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NAS PENSACOLA
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ecology and environment, inc.
316 SOUTH BAYLEN STREET. PENSACOLA, FLORIDA 32501, TEL. (904) 435-8925
International Specialists m the Environment

June 25, 1991

Commanding Officer
Attn: Greg Campbell(Code 480)
Naval Public Works Center
Naval Air Station
Pensacola, FL 32508

Re: Final 1991 Groundvater Plov Rate and Direction Determination Report (GFRDDR), Industrial Vastewater Treatment Plant, Naval Air Station Pensacola, Florida, Contract No. N62467-88-C-0200.

Dear Sir:

Ecology and Environment, Inc. (E & E) is pleased to submit six copies of the final 1991 GFRDDR for the Industrial Wastewater Treatment Plant (IWTP) located at Naval Air Station (NAS) Pensacola, Florida. This report satisfies the requirements of 40 CFR 264.99(e) for Resource Conservation and Recovery Act (RCRA) permitted facilities and has been prepared by E & E for the U.S. Navy, Southern Division, Naval Facilities Engineering Command, under Contract No. N62467-88-C-0200. The report incorporates comments E & E recieved on July 10, 1991, from Ms. Suzanne O. Sanborn of the Southern Division.

SITE HYDROGEOLOGY

The hydrogeologic sequence underlying the IWTP consists of, in descending order, the Sand-and-Gravel Aquifer, the Pensacola Clay, and the Floridan Aquifer. Because of its overall thickness (approximately 380 feet) and the fact that it is the main sourae of potable water in the Pensacola area, the Sand-and-Gravel Aquifer is the most important hydrogeologic unit at NAS Pensacola.

In the NAS Pensacola vicinity, the upper portion of the Sand-and-Gravel Aquifer is comprised of, in descending order, a shallow surficial zone, a lov permeability zone, and a main producing zone. At the IWTP the surficial zone extends from land surface to a depth of approximately 40 feet below level surface (BLS), and is composed of fine- to medium-grained quartz sand. Groundvater recharge to the surficial zone occurs primarily by the downward infiltration of precipitation. The lov permeability zone is approximately 15 feet thick and is composed of a blue-gray, plastic clay with some shell fragments. The lov permeability zone functions as a confining/semi-confining unit and retards the exchange of groundwater between the surficial zone and the underlying main producing zone. The main producing zone extends from the base of the low permeability zone to a depth of approximately 380 feet BLS, and is composed of a mosaic of sands, gravels, and discontinuous clay

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lenses. At the IUTP, the shallow monitoring wells (15 feet deep) are open to the uppermost surficial zone, the intermediate depth monitoring wells (40 feet deep) are open to the lowermost surficial zone, and the deep monitoring wells (65 feet deep) are open to the uppermost main producing zone. For the remainder of this report, these monitored depth intervals will be referred to as the shallow zone, intermediate zone, and deep zone, respectively.

As part of the groundwater sampling activities during the March 1991 quarterly sampling event, water levels were measured in all IVTP monitoring wells from which a sample vas collected. Figure 1 shows the locations of all the monitoring and recovery wells at the IUTP. The results of the water level measurements are provided in Table 1. The following discussions interpret the collected water level data and present groundwater flow directions and flow rates for each of the monitored zones.

It should be noted that the recovery wells at the IWTP are open only to the shallow and intermediate zones. During the water level survey, none of the recovery wells were actively pumping.

WATER LEVELS AND GROUNDWATER FLOW DIRECTIONS

Shallow Zone

Figure 2 shows the water level elevations for the shallow zone of the Sand-and-Gravel Aquifer underlying the IUTP. The figure indicates that the predominant feature influencing the groundwater flow in this zone is a flow divide which medially separates the small peninsula where the IUTP is located. Consequently, groundwater flows away from the central area of the peninsula towards the vest, north, and east. The groundwater elevations mimic the peninsular topography, and flow occurs from areas of higher elevation toward areas of lover elevation. Due to the presence of the confining/semi-confining unit at approximately 40 feet BLS, the majority of the groundwater within the shallow zone probably discharges into Bayou Grande on the vest and Pensacola Bay on the east.

