing at a depth of 2,972 feet bpl. This depth was selected based on the video survey and the TIW liner hanger packer assembly location. The request included the results of the video survey and pressure test on the 16-inch OD steel final casing, the specifications for the 10.75-inch nominal FRP tubing, and a tubing cementing plan. A copy of the letter, the FRP tubing specifications and the cementing plan are provided in **Appendix D**.

10.75-inch nominal Fiberglass Reinforced Plastic tubing on site ready for installation

Installation of the 10.75-inch nominal Fiberglass Reinforced Plastic tubing

On October 17, 2005 YBI began running the 10.75-inch nominal FRP tubing inside the existing 16-inch OD casing. A background cement bond log (CBL) run inside the un-cemented FRP tubing was recorded on October 19, 2005. Clear return signals appear on the log of the free hanging FRP tubing. On October 28, 2005, YBI cemented the 10.75-inch nominal FRP tubing inside the 16-inch OD final casing. Based on a calculation of the annular space to be cemented, approximately 392 barrels (2,200 cubic feet) of cement would be needed. Cementing was completed with approximately 368 barrels of cement pumped under pressure from the base of the FRP tubing at 2,972 bpl to land surface. A final CBL was conducted on October 29, 2005 and indicated the presence of a good cement bond between the FRP tubing and 16-inch OD final casing. Copies of the CBL are included in **Appendix D**. The cement plug was tagged inside the FRP tubing at a depth of approximately 2,950 feet bpl. The cement plug was drilled out on November 1, 2005 to prepare for MIT activities. IW-2 modification was completed as shown in **Figure 4-1**. The certification of well completion is provided in **Appendix I**.

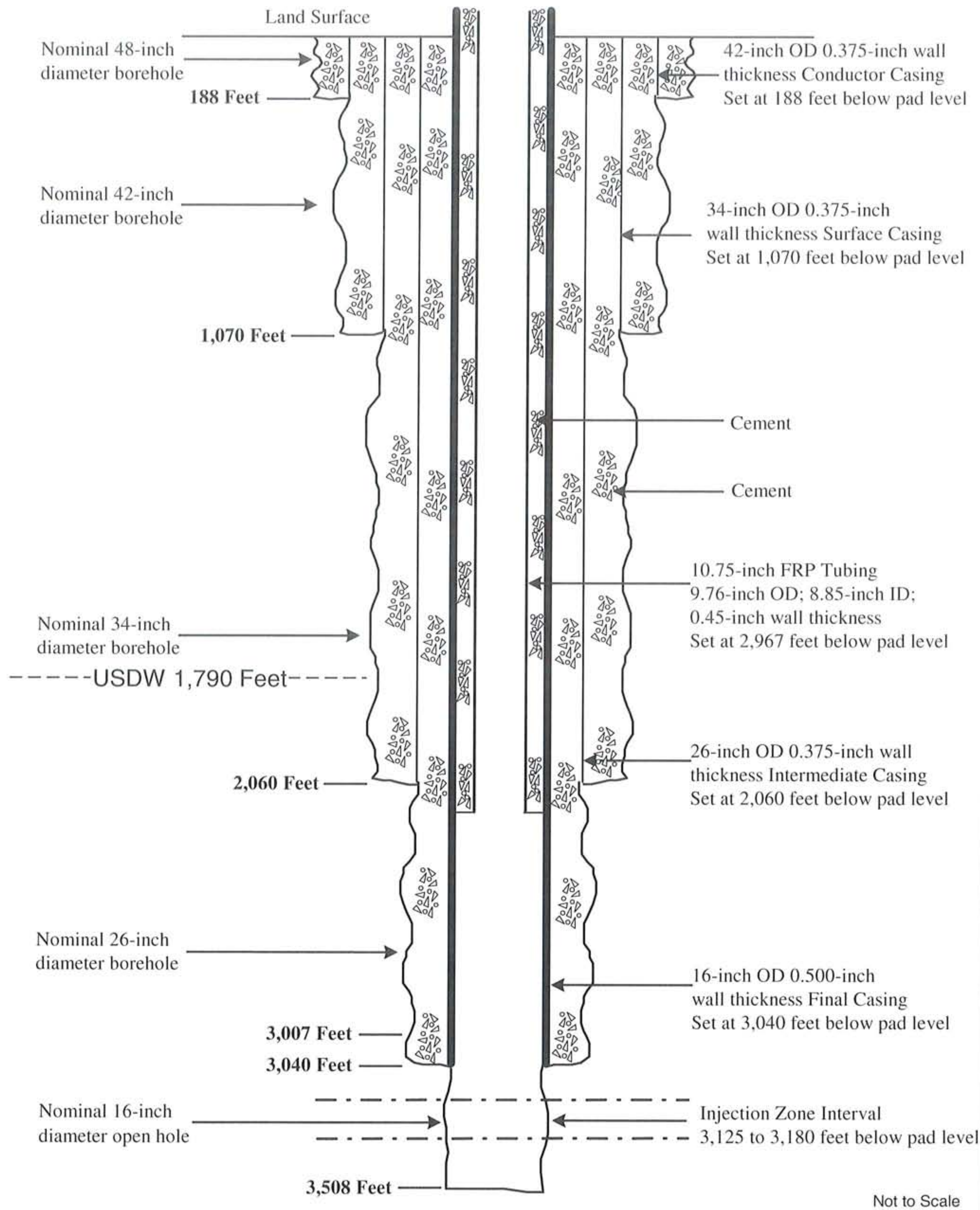
IW-2 MECHANICAL INTEGRITY TESTING

In accordance with the approved Work Plan for the Major Modification Permit, the following MIT activities were performed in IW-2 to verify the internal and external mechanical integrity of the well.

- Pressure test - for internal mechanical integrity
- Downhole video survey
- Radioactive tracer survey - for external mechanical integrity
- Temperature log

Video Survey of the FRP Tubing

A video survey of the inside of the 10.75-inch nominal FRP tubing in IW-2 was performed on November 5, 2005. The video showed that the FRP tubing interior was in good condition over the entire length. The bottom of the tubing was observed at approximately 2,967 feet bpl and the base of the 16-inch final casing was observed at approximately 3,040 feet bpl. These depths were confirmed by the YBI's FRP pipe tally



MWH

Miramar Beauty and Progress

City of Miramar WTP
Injection Well - IW-2
Modified

Figure 4-1

received on November 18, 2005 included in **Appendix D** and the logs performed on November 10, 2005 included in **Appendix H**. All of the joints were visible and there were no observable defects in the casing wall. The condition of the IW-2 tubing indicates an apparent internal mechanical integrity. A copy of the video survey and video log are provided in **Appendix B.**

Pressure Test of FRP Tubing

The pressure test on the newly installed FRP tubing was conducted on the morning of November 4, 2005 in the presence of Ms. Heidi Vandor, P. G. of FDEP and Ms. Alejandra Simon of MWH. The wellhead was sealed with a pressure head equipped with a calibrated pressure gauge and a valve. The packer was set and inflated at a depth of 2,950 feet bpl. The pressure in the casing was increased to 131 psi representing approximately 1.5 times an injection pressure of 86 psi. The valve was closed and the pressure was monitored every 5 minutes for a period of one hour. The pressure at the end of the one-hour period measured 130 psi, which is a 1 psi decrease in pressure from the start of the test. Chapter 62-528, FAC allows a 5 percent change in pressure over one hour to account for environmental influences (heating and cooling of the wellhead and gauges). The detailed pressure test results are provided in **Appendix C**. The FRP tubing demonstrated internal mechanical integrity based on the results of the video survey and the pressure test performed in the well.

Geophysical Logging

The geophysical logging program consisted of a background temperature and gamma ray log. The background temperature and gamma ray logs were run on November 10, 2005 prior to the performance of the RTS. Temperature logs recorded the temperature continuously from land surface to the base of the injection zone. Gamma ray logs were run to record the naturally occurring background gamma radiation. Background gamma ray readings are compared as a baseline to the RTS responses during testing. Copies of the geophysical logs can be found in **Appendix H**. The certifications for the flow meter and Iodine-131 used during the RTS can be found in **Appendix E**. A casing collar locator was also run with these logs to accurately reference the bottom of the 16-inch OD steel casing. The bottom of the final casing was detected at 3,040 feet below the surface.

Temperature Log. The temperature log charts the changes in fluid temperature in the tubing. A sudden or radical change in temperature would indicate a fluid source outside the tubing (a potential breach or opening in the tubing). The temperature log of the cemented 10.75-inch nominal FRP injection tubing shows a decrease in temperature from 79 degrees F at 100 feet bpl to approximately 75 degrees F at 180 feet bpl. The temperature remained stable to approximately 3,070 feet bpl, where it increased to approximately 77 degrees F down to a depth of 3,100 feet bpl (injection zone). The temperature then decreased to 54 degrees F at the base of the temperature log (3,160 feet bpl). The absence of abrupt temperature changes is an indication that the source of fluid in the tubing is either injection zone water or the water used to flush the well after cementing. The temperature log results provide an indication of internal mechanical integrity.

Gamma Ray Log. The background gamma ray log was run on November 10, 2005 prior to running the RTS as a basis of comparison. The background and real time logs were shown together during the RTS so that changes in the gamma ray counts could be directly observed.

Radioactive Tracer Survey

On November 10, 2005 the RTS tool was configured with detectors arranged above and below the ejector as shown on the log provided in **Appendix H**: GR#3-RTST (the Top detector), the Ejector, GR#2-RTSM (the Middle detector), and GR-RTSB (the Bottom detector). The detector names (i.e. GR#2-RTSM) that appear on the log will be used in the following discussions for clarity. Two low flow (5 feet per minute) tests were performed consistent with the approved Work Plan.

Low Flow Test No. 1. A 2 milliCurie slug of Iodine-131 was ejected into the well at 9:51 AM under pumping conditions at 3,036 feet bpl, 5 feet above the bottom of the casing. A flow rate of 49 gpm was used to maintain an Iodine-131 slug movement of approximately 5 feet per minute. The movement of this slug was monitored for one hour with detectors GR#3-RTST at 3,030 feet bpl, GR#2-RTSM at 3,038 feet bpl and GR-RTSB at 3,044 feet bpl. The slug of tracer was detected by GR#2-RTSM approximately 20 seconds after ejection and GR-RTSB 180 seconds after detection due to the rate of fluid movement. GR#3-RTST did not detect any additional gamma ray activity throughout the entire one hour monitoring period, indicating an absence of an upward migration path immediately behind the casing. **Table 4-1** provides a summary of the one-hour monitoring for Test No. 1.

Table 4-1
Summarized Results of IW-2 Low Flow Test No. 1 - One Hour Monitoring

<table>
<tr><th colspan="2">RTS Tool Specifics</th><th colspan="4">Sequence of Events During Test</th></tr>
<tr><th rowspan="2">Tool Detector/ Ejector</th><th rowspan="2">Depth (feet bpl)</th><th>Test Start</th><th colspan="3">Response Time Since Start of Test</th></tr>
<tr><th>Tracer released @ 9:51 AM hours</th><th>20 sec.</th><th>180 sec.</th><th>None detected</th></tr>
<tr><td>GR#3-RTST</td><td>3,030</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td>Ejector</td><td>3,036</td><td>X</td><td></td><td></td><td></td></tr>
<tr><td>GR#2-RTSM</td><td>3,038</td><td></td><td>X</td><td></td><td></td></tr>
<tr><td>GR-RTSB</td><td>3,044</td><td></td><td></td><td>X</td><td></td></tr>
</table>

Following the one-hour monitoring period, a log-out-of-position was performed by moving the tool from its monitoring position at 3,036 feet bpl up to 2,836 feet bpl (200 feet). **Table 4-2** provides a summary of the LOP results The well was then flushed with potable water at a rate of approximately 90 gpm for approximately 15 minutes and a log-after-flush was performed to verify the removal of tracer from the well. **Table 4-3** provides a summary of the LAF results. A minimal amount of radioactive staining was present on the inside of the 16-inch casing at the point of ejection of the tracer.

Table 4-2
Summarized Results of IW-2 Low Flow Test No. 1 - Log Out-of-Position

Tool Detector	Initial Measuring Depth (feet bpl)	Upper Detectable Limit of Tracer (feet bpl)	Final Measuring Depth (feet bpl)
GR#3-RTST	3,030	None	2,830
GR#2-RTSM	3,038	3,036	2,830
GR-RTSB	3,044	3,036	2,830

Table 4-3
Summarized Results of IW-2 Post Low Flow Test No. 1 – Log After-Flush

Tool Detector	Initial Measuring Depth (feet bpl)	Upper Detectable Limit of Tracer (feet bpl)	Final Measuring Depth (feet bpl)
GR#3-RTST	3,030	None	2,840
GR#2-RTSM	3,038	3,036	2,840
GR-RTSB	3,044	3,036	2,840

Following the flushing of the casing, the stain remained on the casing wall at the point of ejection but had diminished in intensity. The upper detector GR#3-RTST measured gamma readings that matched background values indicating no upward movement of tracer material.

Low Flow Test No. 2. A second test was performed to verify the repeatability of the first low flow test. A second 2 milliCurie slug of Iodine-131 was ejected into the well at 11:51 AM under pumping conditions at 3,036 feet bpl, 5 feet above the bottom of the casing. The pumping rate into the well was approximately 50 gpm creating an Iodine slug velocity of approximately 5 feet per minute. The responses of the detectors were similar to those of the first low flow test demonstrating repeatability and are shown in **Table 4-4**.

Table 4-4
Summarized Results of IW-2 Low Flow Test No. 2 - One Hour Monitoring

RTS Tool Specifics		Sequence of Events During Test			
Tool Detector/ Ejector	Depth (feet bpl)	Test Start	Response Time Since Start of Test		
		Tracer released @ 11:51 hours	20 sec.	180 sec.	None detected
GR#3-RTST	3,030				X
Ejector	3,036	X			
GR#2-RTSM	3,038		X		
GR-RTSB	3,044			X	

A log-out-of-position was performed following Low Flow Test No. 2 and the well was flushed again. The tool was positioned in the injection zone and the remainder of the tracer fluid was ejected during the flushing stage. A final background pass was logged over the same interval as the initial background pass to inspect the entire injection casing. No apparent indication of upward migration of concentrate was observed during this test. A summary of the Low Flow Test No. 2 log-out of position and log-after-flush results are presented in **Table 4-5** and **Table 4-6**, respectively.

Table 4-5
Summarized Results of IW-2 Low Flow Test No. 2 - Log Out-of-Position

Tool Detector	Initial Measuring Depth (feet bpl)	Upper Detectable Limit of Tracer (feet bpl)	Final Measuring Depth (feet bpl)
GR#3-RTST	3,030	None	2,830
GR#2-RTSM	3,038	3,036	2,830
GR-RTSB	3,044	3,036	2,830

Table 4-6
Summarized Results of the IW-1 Low Flow Test No. 2 - Log After-Flush

Tool Detector	Initial Measuring Depth (feet bpl)	Upper Detectable Limit of Tracer (feet bpl)	Final Measuring Depth (feet bpl)
GR#3-RTST	3,144	3,035	0
GR#2-RTSM	3,152	3,035	0
GR-RTSB	3,158	3,035	0

The RTS showed no fluid migrating upwards behind the 16-inch OD final steel casing, cement or the annular cement between the 16-inch OD casing and FRP tubing due to channeling or inadequate cement seal. The initial and final background passes showed responses that were similar. This similarity in the initial background and post-test gamma ray log passes indicates the injection well has external mechanical integrity.

INJECTION TEST

The short-term injection test performed in IW-2 began on January 9, 2006 with 27 hours of background pressure monitoring (no injection). Pressures were recorded in IW-2 and the upper and lower zones of Dual-Zone Monitor Well DZMW-1. Injection began on January 10, 2006 at 1200 hours. A combination of concentrate from the Western Water Treatment Plant (WTP) and raw water from the Biscayne aquifer was injected into IW-2. At the start of injection an average flow of 1,300 gpm was recorded, production well No.2 was offline. On January 10, 2006 at 1630 hours production well No. 2 was brought back on line and the average flow rate increased to approximately 1,818 gpm or 9.5 ft/sec for a period of 12 hours. The average wellhead pressure during injection was recorded at 62 psi. The chloride concentration and specific conductance of the injectate was measured at the beginning, middle and end of the injection period and is summarized in Table 1. The average chloride concentration was 82.5 mg/L with a specific conductance of 1,907.5 mS/cm. On January 11, 2005 at 0515 hours injection was followed by approximately 30 hours of recovery monitoring. The pressure in the injection well decreased to 32 psi. At the start of recovery the valve controlling flow to the injection well was not fully closed, flow was recorded at approximately 150 gpm. The valve was completely closed at 0900 and pressure decrease to 31 psi. Pressures were monitored at the IW-2 wellhead and the upper and lower zones of DZMW-1.

Table 4-6
Injectate Water Quality Monitoring
January 10-11, 2006

Time (Hours)	Chloride (mg/L)	Conductance (mS/cm)
12:10	110	2350
16:27	80	1630
22:25	70	1830
04:30	70	1820

Pressure, tidal and water quality data collected throughout the testing period is presented in graphic and hard copy in **Appendix F**:

TEST RESULTS

The short-term injection test in IW-2 was successfully completed on January 12, 2006 at an approximate flow rate of 1,818 gpm (2.62 MGD, 9.5 ft/sec) for 12 hours. The average injection rate expected at the Miramar Western WTP under normal operating conditions is approximately 1,150 gpm. This average is based on the reported daily injection flow under normal operating conditions for the previous year (2005). Under emergency conditions it is expected that, the City of Miramar could inject up to the injection rate of 12 ft/sec (2,300 gpm).

Section 5
Operating Data Summary

Injection flow rate and pressure head in both IW-1 and IW-2 and pressure head and water quality from the DZMW-1 are reported monthly to FDEP as part of the City's monthly operating reports (MORs). Periodic review of these data provides reasonable assurances that the external mechanical integrity of the injection system and confinement of the injection zone exists. In DZMW-1, water quality above and below the base of the USDW is monitored. The zone below the base of the USDW functions as an early warning system to prevent violations of the Safe Drinking Water Act and applicable parts of Chapter 62-528, FAC.

A graphical representation of the injection flow and pressure head, as well as, upper and lower monitor zone water quality for the period between 1995 and the present can be found in **Appendix G**. A copy of the tabular data is also provided.

