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MONITOR WELL REDEVELOPMENT AND SEMIANNUAL SAMPLING EVENT AT
INDUSTRIAL SLUDGE DRYING BEDS, DOMESTIC SLUDGE DRYING BEDS AND
POLISHING PONDS VOLUME 1 NAS JACKSONVILLE FL
3/1/1992
ENVIRONMENTAL SCIENCE AND ENGINEERING

22

MONITOR WELL REDEVELOPMENT AND
JANUARY 1992 SEMIANNUAL SAMPLING EVENT
AT THE NAVAL AIR STATION,
JACKSONVILLE FLORIDA

VOLUME I

Prepared for:

NAVAL FACILITIES ENGINEERING COMMAND
SOUTHERN DIVISION
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LIST OF ACRONYMS AND ABBREVIATIONS

DSDBs	domestic sludge drying beds
ESE	Environmental Science & Engineering, Inc.
FDER	Florida Department of Environmental Regulation
FPDWS	Florida Primary Drinking Water Standards
ft	feet
ft/day	feet per day
ft/ft	feet per foot
ft/yr	feet per year
gal	gallon
gal/day/ft	gallons per day per foot
gpm	gallons per minute
gpm/ft	gallons per minute per foot
GQAP	Generic Quality Assurance Plan
ISDBs	industrial sludge drying beds
IT	International Technology Corporation
K	hydraulic conductivity
mg/L	milligrams per liter
MW	monitor well
NAS	Naval Air Station
NTU	nephelometric turbidity unit
pCi/L	picocuries per liter
PP	polishing pond
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
SouthDiv	Naval Facilities Engineering Command, Southern Division
T	transmissivity
$\mu\text{g/L}$	micrograms per liter

EXECUTIVE SUMMARY

Environmental Science & Engineering, Inc. (ESE) has been contracted by the Naval Facilities Engineering Command, Southern Division (SouthDiv) to perform monitor well redevelopment and semiannual groundwater sampling at the Naval Air Station (NAS), Jacksonville, Florida. These efforts were focused on an existing monitoring network surrounding three former hazardous waste disposal areas which include the Industrial Sludge Drying Beds (ISDBs), Domestic Sludge Drying Beds (DSDBs), and Polishing Ponds (PPs). The efforts involved initial redevelopment of 13 of the existing monitor wells in an attempt to improve well yield and turbidity, followed by a round of sampling and analysis in accordance with an Florida Department of Environmental Regulation (FDER) Closure/Post-Closure permit for the hazardous waste facilities.

The redevelopment effort was only partially successful, although overall well yield was improved and measured turbidity values increased. Water-level measurements in the shallow aquifer zone indicated the direction of groundwater flow has been reversed surrounding the ISDBs and DSDBs due to temporary construction dewatering occurring at the NAS Wastewater Treatment Plant. In the vicinity of the PPs, the gradient remained north-northeast. The direction of groundwater flow in the deep aquifer zone was north, similar to previous results. There was a vertically downward gradient between the two aquifer zones. Calculated flow rates for both aquifer zones were generally similar to, but somewhat lower than, previously calculated flow rate ranges. The results of groundwater sampling and analysis indicated shallow aquifer zone monitor wells exceeded the point of compliance permit standards for 10 compounds including metals and organic compounds. The highest organic concentrations, and the majority of the organic compounds, were detected in MW41-4, located directly

downgradient of the DSDBs. Although the point of compliance wells surrounding each of the facilities exceeded the permit standards for one or more parameters, the DSDBs showed the greatest impact. Only one well in the deep aquifer zone exceeded the permit standards for one metal. Overall, the deeper aquifer zone showed lower concentrations of the various parameters than the shallow zone. With the data points currently available, there does not appear to be any reversal of contaminant plumes in response to the dewatering operation.

1.0 INTRODUCTION

Environmental Science & Engineering, Inc. (ESE) has been contracted by the Naval Facilities Engineering Command, Southern Division (SouthDiv) to perform monitor well redevelopment and semiannual groundwater sampling at the Naval Air Station (NAS), Jacksonville, Florida (Figure 1). Groundwater sampling and analysis is to be performed in compliance with Florida Department of Environmental Regulation (FDER) permit number HF16-152611 for closure and post-closure monitoring of three former hazardous waste surface impoundments. The facilities included in the monitoring effort are located in the northern portion of NAS, adjacent to the Wastewater Treatment Plant and include the industrial sludge drying beds (ISDBs), the domestic sludge drying beds (DSDBs), and the polishing pond (PP) (Figure 2). These three hazardous waste facilities are no longer used by NAS. An extensive network of 39 monitor wells had been previously installed and sampled associated with contamination assessment activities surrounding these hazardous waste facilities. Semiannual compliance monitoring in accordance with the FDER permit includes groundwater sampling and analysis of 13 of the 39 wells (Figure 3). A redevelopment effort preceded the sampling effort to attempt to improve the turbidity of the samples obtained from the wells.

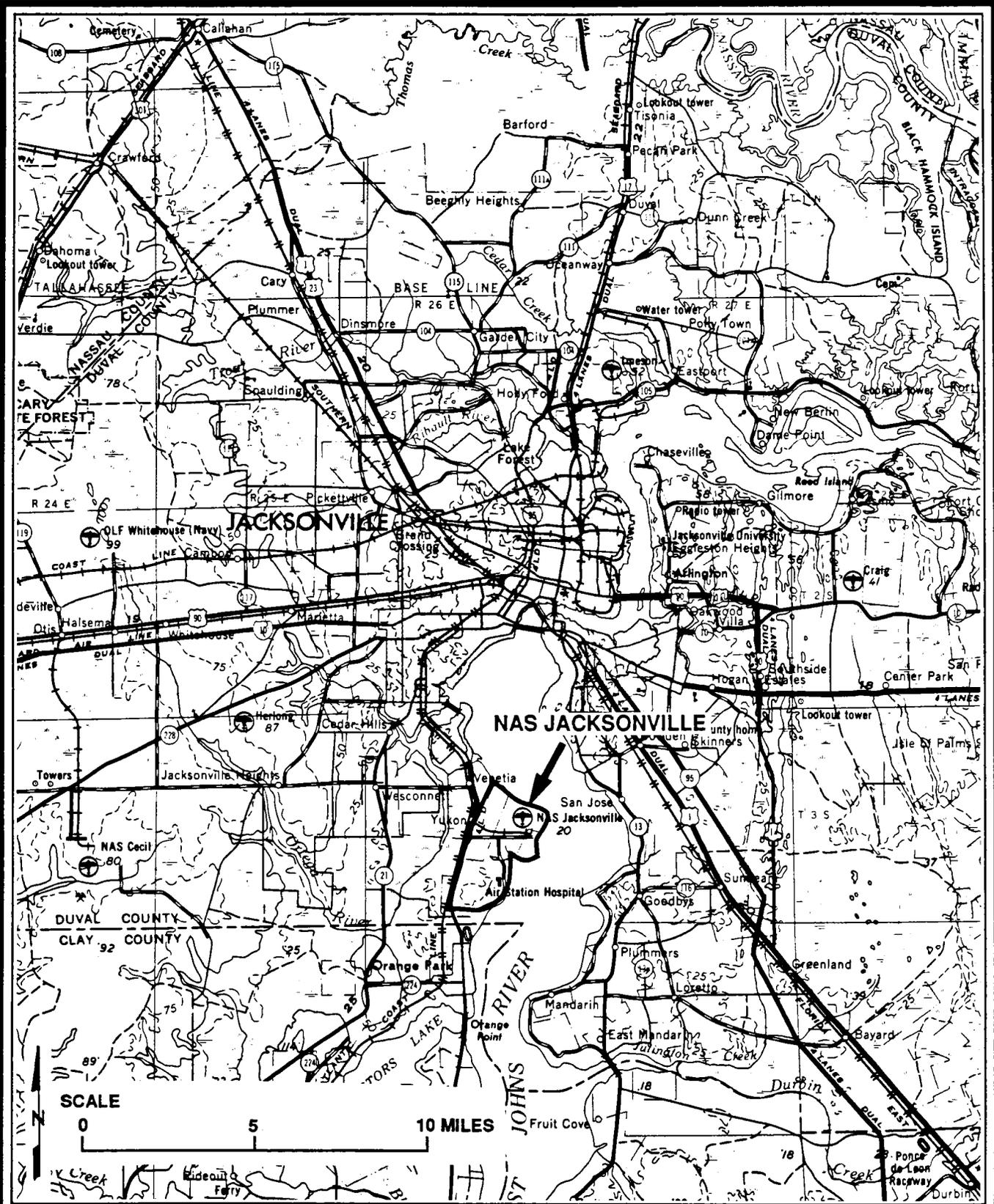


Figure 1
LOCATION OF NAS JACKSONVILLE

SOURCE: USGS, 1966; ESE.

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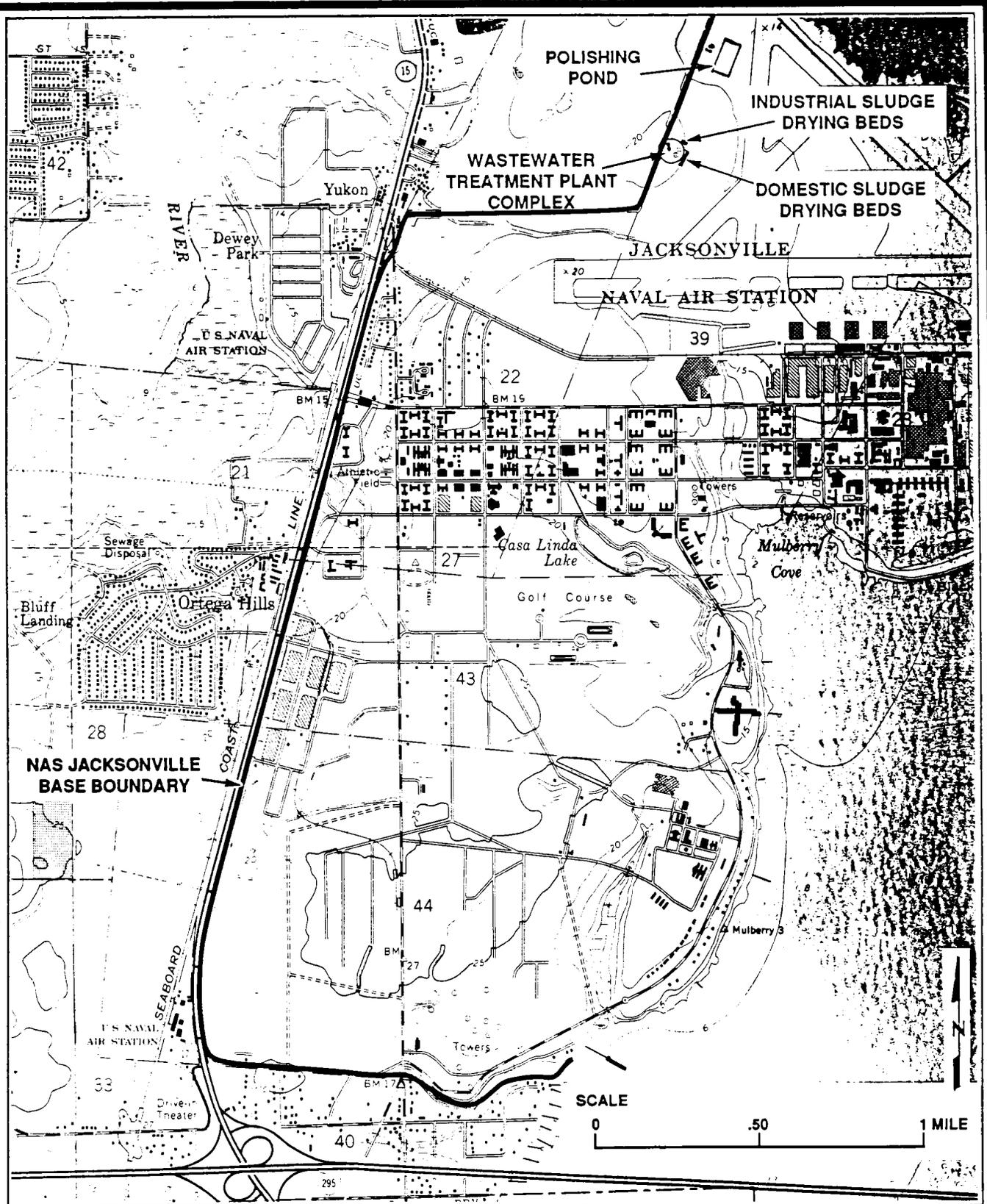
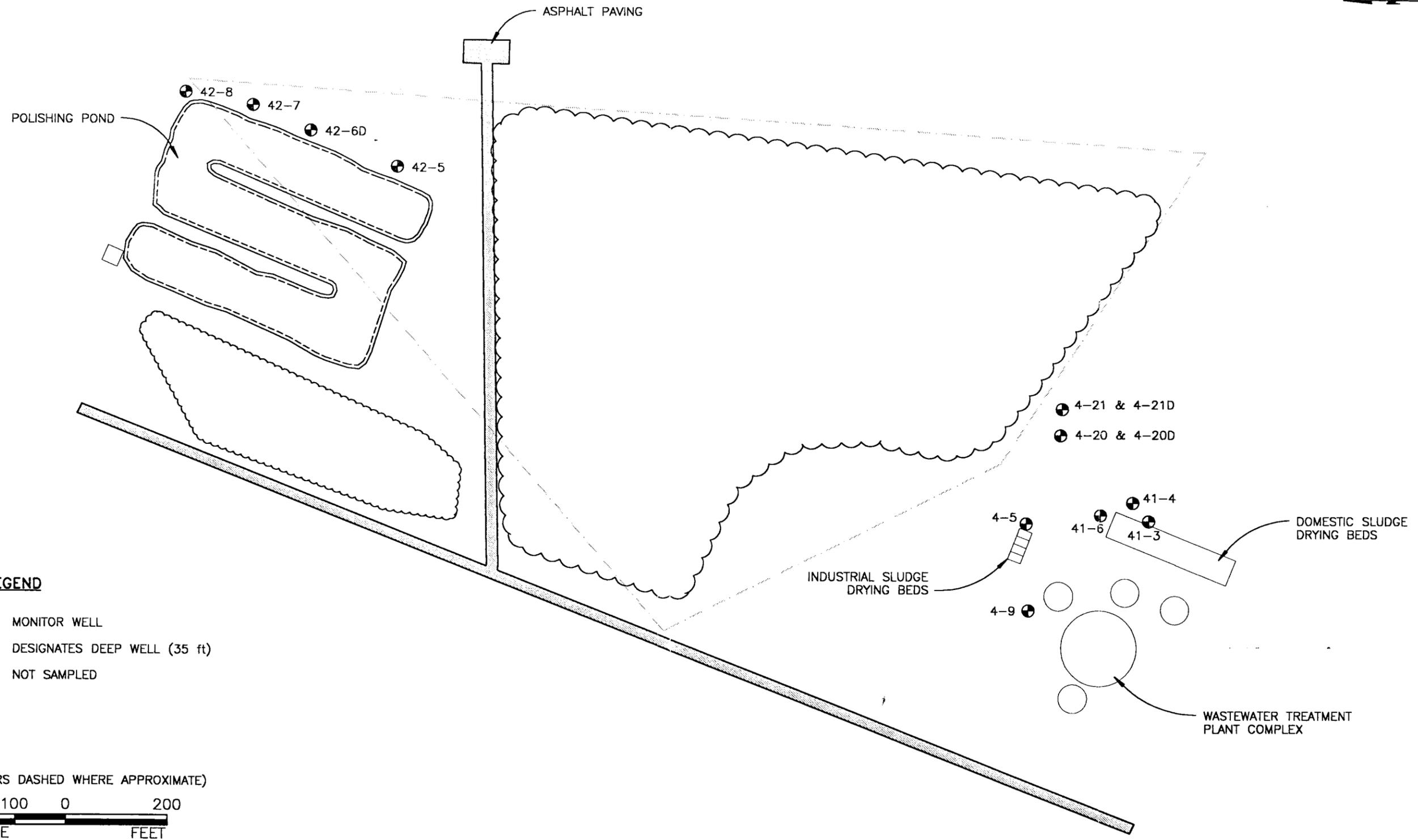


Figure 2
LOCATION OF MONITORING SITES
NAS JACKSONVILLE

SOURCE: USGS, 1970; ESE.