The horizontal hydraulic gradient in the shallow zone underlying the IVTP is approximately 0.00055 along the north-south axis of the peninsula (based on water level elevation differences between wells GM-12R and GM-10), 0.0014 in an east-southeast direction (based on water level elevation differences between wells GH-62 and GM-14), and 0.0015 in a northwest direction (based on water level elevation differences between PCS-1 and GH-77). This difference in hydraulic gradients reflects a lower topographic slope in a north-south direction and the closer proximity of discharge areas to the east and vest.

Table 1

WATER LEVEL ELEVATIONS
(Measured 3/28/91)

Well Number	Well Depth	TOC Elevation	Depth To Water	Water Level Elevation
Shallow Zone				
UG-1	15.0	8.48	7.20	1.28
GM-8	12.0	6.12	4.47	1.65
GU-9	11.8	5.65	4.15	1.50
GM-10	12.0	5.83	4.16	1.67
GU-11	11.8	6.00	3.97	2.03
GM-12R	11.3	9.83	7.57	2.26
GU-13	12.0	5.09	3.80	1.29
GM-14	11.4	4.56	3.35	1.21
GM-62	15.0	7.11	5.12	1.99
GM-67	15.0	6.38	4.86	1.52
GM-71	12.5	6.76	5.68	1.08
GM-72	12.5	7.61	6.42	1.19
GM-76	13.3	7.88	6.28	1.60
GM-77	13.5	4.71	3.18	1.53
GM-78	13.0	7.02	5.51	1.51
GM-79	12.5	4.65	3.53	1.12
GM-83	12.5	4.84	4.10	0.74
PCS-1	20.0	11.40	9.34	2.06
Intermediate Zone				
at64	40.0	6.26	4.51	1.75
at66	40.0	7.48	6.43	1.05
GM-69	40.0	7.85	6.45	1.40
GM-84	40.0	11.84	11.00	0.84
PCI-1	45.0	11.28	9.28	2.00
Deep Zone				
GM-63	65.0	6.97	4.62	2.35
GM-65	65.0	6.67	4.30	2.37
GM-68	65.0	7.00	4.62	2.38
PCD-1	70.0	11.07	8.62	2.41

NOTE: Well depths are in feet below land surface. Elevations are in feet above mean sea level. Depths to water are in feet below top of well casing (TOC).