FLOWS AND PRESSURES

Concentrate Injection flows at the City of Miramar have increased since the last MIT performed in 2000 from approximately 0.8 MGD to 1.8 MGD. The pressure head of the injection zone at approximately 3,130 feet bpl has shown a slight increase from 30 psi to approximately 35 psi over the same time period in response to the injection flow increase. The monitor zones above the injection zone as indicated by the DZMW-1 upper and lower zone pressures have not shown a pressure head increase that corresponds to the increase in injection flows. The DZMW-1 upper and lower zones have displayed stable pressures of approximately 2 psi and 14 psi, respectively. In the month of June 2005 there is a sudden increase in the upper monitoring zone pressure due to monitoring equipment malfunctioning, the equipment was replaced/repaired in July 2005. The absence of a pressure change response in the DZMW-1 upper and lower zones to the inflection flow increase is an indication that there is geohydrologic confinement between the injection zone and monitor zones.

WATER QUALITY

Several key parameters are monitored in the DZMW-1 upper and lower zones. For instance, since salinity increases with depth, increases in chloride, specific conductance, TDS or sulfate in the DZMW-1 might indicate the upward movement of deeper aquifer water. Similarly, ammonia and TKN concentrations are higher in the injection fluid than they are in the native water of the monitoring zones. Therefore, an increase in ammonia or TKN in the DZMW-1 might indicate the movement of injection fluids upward. The following is a brief summary of the observed trends for key water quality data from each monitor zone in the DZMW-1. The "Trend" column in **Tables 5-1**, **5-2** and **5-3** below indicates the concentration change characteristics of the various parameters. The terms "Increasing" and "Decreasing" have a traditional meaning for the behavior of a parameter's concentration over time. The term "Constant" means that the parameter's history shows a concentration that does not vary by much over the review period and the term "Fluctuates" indicates that the parameter's concentration goes up and down with no observed pattern over the review period.

Table 5-1
Summarized Trend for Water Quality Parameter in DZMW-1
Upper Zone (1,639 to 1,738 feet bpl)

Parameter	Range of Concentration	Trend 1995-2005
Chlorides	3,500 mg/L	Constant
Specific Conductance	11,000 μmhos/cm	Constant
TDS	7,000 mg/L	Constant
Sulfate	400 and 600 mg/L	Fluctuates
Ammonia	0.2 to 0.5 mg/L	Constant
TKN	1.0 to 5.0 mg/L	Constant

Upper monitor zone water quality appears to be relatively constant. Minor fluctuations are observed but appear to be laboratory analysis related versus a concentration trend.

Table 5-2
Summarized Trend for Water Quality Parameter in DZMW-1
Lower Zone (1,930 to 2,005 feet bpl)

Parameter	Range of Concentration	Trend 1995-2005
Chlorides	18,000 to 22,000mg/L	Constant
Specific Conductance	48,000 μmhos/cm	Constant
TDS	30,000 to 40,000 mg/L	Fluctuates
Sulfate	4,000 mg/L	Fluctuates
Ammonia	0.2 to 1.0 mg/L	Constant
TKN	0.7 to 5.0 mg/L	Constant

The lower monitor zone shows an increase in chloride concentration (18,000 to 22,000 mg/L) that appears to have started around year 2002 and has stabilized at approximately 20,000 mg/L between year 2003 and 2004. Sulfate has shown an increase (2,000 to 5,000 mg/L) similar to that of the chloride concentrations. However, data from year 2003 and 2004 indicate that sulfate concentrations have returned to previous levels (2,000 mg/L). Chlorides and sulfates increases were not associated with increases in

TDS and specific conductance, as might be expected if injection zone water was moving upward.

Table 5-3
Summarized Trend for Water Quality Parameter in Concentrate

Parameter	Range of Concentration	Trend 1995-2005
Chlorides	1,700 mg/L	Constant
Specific Conductance	7,000 µmhos/cm	Constant
TDS	5,000 mg/L	Constant
Sulfate	800 to 900 mg/L	Fluctuates
Ammonia	3 to 11 mg/L	Fluctuates
TKN	6 to 30 mg/L	Fluctuates

The concentrate data indicate relatively stable concentrations of chlorides, specific conductance, and TDS. Sulfate, ammonia and TKN concentrations increase and decrease with no real pattern.

SUMMARY OF WATER QUALITY DATA

The water quality data from the DZMW-1, in general, indicates that the concentrations of the key parameters in the upper and lower monitor zones are relatively stable. This stability demonstrates that confinement exists between the monitoring zones and the injection zone. The absence of pressure head responses in DZMW-1 to injection flow increases coupled with relatively stable water quality is an indication of the external mechanical integrity of the injection system.

Section 6 Mechanical Integrity Testing Conclusions

The MIT results indicate that IW-1 and IW-2 have external and internal mechanical integrity in accordance with Chapter 62-528, FAC.

The video surveys did not reveal any visual structural defects in the 16-inch OD casing nor 10.75-inch nominal FRP tubing installed in IW-1 and IW-2. The pressure test results from the FRP tubing indicate the tubing holds pressure, and the gradual temperature changes within the tubing indicate that there is no breach in the tubing of either injection well. The video survey, pressure test and temperature log results demonstrate the internal mechanical integrity of IW-1 and IW-2.

The RTS conducted in each modified injection well produced results that indicate good external mechanical integrity of the 16-inch OD final casing, the casing cement seal, and annular cement seal. Injection tests indicate the modified wells are capable of operating at an injection rate of 10 ft/sec (approximately 1,920 gpm or 2.76 MGD).

Injection flows have increased over the review period between 1995 and 2005 with no corresponding increase in pressure in the upper and lower monitor zones of DZMW. The water quality data collected since the well system was constructed does not indicate a connection between the monitoring zones and the injection zone. The results of the RTS and the flow, pressure and water quality review indicate that IW-1 and IW-2 have good external mechanical integrity.

Therefore, all data indicates that IW-1 and IW-2 are mechanically sound and can be operated as a Class I Industrial Injection Wells under Rule 62-528, FAC at a confirmed rate of 10 ft/sec (2.76 MGD) with a modified design. A pressure test and video survey will be performed every 2.5 years and a RTS will be performed every 5 years in accordance with FDEP regulations. Flow, pressure head, and water quality will be monitored in both the injection wells and DZMW-1 upper and lower zones. This data will be provided to the FDEP on a monthly basis.

Section 7 Operations and Maintenance (O&M) Manual Update

This operation and maintenance (O&M) manual is a reference guide for the operation and maintenance of the City of Miramar's Class I injection wells system and Dual Zone Monitoring system, consisting of Injection Wells IW-1 and IW-2 and Dual Zone Monitoring Well DZMW-1 for the Miramar West Water Treatment Plant (WTP). The guidelines and procedures that follow are necessary for efficient system operation. Operating personnel must fully understand the function and interrelationship of all components contained within the membrane concentrate system to prevent unscheduled maintenance or repairs that may require use of the emergency disposal system. Major components are scavenger tank, surge protection system, injection well monitoring system and existing water treatment systems. (Refer to Emergency Response Plan for this system available at the West WTP.)

The injection well system provides the City with an environmentally system for the discharge of concentrate from the membrane softening process. The concentrate disposal zone, accessed through the use of deep injection wells, is a saltwater zone located approximately 3,100 feet below land surface (bls).

GENERAL SYSTEM DESCRIPTION

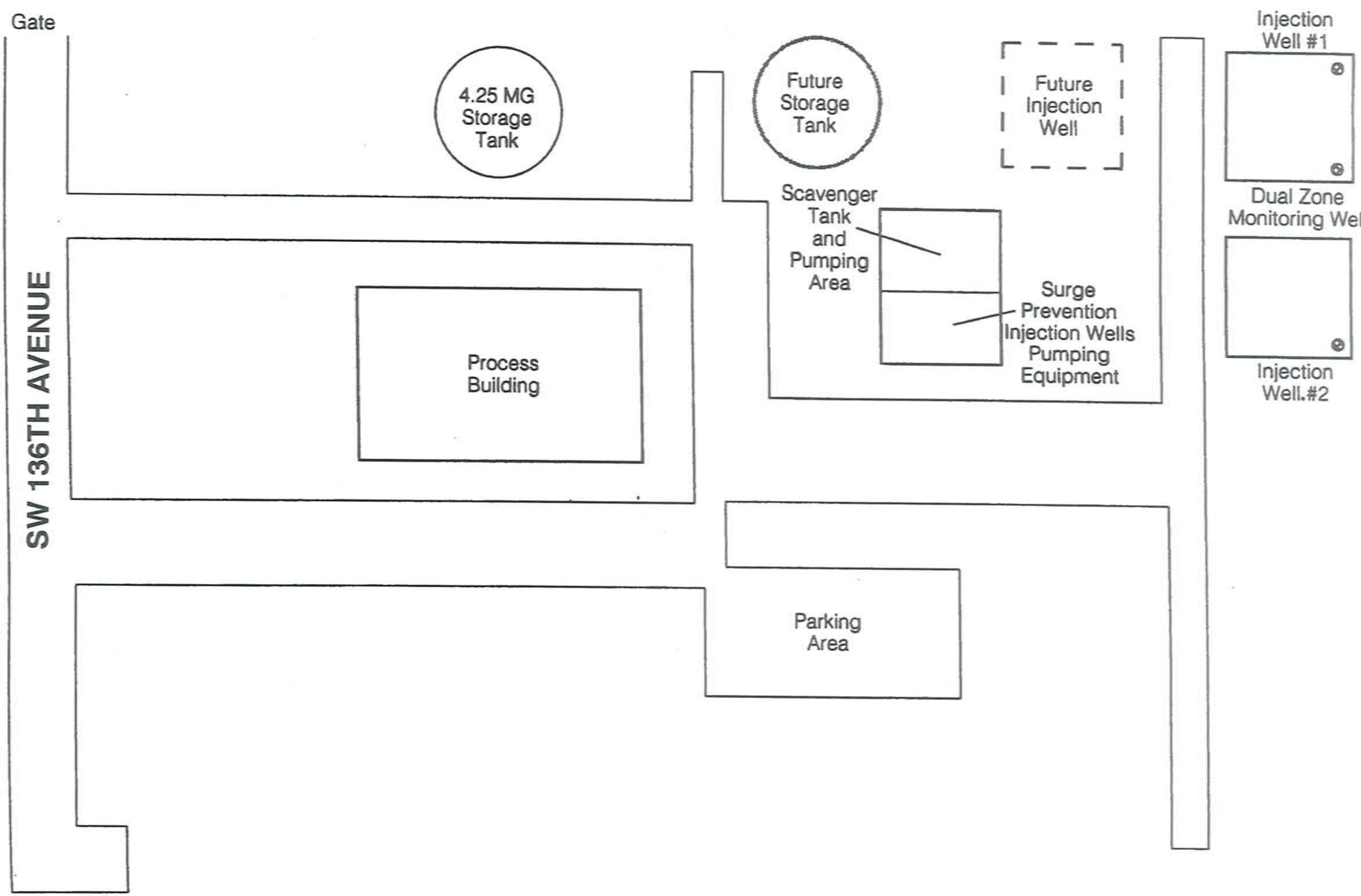
The injection well system at the Miramar West WTP consists of two injection wells, a 10.75-inch nominal Fiberglass Reinforced Plastic (FRP) tubing (8.85-inch inside diameter (ID)) with a scavenger tank system, surge control system, a dual zone monitoring well, and control and monitoring instrumentation. The two injection wells (IW-1 and IW-2) have a rated capacity of 2.74 million gallons per day (MGD) (1,900 gallons per minute (gpm)) of peak hour flow per well (velocity of 10 feet per second (ft/s)) and under emergency conditions could inject up to 12 ft/sec (2,300 gpm). The site plan depicted in **Figure 7-1** shows the location of the two injection well sites (IW-1 and IW-2), and the dual zone monitoring well (DZMW-1). **Figure 7-2** shows schematically the scavenger tank (6-T-1804) with two scavenger pumps (6-P-1803 and 6-P-1804). **Figure 7-3** shows schematically the surge protection system consisting of the hydropneumatic tank (6-T-2301) and air compressor (6-ME-2301) along with the injection wells pumping (6-P-2301, 6-P-2302, 6-P-01) system and one injection well Jockey pump (6-P-2303).

Figures 7-4 and **Figure 7-4A** present the injection well construction details and casing depths for both wells. The injection wells are constructed with four concentric steel casings (42-, 34-, 26-, and 16-inch outside diameter (OD)) designed to protect the subsurface environment. All casing except for the final casing are 0.375-inch wall thickness. The final casing (16-inch OD) extending 3,095 feet in IW-1 and 3,040 feet in IW-2 has a wall thickness of 0.5 inches. All casings, except for the final casing, conform to the standards of ASTM A139 Grade B. The final casing conforms to the standards of ASTM A53 Grade B. All casings are cemented from top to bottom. The injection tubing is Fiberglass tubing conforming to API Specification 15TR, ASTM Specification D2996 (Designation RTRP-11AT-1334 and Classification D2310 (Designation RTRP-11AT) and quality controlled in compliance with ISO-9001 and ANSI-RAB. The 10.75-inch nominal FRP injection tubing set in IW-1 and IW-2 has dimensions of 9.76-inch OD, 8.85-inch ID and a wall thickness of 0.45 inches. The tubing was set at a depth of approximately 3,033 feet in IW-1 and 2,967 feet in IW-2.

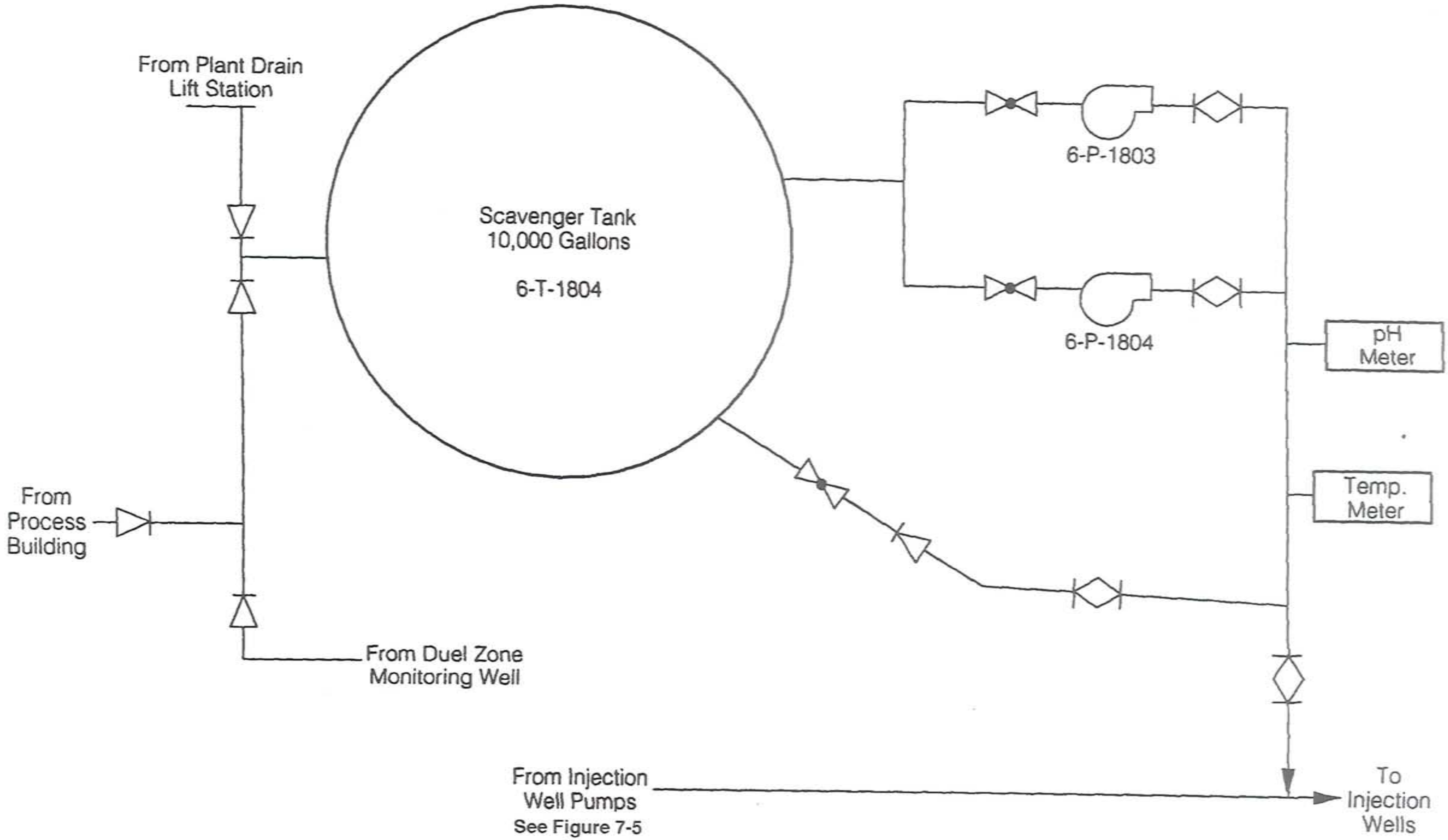
Figure 7-5 presents a detailed schematic of the complete injection well system. The injection pumping equipment includes four variable speed horizontal, centrifugal, split case pumps. Three pumps (6-P-2301, 6-P-2302, 6-P-01) have a design operating point of 700 gpm at 64 feet total dynamic head (TDH). The fourth pump (06-P-2303) serves as a jockey pump with a design operating point of 350 gpm at 64 feet TDH. All well pumps are controlled by the variable speed drives (VSDs) and a pressure control signal from the Central Control Panel (CCP). The Panel Instrumentation Control (PIC) receives the concentrate flow pressure signal from the pressure transmitter (PIT-3831) located upstream from the injection well pumps. Each injection well pump run status is monitored at the Man Machine Interface (MMI). To protect the injection tubings, well heads, pumping equipment and the related piping system from the effects of water hammer, a surge protection system is installed. It provides a hydraulic cushion to dampen the effects of water hammer within the system. The surge tank (6-T-1804) should have 40 percent water (400 gallons) in it at all times. All levels and tank pressures are recorded at the MMI. If levels exceed the 40 percent, the MMI will increase air pressure from the air compressor to reduce the level in the tank.

Scavenger tank (6-T-1804) levels are monitored by an ultrasonic element. The tank level is indicated locally and at the MMI, while a software high/low level switch provides start/stop for the scavenger pumping equipment (6-P-1803 and 6-P-1804). The concentrate is pumped into the selected operating injection well down to an approximate depth of 3,179 feet for IW-1 or 3,100 for IW-2 where it flows into a highly transmissive dolomite from 2,986 to 3,100 feet known as the boulder zone. The overlying formations confine the concentrate to that depth where it migrates radially and horizontally away from the well (refer to **Figures 7-4** and **7-4A**).