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LEGEND

- 4-5 ● MONITOR WELL
- D ● DESIGNATES DEEP WELL (35 ft)
- NS ● NOT SAMPLED

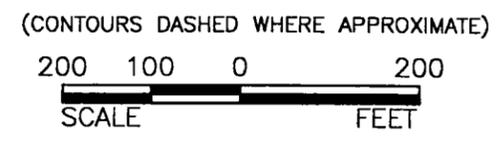


Figure 3
MONITOR WELLS INCLUDED IN SEMI-ANNUAL SAMPLING AT NAS JACKSONVILLE

SOURCE: ESE, 1992



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2.0 SITE HYDROGEOLOGY

The network of 39 wells described in Section 1.0 monitors two zones within a surficial aquifer underlying the site. Shallow wells monitor an upper unconfined aquifer zone composed of fine silty sand deposits encountered from the land surface to a depth of approximately 14 feet below land surface (ft-bls). Shallow monitor wells are generally 13- to 14-ft deep, screened over the bottom 5 ft of the well. A clay-rich layer separates the shallow zone from a deeper zone and is approximately 16 to 18 ft thick. The deep zone is defined by a layer of sand with an approximate thickness of 5 ft. Deep zone wells are generally 35-ft deep and are also screened over the bottom 5 ft. As water levels rise above the top of the sand layer in the deep wells, this zone becomes confined (SouthDiv, 1990 and 1991).

Previous aquifer testing by means of slug testing was performed on wells in each aquifer zone. The results of these tests indicate a range of hydraulic conductivity of the shallow zone from 0.23 to 9.33 feet per day (ft/day). In the deep zone, the hydraulic conductivity was lower, ranging from 0.04 to 0.36 ft/day.

Specific capacity testing has also been performed on wells in each aquifer zone. Specific capacity for shallow zone wells averaged 0.082 gallon per minute per foot (gpm/ft), and from a deep zone well a value of 0.016 gpm/ft was obtained. These values were used to estimate aquifer transmissivity of 125 gallons per day per foot (gpd/ft) (average) for the shallow zone and 30 gpd/ft for the deep zone (SouthDiv, 1990, 1991). Dividing these values of transmissivity (T) by the aquifer thickness (approximately 10 ft for the shallow zone and 5 ft for the deep zone) also provides an estimate of hydraulic conductivity. For the shallow zone,

the average hydraulic conductivity (K) by this method is 1.67 ft/day, and for the deep zone, 0.8 ft/day.

The direction of groundwater flow in both aquifer zones has typically been observed to be northeast or north. The magnitude of the horizontal groundwater gradients in both aquifer zones is generally 10^{-2} to 10^{-3} feet per foot (ft/ft). The range of flow rates previously calculated for the aquifers are 3.0 to 117 feet per year (ft/yr) for the shallow zone, and less than 1 to 7.3 ft/yr for the deep zone. There usually is a downward vertical gradient between the two aquifers with a magnitude from of 10^{-1} to 10^{-3} ft/ft. [SouthDiv, 1990, 1991; International Technology Corporation (IT), July and August 1991].

2.1 SCOPE OF WORK AND PROCEDURES

2.1.1 WELL REDEVELOPMENT

Details of the well redevelopment were presented to SouthDiv in a work plan prepared in January 1992 before the redevelopment effort. The well redevelopment was performed from January 21 through 24, 1992, on each of the 13 monitor wells to be sampled. A copy of the field notes from the redevelopment effort is provided in Appendix A. The wells were redeveloped by pumping and surging using a centrifugal pump and stainless steel drop pipe. A surge block was fabricated from various polyvinyl chloride (PVC) fittings and placed at the end of the drop pipe. The field team manually raised and lowered the surge block within the well, primarily over the 5-ft length of each screen. This procedure was performed alternately while pumping and not pumping for approximately 2 hours at each well. Most of the wells would pump continuously in the range of 0.5 to 1 gallon per minute (gpm). To evaluate the effectiveness of the redevelopment, an initial 5-minute specific capacity test was performed in each well before redevelopment, and a final 5-minute specific capacity test was

performed following redevelopment. During these tests, water turbidity measurements were made with a field turbidity meter. The depth of each well was measured before and after redevelopment. An evaluation of the redevelopment is described in Section 3.0.

The drop pipe and surge block were decontaminated between each use by washing with laboratory detergent and tap water, rinsing with tap water, and rinsing with deionized water. The decontaminated equipment was stored on clean visqueen or in polyethylene bags. Water discharged during redevelopment was containerized in a 200-gallon (gal) tank located in the back of the field vehicle. The water was then transported to the NAS Wastewater Treatment Plant where it was discharged into the plant waste stream for treatment and disposal.

2.1.2 WATER-LEVEL MEASUREMENTS

Several sets of water-level measurements were associated with ESE efforts. Water levels were measured over several days in each well during redevelopment to determine static and drawdown levels. The water levels were measured in accordance with the permit condition, Part V-No. 13, within an 8-hour period immediately prior to the sampling effort. As water levels were measured in only 13 wells, the water levels were all obtained on January 28, 1992, within 1 hour. The total depth of each well was also measured at this time. Water-level measurements are included in Appendix B with the well sampling data. Measurements of water levels and total well depth were made with an electric water-level tape that had been cleaned by rinsing with deionized water between each well.

2.2 GROUNDWATER SAMPLING AND ANALYSIS

Groundwater samples were collected from January 28 through 30, 1992, from 12 of the 13 wells designated in the permit. Field notes and sample data forms are included in Appendix B. A low rate of production and infilling by sand discovered during redevelopment of monitor well (MW) 42-8 prevented collection of a sample from this well. Prior to purging, calculations of purge volumes were made using the information obtained from the round of water-level and total depth measurements. The wells were purged using a centrifugal pump and decontaminated stainless steel drop pipe. Water was containerized using the same method as during the redevelopment effort and taken to the NAS Wastewater Treatment plant for disposal. Latex or PVC gloves were worn by the field team throughout all phases of the sampling effort. Gloves were changed frequently, and new gloves were put on immediately prior to collecting each sample.

The groundwater samples were collected with precleaned Teflon® bailers with new nylon cord. The bailers were prepared at the ESE laboratory in Gainesville in accordance with cleaning procedures described in the ESE Generic Quality Assurance Plan (GQAP). Each bailer was individually wrapped in aluminum foil and then in visqueen for transport to the site. A new bailer was used for sampling each well; therefore, field decontamination of the bailers was unnecessary. Special sterilized sample bottles, bailer cord, and gloves were prepared and used for microbiological sample collection.

Following sample collection, the samples were preserved as required and placed on ice in a cooler. The samples from the initial 2 days of the effort were shipped overnight to the ESE laboratory in Gainesville, Florida. The third day the samples were taken to Gainesville by the field team. Analysis of microbiological

samples was performed by the Technical Services Incorporated (TSI) Laboratory in Jacksonville. Personnel from TSI met the ESE field team daily at the NAS main gate to receive the microbiological samples. Chain of custody was maintained on all samples.

Samples were analyzed for the parameters designated in the permit. Quality assurance/quality control (QA/QC) requirements for the analyses are described in the Quality Assurance Project Plan (QAPP) prepared in January 1992 prior to the sampling effort. The results of the sample analyses, including QA/QC documentation, are provided and described in Section 5.0.

3.0 EVALUATION OF REDEVELOPMENT

3.1 SPECIFIC CAPACITY

The redevelopment effort appears to have been effective in improving overall well yield. Specific capacity test data are summarized in Table 1 and indicate that a majority of the wells showed some improvement of specific capacity. The degree of improvement ranged from 1 percent in MW4-5 to 193 percent in MW4-20D. In three cases where wells had gone dry during the initial test (MW4-21, MW-4-21D, and MW41-4), the percent improvement, ranging from 25 to 150 percent, was calculated as the improvement in the length of time the well was pumped, up to 5 minutes. The data show that although the specific capacity of some of the shallow aquifer wells actually decreased following redevelopment (negative percent improvement in MW4-9, MW41-3 and MW41-6 ranging from 17 to 90 percent), overall, the positive percentage improvement outweighs the negative.

An estimate of T was made using the final specific capacity from each of the wells. The method used to make the estimate is described in Driscoll (1986) and is based on Jacob's modified nonequilibrium equation. The estimate of T of an unconfined aquifer is obtained by multiplying the value of specific capacity by 1,500 and by 2,000 for a confined aquifer. The estimates of T obtained by this method range from 79 to 586 gpd/ft for the shallow aquifer from 135 to 5,333 gpd/ft for the deep aquifer. In terms of K, the range of values is 1.1 to 7.8 ft/day in the shallow aquifer and 3.6 to 142.5 ft/day in the deep aquifer. These calculations are provided in Appendix C. The shallow aquifer results are similar to values previously reported, but the deep aquifer values are significantly higher. The higher values may be the result of aquifer variability, or actual improvements due not only to the well redevelopment effort, but also the

Table 1. Specific Capacity Test Data

Well Number	Initial Well Depth (ft)	Pumping Rate (gpm)	Drawdown (ft)	Initial Specific Capacity (gpm/ft)	Final Well Depth (ft)	Pumping Rate (gpm)	Drawdown (ft)	Final Specific Capacity (gpm/ft)	Percent Improvement	Estimate* of Transmissivity (gal/day/ft)	Well Depth After Development (ft)
4-9	13.94	1.25	2.48	0.504	13.98	1.25	3.40	0.368	-27	551	0.04
4-5	13.28	1.00	7.08	0.141	13.30	1.00	6.98	0.143	1	215	0.02
4-20	14.90	0.75	5.31	0.141	14.86	1.00	6.62	0.151	7	227	-0.04
4-20D	34.84	1.00	8.82	0.113	34.98	0.75	2.26	0.332	193	664	0.14
4-21	14.94	0.50	DRY	NA	15.04	0.50	5.00	0.100	25*	150	0.1
4-21D	35.52	1.50	DRY	NA	34.76	1.25	18.46	0.068	25*	135	-0.76
41-3	14.20	0.75	4.28	0.175	15.60	0.50	9.48	0.053	-70	79	1.4
41-4	16.06	1.00	DRY	NA	16.26	0.50	5.91	0.085	150*	127	0.2
41-6	12.26	0.50	4.42	0.113	14.40	0.50	5.34	0.094	-17	140	2.14
42-5	13.72	1.00	6.33	0.158	13.84	0.75	1.92	0.391	147	586	0.12
42-6	34.70	2.50	2.70	0.926	34.70	4.00	1.50	2.667	188	5333	0
42-7	13.16	0.50	4.82	0.104	13.40	1.00	6.90	0.145	40	217	0.24
42-8	13.60	0.25	DRY	NA	13.40	NA	DRY	NA	NA	0	-0.2

Note: DTW = depth to water.

TOC = top of casing.

DRY = well pumps dry before test could be completed.

NA = cannot calculate due to dry well.

*Percent Improvement calculated based on improved length of pumping, up to 5 minutes

(i.e.: Well pumped 25 percent longer during final test than during initial test)

**Estimate of Transmissivity based on Driscoll (1986), pg 1021

Source: ESE.

continued well usage since the previous evaluation. The values are all within the range of typical silty sand or sand aquifer zones (Freeze and Cherry, 1979).

Well depths were measured before redevelopment and following redevelopment. In most cases, the changes in well depth are minimal (less than 0.24 ft, or approximately 3 inches). Usually, the well depth was deeper following redevelopment. Large differences were noted in MW41-6, where approximately 2 ft of depth was gained as a result of redevelopment. Following redevelopment of MW4-21D, the measured depth was 0.76 ft or 9 inches, indicating the well produced more sand as a result of pumping shallower. Well depths were measured again prior to sample collection during the round of water-level measurements. These measurements tend to indicate the wells all became deeper by approximately 0.2 ft during the period from completion of the redevelopment to the initiation of sampling. Due to the unlikely nature of this observation, it is probable the two sets of depth measurements were obtained with different water-level tapes with a measurement error of approximately 0.2 ft, and these apparent differences are not significant.

The most significant problem during well redevelopment was encountered at MW42-8. Abundant sand and sediment were removed from the well during redevelopment. The grain size of the material removed by pumping ranged from very fine silt to coarse-grained sand pack material. Although immediately following redevelopment the well was measured to be 6 inches deeper than before development, during the next 3 days the depth slowly decreased. As the well filled with sand over this time, the water level in the well did not return to static following redevelopment and, at the time of sampling, was 4.5 to 5 ft below the expected depth. Based on the results from this well, it appears that the well has been damaged since installation. Due to the problems encountered

with MW42-8, primarily poor recovery, a sample could not be collected. ESE has submitted a cost estimate to SouthDiv to abandon this well and drill a new well. The new well will be constructed approximately 10 ft south of the existing well with similar materials and to a comparable depth. The well replacement is tentatively scheduled during mid-April 1992.

3.2 TURBIDITY

Generally, results of the field turbidity measurements before and after redevelopment are inconclusive (Table 2). Some wells showed improvement as a result of the effort, and some wells either showed no change or became more turbid. Previous turbidity measurements have been made in the laboratory, but only for the sample collection and analysis of May 1991, which included only a portion of the wells. Compared to the limited previous turbidity data, the turbidity increased. These results appear to be due to the fine-grained silty nature of the aquifer material. Although redevelopment appears to have helped increase well yield, the effort apparently did little to reduce turbidity.