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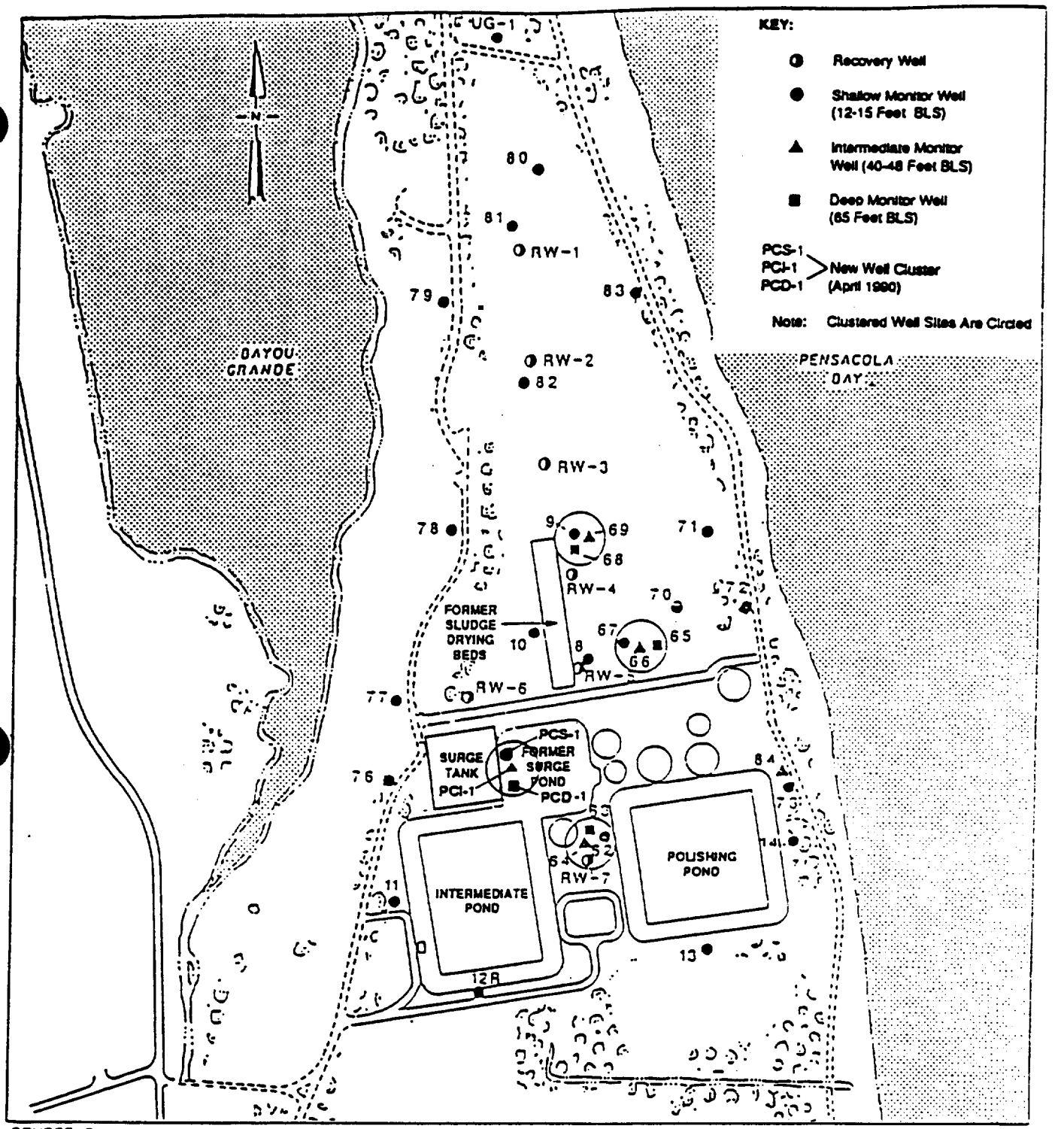