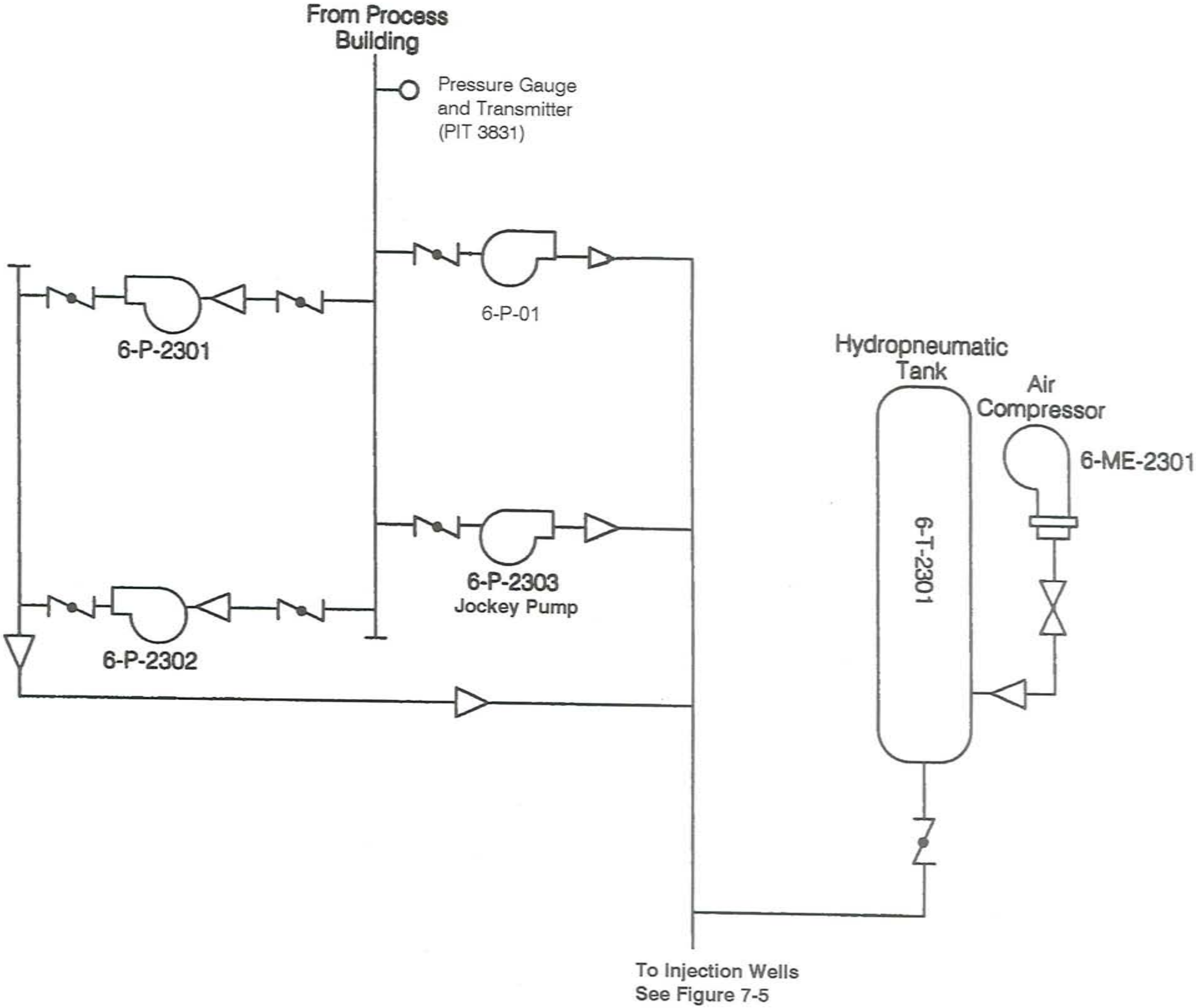
The flow rates at the two injection wells are monitored locally and are indicated and recorded at the MMI. Flows are measured by a magnetic flow meter (4-20 mA-dc) and scaled pulse type (4-M-2401 and 4-M-2402). Both flow rates are summed and integrated over time for total indication, recording and storing. At the same time, wellhead injection pressures are monitored locally and transmitted to the MMI for indication, recording, and storage.



INJECTION WELL SITE PLAN
FIGURE 7-1

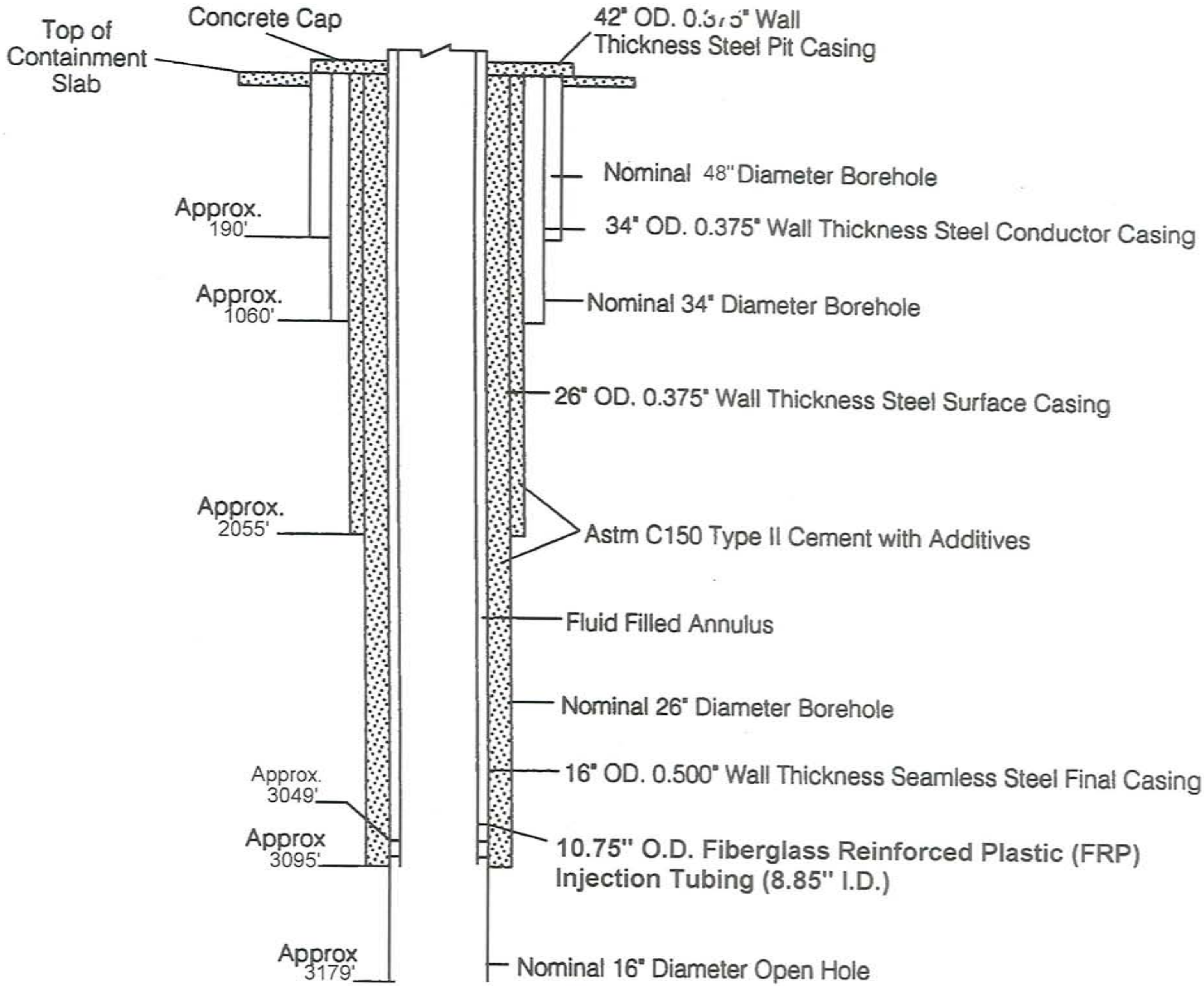


SCAVENGER TANK & PUMPING EQUIPMENT
SCHEMATIC DIAGRAM
FIGURE 7-2

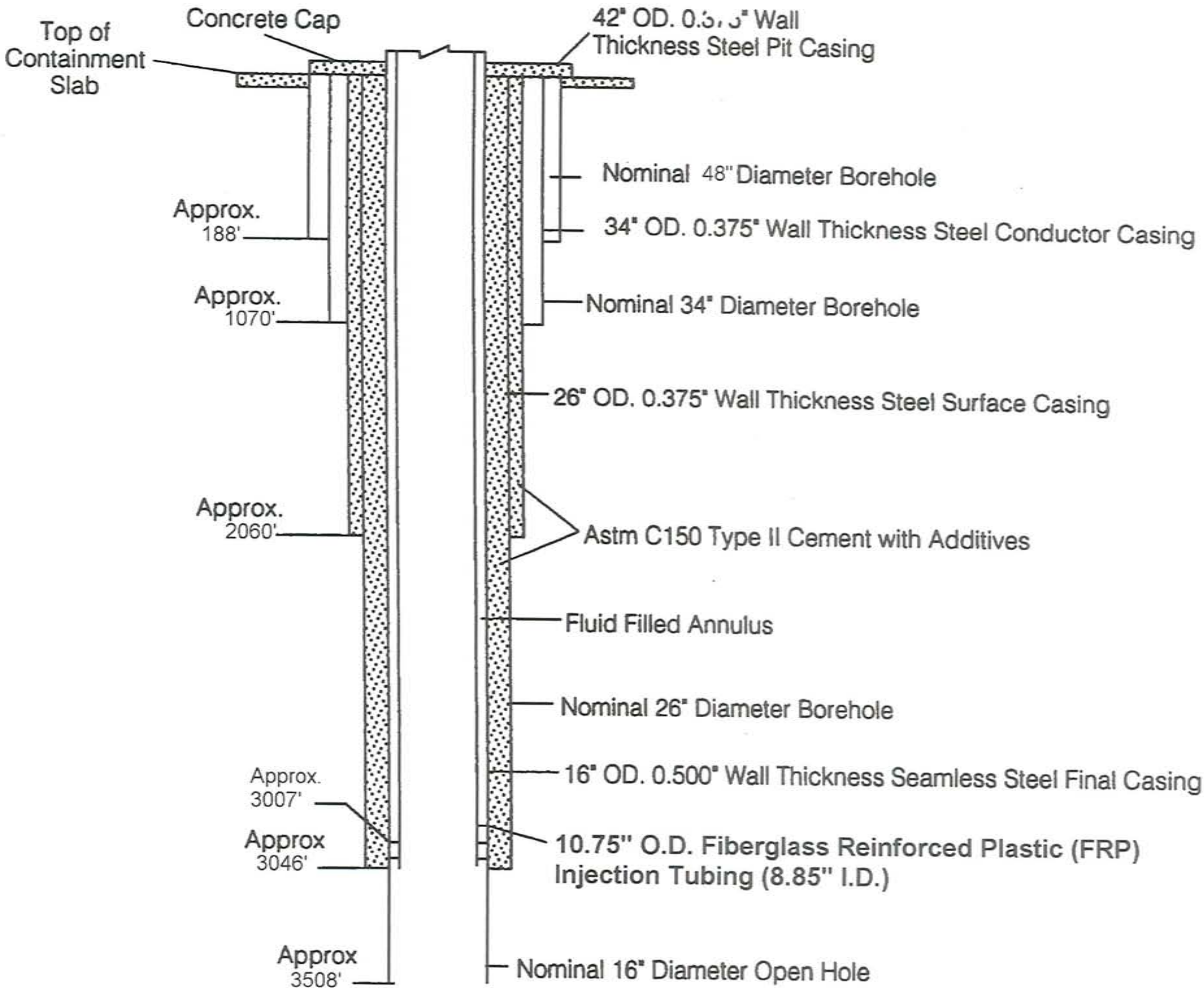


INJECTION WELLS PUMPING AND SURGE PROTECTION EQUIPMENT SCHEMATIC DIAGRAM

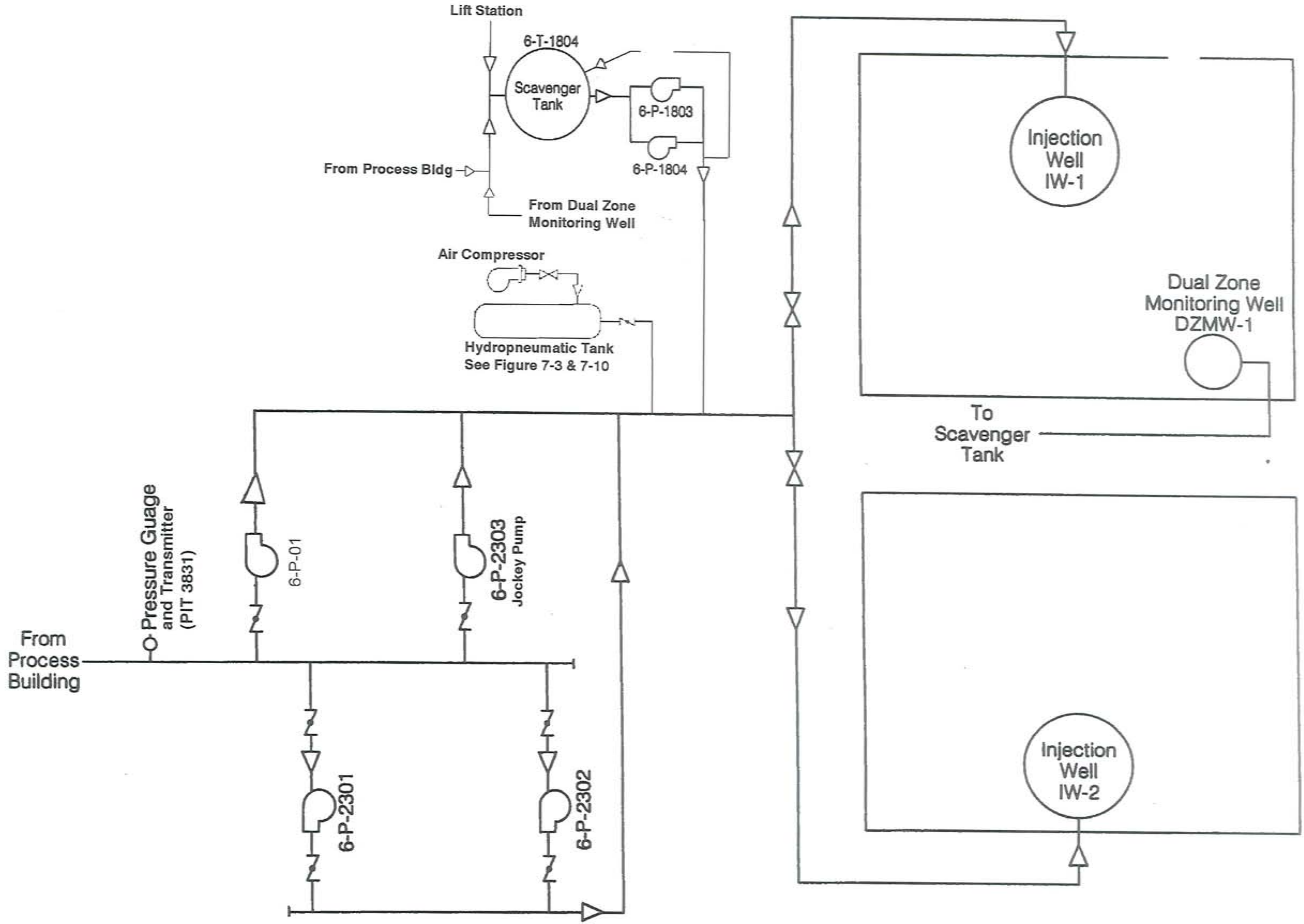
FIGURE 7-3



INJECTION WELL DETAIL FOR IW-1
FIGURE 7-4



INJECTION WELL DETAIL IW-2
FIGURE 7-4A



INJECTION WELL SYSTEM SCHEMATIC DIAGRAM
FIGURE 7-5

Operator Responsibility

The injection well pumping system is an integral part of the Miramar water treatment facility and must be maintained by skilled personnel to ensure proper disposal of the concentrate. A qualified operator should have a good working knowledge of pumps, motors, electrical and electronic equipment, the surge protection system, hydraulic, water treatment and good safety practices. The operator must also properly interpret, record, file and correctly and accurately report system operating and monitoring data. Successful plant operation depends on qualified personnel and adequate supplies to enable a prompt and thorough response to system operation and maintenance requirements and issue corrections.

SYSTEM DESCRIPTION

Injection Flow Diagram, Equipment, and Instrumentation

Figure 7-5 and **Table 7-1** schematically detail the equipment and instrumentation used at the Miramar West WTP injection well system and their functional relationships. The operator is encouraged to consult the equipment manufacturers' operation and maintenance literature on file at the WTP for further technical information on system components.

Table 7-1
Concentrate Disposal System Design Criteria

Concentrate Injection Well Pumps	
Injection Well Pumps (6-P-2301, 6-P-2302, 6-P-01)	Three horizontal split case pumps, each pump rated at a capacity of 700 gpm at 64 feet total dynamic head (TDH). Minimum pump efficiency is 60 percent. Motor speed is 1800 rpm, with a minimum horsepower of 15 hp.
Injection Well Jockey Pump (6-P-2303)	One horizontal split case pump, rated at a capacity of 350 gpm and 64 feet TDH. Minimum pump efficiency is 60 percent. Motor speed is 1800, with a minimum of 15 hp.

Table 7-1
Concentrate Disposal System Design Criteria

Concentrate Injection Surge Suppression Hydropneumatic Tank	
Surge Suppression Hydropneumatic Tank (6-T-2301)	One welded steel hydropneumatic tank of 1,000 gallon capacity for hydraulic surge suppression on concentrate water during flow to the injection wells. Tank is fabricated in accordance with ASME Code requirements, with a pressure rating 50 percent above the 125 psi design working pressure.
Injection Well Head Appurtenances	
Well Head Flow Meters	
Well Head Air Vacuum Relief and Air Release Valves	

Injection Well Pumps

The four injection well pumps are variable speed horizontal, centrifugal, split case pumps. Three pumps (6-P-2301, 6-P-2302, 6-P-01) are Peerless model 5AE11 with a design point of 700 gpm at 64 feet TDH. The fourth pump (06-P-2303) serves as a jockey pump and is a Peerless model 3AE9G with a design point of 350 gpm at 64 feet TDH. The injection well pumps are controlled by the variable speed drives (VSDs) with two pressure control signals from the CCP. The PIC receives the concentrate flow pressure signal from the pressure transmitter (PIT-3831) located upstream from the injection well pumps. The PIC operates in an automatic or manual mode. In the manual mode, the operator adjusts the PIC output at the CCP. In the automatic mode, the PIC adjusts the speed of each pump to maintain a preset value. Each injection well pump-run status is monitored at the MMI. Each pump start, stop and total run time is stored at the MMI. Pump run time shall be indicated at the MMI. Each pump failure alarm annunciates at the MMI. Injection well pump run status is monitored by the MMI at all times. **Figures 7-6** presents the pump curve for pumps 06-P-2301, 06-P-2302, and 06-P-01. **Figure 7-7** presents the pump curve for the jockey pump 06-P-2303. **Figure 7-8** presents the system curve for the injection well system with pumps 06-P-2301, 06-P-2302, and 06-P-01 operating. **Figure 7-8A** presents the system curve for the injection well system with the jockey pump (06-P-2303) operating. Pump curves are shown for the pumps operating at variable speeds.