Table 2. Turbidity During Specific Capacity Testing

Well No.	4-9	4-5	4-20	4-20D	4-21	4-21D	41-3	41-4	41-6	42-5	42-6	42-7	42-8
FIELD TURBIDITY													
Initial Sp Cap Test													
Start	>100	>100	>100	>100	75	1	>100	>100	6.9	95	>100	>100	66
Mid	>100	NR	>100	>100	>100	>100	70	DRY	1	58	73	NR	33
End	35	85	>100	>100	DRY	>100	25	DRY	1	30	6	7.5	DRY
Final Sp Cap Test													
Start	>100	35	>100	>100	>100	1	>100	>100	40	3.5	14	60	DRY
Mid	40	25	>100	>100	>100	1	>100	>100	40	NR	>100	60	DRY
End	10	35	>100	>100	NR	1	70	>100	10	NR	NR	>100	DRY
Improvement	yes	yes	NC	NC	NC	yes	NC	NC	no	yes	no	no	no
LABORATORY TURBIDITY													
April 1991	NA	NA	NA	NA	NA	NA	70	60	500	24	24	230	600
January 1992	94	500	230	7.25	1950	4.3	2150	<0.4	1100	388	838	725	NS

Note: NR = no reading.
 NS = not sampled.
 NC = no change.

Source: ESE.

4.0 DIRECTION OF GROUNDWATER FLOW

The direction and rate of groundwater flow in both the shallow and deep aquifer zones were determined based on a round of water-level measurements in the 13 monitor wells. The water levels shown in Table 3 were all measured within 1 hour on January 28, 1992, prior to sample collection. Water-level contour maps for the shallow and deep zones are shown in Figures 4 and 5, respectively. Groundwater flow gradients were calculated from these maps. The rate of groundwater flow was determined using the measured gradients and the range of hydraulic conductivities determined for the site during previous investigations (SouthDiv, 1990 and 1991). Calculations of gradients and flow rates are provided in Appendix C.

4.1 SHALLOW AQUIFER ZONE

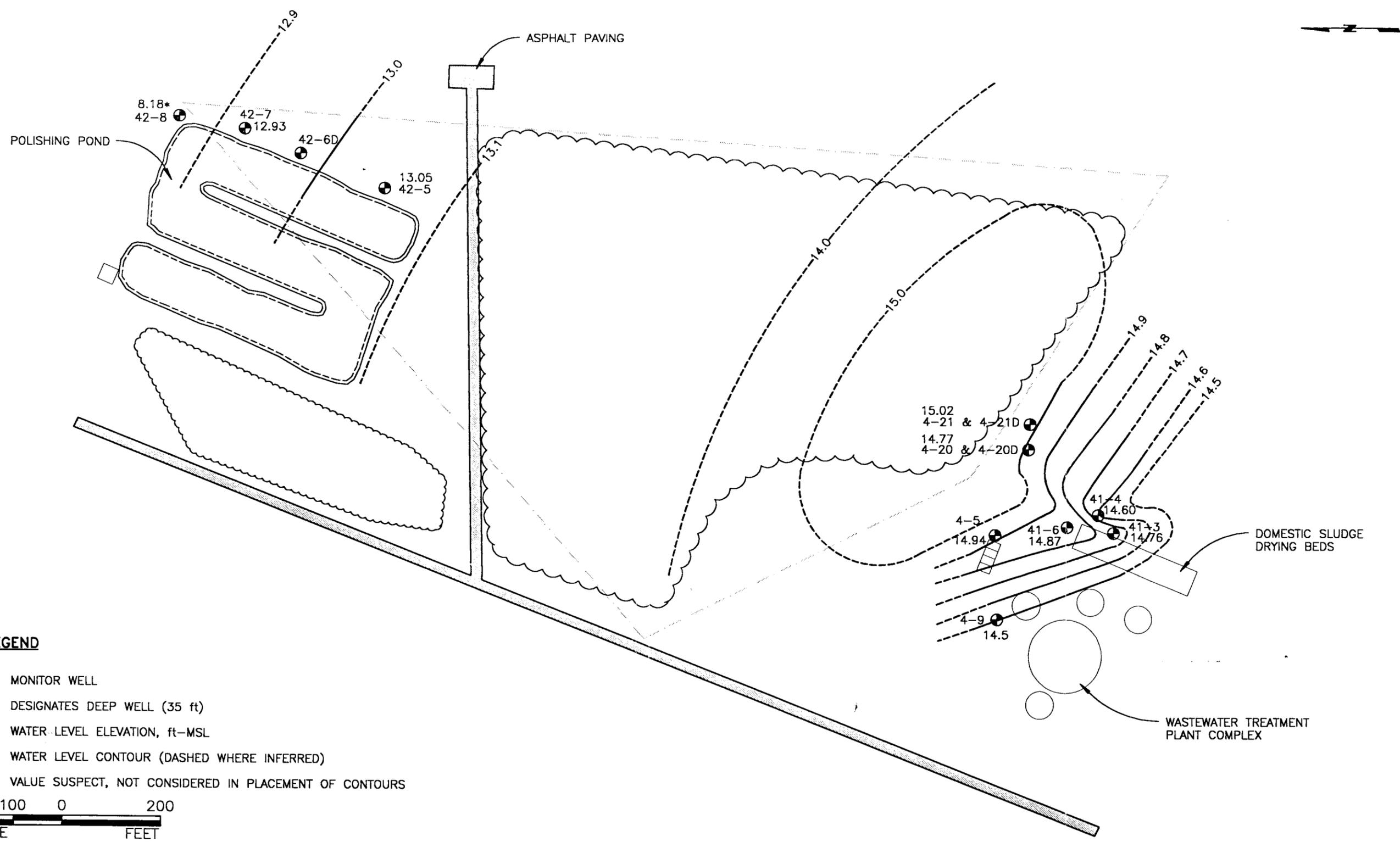
In the shallow aquifer surrounding the ISDBs and DSDBs, an unusual flow direction is observed. The water levels measured in January 1992 indicate flow in this area is south-southwest, generally toward the Wastewater Treatment Plant. As flow has typically been observed to the northeast in this area, the reversal of flow direction is most likely due to localized and temporary dewatering occurring at the Wastewater Treatment Plant associated with the construction of new foundations. Water-level measurements obtained before and after redevelopment, although not obtained within 8 hours of redevelopment and therefore not contoured, show a similar pattern. Water produced from the dewatering operation is transferred to the Wastewater Treatment Plant waste stream for treatment and disposal. There also appears to be a slightly higher water level, indicating some amount of mounding near the DSDBs. These results may indicate preferential infiltration through the disturbed soils and gravel base within the DSDBs. The average gradient in the vicinity of the ISDBs and DSDBs

Table 3. Water Level Information for NAS Jacksonville
Measured January 28, 1992

Well Number	TOC Elevation (ft-msl)	Depth to Water (ft)	Water Level Elevation (ft-msl)	Depth of Well from TOC (ft)	Change from Development (Final) (ft)
4-9	23.52	9.02	14.50	14.20	-0.22
4-5	20.62	5.68	14.94	13.50	-0.2
4-20	20.81	5.84	14.97	15.08	-0.22
4-20D	20.67	5.82	14.85	35.10	-0.12
4-21	20.45	5.43	15.02	15.24	-0.2
4-21D	19.95	5.00	14.95	35.00	-0.24
41-3	20.09	5.33	14.76	16.84	-1.24
41-4	20.64	6.04	14.60	16.40	-0.14
41-6	20.25	5.38	14.87	14.60	-0.2
42-5	18.57	5.52	13.05	14.06	-0.22
42-6	18.18	10.00	8.18	34.94	-0.24
42-7	18.19	5.26	12.93	13.26	0.14
42-8	18.06	9.88	8.18	13.62	-0.22

Note: ft-msl = feet above mean sea level.

Source: ESE.



LEGEND

- 4-5 ● MONITOR WELL
- D DESIGNATES DEEP WELL (35 ft)
- 15.02 WATER LEVEL ELEVATION, ft-MSL
- 15.0— WATER LEVEL CONTOUR (DASHED WHERE INFERRED)
- * VALUE SUSPECT, NOT CONSIDERED IN PLACEMENT OF CONTOURS

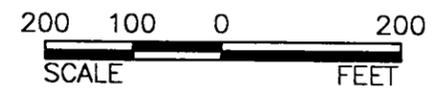


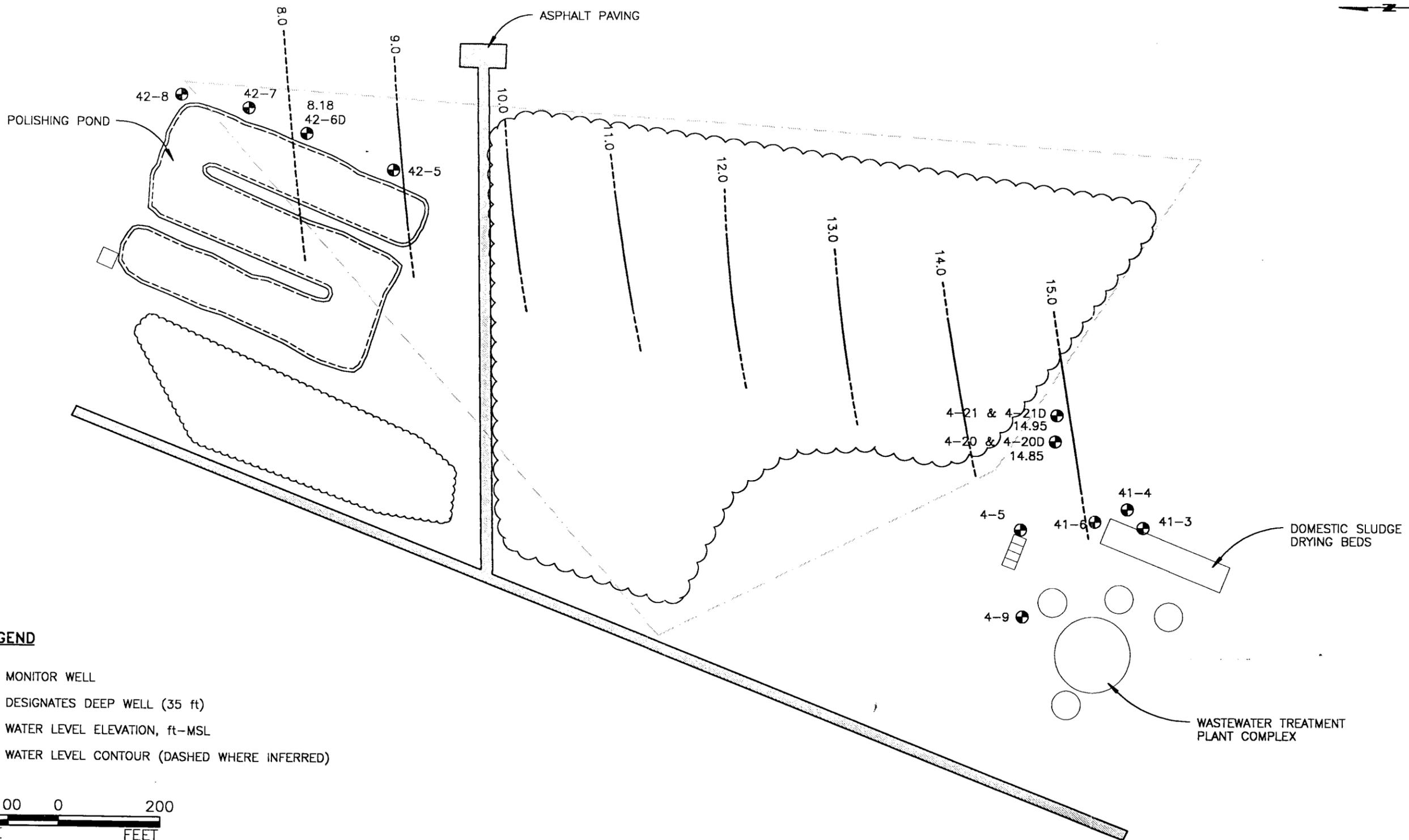
Figure 4
SHALLOW AQUIFER WATER LEVEL CONTOUR MAP - WATER LEVEL ELEVATIONS MEASURED JANUARY 28, 1992

SOURCE: ESE, 1992



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LEGEND

- 4-5 MONITOR WELL
- D DESIGNATES DEEP WELL (35 ft)
- 14.95 WATER LEVEL ELEVATION, ft-MSL
- 15.0— WATER LEVEL CONTOUR (DASHED WHERE INFERRED)

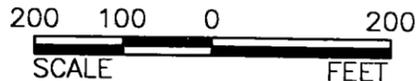


Figure 5
DEEP AQUIFER WATER LEVEL CONTOUR MAP - WATER LEVEL ELEVATIONS MEASURED JANUARY 28, 1992

SOURCE: ESE, 1992

is 2.2×10^{-3} ft/ft. As shown in Figure 4, at some distance from the ISDBs and DSDBs, the influence of the construction dewatering is no longer effective and the gradient most likely returns to the northeastern trend. The rate of groundwater flow near the ISDBs and DSDBs, from 9.1×10^{-1} to 36.5 ft/yr, was generally within the range but somewhat lower than the previously reported ranges.

In the vicinity of the PPs, the more typical northeast gradient was observed. The water level measured in MW42-8 was much lower than expected. This unusual water level is apparently a function of well damage, as noted during the redevelopment. The water level in MW42-8 was not considered in the contour placement shown in Figure 4. The water level measured in the well prior to redevelopment was consistent with the northeast flow direction, although the water level measured following redevelopment was similar to the level shown in Figure 4. Following the initial evacuation of MW42-8 for redevelopment and the discovery of the problem, the water level was monitored several times and never returned to the static level. By the time of sampling the following week, the water level had still not returned to static. Possibly, if enough time passed (several weeks or more), the water level in the well may return to static conditions, but given the characteristics observed during this effort, the water-level response provides additional support for proper well abandonment and the construction of a new well directly connected with the aquifer. Without considering the water level in MW42-8, the gradient near the PPs is 3.97×10^{-4} ft/ft. This translates to a flow rate ranging from 1.6×10^{-1} to 6.6 ft/yr in this area, also somewhat lower than the previously reported range of flow rates.

4.2 DEEP AQUIFER ZONE

The groundwater flow direction in the deep aquifer zone, based on water-level measurements in three monitor wells, is north toward the St. Johns River (Figure 5). The flow direction in the deep aquifer zone is typically north or northeast. The gradient in the deep zone, based on these measurements, is 4.2×10^{-3} ft/ft. The range of flow rates in the deep zone is calculated to be 3.1×10^{-1} to 2.8 ft/yr. This range of flow rate is also somewhat lower than that previously reported. These calculations are shown in Appendix C. No unusual measurements were associated with the deep aquifer zone.

4.3 VERTICAL GRADIENTS

Vertical flow gradients between the shallow and deep aquifer zones were downward from the shallow zone toward the deep aquifer zone in all cases. The magnitude of the vertical gradient near the ISDBs and DSDBs was delineated by comparison of water levels in MW4-20 and MW4-20D and in MW4-21 and MW4-21D. The water-level difference between each set of wells was divided by 17 ft, the distance from the bottom of the shallow zone well screen to the top of the deep zone well screen. The average vertical gradient in this area was 5.6×10^{-3} ft/ft, downward. Vertical gradient calculations are provided in Appendix C.

Near the PPs, the vertical gradient was determined by the difference in water levels between MW42-6 and the adjacent wells MW42-5 and MW42-7. Screen separations were 18 and 19 ft, respectively, between these wells and MW42-6. The average vertical gradient in this area is 2.6×10^{-1} , higher than near the ISDBs and DSDBs. The higher gradient in this area is most likely the result of the influence of the surface water infiltration in the PPs. If more data points were available surrounding the PPs, some amount of deflection of shallow

aquifer water-level contours indicative of mounding may be apparent. This effect would most likely be more pronounced following a rainfall event when the pond level would rise after receiving additional runoff.