SOURCE: Geraghty & Miller, Inc. 1988

SCALE

0 300 600 FEET

Figure 1
LOCATIONS OF MONITORING AND RECOVERY WELLS AT NAS PENSACOLA WASTEWATER TREATMENT PLANT

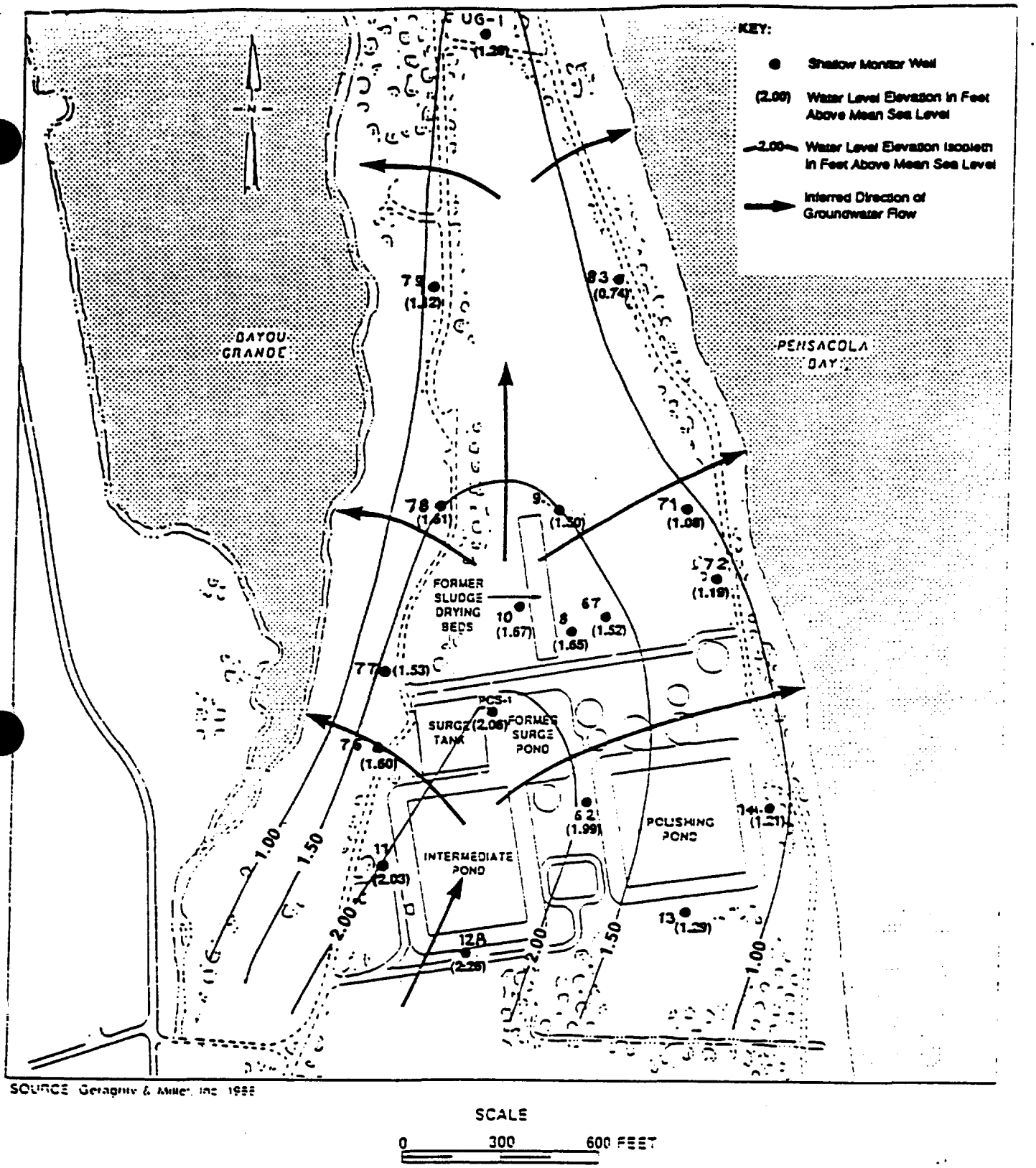


Figure 2
WATER LEVEL ELEVATION MAP FOR THE SHALLOW ZONE, 3/28/91

Intermediate Zone

Figure 3 shovs the water level elevations for the intermediate zone of the Sand-and-Gravel Aquifer at the IWTP. For the area immediately underlying the facility, the figure indicates that groundwater flow in this zone is to the east-northeast. It does not appear that flow in this zone is controlled by the peninsular topography, and it is probable that it may be influenced by recharge on higher land west of Bayou Grande. Due to the presence of the confining/semi-confining unit below this zone at approximately 40 feet BLS, the majority of groundwater in the intermediate zone underlying the IWTP probably discharges into Pensacola Bay.

The horizontal hydraulic gradient, calculated using the water level elevation differences between wells PCI-1 and GM-84, is approximately 0.0015.