Scavenger Tank and Pumping Equipment Station

The scavenger pump station shown in **Figure 7-2** consists of one 10,000 gal. Scavenger tank (6-T-1804) and two scavenger tank discharge pumps (6-P-1803 and 6-P-1804). These pumps pump the scavenged waste flows into the injection well's piping system downstream of the injection well pumping equipment. Scavenger tank (6-T-1804) levels are monitored by an ultrasonic element. The tank level is indicated locally and at the MMI, while a software high/low level switch provides start/stop operations for the scavenger pumping equipment (6-P-1803 and 6-P-1804).

Injection Piping

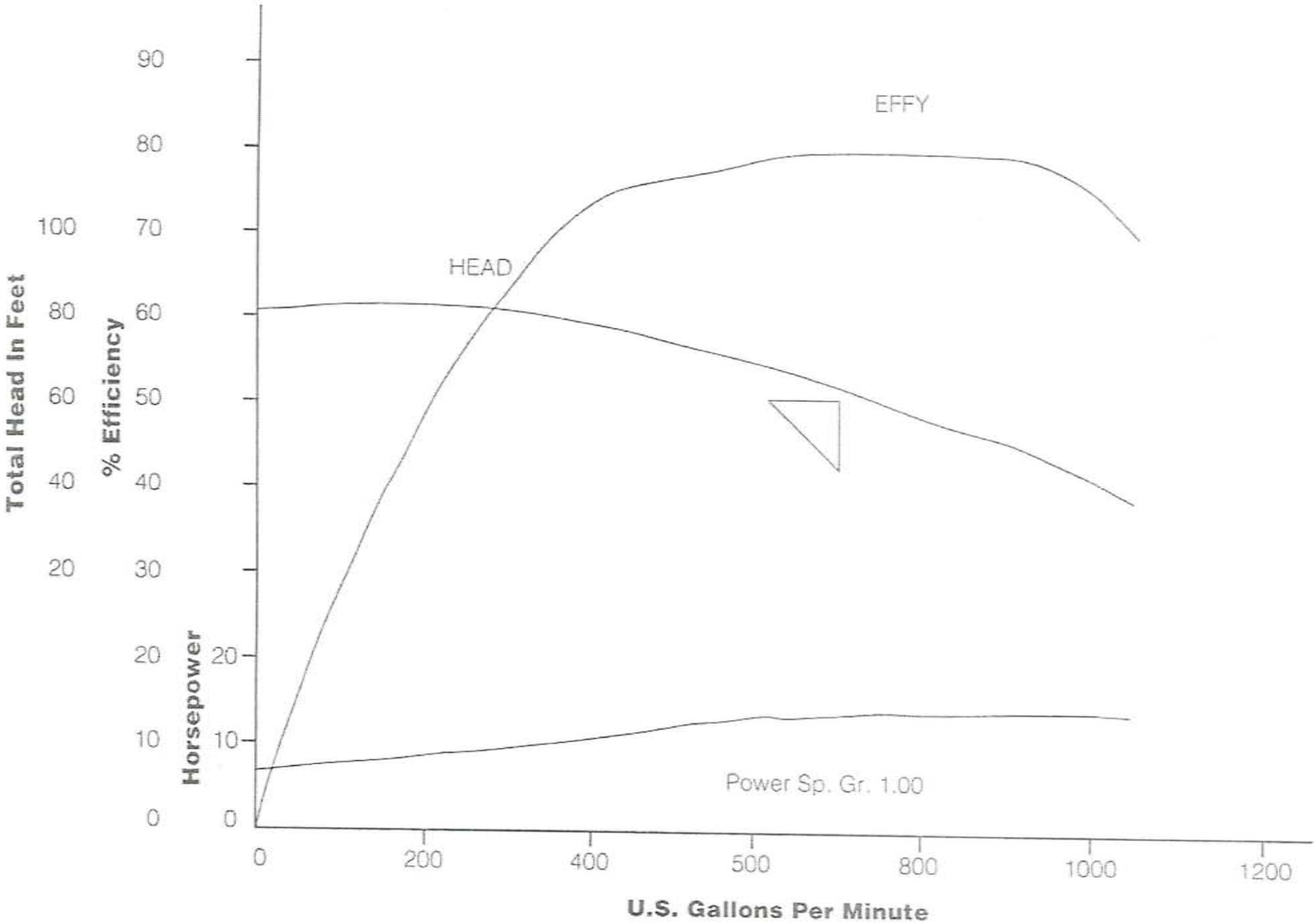
Each pump discharge at the injection pump station is individually connected to the 12-inch injection well pipeline. Each pump is fitted with an 8-inch check valve that prevents concentrate backflow and an 8-inch butterfly valve used to isolate the individual pumps from the injection pipeline. The pipeline remains pressurized when no injection is taking place due to the artificial "artesian head" produced at the injection wells. A 12-inch gate valve at the injection wellhead shown in **Figure 7-9** isolates the well from the remainder of the system. The injection well pump station piping was originally sized for an expected buildout capacity of 12 MGD.

Pump Control

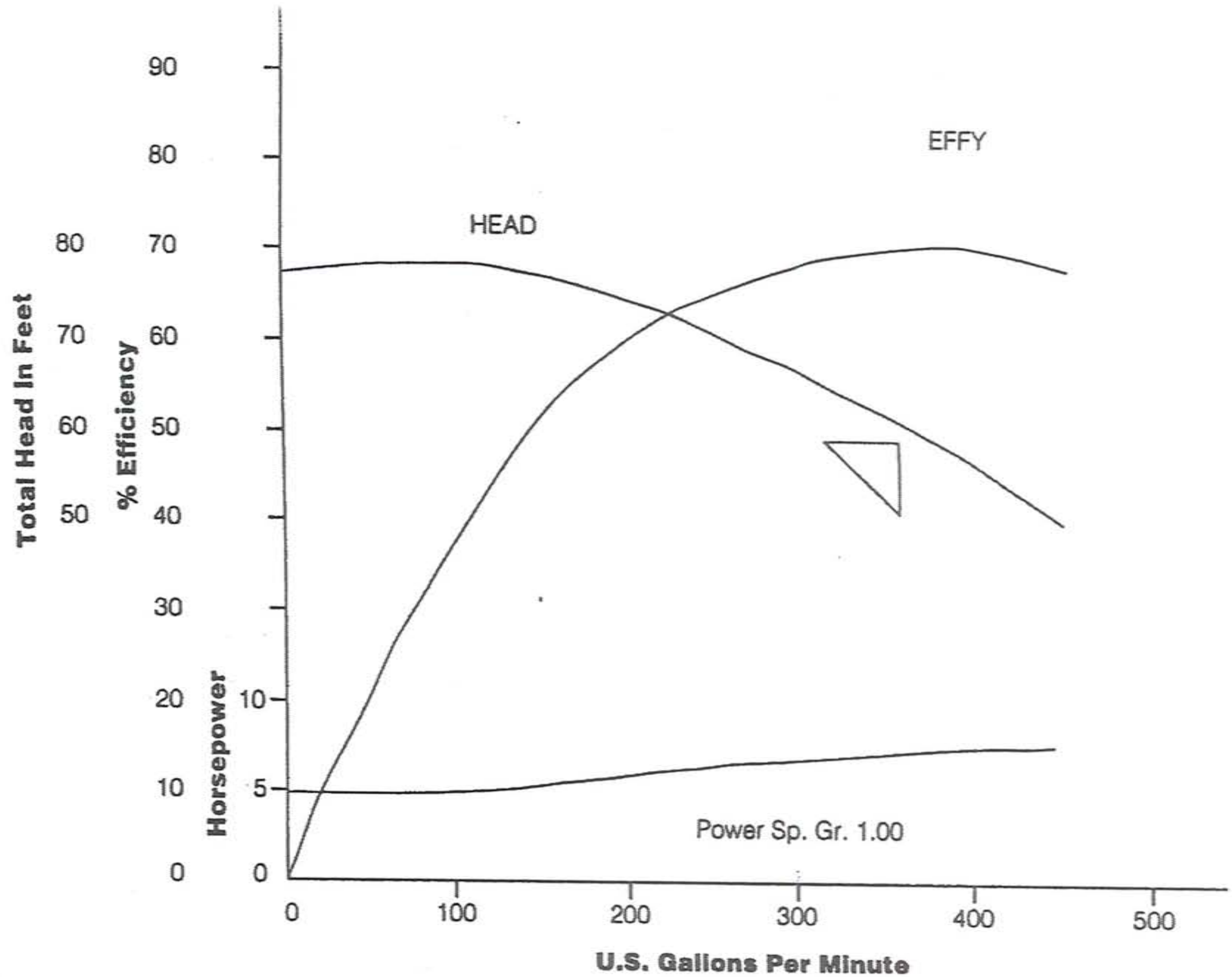
The operation of the injection pumps is controlled by the variable speed drives (VSDs) with a pressure control signal from the CCP. The PIC receives the concentrate flow pressure signal from the pressure transmitter (PIT-3831) located upstream from the injection well pumps. The PIC operates in either an automatic or manual mode. In the manual mode, the operator adjusts the PIC output at the CCP. In the automatic mode, the PIC adjusts the speed of each pump to maintain a preset value. Each injection well pump run status is monitored at the MMI.

Each pump start, stop and total run time is stored at the MMI. Pump run time is indicated at the MMI. Each pump failure alarm annunciates at the MMI. Injection well pump run status is monitored at the MMI. The MMI provides all systems operations data for the pumps, scavenger tank level and surge control system. CCP and MMI show the pump status and an audible alarm sounds should a pump failure, a scavenger tank high, or a surge control system trouble alarm occur.

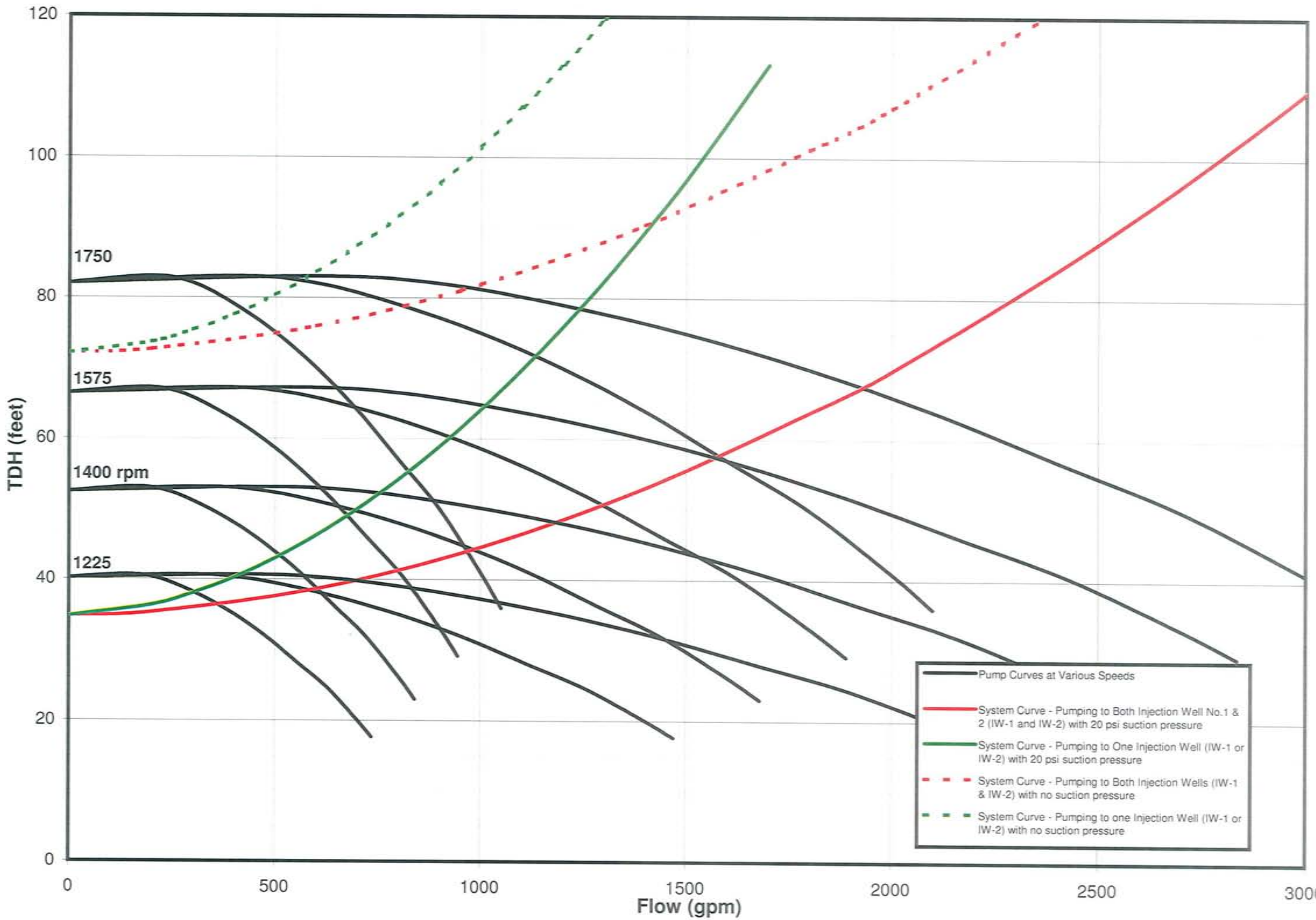
Should a pump fail to produce discharge pressure within a preset time period after it has been called to run, a pump fail alarm is indicated and sounded at the annunciator panel. The On/Off status of the pump is also indicated at the MMI. OFF status is indicated by a control relay contact which is closed only if the motor starter breaker is closed and the starter is not energized.



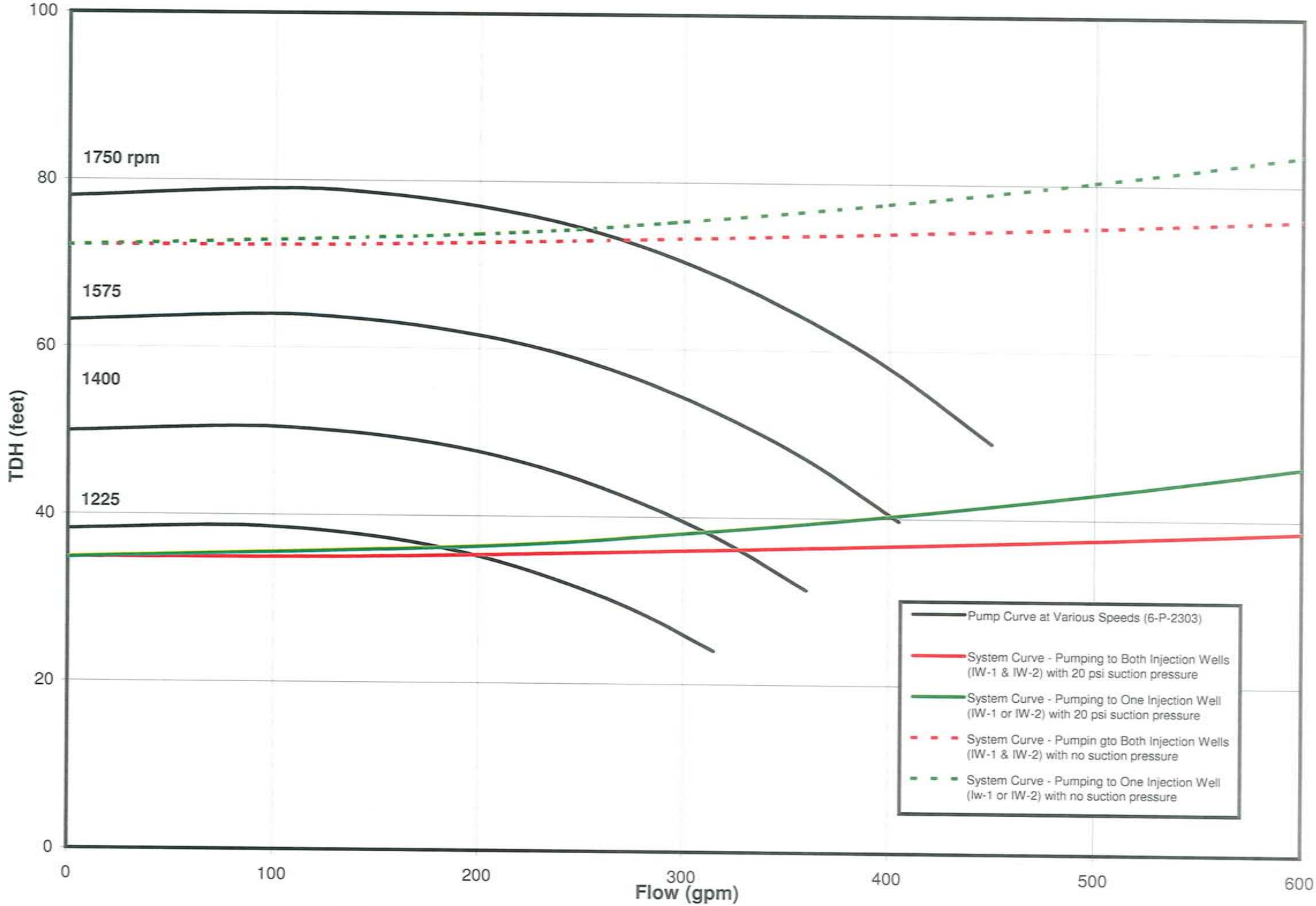
INJECTION WELL PUMP HEAD CAPACITY CURVE
(PUMP 06-P-2301, 06-P-2302, and 6-P-01)
FIGURE 7-6