5.0 RESULTS OF GROUNDWATER ANALYSIS

Groundwater samples were collected from 12 of the 13 monitor wells designated in the FDER permit. As explained in Section 3.0, a sample could not be collected from MW42-8 due to poor recharge in the well. The wells and their monitoring purpose are shown in Table 4.

The parameters analyzed are those listed in the FDER permit, Part V-No. 8 and No. 9. The results of the analyses are summarized in Table 5. Complete analytical results, including detection limits, are presented in Appendix D. All QA/QC data developed for the analyses are also provided in Appendix D.

To evaluate permit compliance, the analytical results for the No. 8 compounds from each well were compared to Florida Primary Drinking Water Standards (FPDWS) where designated, or to the background concentrations. Permit condition Part V-No. 10 states:

"Background concentrations shall be established through sampling at the upgradient background well (MW4-9) each time groundwater is sampled at the Point of Compliance. The background concentration limit shall be the mean of the four most recent background samples of the hazardous constituent [40 CFR Part 264.99(c)(1)]."

Table 6 was prepared showing the results of the four most recent analyses from MW4-9 for various compounds listed in No. 8 to aid in the determination of background concentrations. In preparing the table, it became obvious that a majority of the parameters had never been detected in MW4-9, or analyses for that compound had not previously been performed. In this case, the permit standard, defined as the Groundwater Protection Standard of Background, was

Table 4. Monitor Wells Included in Semi-Annual Sampling at NAS Jacksonville

Monitor Well	Monitor Location	Point of Compliance	Aquifer Zone
4-9	Background	Determines Background Concentration	Shallow
4-5	ISDBs	yes	Shallow
41-3	DSDBs	yes	Shallow
41-4	DSDBs	yes	Shallow
41-6	DSDBs	yes	Shallow
42-5	PPs	yes	Shallow
42-6	PPs	yes	Deep
42-7	PPs	yes	Shallow
42-8	PPs	yes, but not sampled	Shallow
4-20	DSDBs and ISDBs	no	Shallow
4-20D	DSDBs and ISDBs	no	Deep
4-21	DSDBs and ISDBs	no	Shallow
4-21D	DSDBs and ISDBs	no	Deep

Note: DSDB = domestic sludge drying beds.
ISDB = industrial sludge drying beds.
PP = polishing pond.

Source: ESE.

Table 5. Summary of Analytical Results

Environmental Science & Engineering, Inc. 03/17/92 STATUS: FINAL PAGE 1
 PROJECT NUMBER 3924001G 0201 PROJECT NAME NAS - JAX PERMIT HF16
 FIELD GROUP NASJW1A LAB COORDINATOR J.D. SHAMIS

SAMPLE ID'S		NAS4-5	NAS4-9	NAS4-20	NAS4-20D	NAS4-21	NAS4-21D	NAS41-3	NAS41-4	NAS41-6	NAS42-5
PARAMETERS	STORET METHOD	NASJW1A									
UNITS		2	1	12	13	10	11	5	3	4	6
DATE		01/29/92	01/30/92	01/28/92	01/28/92	01/28/92	01/28/92	01/29/92	01/29/92	01/29/92	01/30/92
TIME		08:15	10:30	13:45	17:00	11:30	12:15	16:45	10:00	10:00	
PH, FIELD	400	6.2	5.40	5.30	5.2	5.90	6.00	9.00	9.60	7.50	5.50
	STD UNITS										
SP.COND., FIELD@25C	94	365	266	132	123	84.0	182	929	2750	937	582
	UMHOS/CM										
COLIFORM, T., MPN	31506	--	--	2	--	2	8	2	--	--	--
	#/100ML										
TURBIDITY	76	500	94.0	230	7.25	1950	4.30	2150	--	1100	388
	NTU										
NITROG, NO2+NO3	630	0.021	0.014	0.010	--	--	--	0.017	0.043	--	0.250
	MG/L AS N										
NITROGEN, NO2	615	0.124	0.041	0.025	--	0.077	--	0.265	0.476	0.299	0.138
	MG/L- AS N										
NITROG, NO3	620	--	--	--	--	--	--	--	--	--	0.112
	MG/L-AS N										
CHLORIDE	940	6.4	5.2	6.2	9.7	6.2	5.8	66.8	112	10.7	27.6
	MG/L										
SULFATE	945	30.4	54.2	51.0	--	--	--	238	--	105	98.9
	MG/L										
FLUORIDE	951	--	--	--	--	--	--	--	2.16	--	--
	MG/L										
ALPHA, GROSS	1501	8.6	31.7	5.4	1.3	31.5	0.4	289	62.3	148	33.5
	PC/L										
ALPHA, GR., CT.ERROR	1502	6.3	10.5	2.0	1.2	11.8	1.8	91.2	32.4	46.8	21.0
	+/-PC/L										
BETA, GROSS	3501	9.3	14.6	6.2	--	22.3	6.5	84.7	36.3	27.7	--
	PC/L										
BETA, GR., CT.ERROR	3502	10.0	6.2	1.5	1.8	8.3	2.8	53.3	27.3	27.4	20.6
	+/-PC/L										
RADIUM 226	9501	3.9	4.7	8.3	1.1	5.7	0.7	17.9	12.4	4.5	3.8
	PC/L										
RADIUM 226, CT.ERROR	9502	1.0	1.0	1.2	0.5	1.0	0.5	1.8	1.6	0.9	0.9
	+/-PC/L										
RADIUM 228	11501	0.5	0.6	0.7	--	0.4	--	1.3	--	1.1	0.9
	PC/L										
RADIUM 228, CT.ERROR	11502	0.4	0.5	0.5	0.4	0.5	0.4	0.5	0.5	0.4	0.5
	+/-PC/L										
PHENOLS	32730	3	5	2	4	15	--	9	960	8	10
	UG/L										
CYANIDE	720	0.003	--	--	--	--	--	0.016	0.019	--	0.007
	MG/L										
ARSENIC	1002	--	--	--	--	--	--	6.5	32.1	3.7	169
	UG/L										
BARIUM	1007	35.0	94.3	224	32.5	163	30.6	738	222	225	100.0
	UG/L										
CADMIUM	1027	516	--	--	12.0	--	16.7	5.9	7.1	--	--
	UG/L										
CHROMIUM	1034	56.0	--	52.8	--	44.4	23.9	158	153	97.0	95.6
	UG/L										
COPPER	1042	66.4	--	11.1	--	7.6	--	28.3	7.3	29.7	6.9
	UG/L										
IRON	1045	2130	4350	13000	6050	11700	1440	35800	6330	9260	60100
	UG/L										
LEAD	1051	39.1	6.4	8.8	3.5	7.5	3.5	39.9	35.0	24.3	10.4
	UG/L										
MANGANESE	1055	25.4	15.9	35.4	25.9	30.7	29.0	690	30.8	93.3	121
	UG/L										
MERCURY	71900	--	--	--	--	--	--	0.20	1.90	--	--
	UG/L										
NICKEL	1067	312	--	25.9	--	--	17.7	80.5	207	23.7	25.9
	UG/L										
SELENIUM	1147	--	--	--	--	--	--	--	2.3	--	--
	UG/L										
SILVER	1077	--	--	--	--	--	7.5	--	--	6.4	--
	UG/L										
SODIUM	82035	44200	3500	17300	12300	3590	9800	85400	744000	187000	20700
	UG/L										
VANADIUM	1087	187	63.5	150	--	55.6	--	203	423	68.1	35.5
	UG/L										
ZINC	1092	37.2	7.1	21.9	48.0	28.0	57.8	149	33.5	66.2	13.3
	UG/L										

Table 5. Summary of Analytical Results (Continued, Page 2 of 3)

Environmental Science & Engineering, Inc. 03/17/92 STATUS: FINAL PAGE 2
 PROJECT NUMBER 3924001G 0201 PROJECT NAME NAS - JAX PERMIT HF16
 FIELD GROUP NASJW1A LAB COORDIATOR J.D. SHAMIS

SAMPLE ID'S PARAMETERS UNITS	STORET METHOD	NAS4-5 NASJW1A 2	NAS4-9 NASJW1A 1	NAS4-20 NASJW1A 12	NAS4-20D NASJW1A 13	NAS4-21 NASJW1A 10	NAS4-21D NASJW1A 11	NAS41-3 NASJW1A 5	NAS41-4 NASJW1A 3	NAS41-6 NASJW1A 4	NAS42-5 NASJW1A 6
DATE TIME		01/29/92 08:15	01/30/92 10:30	01/28/92 13:45	01/28/92 17:00	01/28/92 11:30	01/28/92 12:15	01/29/92 16:45	01/29/92 10:00	01/29/92 10:00	01/30/92
CHLOROMETHANE UG/L GMS	34418	--	--	1.6	--	--	--	--	--	--	--
1,1-DICHLOROETHANE UG/L GMS	34496	--	--	--	--	--	--	14	5.0	--	--
1,1-DICHLOROETHYLENE UG/L GMS	34501	--	--	--	--	--	--	--	2.2	--	--
METHYLENE CHLORIDE UG/L GMS	34423	--	--	--	--	--	--	1.5	20	--	--
TOLUENE UG/L GMS	34010	--	--	--	--	--	--	--	2.8	--	--
ACETONE UG/L GMS	81552	--	6.9	47	5.6	--	40	47	450	120	6.6
METHYL ETHYL KETONE UG/L GMS	81595	--	--	--	--	--	--	--	16	--	--
2-METHYL PHENOL UG/L GMS	99073	--	--	--	--	--	--	--	22.5	--	--
4-METHYL PHENOL UG/L GMS	99074	--	--	--	--	--	--	--	21.3	--	--
BIS(2-ETHYLHEXYL) PHTHALATE UG/L GMS	39100	7.9	5.4	60	7.1	86	63	120	22	33	7.9

Table 5. Summary of Analytical Results (Continued, Page 3 of 3)

Environmental Science & Engineering, Inc. 03/17/92 STATUS: FINAL PAGE 3
 PROJECT NUMBER 3924001G 0201 PROJECT NAME NAS - JAX PERMIT HF16
 FIELD GROUP NASJW1A LAB COORDIATOR J.D. SHAMIS

SAMPLE ID'S PARAMETERS	STORET METHOD	NAS42-6	NAS42-7	FD#	FD#	EQPBLK	FLDBLK	TRPBLK	TRPBLK	TRPBLK
		NASJW1A								
UNITS		7	8	14	15	17	16	18	19	20
DATE		01/29/92	01/30/92	01/29/92	01/28/92	01/29/92	01/28/92	01/28/92	01/29/92	01/30/92
TIME		12:30	08:45			09:30				
PH, FIELD	400	4.70	6.40					NRQ	NRQ	NRQ
STD UNITS	0									
SP. COND., FIELD@25C	94	107	1530					NRQ	NRQ	NRQ
UMHOS/CM	0									
COLIFORM, T., MPN	31506	14	--	8	--	--	--	NRQ	NRQ	NRQ
#/100ML	0									
TURBIDITY	76	838	725	850	675	--	--	NRQ	NRQ	NRQ
NTU	1									
NITROG, NO2+NO3	630	--	11.4	--	--	--	--	NRQ	NRQ	NRQ
MG/L AS N	TECH									
NITROGEN, NO2	615	0.247	0.149	0.253	0.025	--	--	NRQ	NRQ	NRQ
MG/L- AS N	TECH									
NITROG, NO3	620	--	11.3	--	--	--	--	NRQ	NRQ	NRQ
MG/L-AS N	CALC									
CHLORIDE	940	8.7	47.0	8.2	8.2	--	--	NRQ	NRQ	NRQ
MG/L	TITR									
SULFATE	945	52.4	567	6.28	--	--	--	NRQ	NRQ	NRQ
MG/L	TURB									
ALPHA, GROSS	1501	54.5	26.0	81.8	0.9	0.6	0.9	NRQ	NRQ	NRQ
PC/L	R									
ALPHA, GR., CT. ERROR	1502	16.5	19.6	21.1	1.7	0.7	0.7	NRQ	NRQ	NRQ
+/-PC/L	R									
BETA, GROSS	3501	45.7	66.7	39.7	--	--	--	NRQ	NRQ	NRQ
PC/L	R									
BETA, GR., CT. ERROR	3502	12.4	23.2	15.7	2.3	1.8	1.7	NRQ	NRQ	NRQ
+/-PC/L	R									
RADIUM 226	9501	10.1	3.6	9.9	0.6	1.0	0.8	NRQ	NRQ	NRQ
PC/L	R									
RADIUM 226, CT. ERROR	9502	1.5	0.8	1.3	0.7	0.5	0.5	NRQ	NRQ	NRQ
+/-PC/L	R									
RADIUM 228	11501	0.4	0.7	1.4	--	--	0.4	NRQ	NRQ	NRQ
PC/L	R									
RADIUM 228, CT. ERROR	11502	0.5	0.5	0.5	0.4	0.4	0.5	NRQ	NRQ	NRQ
+/-PC/L	R									
PHENOLS	32730	--	9	2	4	--	2	NRQ	NRQ	NRQ
UG/L	I									
CYANIDE	720	--	0.004	--	--	--	--	NRQ	NRQ	NRQ
MG/L	I									
ARSENIC	1002	7.5	8.6	8.9	--	--	--	NRQ	NRQ	NRQ
UG/L	GFAA									
BARIUM	1007	23.1	162	22.2	142	--	1.9	NRQ	NRQ	NRQ
UG/L	ICAP									
CADMIUM	1027	--	--	--	17.1	--	--	NRQ	NRQ	NRQ
UG/L	ICAP									
CHROMIUM	1034	33.4	106	30.2	49.6	--	--	NRQ	NRQ	NRQ
UG/L	ICAP									
COPPER	1042	4.6	15.0	5.1	25.7	--	--	NRQ	NRQ	NRQ
UG/L	ICAP									
IRON	1045	9170	22700	9820	16700	17.4	46.5	NRQ	NRQ	NRQ
UG/L	ICAP									
LEAD	1051	1.7	14.4	--	8.4	--	--	NRQ	NRQ	NRQ
UG/L	GFAA									
MANGANESE	1055	21.5	299	20.9	75.1	1.8	1.8	NRQ	NRQ	NRQ
UG/L	ICAP									
NICKEL	1067	36.3	26.5	29.0	40.7	--	--	NRQ	NRQ	NRQ
UG/L	ICAP									
SODIUM	82035	8680	51000	8450	9590	183	--	NRQ	NRQ	NRQ
UG/L	ICAP									
VANADIUM	1087	9.5	91.0	13.3	53.1	7.1	7.1	NRQ	NRQ	NRQ
UG/L	ICAP									
ZINC	1092	33.6	31.5	34.2	143	10.8	23.9	NRQ	NRQ	NRQ
UG/L	ICAP									
CHLOROFORM	32106	--	--	--	--	--	1.7	--	--	--
UG/L	GMS									
ACETONE	81552	100	13	78	41	--	--	--	2.4	--
UG/L	GMS									
METHYL ETHYL KETONE	81595	--	--	--	--	--	2.6	--	--	--
UG/L	GMS									
BIS(2-ETHYLHEXYL)	39100	15	--	--	46	--	11	NRQ	NRQ	NRQ
PHthalate UG/L	GMS									

chosen as the most recent (January 1992) detection limit for that compound. Only barium and lead had sufficient results (four and two, respectively) over the detection limit from which to obtain an average. These results are shown as the Mean of Detections in Table 6. For each of these metals, the permit standard is defined as the Primary Drinking Water Standard and, in fact, the averaging was not necessary. The Primary or Secondary Drinking Water Standards for the various compounds, where available, are also provided on Table 6. A concentration listed as Guidance was available for some compounds. These values were obtained from an FDER Guidance document prepared by Merchant (1989). The regulatory standards are shown for reference only as they are not necessarily the permit standards.