Deep Zone

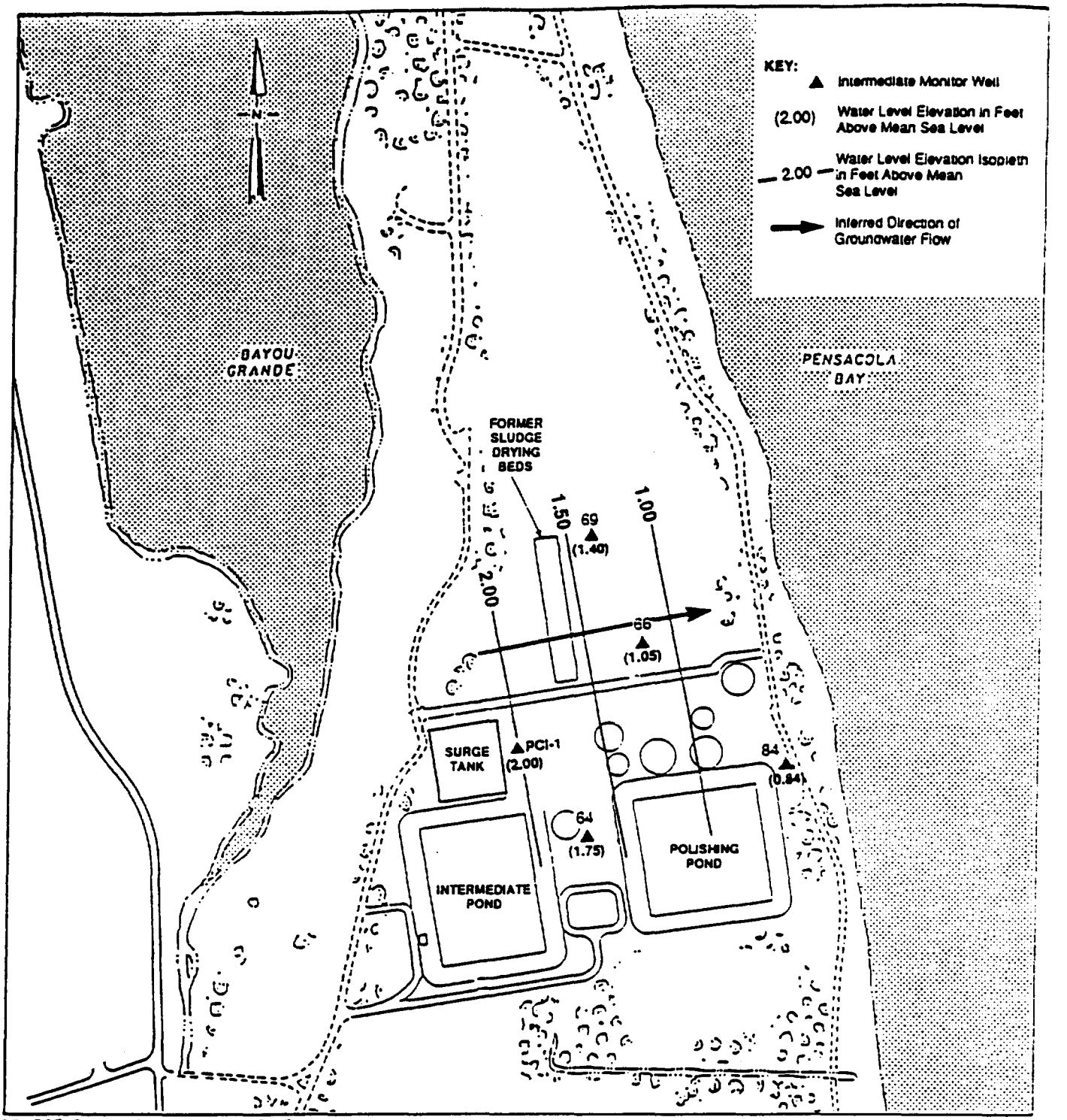
Figure 4 shows the water level elevations for the deep zone of the Sand-and-Gravel Aquifer underlying the IWTP. Given the short horizontal distance between PCD-1 and GM-63, GM-65, and GM-68, and the consistent southward decrease in water level elevations measured in latter three wells, the water level elevation measured in PCD-1 (2.45 feet above Mean Sea Level) is questionable and was not used in generating the isopleths or determining the flow direction in this zone. The vater level elevations measured in GH-63, GH-65, and GM-68 suggest that the groundwater in this zone flows toward the south. Thus, it is probable that flow from this zone discharges into Pensacola Bay or, depending on the lateral extent of the low permeability zone, the Gulf of Mexico. Given that the deep zone is below the low permeability zone, this flow direction is probably reflective of more regional factors (i.e., recharge to the north on the mainland and discharge into Pensacola Bay and/or the Gulf of Mexico to the south).