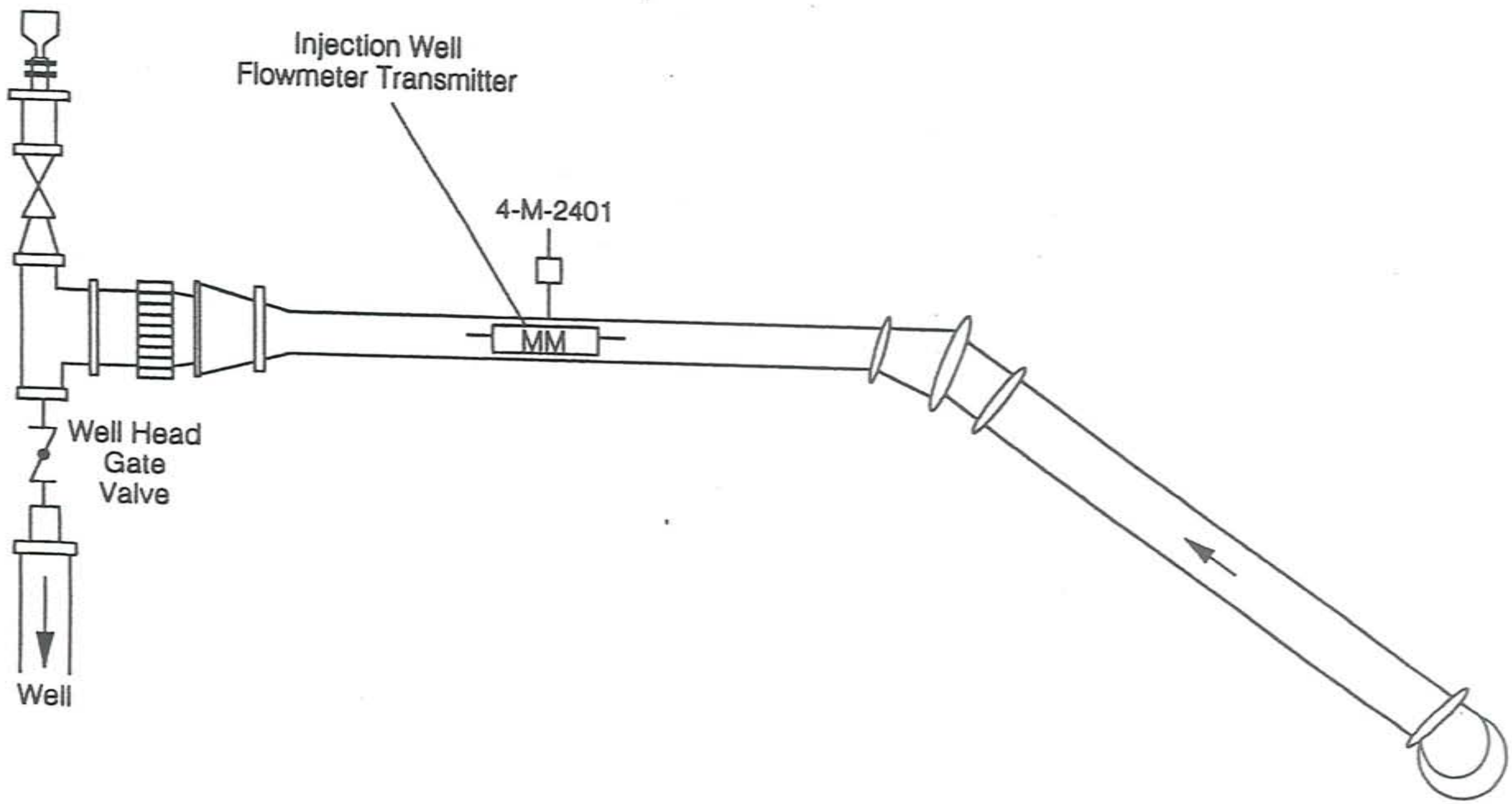
JOCKEY PUMP (06-P-2303)
HEAD CAPACITY CURVES
FIGURE 7-7



INJECTION WELL SYSTEM CURVE AND PUMP CURVES
FIGURE 7-8



INJECTION WELL SYSTEM CURVE AND JOCKEY PUMP CURVES
FIGURE 7-8A



INJECTION WELLHEAD GATE VALVE AND FLOWMETER TRANSMITTER
FIGURE 7-9

Surge Protection System

The injection piping is connected to the 1000-gal. surge tank downstream from the pumps (see **Figure 7-3**, **Figure 7-5**, and **Figure 7-10**). The purpose of the surge protection system is to dissipate hydraulic surges caused by an increase or decrease in the flow velocity within the piping system. It is also effective against surges that may occur during a power failure which would stop all pumps instantaneously.

When the pumps are stopped, the water in the piping system initially remains in motion due to its momentum. This momentum causes a low pressure downstream of the pump check valves. If the liquid is flowing at high velocity, a void opens at the face of the valve. The reversal of the water column after the momentum dissipates may produce a damaging pressure when these cavities collapse. This phenomenon is knows as "water hammer". The surge tank reduces the magnitude of the downsurge by providing a reservoir of water to fill voids caused by the low pressure wave and to help prevent water column separation. The backsurge is reduced by the cushioning effect of the compressed air in the tank. The water in the tank is maintained within a proper level range during the steady state condition by a level control system which, in this facility, consists of a control panel, level switches mounted on the tank, air addition and air vent valves, and an air compressor.

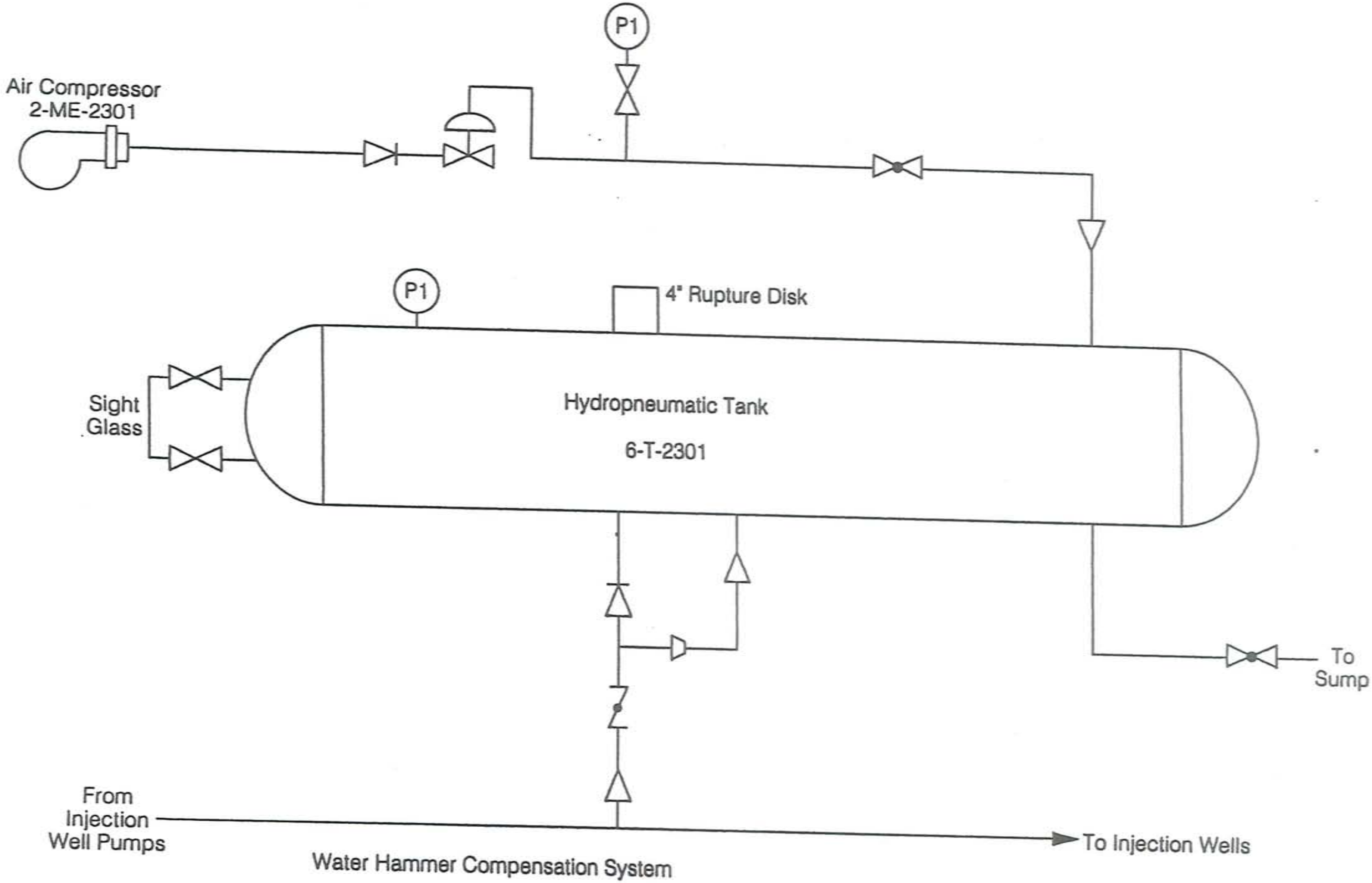
The function of this control system, which should operate only during liquid steady state conditions, is to add air to the tank if the water level is above the maximum level and to vent air from the tank if the level is below the minimum level. Should the air supply pressure drop below a pre-set minimum, a low pressure alarm will be sounded at the annunciator panel. Daily visual inspections are recommended to ensure proper water level in the surge tank.

Note: The automatic functions of this system work properly only when the pump controls in the Motor Control Center "MCC" are set on "Auto". If the controls are operated manually or are "Off", the surge tank controls will not operate.

For manual operation of the system, air can be added to the tank by opening the bypass valve adjacent to the air supply solenoid. The water level change can be observed in the sightglass. Air can be released from the tank by opening the bypass valve adjacent to the air release solenoid.

Electrical Service

The pumps operate on 460-volt, three-phase, 60-Hz power. A 120/240 lighting panel located near the Motor Control Center (MCC) provides power for controls, MCC heaters, lights, receptacles, etc. Power is supplied to the MCC from a 400-amp circuit breaker at the service entrance panel located in the electrical service room. See **Section 9** (Plant Utilities) of this manual for more details.



SURGE PROTECTION SYSTEM
FIGURE 7-10

Injection Wells Flow Rate and Pressure Instruments

The injection well flow rate is measured with a magnetic flowmeter transmitter located in the injection piping near the wellhead as shown in **Figure 7-9**. The signal is transmitted to the MMI located in the Control Building. Injection pressure is measured at the high pressure side of the flow element. An analog signal proportional to that pressure is transmitted to the MMI located in the Control Building.

Injection Well Description

The injection wells were constructed according to the design and construction standards in the Chapter 62-528, Florida Administrative Code (F.A.C.), as required by the Florida Department of Environmental Protection (FDEP). The wells consist of four concentric steel casings, as shown in **Figure 7-4** and **7-4A**, designed to protect the subsurface environment from the potential contamination from injected concentrate. The first of the casings, the 42-inch diameter conductor casing, protects the surficial freshwater aquifer. Each subsequent casing telescopes to increasing depth, casing-off deeper water producing zones (aquifers), or confining units (aquitards). All casings are fully cemented from the base of the casing up to land surface. The 34- and 26-inch OD casings case-off the brackish water of the Floridan aquifer. The 16-inch final casing (0.500-inch wall thickness), set to 3,095 feet for IW-1 and 3,040 feet for IW-2, protects the confining beds between the brackish water and the injection zone.

A highly fractured cavernous dolomite within the Oldsmar Formation that makes up the injection zone is located between the depths of 3,095 feet and 3,179 feet for IW-1 and 3,040 feet and 3,100 feet IW-2. Injection occurs between these two points. The injection zone is separated from the potable water-bearing strata of the surficial aquifer by approximately 2,900 feet of limestone and clay. The base of the Underground Source of Drinking Water (USDW) is located at approximately 1,778 feet below land surface. The base of the USDW is considered by regulators to be the deepest that it would be feasible to extract water for potable supply purposes delineated by a total dissolved solids (TDS) concentration of 10,000 milligrams per liter (mg/L). This zone lies 1,300 feet above the top of the injection zone. The natural water quality in the injection zone is similar to that of seawater.

Positive head means that the injection wells remain under pressure at the wellheads under static and pumping conditions. The wellhead pressure will increase during injection, in proportion to the flow rate. The wellhead pressure increase is attributable to friction losses in the well casing and the buoyancy of the less dense injected fluid on the native saltwater and the loss into the geologic formation.

Monitoring Well Description

The Floridan aquifer is monitored by the dual zone monitoring well (DZMW-1) located in the containment area of injection well IW-1. The monitor well is located equidistant between the two injection wells that are located 220 feet apart. As such, the monitor well is 110 feet from each injection well. **Figure 7-11** and **Figure 7-12** present details of the dual zone monitoring well.

Conductor Casing is 24-inch (OD), 0.375-inch wall thickness, conforming to the standards ASTM A139 Grade B, and was set in cement in one stage to a depth of 186 feet. The Intermediate Casing is 16-inch (OD), 0.375-inch wall thickness, conforming to the standards of ASTM A139 Grade B, and was set in cement to a depth of 1,639 feet below land surface. Monitor Tubing is 6 5/8-inch (OD), 0.562-inch wall thickness, conforming to the standards of ASTM A53 Grade B, was set and interval cemented between 1,930 feet 1,738 feet bls. The exterior of the casing above 1,738 feet bls was coated with an epoxy phenolic paint for protection where it is uncemented. The upper monitoring zone is between 1,639 feet bls and 1,738 feet bls. While the lower monitoring zone is set at between bls 1,930 and 2,005 feet bls. The monitoring well test results show the water from this zone is brackish with TDS of approximately 6,000 mg/l for the upper zone and 29,000 mg/l for the lower zone.

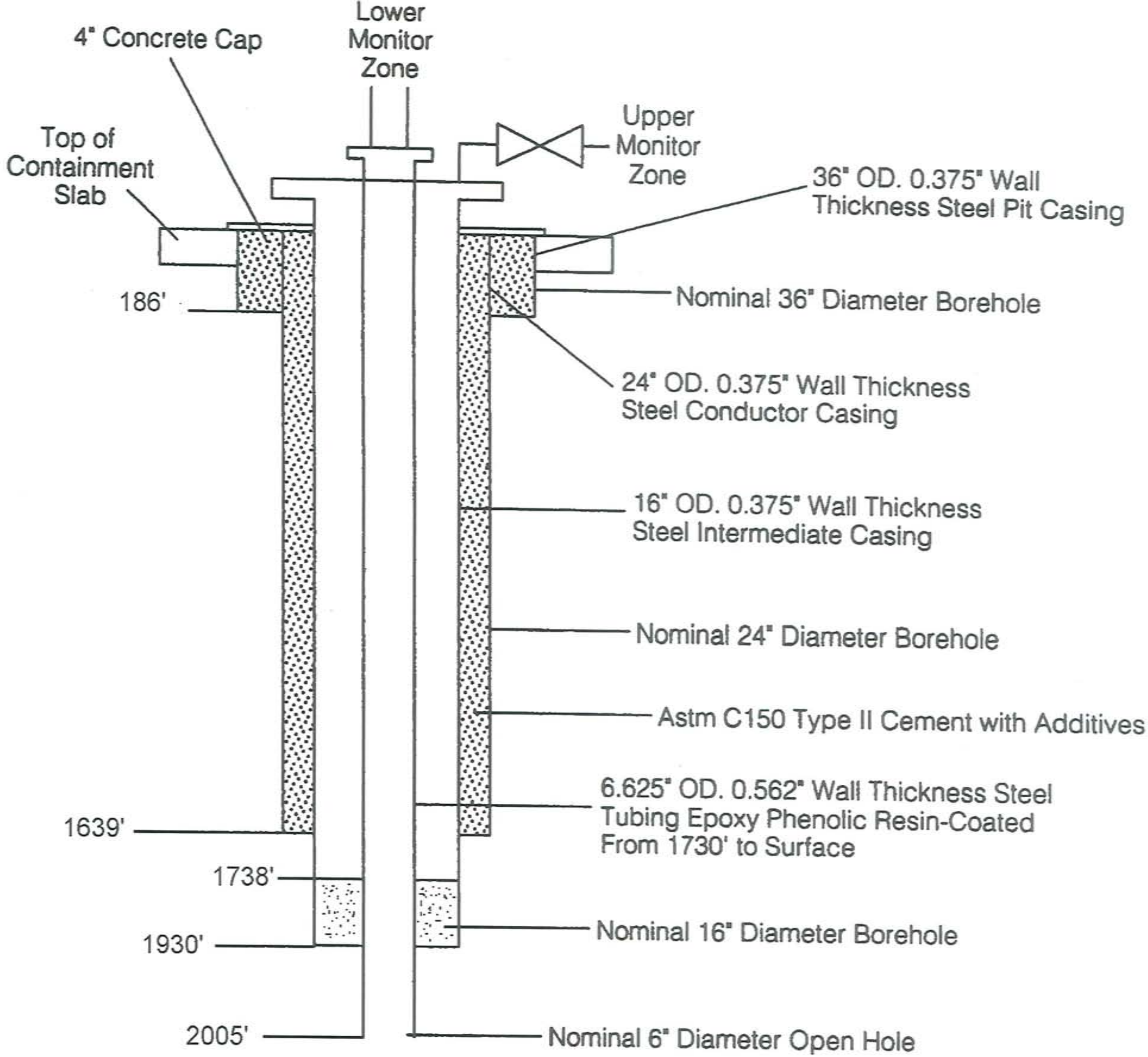
The hydraulic head for the upper monitor zone is approximately 10 feet above the injection well containment pad. The monitoring wellhead diagram in **Figure 7-12** shows the monitoring zone sample taps and piping. Sample pumps are in place for the upper and lower monitor zones. The sample discharge lines feed to the scavenger system.

The purpose of the monitoring well is to detect any vertical migration of concentrate from the injection zone into overlying permeable zones. If such an event occurs, the lighter density fluids will move upward into the monitoring zones. The lighter fluid will first cause the water level in the lower zone to rise and the water quality to freshen. If the lighter fluid reaches the upper monitoring zone, the water level will also rise and the water quality changes will occur.