For the No. 9 parameters, a Groundwater Protection Standard is not designated in the permit. Table 7 was also prepared showing the results of the four most recent analyses for these compounds, to aid in evaluation of these compounds. A Mean of Detections is shown, and in many cases there is only one value to average to obtain this mean. As in Table 6, Table 7 also shows a Regulatory Standard based either on the Primary or Secondary Drinking Water Standards or FDER guidance. The parameters exceeding the permit standards and the wells where they were exceeded are summarized in Table 8.

Contour maps were prepared for the shallow aquifer depicting several compounds which had either previously been contoured, or represented a typical distribution of the compounds. Due to only three data points in the deeper zone, contour maps for this zone were not prepared. The preparation of contour maps is somewhat biased as only selected wells were sampled. A more accurate picture of a contaminant plume would be obtained with a larger spread of data points. This relates to the purpose of the present monitor effort, which is to

Table 6. Determination of Mean concentration in NAS4-9
 [Permit Part V - Groundwater Monitoring Program No. 8 - Groundwater Protection Standard (40 CFR Part 264.92)]

Compound Name	Units	Most Recent Sampling Event That Compound Was Analyzed						Mean of Detections	Permit Standard*	Regulatory Standard (for reference only)
		1/92	8/91	4/91	1/91	11/89	9/88			
tetrachloroethylene	ug/L	< 1	< 0.05	< 0.05	< 3			1	3 Primary	
methylene chloride	ug/L	< 1	< 0.05	< 1	< 1			1	5 Guidance	
trichloroethylene	ug/L	< 1	< 0.05	< 0.05	< 3			1	3 Primary	
1,1,2-trichloroethane	ug/L	< 1			< 1	< 5	< 5	1	1 Guidance	
toluene	ug/L	< 1			< 1	< 5	< 1	1	24 Guidance	
carbon tetrachloride	ug/L	< 1	< 0.05	< 0.05	< 1			1	3 Primary	
chloroform	ug/L	< 1			< 1	< 5	< 5	1	100 Primary**	
methyl ethyl ketone	ug/L	< 2			< 5	< 10	< 10	2	170 Guidance	
ethylene dibromide	ug/L	< 0.02						0.02	0.02 Primary	
benzene	ug/L	< 1	< 0.05	< 0.05	< 1			1	1 Primary	
1,2-dichlorobenzene	ug/L	< 1						1	10 Guidance	
chlorobenzene	ug/L	< 1			< 1	< 5	< 1	1	10 Guidance	
vinyl chloride	ug/L	< 1	< 0.05	< 0.05	< 1			1	1 Primary	
total cresols	ug/L	< 2			< 11			2	3000 Guidance	
crselic acid	ug/L	same compounds as total cresols								NC
total phenols	ug/L	5	< 10	< 10	< 11			5	20 Guidance	
total xylene	ug/L	< 1			< 1	< 5	< 5	1	50 Guidance	
carbon disulfide	ug/L	< 1			< 1	< 5	< 5	1	NC	
trichlorofluoromethane	ug/L	< 1			< 1	< 5	< 5	1	NC	
pyridine	ug/L	< 10			< 4000	< 10000	< 10	10	NC	
2-nitropropane	ug/L	< 10						10	NC	
nitrobenzene	ug/L	< 1			< 11	< 10	< 10	1	30 Guidance	
1,2-dichlorobenzene	ug/L	< 1						1	10 Guidance	
1,2,3-trichloropropane	ug/L	< 2	< 0.05	< 10	< 5			2	NC	
arsenic	mg/L	< 0.0023	< 0.01	< 0.01	0.04			0.05	0.05 Primary	
barium	mg/L	0.0943	0.024	0.032	0.059			0.052325	1 Primary	
cadmium	mg/L	< 0.0044	< 0.005	< 0.005	< 0.005			0.01	0.01 Primary	
total chromium	mg/L	< 0.0074	< 0.01	< 0.01	< 0.01			0.05	0.05 Primary	
lead	mg/L	0.0064	0.0064	< 0.01	< 0.03			0.0064	0.05 Primary	
mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.001			0.002	0.002 Primary	
selenium	mg/L	< 0.002	< 0.01	< 0.01	< 0.06			0.01	0.01 Primary	
silver	mg/L	< 0.0061	< 0.01	< 0.01	< 0.05			0.05	0.05 Primary	
nickel	mg/L	< 0.0175	< 0.04	< 0.04	< 0.02			0.0175	150000 Guidance	
complexed cyanide	mg/L	< 0.003	< 0.01	< 0.01	< 0.01			0.003	154000 Guidance	

Note: Primary = Florida Primary Drinking Water Standard (FAC 17-550.310).
 Secondary = Florida Secondary Drinking Water Standard (FAC 17-550.320).
 Guidance = FDER Guidance Concentration (Merchant, 1989).

*If all values are below detection limit, the Permit Standard is the latest detection limit

**Regulatory Standard is Total Trihalomethanes

Source: ESE.

Table 7. Determination of Mean concentration in NAS4-9
(Permit Part V - Groundwater Monitoring Program No. 9 - Semiannual Constituents)

Compound Name	Units	Most Recent Sampling Event That Compound Was Analyzed						Mean of Detections	Permit Standard*	Regulatory Standard (for reference only)
		1/92	8/91	4/91	1/91	11/89	9/88			
pH	st. units	5.4	6	6.26	5.19			5.7125	NA	6.5-8.5 Secondary
specific conductance	umhos/cm	266	294	408	215			295.75	NA	500 Secondary
turbidity	NTU	94						94	NA	1 Primary
total coliform	#/100ml	<2							NA	<1/100ml Primary
nitrate	mg/L	<0.041							NA	10 Primary
radium 226	PC/L	4.7						4.7	NA	total 226
radium 228	PC/L	0.6						0.6	NA	+228 = 5 Primary
gross alpha	PC/L	31.7						31.7	NA	15 Primary
gross beta	PC/L	14.6						14.6	NA	NC
chloride	mg/L	5.2						5.2	NA	250 Secondary
1,1-dichloroethane	ug/L	< 1	< 0.05	< 1	< 1				NA	2400 Guidance
1,2-dichloroethane	ug/L	< 1	< 0.05	< 0.05	< 5				NA	3 Primary
1,1,1-trichloroethane	ug/L	< 1	< 0.05	< 0.05	< 5				NA	200 Primary
isobutanol	ug/L	< 500			< 400	< 2000	< 50		NA	NC
1,1,2-trichloro- 1,2,2-trifluoroethane	ug/L	< 1							NA	NC
2-ethoxyethanol	ug/L	< 5000							NA	NC
copper	mg/L	< 0.0038	< 0.025	0.025	0.02				NA	1 Secondary
fluoride	mg/L	< 0.1							NA	2 Secondary
iron	mg/L	4.35						4.35	NA	0.3 Secondary
manganese	mg/L	0.0159						0.0159	NA	0.05 Secondary
sodium	mg/L	3.5						3.5	NA	160 Primary
vanadium	mg/L	0.0635	0.032	0.041	0.02			0.039125	NA	NC
zinc	mg/L	0.0071	0.42	< 0.02	0.034			0.1537	NA	5 Secondary
sulfate	mg/L	54.2						54.2	NA	250 Secondary

Source: ESE.

Table 8. Parameters Exceeding Permit Standards, NAS Jacksonville

	4-9	Point of Compliance Wells							4-20	4-20D	4-21	4-21D	Total No. of Wells
		4-5	41-3	41-4	41-6	42-5	42-6	42-7					
Total Phenols			X	X	X	X		X			X		6
Cyanide			X	X		X		X					4
Arsenic						X							1
Cadmium		X									X	X	3
Chromium		X	X	X	X	X		X	X				7
Nickel		X	X	X	X	X	X	X	X			X	9
Methylene Chloride			X	X									2
Toluene				X									1
Methyl Ethyl Ketone				X									1
Total Cresols				X									1

Note: NS = not sampled.

Source: ESE.

determine permit compliance and not necessarily plume delineation which has previously been performed.

5.1 SHALLOW AQUIFER

Ten compounds were found exceeding the standards associated with the FDER Permit, Part V-No. 8 in the shallow aquifer zone. These included five metals and five organic compounds (Table 8). The metals most frequently exceeding the permit standards include chromium, nickel, and cyanide. The chromium standard designated in the permit is also the Primary Drinking Water Standard. Contour maps of chromium and nickel concentrations were prepared (Figures 6 and 7, respectively). As expected, the wells most frequently exceeding the standards and the wells with the highest concentrations are those closest to the ISDBs, DSDBs, and PPs. Arsenic was detected in only one well, MW42-5 adjacent to the PPs, and cadmium was detected in only one well, MW4-5 adjacent to the ISDBs.

Five organic compounds were detected in the shallow aquifer zone, with total phenols being the compound detected most frequently. The highest concentration was detected in MW41-4 [960 micrograms per liter ($\mu\text{g/L}$)], approximately two orders of magnitude greater than the concentrations detected in any other well, which ranged from 2 to 15 $\mu\text{g/L}$. The permit standard for total phenols is based on the January 1992 detection of 5 $\mu\text{g/L}$ of total phenols in the background well. A contour map of the total phenols distribution is shown in Figure 8. With one exception, all other organic compounds exceeding the standard were detected in MW41-4. The permit standard for these organic compounds is based on the analytical method detection limit for the compound. The concentrations of total phenols, methylene chloride, methyl ethyl ketone, and toluene in MW41-2 also exceeded the guidance criteria for these compounds. MW 41-4 is located northeast, typically downgradient, of the DSDBs. One