The horizontal hydraulic gradient, calculated using the water level elevation differences between wells GH-63 and GH-68, is approximately 0.00004.

Vertical Hydraulic Gradients

The presence of clustered wells allovs the calculation of vertical hydraulic gradients between the shallow, intermediate, and deep zones of the Sand-and-Gravel Aquifer. Table 2 shows the calculated vertical hydraulic gradients between these zones..

In general, there is an overall potential for downward groundwater flow to occur from the shallow zone to the intermediate zone. However, the potential also exists for upward groundwater flow to occur from the deep zone to the intermediate and shallow zones.



SOURCE: Geraghty & Miller, Inc. 1988; E & E, 1990

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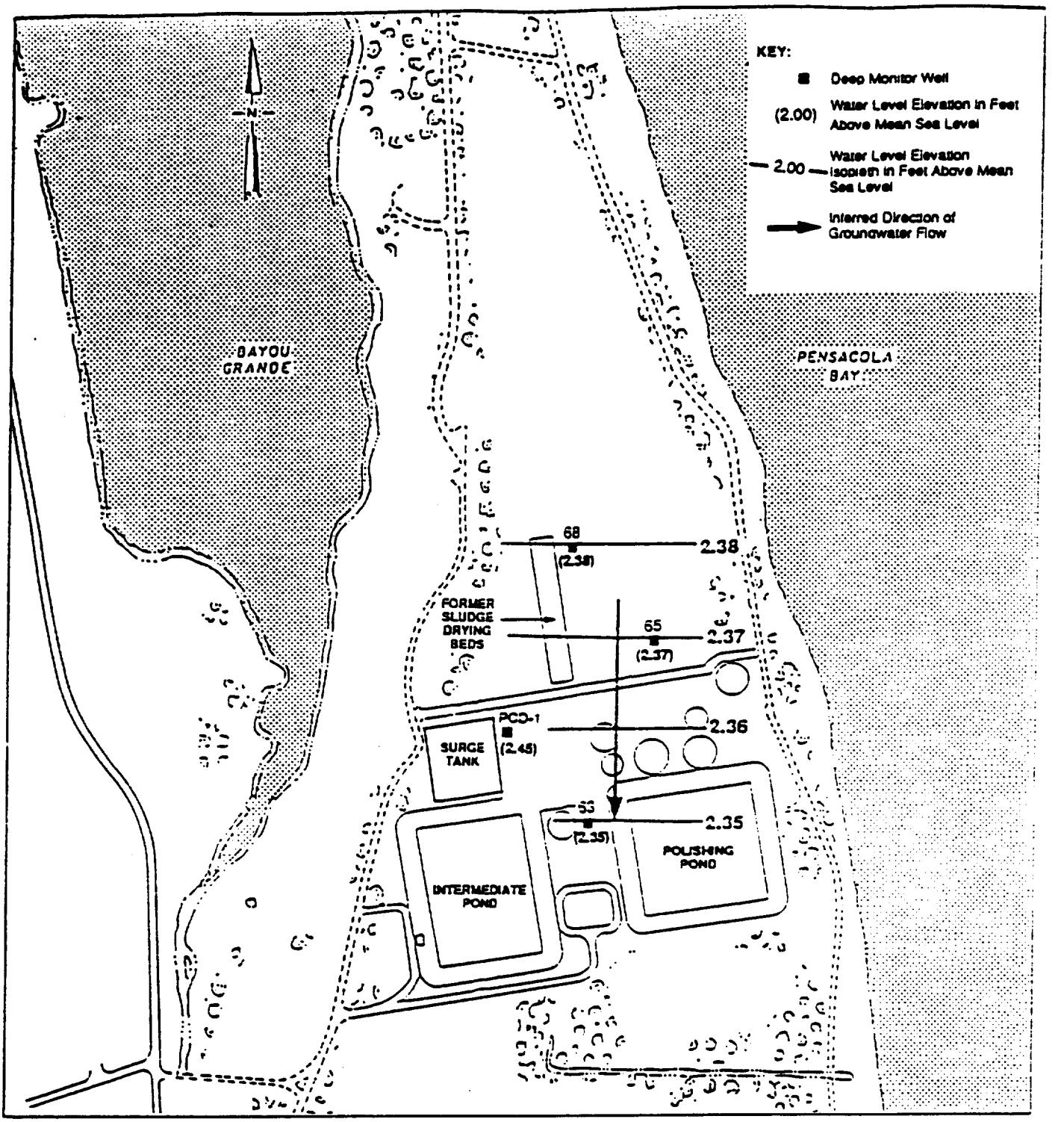
Figure 3