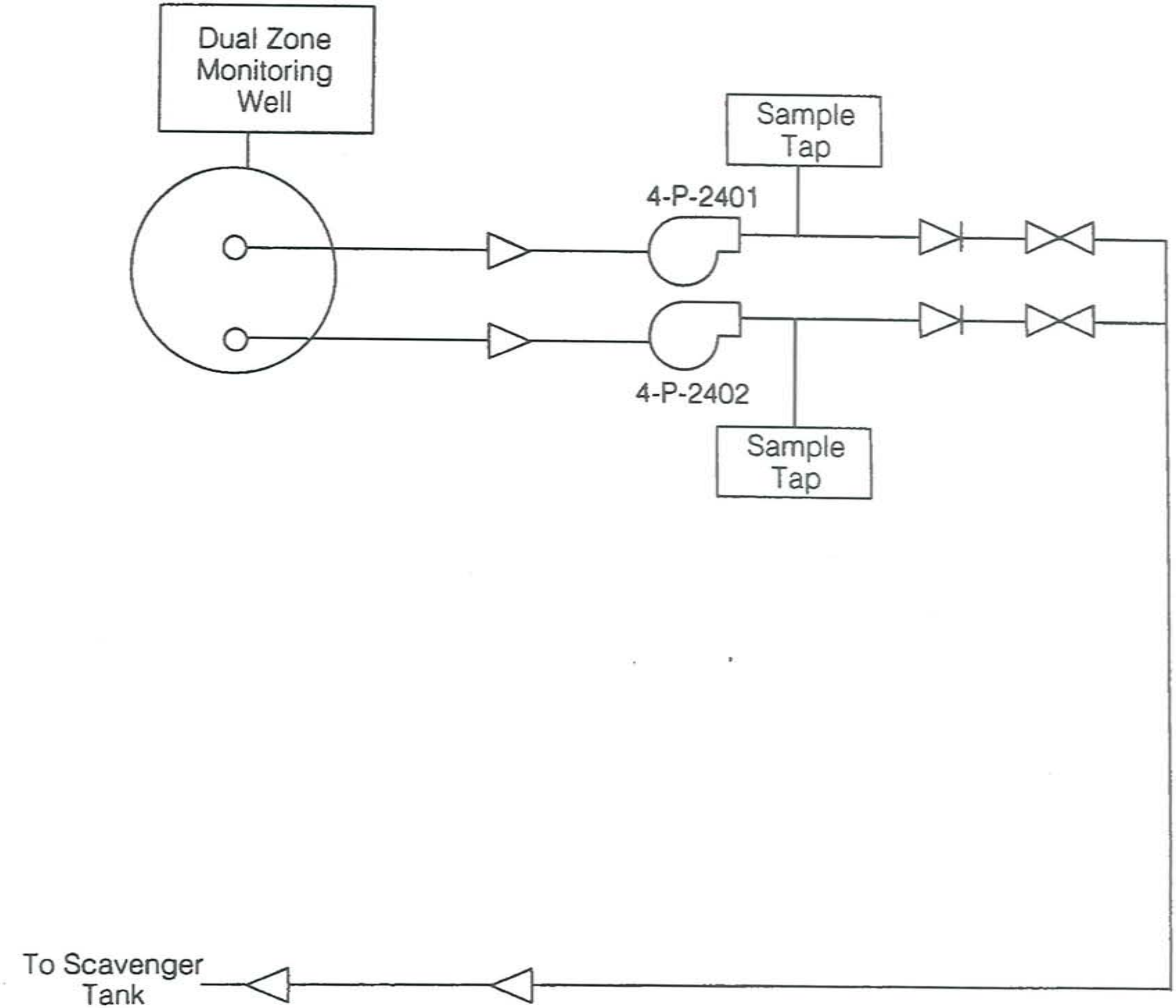
SYSTEM OPERATION AND MONITORING

General Pumping Instructions

The following are general instructions that apply to operation of the injection wells pumping system.



MONITORING WELL DETAIL
FIGURE 7-11



DUAL ZONE MONITORING WELL MECHANICAL PLAN
FIGURE 7-12

Do not operate pumps against a closed valve on the discharge of the pump. Damage to the pumps may result due to overheating or pressure buildup. Check to make sure that:

1. All valves in the flow path to the injection well are open before leaving the station.
2. All valves should be operated at least once each month. When valves remain in one position for a long time, they can "freeze" in that position and can break when an attempt is made to free them.
3. To prevent personal injury or damage to the equipment:
   a. De-energize, lock, and tag out each piece of electrical equipment at its main disconnect (circuit breaker) in the motor control panel adjacent to the pumps prior to performing repairs or maintenance.
4. Do not operate the injection pumps if the SURGE PROTECTION SYSTEM TROUBLE alarm light is activated on the MMI system. Notify supervisor immediately.

Weekly, inspect the lead and lag pumps to verify that the MMI system has alternated them. This will provide even wear on the pumps. If MMI has failed to alternate the lead and lag pumps, manually switch them and notify supervisor immediately of MMI failure.

Emergency Storage/Disposal Facilities

The injection system at the WTP does not have emergency storage facilities for storage of concentrate. The injection system only needs one injection well to handle the flow of concentrate from the WTP. The second injection well is in place to handle an emergency similar to a failure of an injection well due to clogging or if the well becomes unusable. Preventive and timely corrective action is needed at all times to ensure that all equipment is ready for service to both wells at all times.

Note: Do not allow concentrate or any other water to collect in the containment areas of the injection wells. These containment areas are to be used only for small spills and any use of these areas as emergency storage for concentrate would be a permit violation and could carry a fine.

For details on emergency procedures in case of a total injection well failure, see Appendix A, Emergency Response Plan.

Pump Station Out of Service

If the injection well pumping station is out of service, the entire Miramar West WTP will have to completely halt water production because there are no storage facilities for the concentrate upstream of this station. An electrical power failure should not interrupt the injection well system operations since the complete system is connected to the main plant emergency power generator system.

Safety

To prevent personal injury or damage to the equipment:

1- De energize lock and tag out each piece of electrical equipment at its main disconnect (circuit breaker) prior to performing repairs or maintenance.

2- This system is under artesian pressure even when no fluid is being injected into the well. Properly isolate the injection well and monitor wells, as wells as concentrate and wastewater effluent sources, before performing maintenance on piping and pumping systems.

FDEP Operating Requirements

When emergency procedures become necessary in the use of the concentrate injection well system, the following actions must be taken, as required by Chapter 62-528 of the Florida Administrative Code, (FDEP, 1995):

Chapter 62-528.415 Operating Requirements for Class I and III wells: Paragraph (4) Abnormal Events:

(a) In the event the permittee is temporarily unable to comply with any of the conditions of a permit due to a breakdown of equipment, power outages, destruction by hazard of fire, wind or by other cause, the permittee of the facility shall notify the Department. Notification shall be in person, by phone or telegraph to the nearest office of the Department within 24 hours of breakdown or malfunction.

(b) A report shall be required by the appropriate district office within 72 hours of the notification referenced in (a), above. A final written report shall be submitted to FDEP within two weeks. The report shall describe the following:

- The nature and cause of the breakdown or malfunction
- The steps being taken or planned to be taken to correct the problem and prevent its recurrence;
- Emergency procedures in use pending correction of the problem;
- The time when the facility will again be operating in accordance with permit conditions.

(c) Under emergency conditions in which the permittee is unable to use a permitted disposal method, the permittee may use an emergency discharge only if prior Department approval of the emergency method has been obtained. The applicant shall address the emergency disposal methods in the construction permit application and the operating manual.

(d) In the event a well must be redeveloped, the applicant shall address disposal of backwashed fluids. The disposal method shall be approved by the Department.

The Operations Manager or his/her designee should make the notification to FDEP.

Monitoring Data Collection and Reporting

Injection well system monitoring data are collected to provide a record of system performance and to guide the operator in locating and solving operating problems. This record represents the only direct indication of the injection system performance and serves to substantiate decisions and recommendations. It also provides information the FDEP requires as stipulated in the operating permit. The data provides necessary information for planning future system expansion. **Table 7-2** lists the monitoring data to be collected from the injection well system and reported to FDEP.

Table 7-2
Monitoring Data for the Injection System

Injection Wells Parameter	Equipment	Frequency	Data to be Collected
Injection flow rate (MGD)	MMI Data	Daily	• Average • Maximum sustained (15 minutes minimum) • Minimum sustained (15 minutes minimum)
		Monthly	• Average • Maximum (peak hour) • Minimum
Volumetric Parameters (MG)	MMI Data	Daily	• Total daily flow volume
		Monthly	• Total monthly flow volume • Monthly average of daily flow volumes • Monthly maximum of daily flow volumes • Monthly minimum of daily flow volumes
Wellhead pressure parameters (psig)	MMI Data	Daily	• Average pressure • Maximum sustained (15 minutes minimum) • Minimum sustained (15 minutes minimum)
		Monthly	• Average • Maximum sustained • Minimum sustained • Wellhead pressure with no flow (shut-in pressure)

Table 7-2 (continued)
Monitoring Data for the Injection System

Annular Pressure Parameters (psig)	MMI Data	Daily	• Average pressure • Maximum sustained (15 minutes minimum) • Minimum sustained (15 minutes minimum) • Pressure added or removed
		Monthly	• Average pressure • Maximum sustained • Minimum sustained • Wellhead pressure with no flow (shut-in pressure) • Pressure added or removed
Additional parameters (gallons)	MMI Data	Daily and monthly volume of water added or removed	
Monthly Injectivity Test Inject at a rate that approaches the maximum design flow of 10 ft/sec or 1,900 gpm		Sample after 5 minutes of stabilized flow:	
		Flow rate	• Injection flow rate (MGD) • Initial totalizer reading (gal) • Final totalizer reading (gal) • Time (minutes)
		Pressure	• Static injection pressure fall-off • Wellhead injection pressure fall-off every 30 seconds until static (psig) • Final pressure upon test cessation (10-15 min) • Wellhead pressure with no flow (shut-in pressure) • Monitoring zone pressures
		Specific Injectivity Index (gpm/psig)	

Table 7-2 (continued)
Monitoring Data for the Injection System

Water Quality Wastewater stream sampled from the active wet well.		Monthly averages for all parameters sampled daily.	• Residue, total filterable (mg/L) (total dissolved solids (TDS)) • Chloride (mg/L) • Specific conductance (temperature compensated) (µmho/cm or µS/cm) • Temperature (degrees C) • Total suspended solids (TSS)(mg/L) • Ammonia total as N (mg/L) • Total Kjeldahl (TKN) as N (mg/L) • Nitrate total as N (mg/L) • Phosphorous total as P (mg/L) • pH (standard units) • Sulfate total as SO_4 (mg/L)
		Quarterly	• Gross alpha (pCi/L) • Radium 226 (pCi/L) • Radium 228 (pCi/L)
<u>**Dual Zone Monitoring Well**</u>			
Water elevation Lower monitoring zone (1,910-ft.-2,001 ft.) bls Water level (ft of head) or pressure (psig) relative to NAVD 1998	MMI Data	Daily	• Maximum • Minimum • Average
		Monthly	• Maximum • Minimum • Average
Water elevation Upper monitoring zone, (1,679 ft.– 1,735 ft.) bls Water level (ft of head) or pressure (psig) relative to NAVD 1998	MMI Data	Daily	• Maximum • Minimum • Average
		Monthly	• Maximum • Minimum • Average

Table 7-2 (continued)
Monitoring Data for the Injection System

Water Quality Upper and Lower monitoring zones Sample after flowing a minimum of three casing volumes from both zones		Monthly	• Residue, total filterable (mg/L) (total dissolved solids (TDS)) • Chloride (mg/L) • Specific conductance (temperature compensated) (µmho/cm or µS/cm) • Temperature (degrees C) • Ammonia total as N (mg/L) • Total Kjeldahl (TKN) as N (mg/L) • Nitrate total as N (mg/L) • Phosphorous total as P (mg/L) • pH (standard units) • Sulfate total as SO_4 (mg/L)
		Quarterly	• Gross alpha (pCi/L) • Radium 226 (pCi/L) • Radium 228 (pCi/L)

Monitoring Well Water Quality Report

Every month, water quality samples are to be collected from the two monitoring zones in the monitoring well and the wastewater stream from the active wet well. **Table 7-2** lists the parameters to be sampled from the wells and the frequency of sampling. The results of the analysis should be sent to FDEP with the Monthly Operating report (MOR). Operators should report immediately significant deviations from background water quality or level values to their supervisors. Background water quality from the upper and lower monitoring zones is provided in **Tables 7-3** and **7-4**.

The monthly water samples are collected as follows:

1. Turn on monitoring well pump (4-P-2401) for upper zone sampling and monitoring well pump (4-P-2402) for lower zone sampling. The pressure and water level indication will drop significantly.
2. Allow the two zones to flow until approximately three casing volumes have been purged. The monitoring zone volumes are as follows:

Upper zone (annulus) – three casing volume = 36,500 gal. (allow to flow a minimum of 185 minutes at 200 gpm)

Lower zone– three casing volume = 7,500 gal. (allow to flow a minimum of 40 minutes at 200 gpm)

- Monitor specific conductivity, pH and temperature.
- Sufficient purging has been reached when either of the following conditions have been met:
    - Specific conductivity, pH and temperature when sampled, upon purging the third or subsequent well volume, each vary less than 5% from that sampled upon purging the previous well volume or
    - Upon purging the fifth well volume.

3. Measure specific conductivity, pH and temperature, collect two sample bottles from each zone and label appropriately.

4. Turn off monitor well pump or pumps and close all sample valves. Check to ensure that monitoring pressures and water levels return to pre-test levels.

Table 7-3
Background Water Quality of Upper Monitor Zone

Parameter	Upper Monitor Zone
GENERAL	
• Field pH (units)	6.57
• Color (APHA)	< 5.0
• Conductivity (umhos/cm)	8,800
• Calcium hardness (as CaCO3)	1,300
• Turbidity (NTU)	16
• Temperature (field) degree C	20
• Non-Carbonate hardness as CaCO3	1,200
SOLIDS	
• Total dissolved solids	6,000
• Bacarbonate	120
• Calcium	160
• Carbonate	< 1.0
• Carbon Dioxide	110
• Iron	0.12
• Hydroxide	< 1.0
• Magnesium	220
• Potassium	47
• Sodium	1,900
• Chloride	3,400
• Sulfate	340
• Suldide	< 0.10
• Ammonia (as N)	0.38
• Nitrate and nitrite (as N)	< 0.010
• Organic Nitrogen (as N)	0.30
• Kjeldahl nitrogen (as N)	0.68
• Ortho-Phosphorus (as N)	< 0.10

NOTE: Values are mg/l unless otherwise stated

Table 7-4
Background Water Quality of Lower Monitor Zone

Parameter	Upper Monitor Zone
GENERAL	
• Field pH (units)	6.25
• Color (APHA)	10
• Conductivity (umhos/cm)	40,000
• Calcium hardness (as CaCO3)	5,000
• Turbidity (NTU)	38
• Temperature (field) degree C	14.5
• Non-Carbonate hardness as CaCO3	4,900
SOLIDS	
• Total dissolved solids	29,000
• Bacarbonate	130
• Calcium	430
• Carbonate	< 1.0
• Carbon Dioxide	120
• Iron	1.2
• Hydroxide	<1.0
• Magnesium	960
• Potassium	320
• Sodium	10,000
• Chloride	17,000
• Sulfate	1,700
• Suldide	< 0.10
• Ammonia (as N)	0.16
• Nitrate and nitrite (as N)	<0.010
• Organic Nitrogen (as N)	0.15
• Kjeldahl nitrogen (as N)	0.31
• Ortho-Phosphorus (as N)	< 0.15

NOTE: Values are mg/l unless otherwise stated

Injectivity Test

A controlled injectivity test (rate/pressure) needs to be completed monthly and reported to FDEP. The test needs to be conducted at a rate that approaches the maximum design flow of 10 ft/sec or 1,900 gpm, but which can be repeated on a monthly basis. The following data needs to be recorded and reported:

Parameters pertinent to flow rate:
- Injection flow rate as measured from flowmeter (MGD).
- Initial totalizer reading (gallons).
- Final totalizer reading (gallons).
- Time (minutes) from initial to final totalizer readings.

Pressure parameters:
- Static injection pressure fall-off
- Wellhead injection pressure fall-off (psig) every 30 seconds until again static
- Final pressure upon test cessation, approximately 10 to 15 minutes
- Wellhead pressure with no flow (shut-in pressure in psig)
- Monitoring zone pressures (psig)

The monthly injectivity test is performed as follows:

1. Start injection and maintain constant rate.

2. After a minimum of 5 minutes of stabilized flow rate, start recording every 5 minutes for 15 minutes. The injection rate, wellhead pressure and totalizer reading taken over the 15-minute period need to be recorded.
3. Stop injection, shut in well.

4. Record fall-off data every 30 seconds for the first 10 minutes, until three consecutive readings remain unchanged or upon reaching 40 minutes.

5. Calculate specific injectivity value by dividing the (15 minute-average injection rate) by the (15 minute- average wellhead injection pressure minus the static wellhead pressure).

   (15 minute-average injection rate) / (15 minute- average wellhead injection pressure - static wellhead pressure).

   - Specific Injectivity needs to be reported in gpm/psig. A form for data collection throughout the injectivity test is attached for calculation purposes.

Pad Monitoring Wells (PMWs)

The four permanent surficial aquifer-monitoring wells located at the corners of the injection well pad need to be sampled and analyzed for:

- Chlorides (mg/L)
- Specific conductance (μmho/cm or μS/cm)
- Temperature
- Total dissolved solids (TDS) (mg/L)
- And water level (relative to NAVD 1988) (feet)

The PMWs will be identified by location number and pad location (NW, NE, SW, and SE). These monitoring wells shall be sampled forty-eight (48) hours prior to any maintenance, testing (including mechanical integrity testing) or repairs to the system. The results of these analyses need to be submitted within thirty (30) days of completion of the activity.

Additionally, the PMWs need to be sampled quarterly once normal operations are resumed. A summary sheet from the FDEP Southeast District "Surficial Aquifer monitoring Well (SAMW) report" is attached for reporting purposes.

Monitoring Data - Monthly Operating Report (MOR)

All injection well and monitor well data collected above need to be submitted to FDEP in the Monthly Operating Report (MOR) no later than the last day of the month immediately following the month of record.

The data for the MOR are to be compiled on a daily basis using data stored in the MMI computer system. The MMI computer system monitors the well's flow, pressures and system status on a daily basis. Download this data from the MMI and transfer it to the proper FDEP form and format. The operator will then send this report monthly, with the other required treatment plant data no later than the last day of the month immediately following the month of record. The completed MORs will be sent to the FDEP Southeast Florida District office in West Palm Beach and a copy sent to the DEP Tallahassee office to the addresses specified below:

Department of Environmental Protection
Southeast District Office, UIC Section
400 N. Congress Avenue, Suite 200,
West Palm Beach, Fl 33401

Department of Environmental Protection
Underground Injection Control Program
MS 3530
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

All injection well data submissions included in the MORs, need to be clearly identified on each page with: facility name, I.D. Number, permit number, operator's name, license number, daytime phone number, date of sampling/recording and type of data. Monitoring zones shall be identified by well number and depth interval.