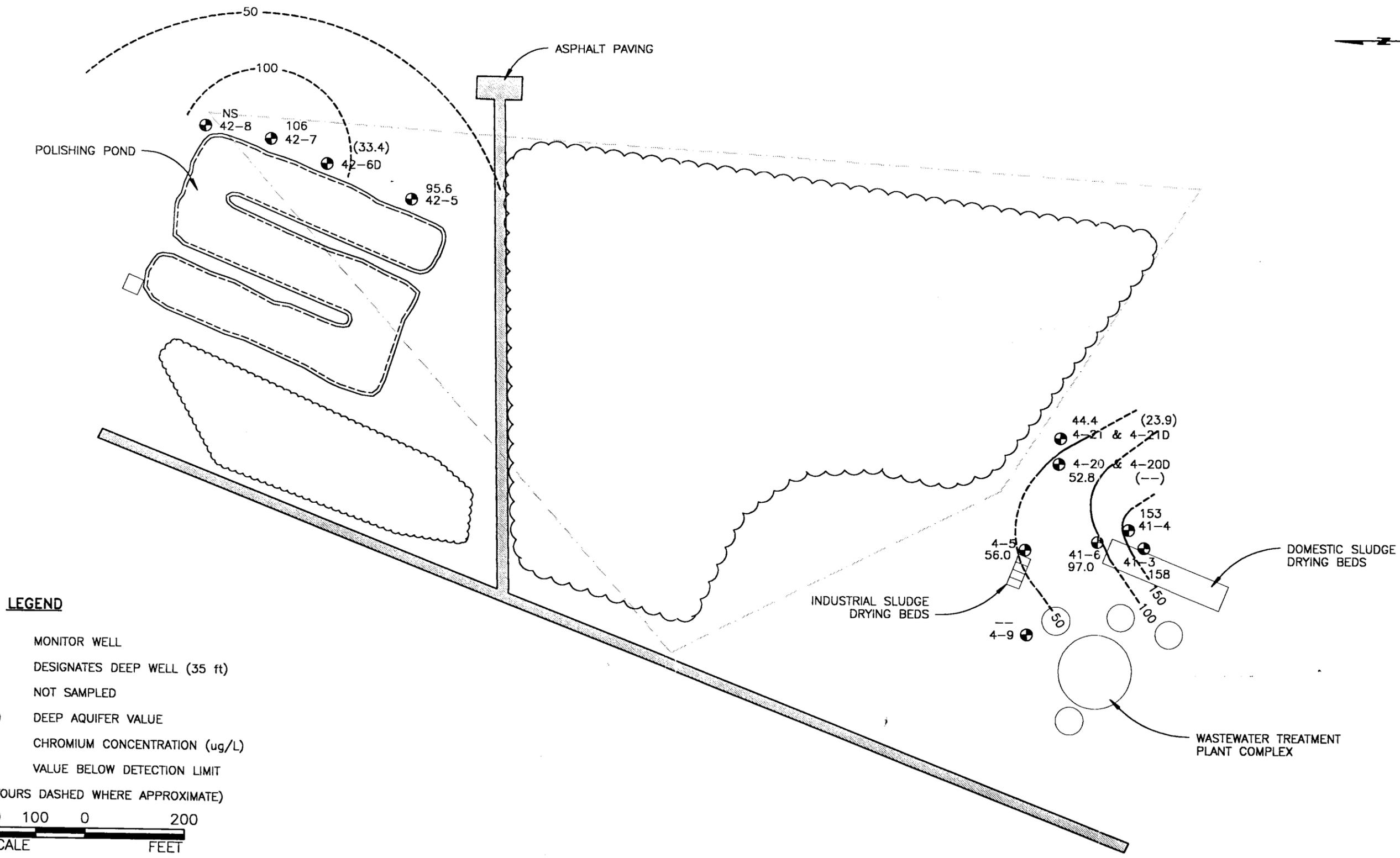


Figure 6
CHROMIUM IN MONITOR WELLS SAMPLED BY ESE AT NAS JACKSONVILLE, JANUARY 1992

SOURCE: ESE, 1992



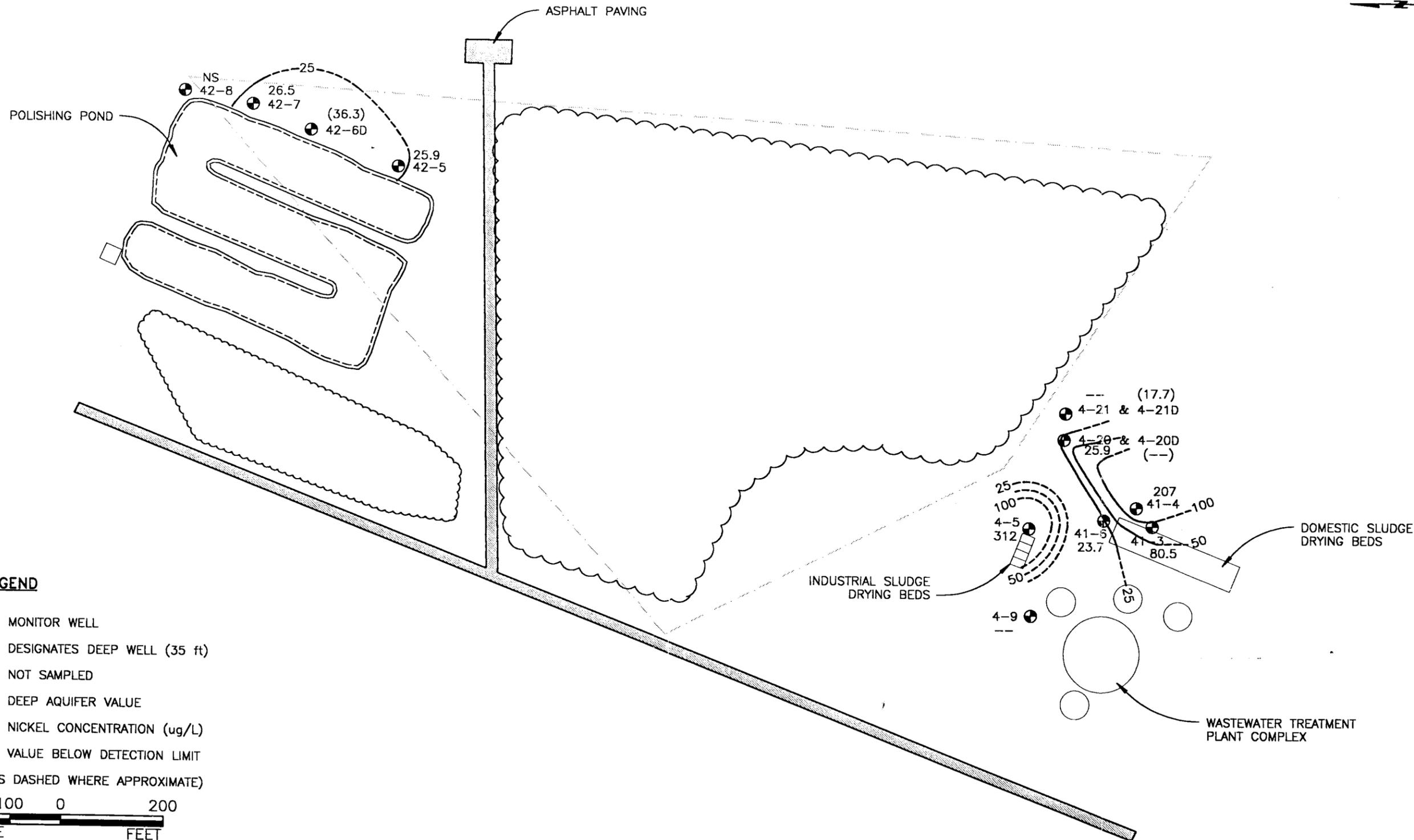


Figure 7

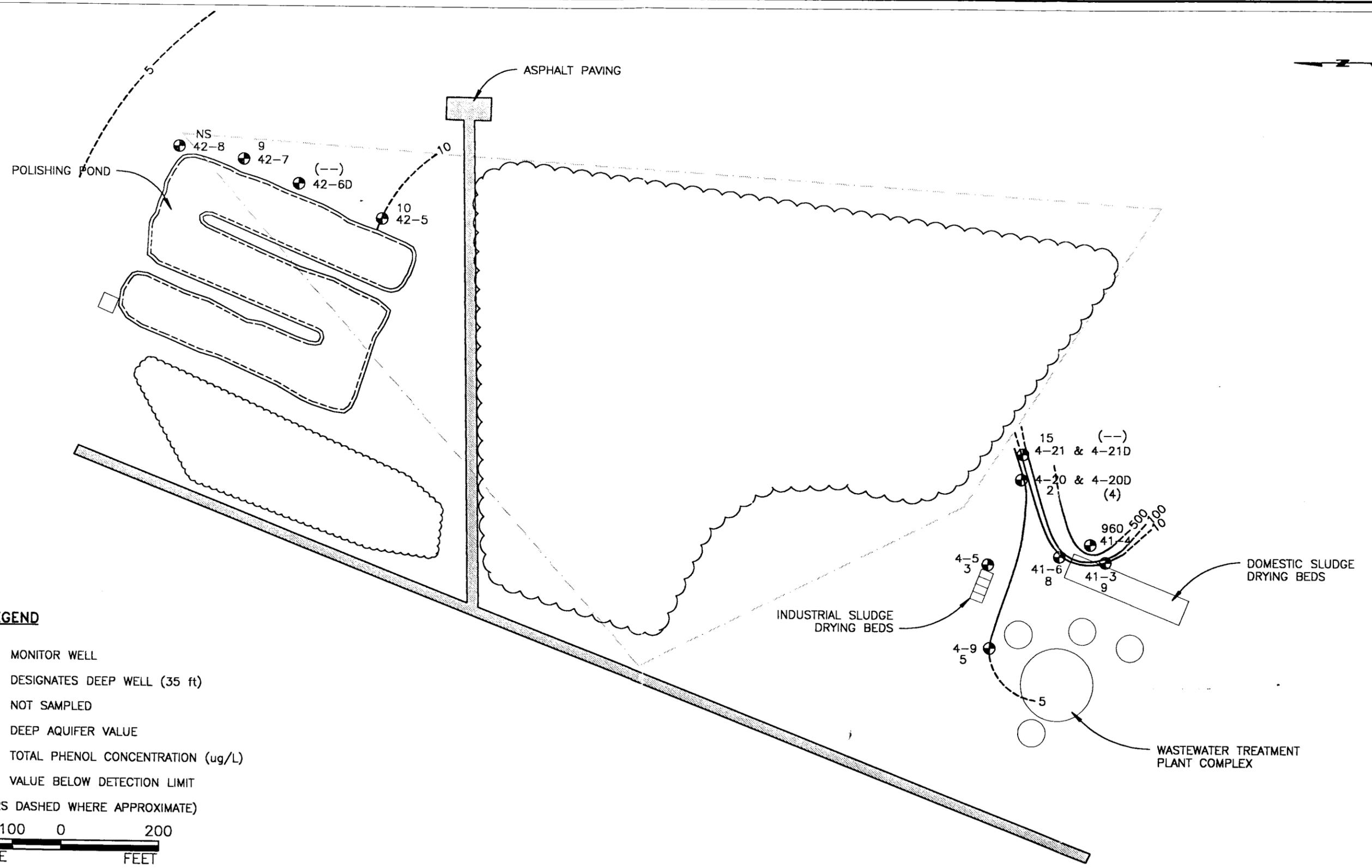
NICKEL IN MONITOR WELLS SAMPLED BY ESE AT NAS JACKSONVILLE, JANUARY 1992

SOURCE: ESE, 1992



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LEGEND

- 4-5 ⊕ MONITOR WELL
- D DESIGNATES DEEP WELL (35 ft)
- NS NOT SAMPLED
- (4) DEEP AQUIFER VALUE
- 9 TOTAL PHENOL CONCENTRATION (ug/L)
- VALUE BELOW DETECTION LIMIT

(CONTOURS DASHED WHERE APPROXIMATE)

200 100 0 200

SCALE FEET

Figure 8
TOTAL PHENOL IN MONITOR WELLS SAMPLED BY ESE AT NAS JACKSONVILLE, JANUARY 1992

SOURCE: ESE, 1992



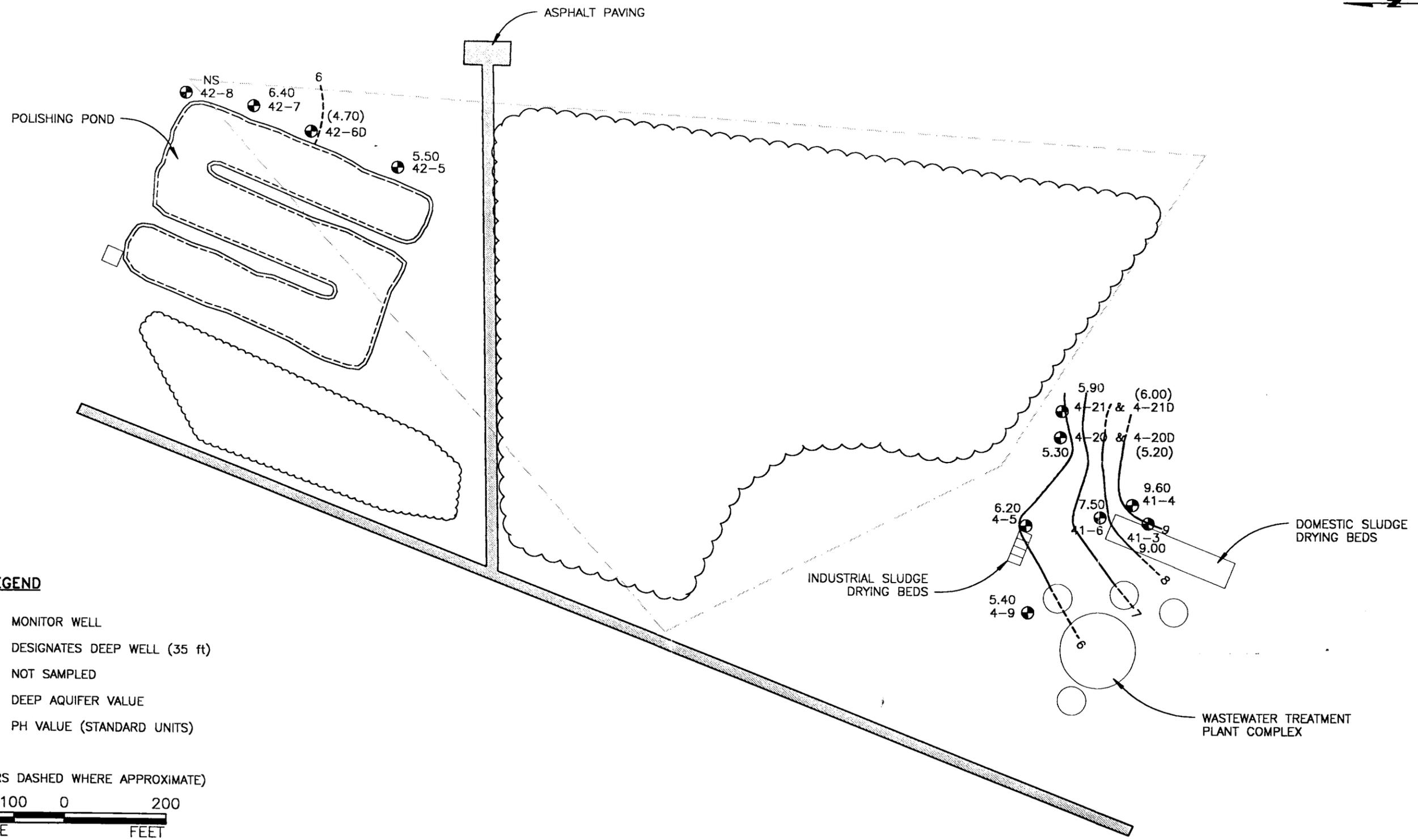
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relatively low concentration of methylene chloride was also detected in MW41-3 near MW41-4 and also adjacent to the DSDBs. The prevalence of organic compounds at this location tends to indicate the DSDBs are a source of organic compounds to the shallow aquifer.

An unusual characteristic of the groundwater from MW41-4 was also noted by the field team during development and sampling of the well. The water was described as reddish brown or red and observed to be foamy. Perhaps these unusual characteristics are produced by the contamination present in this well.

Compounds were also detected associated with requirements of the FDER Permit Part V-No. 9. Although there are no permit standards for these compounds, contour maps showing the distribution of these parameters in the shallow aquifer zone were prepared. Figure 9 is a contour map of field pH values obtained at the time of sample collection. Based on this figure, the typical range of pH of the aquifer appears to be 5 to 6. Significantly higher values are observed near the DSDBs and may be related to other contamination in this area. Specific conductance, depicted in Figure 10, was also measured in the field at the time of sample collection and shows higher values associated with the northeastern corners of the three waste disposal areas. Highest values were observed at the northeast corners of the DSDBs and the PPs.

Turbidity values were measured in the laboratory at the time of sample analysis (Figure 11). Overall, the turbidity values were for the most part higher than previously measured values at the site (see Section 3.0). Figure 11 shows the higher turbidity values tend to correspond to the previously delineated source areas. The unusual result is the turbidity value in MW41-4, where no turbidity was detected, although relative to concentrations of other parameters detected,



LEGEND

- 4-5 ● MONITOR WELL
- D DESIGNATES DEEP WELL (35 ft)
- NS NOT SAMPLED
- (4.70) DEEP AQUIFER VALUE
- 6.40 PH VALUE (STANDARD UNITS)

(CONTOURS DASHED WHERE APPROXIMATE)

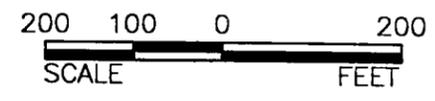


Figure 9
PH IN MONITOR WELLS SAMPLED BY ESE AT NAS JACKSONVILLE, JANUARY 1992

SOURCE: ESE, 1992.



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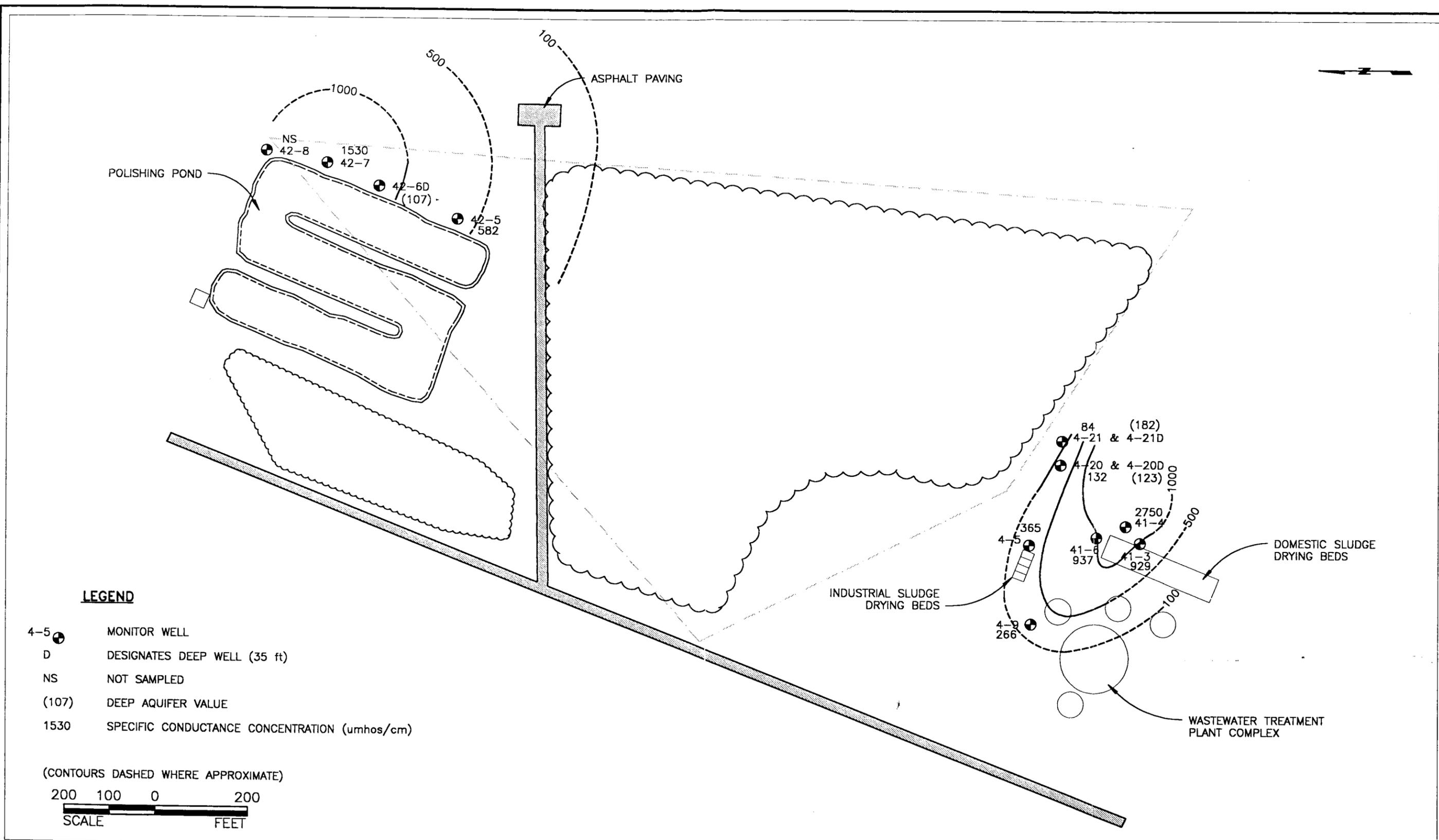


Figure 10
SPECIFIC CONDUCTANCE IN MONITOR WELLS SAMPLED BY ESE AT NAS JACKSONVILLE, JANUARY 1992

SOURCE: ESE, 1992



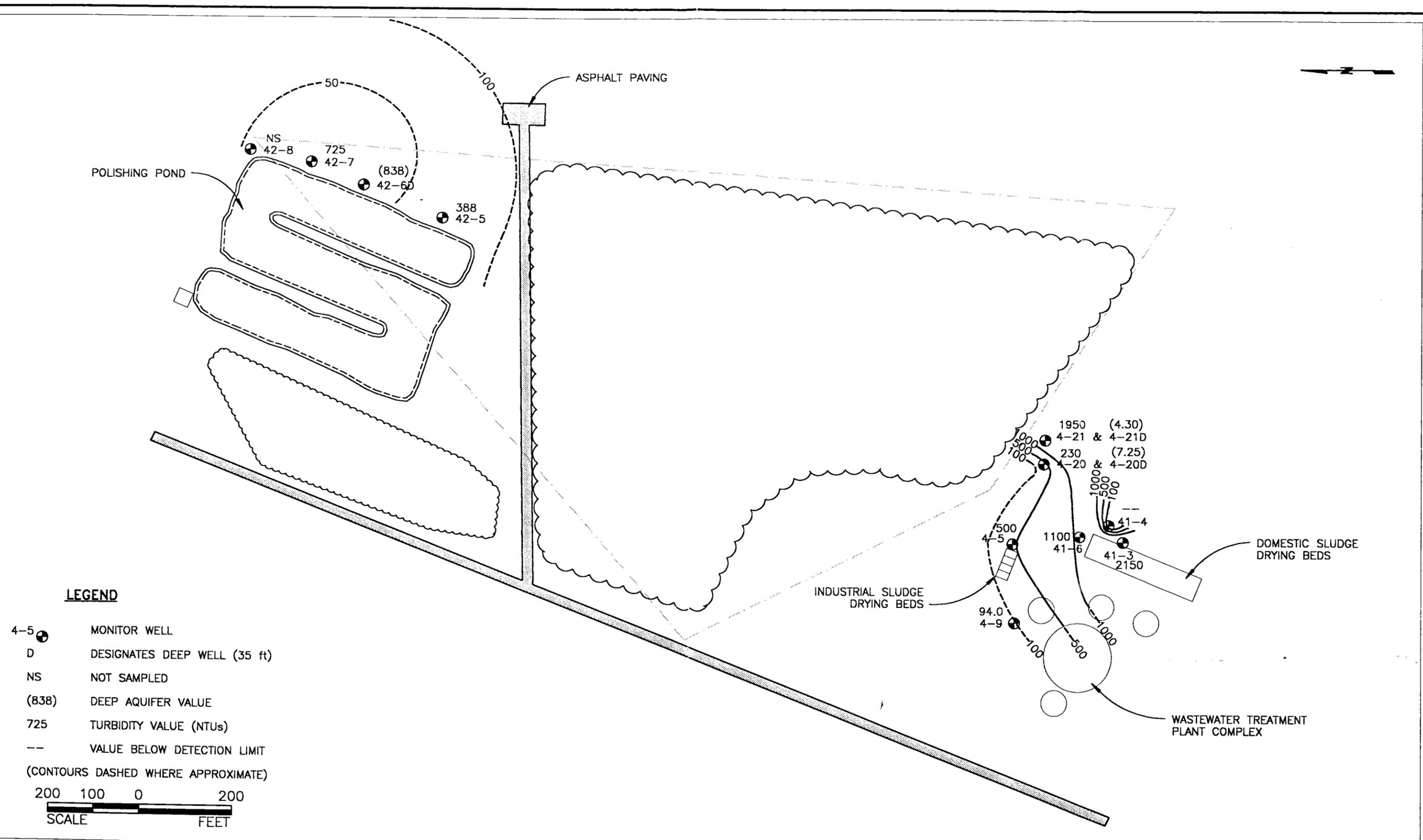


Figure 11
TURBIDITY IN MONITOR WELLS SAMPLED BY ESE AT NAS JACKSONVILLE, JANUARY 1992

SOURCE: ESE, -4992



this well is the most contaminated. Perhaps the absence of turbidity is a function of the characteristics of the specific compounds present.

The high turbidity values can also influence the concentrations of other compounds, particularly metals and radionuclides. Most often, high values of turbidity are correlated with high concentrations of metals and radionuclides, often with concentrations exceeding drinking water standards. Frequently, filtration of this type of sample will reduce metals and radionuclides to below detection limits.

Radionuclide compounds had not been analyzed previously at the site. A contour map was prepared depicting the concentration of gross alpha (Figure 12). Although no standards are specified in the permit, both gross alpha and the combined concentration of radium-226 plus radium-228 exceeded the Primary Drinking Water Standards. A significant concentration of gross beta of 84.7 picocuries per liter (pCi/L) was also found in MW41-3 adjacent to the DSDBs. Although these compounds can be correlated with excess turbidity, the highest concentrations appear to be centered around the DSDBs and may indicate this area is also a source area of radionuclides in the shallow aquifer.

Chloride is commonly used as an indicator of contamination because higher values are often associated with other contaminant compounds. The chloride distribution in the shallow aquifer is shown in Figure 13 and when correlated with most other compounds, indicates a source area associated with the DSDBs and with the PPs.

Iron concentrations detected in the monitor wells at the site overall were significantly higher than the Secondary Drinking Water Standard of 0.3 milligram

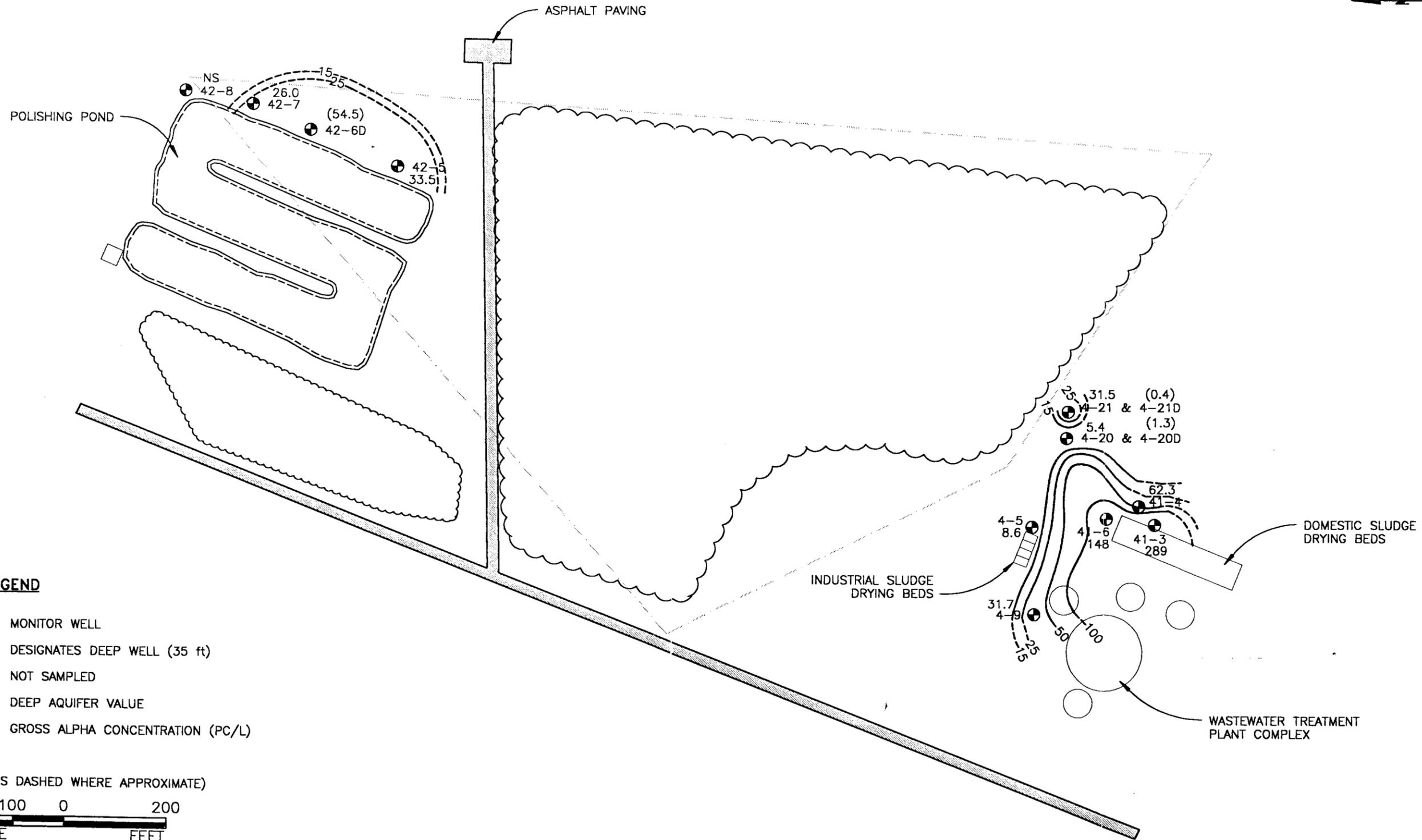


Figure 12
GROSS ALPHA IN MONITOR WELLS SAMPLED BY ESE AT NAS JACKSONVILLE, JANUARY 1992

SOURCE: ESE, 1992.



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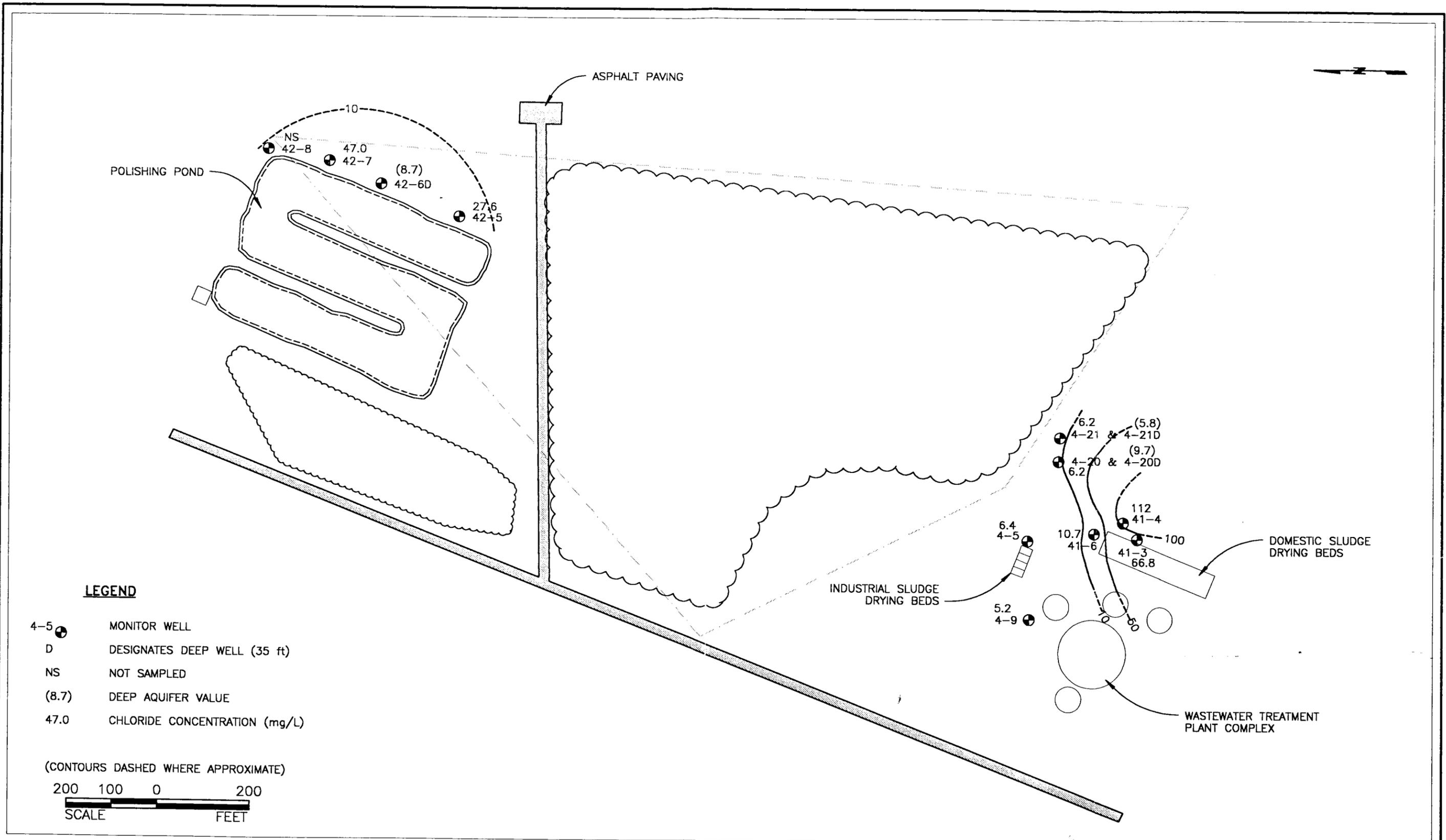