Wastewater Stream Analysis

A wastewater stream analysis (24-hour composite sample) for primary and secondary drinking water standards and minimum criteria need to be submitted annually to FDEP. The wastewater need to be sampled in February and submitted on or before April 30th. VOC parameters and biological parameters can be sampled either in-situ or grab. A list of the parameters to be sampled is attached.

Interim Mechanical Integrity Testing

Interim mechanical integrity testing (IMIT) needs to be performed in both, IW-1 and IW-2 at least every two and one half years from the date of the last completed MIT under the existing FDEP Operating Permit 125256-007-UO. As part of the IMIT a pressure test and a video survey are required in each well every two and one half years. A radioactive tracer test (RTS) is required every five years in both wells. A plan describing the IMIT procedures needs to be submitted to FDEP at least 180 days prior to the due date. Below is a tentative schedule for the IMITs needed to be performed in IW-1 and IW-2.

Date	Test/Plan	To be completed
December, 2005	Mechanical integrity testing (MIT)	Completed
December, 2007	IMIT procedure plan	180 days prior to IMIT due date.
June, 2008	Interim mechanical integrity testing (IMIT)	2 ½ years since last completed MIT.
June 2,010	IMIT procedure plan	180 days prior to IMIT due date.
December, 2010	Interim mechanical integrity testing (IMIT)	2 ½ years since last completed IMIT.

SOUTHEAST DISTRICT UIC SECTION
SURFICIAL AQUIFER MONITORING WELL (SAMW) REPORT

FACILITY NAME ______________________________
REPORT MONTH/YR. __________________

OPERATOR NAME ______________ LICENSE # __________________

INJECTION WELL # ______________ PERMIT # __________________

SAMPLING DATE ______________ TIME __________________

	SAMW #1	SAMW #2	SAMW #3	SAMW #4
LOCATION	NE CORNER	NW CORNER	SE CORNER	SW CORNER
ELEVATION OF TOC* (NAVD)				
DEPTH TO WATER (TOC*)				
WATER LEVEL (NAVD)				
CHLORIDE (mg/L)				
CONDUCTIVITY(μmhos/cm)				
TOTAL DISOLV. SOLIDS (mg/L)				
TEMPERATURE (° C)				

* TOC: indicates the "top of the casing" of the Surficial Aquifer Monitoring Well

ANALYZED BY__________________ SAMPLED BY ________________

PHONE # __________________ TITLE ________________

SITE PLAN OF SAMW LOCATIONS

PRIMARY & SECONDARY DRINKING WATER STANDARDS & MINIMUM CRITERIA

Updated May 6, 2002

PRIMARY DRINKING WATER STANDARDS

PARAMETER

Alachlor (Polychlorinated Biphenyl or PCB)
Aldicarb
Aldicarb sulfoxide
Aldicarb sulfone
Aroclors (Polychlorinated Biphenyls or PCBs)
Alpha, Gross
Antimony
Arsenic
Atrazine
Barium
Benzene
Benzo(a)pyrene
Beryllium
Bis(2-ethylhexyl) adipate (Di(2-ethylhexyl) adipate)
Bis(2-ethylhexyl) phthalate (Di(2-ethylhexyl) phthalate)
Cadmium
Carbofuran
Carbon Tetrachloride (Tetrachloromethane)
Chlordane
Chlorobenzene (Monochlorobenzene)
Chloroethylene (Vinyl Chloride)
Chromium
Coliforms, Total
Cyanide
2,4-D (2,4-Dichlorophenoxyacetic acid)
Dalapon (2,2-Dichloropropionic acid)
Dibromochloropropane (DBCP)
1,2-Dibromoethane (EDB, Ethylene Dibromide)
1,2-Dichlorobenzene (o-Dichlorobenzene)
1,4-Dichlorobenzene (p-Dichlorobenzene or Para Dichlorobenzene)
1,2-Dichloroethane (Ethylene dichloride)
1,1-Dichloroethylene (Vinylidene chloride)
1,2-Dichlorethylene (cis-1,2-Dichloroethylene or trans-1,2-Dichloroethylene)
cis-1,2-Dichloroethylene (1,2-Dichlorethylene)
trans-1,2-Dichloroethylene (1,2-Dichlorethylene)
Dichloromethane (Methylene chloride)
1,2-Dichloropropane
Di(2-ethylhexyl) adipate (Bis(2-ethylhexyl) adipate)
Di(2-ethylhexyl) phthalate (Bis(2-ethylhexyl) phthalate)
Dinoseb
Diquat
EDB (Ethylene dibromide, 1,2-Dibromoethane)
Endothall
Endrin
Ethylbenzene
Ethylene dichloride (1,2-Dichloroethane)
Fluoride
Glyphosate (Roundup)
Gross Alpha
Heptachlor
Heptachlor Epoxide
Hexachlorobenzene (HCB)
gamma-Hexachlorocyclohexane (Lindane)
Hexachlorocyclopentadiene
Lead

PRIMARY & SECONDARY DRINKING WATER STANDARDS & MINIMUM CRITERIA

Updated May 6, 2002

PRIMARY DRINKING WATER STANDARDS, CONT'D

PARAMETER

Lindane (gamma-Hexachlorocyclohexane)
Mercury
Methoxychlor
Methylene chloride (Dichloromethane)
Monochlorobenzene (Chlorobenzene)
Nickel
Nitrate (as N)
Nitrite (as N)
Total Nitrate + Nitrite (as N)
Oxamyl
p-Dichlorobenzene or Para Dichlorobenzene (1,4-Dichlorobenzene)
Pentachlorophenol
Perchloroethylene (Tetrachloroethylene)
Picloram
Polychlorinated biphenyl (PCB or Aroclors)
Radium
Roundup (Glyphosate)
Selenium
Silver
Silvex (2,4,5-TP)
Simazine
Sodium
Styrene (Vinyl benzene)
Tetrachloroethylene (Perchloroethylene)
Tetrachloromethane (Carbon Tetrachloride)
Thallium
Toluene
Toxaphene
2,4,5-TP (Silvex)
1,2,4-Trichlorobenzene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethylene (Trichloroethene, TCE)
Trihalomethanes, Total
Vinyl Chloride (Chloroethylene)
Xylenes (total)

SECONDARY DRINKING WATER STANDARDS

PARAMETER

Aluminum
Chloride
Color
Copper
Ethylbenzene
Fluoride
Foaming Agents (MBAS)
Iron
Manganese
Odor
pH
Silver
Sulfate
Toluene
Total Dissolved Solids (TDS)
Xylenes
Zinc

MUNICIPAL WASTEWATER MINIMUM CRITERIA
GROUND WATER MONITORING PARAMETERS

INORGANICS

Ammonia
Nitrogen (organic)
Total Kjeldahl Nitrogen
Total Phosphorus (phosphate)

VOLATILE ORGANICS

Chloroethane
Chloroform
para-Dichlorobenzene (1,4 Dichlorobenzene)
1,2-Dichloroethylene (cis-1,2-Dichloroethylene or trans-1,2-Dichloroethylene)

BASE/NEUTRAL ORGANICS

Anthracene
Butylbenzylphthalate
Dimethylphthalate
Napthalene
Phenanthrene

PESTICIDES AND PCBs
Aldrin
Dieldrin

ACID EXTRACTABLES

2-chlorophenol
Phenol
2,4,6-trichlorophenol

OTHER

Specific Conductance
Biological Oxygen Demand
Chemical Oxygen Demand
Temperature

Specific Injectivity Index and Fall-Off Data

Date of Test: ____________________

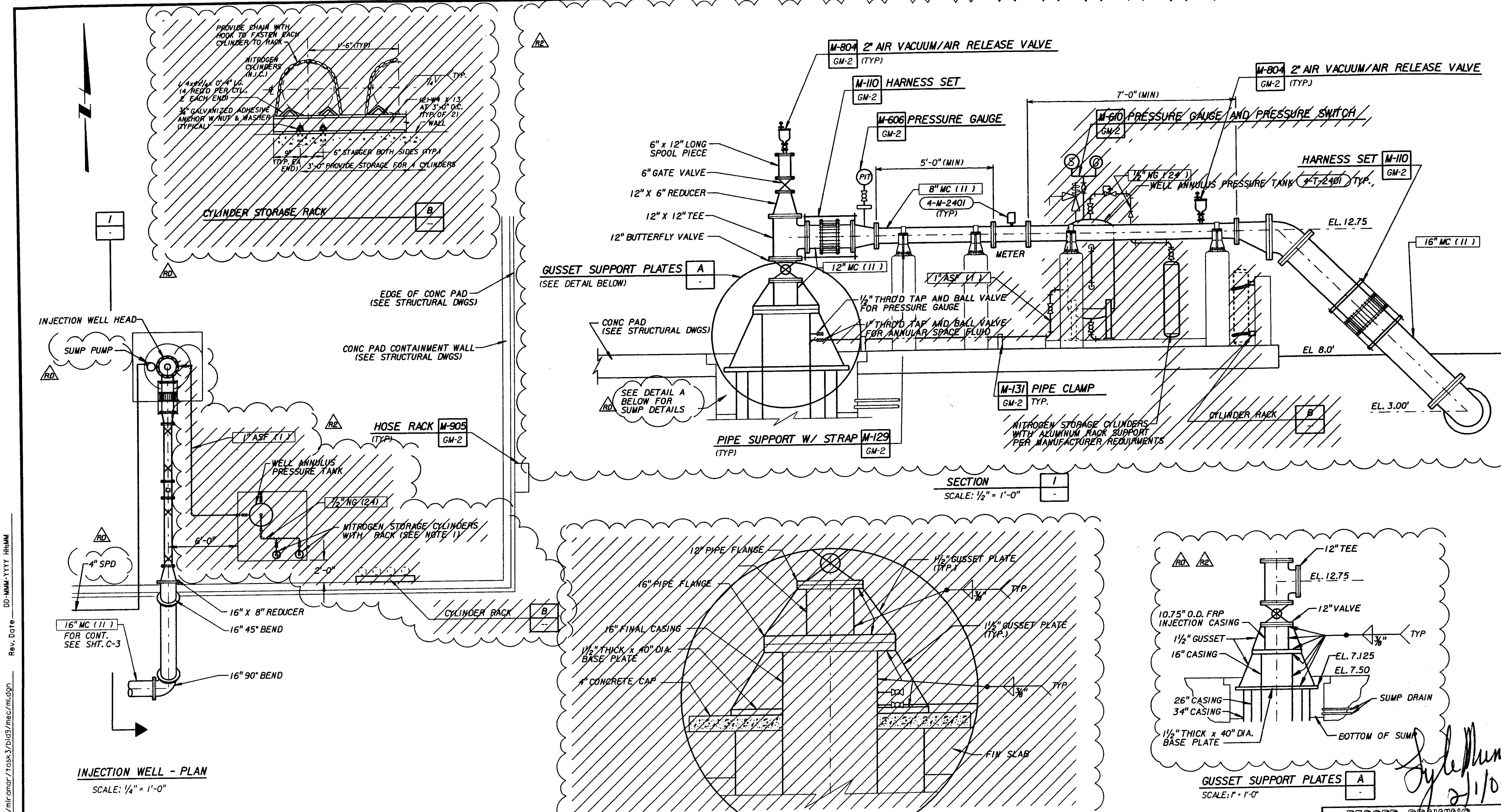
Name(s) of Test Personnel: ____________________

Permit # / Well ID:

Operation/Sequence	Clock Time (24-hr; enter with colon)	Injection Rate (gpm)	Wellhead Pressure (psig)	Totalizer Reading (gallons)	Comments
START INJECTION. Maintain constant rate. After a minimum of 30 minutes of constant rate injection, start recording readings every 5 minutes (starting at time = 0 minutes), resulting in 4 sets of readings taken over 15 minutes. The injection rate and wellhead pressure readings taken over the 15 minute period must be entered for the spreadsheet to calculate the specific injectivity index.					
0 minutes					
5 minutes					
10 minutes					
15 minutes					
Averages (calculated by spreadsheet)		#DIV/0!	#DIV/0!		
STOP INJECTION - SHUT IN WELL. Record falloff data every 30 seconds (for first 10 minutes), until 3 consecutive readings remain unchanged, or upon reaching 40 minutes. Repeat entry of last wellhead pressure reading where it states "Repeat Last Pressure Reading." This last wellhead pressure reading must be re-entered for spreadsheet to calculate the specific injectivity index.					
0 minutes					
0.5 minutes					
1.0 minutes					
1.5 minutes					
2.0 minutes					
2.5 minutes					
3.0 minutes					
3.5 minutes					
4.0 minutes					
4.5 minutes					
5.0 minutes					
5.5 minutes					
6.0 minutes					
6.5 minutes					
7.0 minutes					
7.5 minutes					
8.0 minutes					
8.5 minutes					
9.0 minutes					
9.5 minutes					
10.0 minutes					
11.0 minutes					
12.0 minutes					
13.0 minutes					
14.0 minutes					
15.0 minutes					
20.0 minutes					
25.0 minutes					
30.0 minutes					
35.0 minutes					
40.0 minutes					
Repeat Last Pressure Reading:					

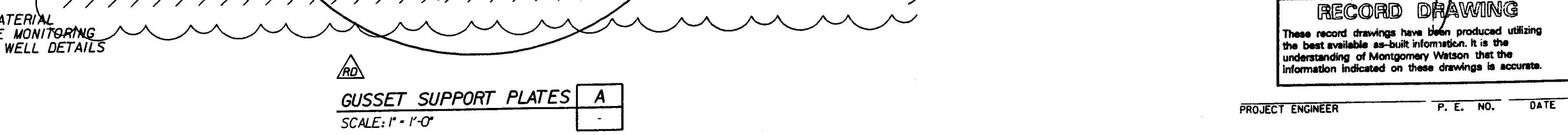
Specific Injectivity Index = (15-min average injection rate) / (average wellhead injection pressure - static wellhead pressure)

Specific Injectivity =	#DIV/0!	gpm/psig



NOTE 1: A TWO CYLINDER FREE STANDING SUPPORT RACK SHALL BE PROVIDED FOR EACH SET OF TWO NITROGEN CYLINDERS. RACK SHALL BE CAST ALUMINUM CAPABLE OF SUPPORTING 9" AND SIMILAR SIZE CYLINDERS. STANDS SHALL BE SECURELY FASTENED TO THE CONCRETE SLAB UTILIZING STANLESS STEEL CONCRETE ANCHORS.

NOTE 2: FOR WELL CASING SIZES AND MATERIAL SEE INJECTION WELL, DUAL ZONE MONITORING WELL AND SHALLOW MONITORING WELL DETAILS SHEET M-3.



PROJECT ENGINEER P. E. NO. DATE

REV	DATE	BY	DESCRIPTION
R2	11/05	BWL	DELETED ANNULUS TANK, NEW INJ TUBING
RD	6/95	JO	RECORD DRAWING

SCALE: AS SHOWN

WARNING: 0 1/2 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE.

DESIGNED L. MUNCE
DRAWN J. OROZCO
CHECKED D. BOUCK

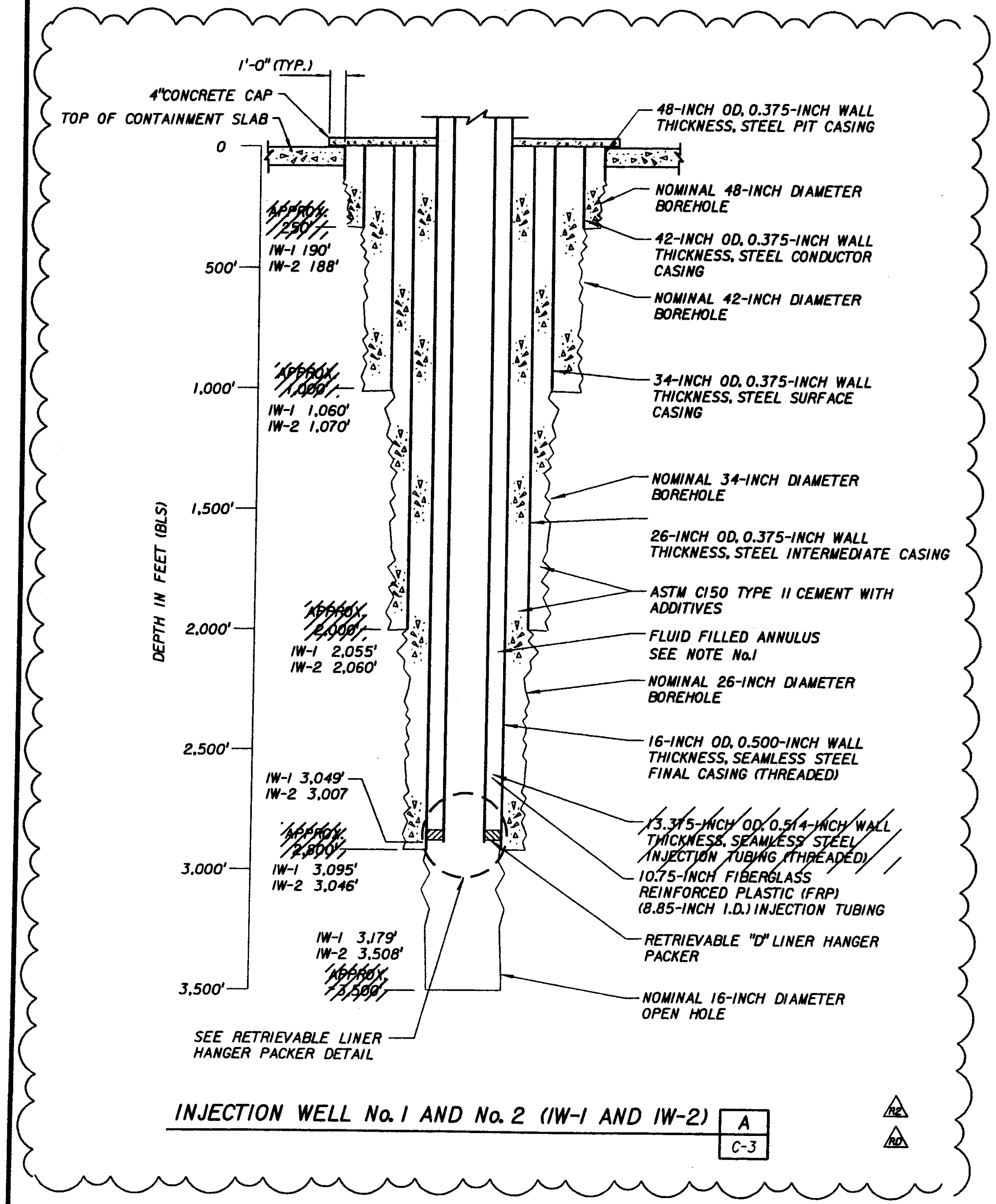
SUBMITTED
PROJECT MANAGER P. E. NO. DATE
MONTGOMERY WATSON P. E. NO. DATE

MONTGOMERY WATSON
Plantation, Florida

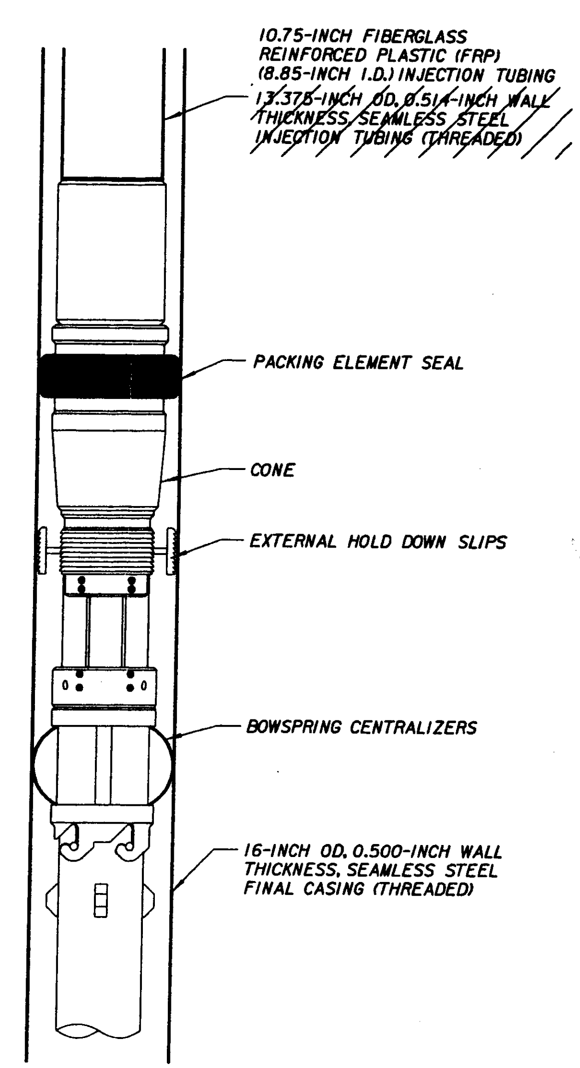
CITY OF MIRAMAR
BID PACKAGE 9: WATER TREATMENT PLANT INJECTION WELLS
INJECTION WELL
MECHANICAL PLAN & SECTIONS