Figure 13
CHLORIDE IN MONITOR WELLS SAMPLED BY ESE AT NAS JACKSONVILLE, JANUARY 1992

SOURCE: ESE, -1992



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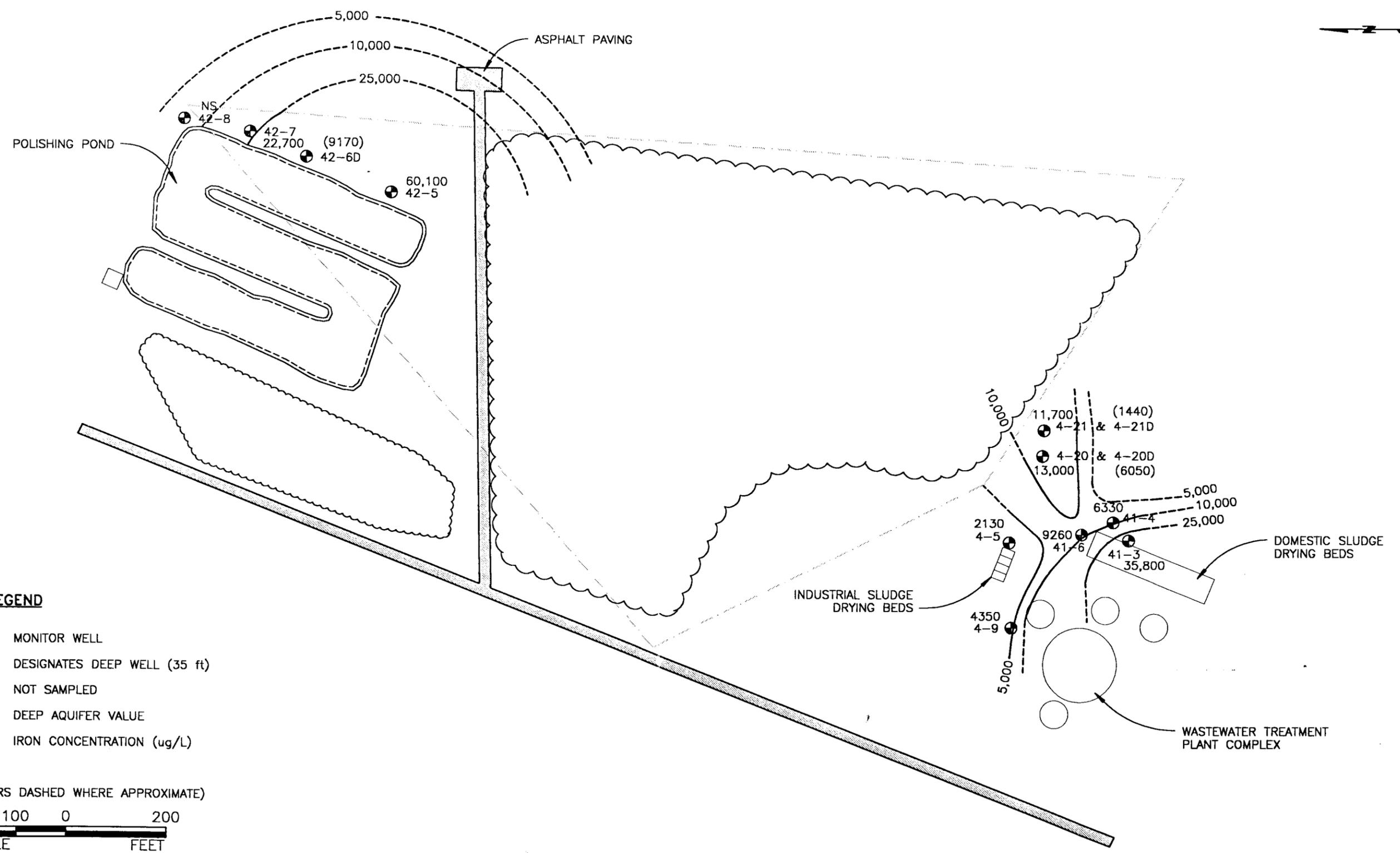
per liter (mg/L), or 300 $\mu\text{g/L}$. Iron concentrations ranged from 2,130 $\mu\text{g/L}$ in MW4-5, adjacent to the ISDBs, to as high as 35,800 $\mu\text{g/L}$ in MW41-3, adjacent to the DSDBs. The concentration distribution depicted in Figure 14 generally shows a correlation to the source areas of the DSDBs and the PPs. An unusual feature of this figure is higher concentrations in MW4-20 and MW4-21, apparently separated from the source areas by lower concentrations. High iron concentrations in a shallow aquifer are not atypical, and part of the concentrations may also be the result of turbidity. The concentrations observed in MW4-20 and MW4-21 may be the result of localized aquifer conditions in this area.

As stated previously, contour maps of the data are somewhat biased as there are relatively few data points to delineate plumes of the various compounds. Considering this limitation, the highest areas of contamination appear to be adjacent to the known source areas. Reversal of the contaminant distribution patterns in accordance with the reversal of the groundwater flow direction near the Wastewater Treatment Plant is not apparent from the data.

5.2 DEEP AQUIFER

Generally, in the deep aquifer zone, fewer compounds were detected exceeding the permit standards than in the shallow zone. Results of deep zone well analysis are also shown in Tables 5 and 8. The deep aquifer data points are shown on each of the contour maps, although deep aquifer values were not considered when contouring, or they were contoured with respect to one another due to the spread of the data points.

No organic compounds and only two metals, nickel and cadmium, were found to exceed the permit standards in the deep aquifer zone. Nickel was found over the



LEGEND

- 4-5 ● MONITOR WELL
- D DESIGNATES DEEP WELL (35 ft)
- NS NOT SAMPLED
- (9170) DEEP AQUIFER VALUE
- 22,700 IRON CONCENTRATION (ug/L)

(CONTOURS DASHED WHERE APPROXIMATE)

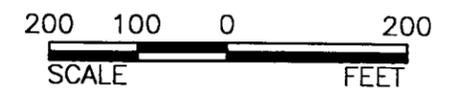


Figure 14
IRON IN MONITOR WELLS SAMPLED BY ESE AT NAS JACKSONVILLE, JANUARY 1992

SOURCE: ESE, 1992



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permit standard in MW42-6 (the deep zone point of compliance well for the PPs) and in MW4-21D. Nickel was found exceeding the permit standards in almost all shallow zone wells. Considering a downward vertical gradient is present across the site, the presence of any of the contaminants in the deep aquifer zone is not unexpected. The concentration of nickel in MW4-6 is somewhat higher than that found in the adjacent shallow wells and most likely is a function of turbidity in the sample.

Cadmium was found exceeding the permit standard in both MW4-20D and MW4-21D. Cadmium was found significantly over the permit standard in shallow zone well MW4-5 adjacent to the ISDBs, and is also present in these deeper aquifer wells located in the typical downgradient direction. This result suggests that the ISDBs are the source of cadmium in the deep aquifer zone.

Overall, in the deep aquifer zone, concentrations of the Permit Part V-No. 9 compounds were typically lower than concentrations in the shallow zone. This result would also be expected, considering the downward gradient between the two zones and the adsorption of contaminants within the clayey unit separating the two aquifers. A relatively high turbidity value was observed in the sample from MW42-6, particularly compared to the other deep zone wells and in comparison to the shallow zone at this location. The high turbidity is most likely influencing the somewhat higher values of the radionuclides in this well as opposed to the presence of a source area of radionuclides only in the deep zone at this location. The high turbidity may also be influencing the somewhat higher metals concentrations of nickel and iron.

5.3 RESULTS OF QA/QC SAMPLES

Field QA/QC samples included the collection of two duplicates, one equipment blank, one field blank, and three trip blanks. The duplicate samples represented 10 percent of the number of samples collected. Duplicates were collected from MW42-6 (Sample 14) and from MW4-21D (Sample 15). Originally, field blanks were to be collected each sampling day with only two of those analyzed. Due to a misunderstanding by the field team as to the number of equipment blank samples required, only one equipment blank was collected. This sample was collected by filling a laboratory-decontaminated bailer with ultra-pure water and then transferring the water to the appropriate sample containers. The field blank is a sample of the deionized water used for field equipment decontamination. This water was also obtained from the laboratory in Gainesville. Trip blanks were shipped with each cooler containing samples for volatile organic compounds.

The results of the duplicate samples from MW42-6 agreed relatively well with each other. The most significant difference was in the sulfate concentration, which was approximately eight times higher in one than in the other. The duplicate samples from MW4-21D varied considerably from each other. Replicate values for turbidity of this sample were 4.3 nephelometric turbidity units (NTUs), versus 675 NTUs. The higher turbidity apparently resulted in higher metals concentrations also. These data provide further evidence that high metals concentrations are correlated to turbidity.

All the blank samples were generally free from contamination. The equipment blank was free of low concentrations of typically ubiquitous compounds. The field blank contained 2 $\mu\text{g/L}$ of phenol, which was the detection limit for phenol. The field blank also contained a low concentration of 2.6 $\mu\text{g/L}$ of methyl ethyl

ketone, just above the detection limit of 2 $\mu\text{g/L}$. The only other detection of methyl ethyl ketone was in MW41-4 with a concentration of 16 $\mu\text{g/L}$. The presence of these two contaminants may potentially be correlated to the site contamination, but considering the low concentrations detected in the field blank, the impact of these results on the other sample analyses is not significant. Phthalates were also detected in the field blank sample, most likely a result of carrying the water in a plastic container. These results also are not significant. In one trip blank sample, a low concentration of 2.4 $\mu\text{g/L}$ of acetone was detected. The detection limit for acetone is 2 $\mu\text{g/L}$. Considering acetone is commonly used in the laboratory, this low concentration in the trip blank is also not significant.

The laboratory data, including laboratory QA/QC samples, were reviewed for QC compliance prior to release from the laboratory. Aside from the nitrate/nitrite matrix problems flagged on the results table (Appendix D), all QC data were within criteria. QC data are also reported in Appendix D.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 WELL REDEVELOPMENT

Well yield appears to have improved as a result of the redevelopment efforts. In all but three wells, the percent of improvement ranged from 1 to 193 percent. Estimates of T and K based on the specific capacity data indicate values similar to previous shallow zone values, but significantly higher values for the deep zone. Considering the apparent improvement in deep aquifer well yields and, thus, aquifer hydraulic conductivity, a re-evaluation of aquifer permeability of this zone may be warranted. This effort would best be performed by either additional slug tests or an aquifer pumping test.

The well redevelopment effort helped to improve well yield but did little to improve turbidity. In spite of redevelopment efforts, turbidity remains high in almost all the wells. Turbidity in the most contaminated well, MW41-4, was not detected, and the absence may be due to the specific contaminants detected in the well.

The simplest solution to the turbidity problem may be to collect unfiltered and filtered sample fractions. FDER may still want to see unfiltered sample results, but with the filtered sample data available, a positive conclusion can be made as to the cause of high metals and/or radionuclide results. At another site in Florida where ESE has been performing quarterly sampling from a shallow monitor well network, turbidity has also been high. To reduce the impacts of the high turbidity on certain analytical parameters, field filtered samples are also collected and analyzed. Filtered samples typically show much lower concentrations of metals than unfiltered samples. Turbidity at this site has been monitored for approximately 2 years. At the beginning of the effort, turbidity

values were quite erratic and high. Redevelopment of the wells at this site has not been performed, but with continued sampling of the monitoring network, turbidity has stabilized.

Regarding turbidity at NAS, replacement of all the wells does not seem appropriate. The source of the turbidity is fine-grained sediments in the aquifer. All the information concerning the existing well construction indicates the wells were installed properly with standard materials. New wells could be installed with finer screens and sand packs. These finer materials are not typical and would require special orders and higher costs. Perhaps a smaller diameter screen and sand pack could be installed in existing wells, but this would create additional problems with the need for special purging and sampling techniques.

Another option may be the permanent installation of low-volume sample pumps in each well. A specially designed system would be required equipped with a Teflon® discharge line to permit the collection of volatile samples directly from the discharge. A permanent installation would avoid the disruption of the formation that occurs each time the bailer is dropped down the well. As the wells appear to be difficult to develop due to the fine-grained formation, the use of the bailer during sample collection is agitating the formation and in effect helping to further develop the wells each time sampling is performed. Once a well is developed with the permanent pump, if no further surging was performed with the pump, the formation material should stay in place and the well should yield a clear sample.

Based on the information generated during the redevelopment effort, it is recommended that sampling continue in the wells as planned and more data be obtained on the turbidity. Repeating the redevelopment effort, or a modified

well sampling effort without the collection of samples, every quarter would help to keep the wells active between semiannual sampling events. These efforts would essentially provide for further well development and potentially reduce and stabilize the turbidity over time.

During well redevelopment, MW42-8 was found to be damaged. The well will be properly abandoned and replaced prior to the next sampling event.

6.2 GROUNDWATER FLOW DIRECTIONS

The typical direction of groundwater flow in the shallow aquifer zone north-northeast was observed near the PPs. The direction of groundwater flow in the shallow aquifer adjacent to the NAS Wastewater Treatment Plant appears to have reversed as a result of temporary construction dewatering. The deep aquifer zone flow direction was observed to be north toward the St. Johns River, characteristic of previous flow directions. The vertical flow direction between the two aquifer zones was downward from the shallow zone to the deep zone. Rates of groundwater flow based on these measurements were generally similar but somewhat lower than the previously reported range of flow rates.

6.3 GROUNDWATER SAMPLING AND WATER QUALITY

A sample was not collected from MW42-8 due to poor recharge. The well will be replaced prior to the next semiannual sampling event and the new well, to be designated MW42-8R, will be used to collect the groundwater sample from this point of compliance.

Ten compounds were found to exceed permit standards at the point of compliance in the shallow aquifer zone. These compounds included metals in a majority of point of compliance wells. Chromium, nickel, and cyanide exceeded

the standards most frequently, with arsenic and cadmium detected in only one well each. The organic compound detected most frequently was total phenols. By far the highest concentration of total phenols, as well as all other organic compounds exceeding the permit standards, was detected in MW41-4, adjacent to the DSDBs. Other unusual characteristics of this well include that the water from the well had a red color and was foamy, as reported by the field team. Turbidity of the water is absent, which may be a function of the specific chemical compounds in the well. The overall shallow aquifer zone data reveal the influence of the three source areas, with the DSDBs providing the most significant impact to the shallow aquifer zone.

In the deep aquifer zone, only nickel and cadmium were found to exceed the permit standards. Nickel was the only parameter in MW42-6 to exceed the standard. Generally, the concentrations in the deep zone wells were lower than the concentrations in the shallow zone wells.

As the current scope of well sampling includes only 13 wells for permit compliance and not to determine plume configuration, contour maps attempting to depict contaminant plumes become somewhat biased based on the few data points. Based on the current spread of available data points in both aquifer zones, reversal of contaminant patterns due to the construction dewatering at the NAS Wastewater Treatment Plant is not apparent.

The results of QA/QC samples provide evidence that the sampling and analysis effort was performed properly. Some disagreement of metals results from the duplicate sample from MW4-21D appears to be the result of variable turbidity of the samples. Only very low levels of selected organic compounds, present with concentrations slightly over the detection limit, were detected in the various

blank samples. These results do not appear to have impacted other sample analyses and are not significant.

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