SHEET M-1

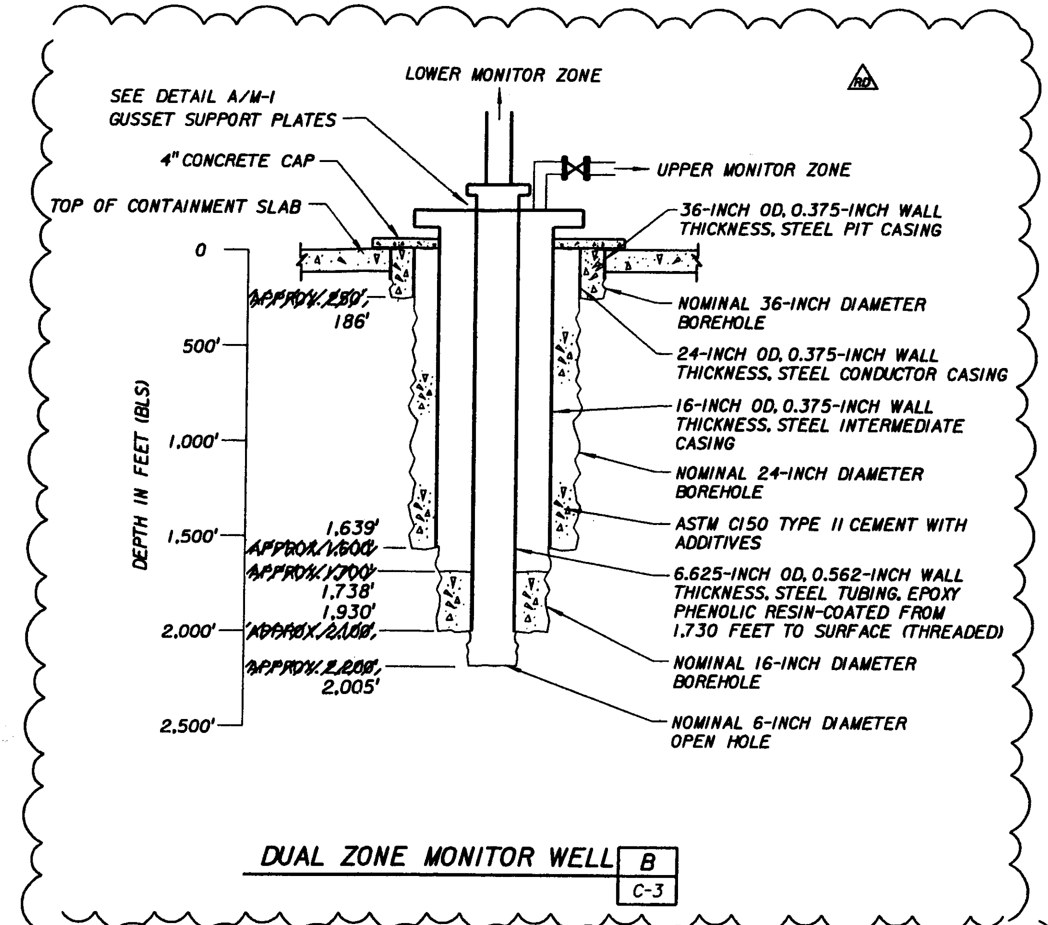
JOB No. 3007.0123 FILE No. /usr2/proj/miramar/task3/bid8/mec/m1.dgn Rev. Date DD-MMM-YYYY HH:MM



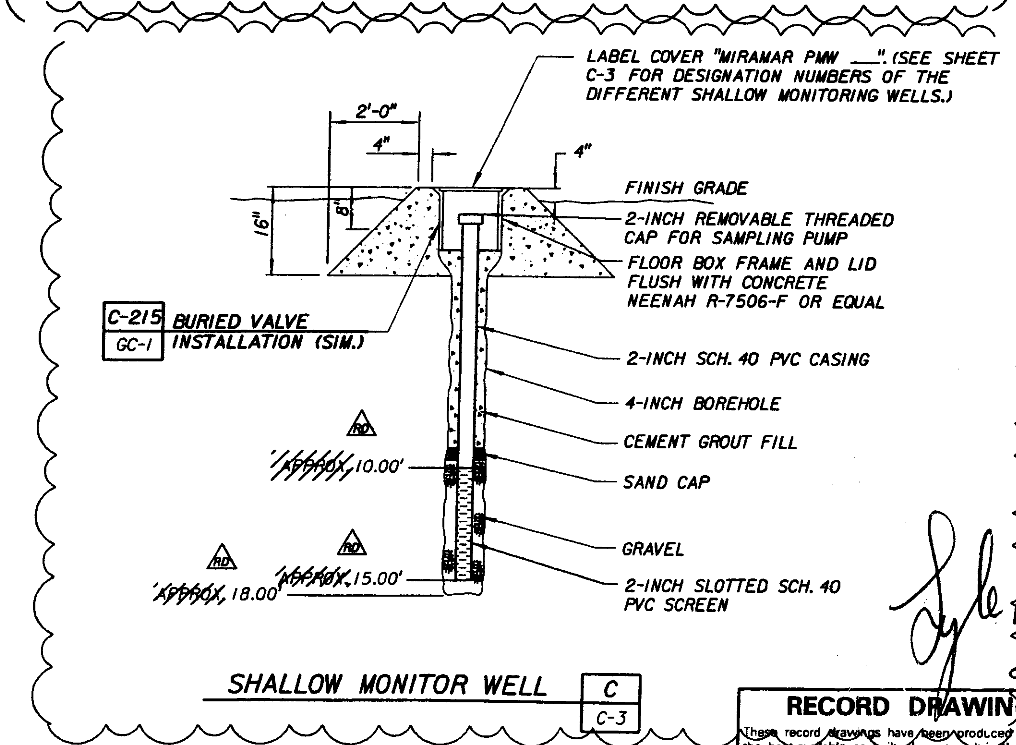
INJECTION WELL No. 1 AND No. 2 (IW-1 AND IW-2) A C-3



RETRIEVABLE "D" LINER HANGER PACKER DETAIL



DUAL ZONE MONITOR WELL B C-3



SHALLOW MONITOR WELL C C-3

NOTE :

ANNULAR SPACE FLUID IS FILLED WITH A 5% SOLUTION OF BARCOR-100.

RECORD DRAWING

These record drawings have been produced utilizing the best available as-built information. It is the understanding of Montgomery Watson that the information indicated on these drawings is accurate.

PROJECT ENGINEER — P. E. NO. — DATE

JOB No. 3007.0122 FILE No. /USR2/PROJ/MIRAMAR/TASK3/BID9/MEC/M3.DGN

REV	DATE	BY	DESCRIPTION
R2	11/05	BWL	NEW INJ TUBING
RD	6/95	JO	RECORD DRAWING

SCALE: NO SCALE

WARNING: 0 ½ 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE.

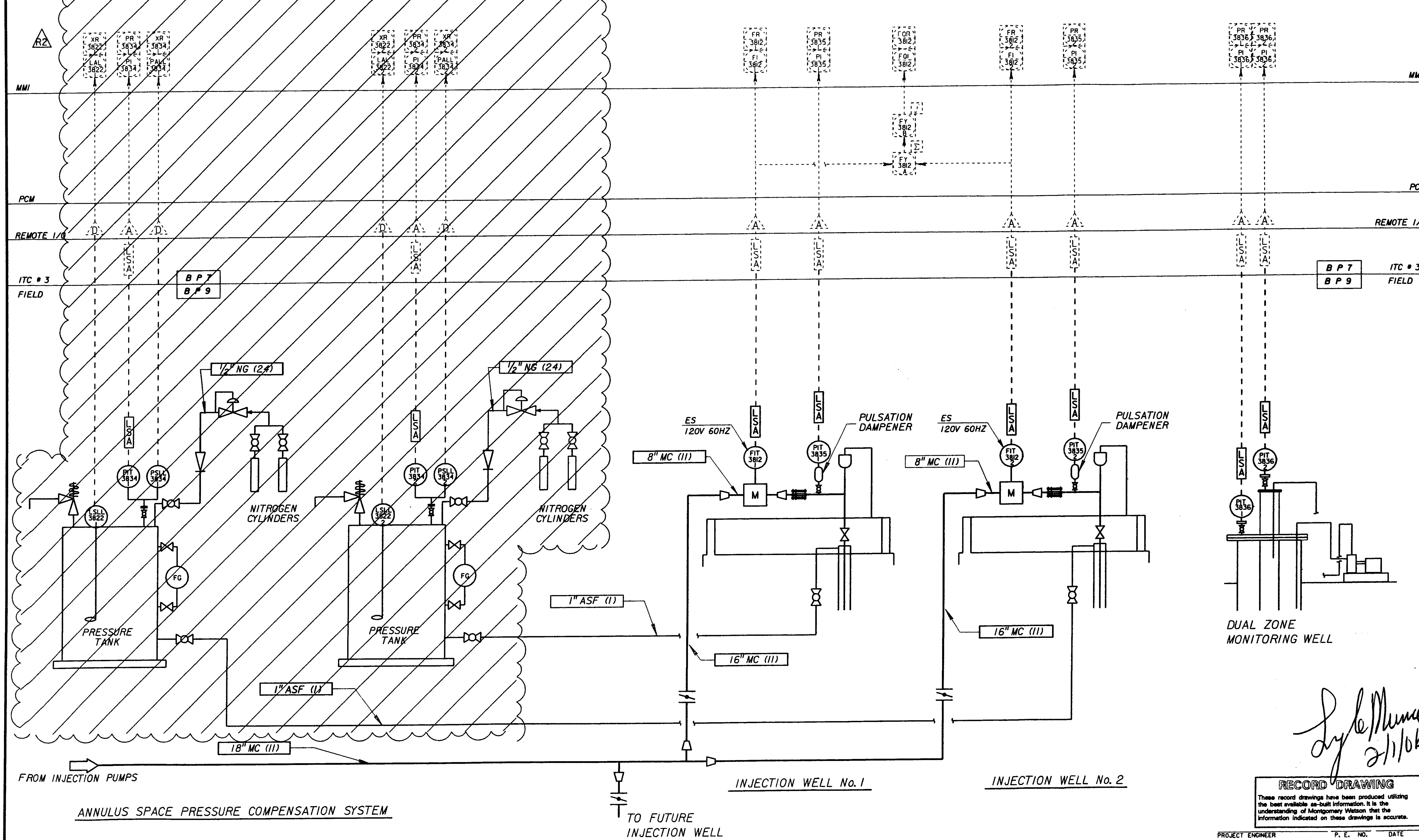
DESIGNED: H.V. MADEKSHO
DRAWN: M.A. CANNATA
CHECKED: J. KELLY

SUBMITTED
PROJECT MANAGER — P. E. NO. — DATE
MONTGOMERY WATSON — P. E. NO. — DATE

MONTGOMERY WATSON
Plantation, Florida

CITY OF MIRAMAR
BID PACKAGE 9: WATER TREATMENT PLANT INJECTION WELLS
INJECTION WELL AND MONITORING WELL DETAILS

SHEET M-3



RECORD DRAWING

These record drawings have been produced utilizing the best available as-built information. It is the understanding of Montgomery Watson that the information indicated on these drawings is accurate.

PROJECT ENGINEER P. E. NO. DATE

REV	DATE	BY	DESCRIPTION
R2	11/05	BWL	REMOVED ANNULUS TANK,NEW INJ TUBING
R1	6/95	JO	RECORD DRAWING

SCALE: NONE

WARNING: 0 1/2 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE.

DESIGNED L. AMARAL
DRAWN L. AMARAL
CHECKED J. REES

SUBMITTED
PROJECT MANAGER P. E. NO. DATE
MONTGOMERY WATSON P. E. NO. DATE

MONTGOMERY WATSON
Plantation, Florida

CITY OF MIRAMAR
BID PACKAGE NO. 9: WATER TREATMENT PLANT INJECTION WELLS
PROCESS AND INSTRUMENTATION DIAGRAMS INJECTION WELLS

SHEET I-2

JOB No. 3007.0123 FILE No. /usr2/PROJ/MIRAMAR/TASK3/BI09/INS/I02.DGN Date DD-MMM-YYYY HH:MM

City of Miramar

Plugging and Abandonment Plan for City of Miramar Injection Well System

November 2005

MWH

Plugging and Abandonment Plan for City of Miramar Injection Well System

This Plugging and Abandonment (P&A) Plan outlines the procedures and costs for plugging and abandoning the two injection wells and one dual zone monitor well located at the City of Miramar Western Water Treatment Plant (WTP). In the event that the injection well system has to be abandoned, the injection zones must be effectively plugged and sealed. This would prevent the upward migration of fluid from the injection zone and/or an interchange of formation waters between aquifers. Well design details are provided in **Figure 8-1** through **Figure 8-3**.

This plan describes a procedure for plugging each of the two injection wells and the lower zone of the monitoring well using bridge plugs; and the sealing of the upper annular monitor zone using gravel and cement. In this procedure, a bridge plug is initially set approximately 10 feet below the base of the 16-inch final steel casing in each of the injection wells and in the final tubing of the monitor well. The casings are then plugged with cement above the bridge plug. The upper monitor zone annulus is filled with gravel in the open borehole, and cemented to land surface.

The following is a description of (1) the bridge plug method of abandonment for the injection wells and the lower zone of the monitor well; and (2) modifications to the plan that apply to the open annulus section (upper monitor zone) of the monitor well, where a bridge plug can not be set. The cost calculations allow for the purchase of all the materials necessary for these tasks, and represent an approximate cost for the plugging and abandonment of both injection wells and the dual zone monitor well, including a 20 percent contingency and estimated associated engineering costs.

A. To plug the injection wells and the lower zone of the monitor well by the bridge plug method, the proposed plan is as follows:

1. Mobilize a drill rig, "kill" the well by filling the casing with 9.0 pounds per gallon (ppg) drilling mud, and remove the valve assembly and appurtenances from the wellhead.
2. Set a bridge plug, consisting of a short section of threaded pipe with a bottom plug and a hydraulically operated packer, at approximately 10 feet below the bottom of the casing (**Table 8-1**). This bridge plug will be lowered to the bottom of the casing by a drill string consisting of threaded pipe, a "J" disconnect and an on/off tool followed by enough drill pipe to set the bridge plug.

Figure 8-1

Figure 8-2

Figure 8-3

Table 8-1
Bridge Plug Setting Depths Based on Well Design

Well	Final Casing Depth	Approximate Bridge Plug Setting Depth
IW-1	3,095 feet bls	3,105 feet bls
IW-2	3,046 feet bls	3,056 feet bls
DZMW-1 Lower Zone	1,930 feet bls	1,940 feet bls

3. Expand the bridge plug and set it by pumping water or other fluid under pressure to the mechanical packer. The drill string will then be backed off, disconnecting at the "J" disconnect. A slurry of neat cement will be pumped in stages into the hole through a tremie pipe to the bridge plug assembly. The quantity of cement pumped should be equivalent to the volume of slurry required to fill the casing 20 to 25 feet above the top of the bridge plug.
4. The cement should be allowed to set for 24 hours and then tagged with a wire line to determine if sufficient fill up has been achieved.
5. The remainder of the casing will then be filled with neat cement.

The method described above could be used to plug the injection wells and the lower zone (deep zone) section of the monitor well. However, the open annulus section in the upper, or shallow, zone of the monitor well can not be filled using this method. It will be necessary to plug the upper zone by filling the open hole portion of the well with gravel, tagging and pumping cement to land surface in stages.

B. To plug the upper zone of the monitor well by the gravel and cement method, the proposed plan is as follows:

1. Mobilize a drill rig, "kill" the well by filling the casing with 9.0 ppg drilling mud, and remove the valve assembly and appurtenances from the wellhead.
2. Add a volume of gravel to the well equal to the volume of the open hole section of the well. Fill the open formation with gravel to approximately 10 feet below the bottom of the casing, or a depth of approximately 1,649 feet bls.
3. Verify the depth to gravel by tagging with a wire line.
4. Pump a slurry of neat cement into the well through a tremie pipe to the top of the gravel and fill the annulus of the 16-inch diameter casing with cement slurry in stages to land surface.