WATER LEVEL ELEVATION MAP FOR THE INTERMEDIATE ZONE, 3/28/91



SOURCE: Geragnty & Miller, Inc. 1988; E & E, 1990

SCALE

0 300 600 FEET

Figure 4
WATER LEVEL ELEVATION MAP FOR THE DEEP ZONE, 3/28/91

Table 2

VERTICAL HYDRAULIC GRADIENTS
(Measured 3/28/91)

Well Cluster	Well Depth	Water Level Elevation	Hydraulic Gradient S -> I	S -> D	I -> D
GM-62 (S)	15	1.99			
GM-64 (I)	40	1.75			
GM-63 (D)	65	2.35			
			0.0096	-0.0072	-O.024
GM-67 (S)	1s	1.52			
GM-66 (I)	40	1.05			
GM-65 (D)	65	2.37			
			0.0188	-0.0174	-0.0528
GM-9 (S)	11.8	1.50			
GM-69 (I)	40	1.40			
GM-68 (D)	65	2.38			
			0.0035	-0.0165	-0.0392

S = Shallow Zone
I = Intermediate Zone
D = Deep Zone

NOTE: Well depths are in feet below land surface. Water level elevations are in feet above mean sea level. Vertical hydraulic gradients are dimensionless. Positive gradients indicate a potential for downward groundwater flow to occur between zones, while negative gradients indicate a potential for upward groundwater flow to occur between zones.

GROUNDWATER FLOW RATES

As part of the tasks required for the GFRDDR for 1990, short-term aquifer tests were performed by E & E personnel at the IWTP during March 1990. The aquifer tests consisted of both "slug" and pumping tests, and the purpose of these tests was to determine the approximate transmissivity (T), hydraulic conductivity (K), and groundwater flow velocity (V) for each depth zone. The methodology applied in obtaining T and K using these aquifer test results and the estimated T and K for each zone are presented in E & E's 1990 GFRDDR for the IWTP.

Given that K and T are measurements of aquifer characteristics and are not time-dependent variables, aquifer testing was not repeated as part of the tasks required for this report. Therefore, the average estimated values for K and T presented in E & E's 1990 GFRDDR for the IWTP are used in this report to calculate the groundwater flow velocity for each zone. These average estimated values and calculated groundvater flow rates are presented in Table 3.

The horizontal groundwater flow velocity (V) for each zone was determined using the average estimated K values and a derivation of Darcy's Law:

$$V = \frac{KI}{n_e}$$

where: V = Velocity
K = hydraulic conductivity
I = horizontal hydraulic gradient
n_e = effective porosity.

The effective porosity for these calculations was estimated at 28 percent, a value typical of unconsolidated, medium-grained sands.

The average estimated K for wells open to the shallow zone (23.15 feet per day [ft/day], see Table 3) indicates that this zone is moderately permeable. For the purposes of calculating the horizontal flov velocity for this zone, the three reported hydraulic gradients (0.00055, 0.0014 and 0.0015) were averaged. The resultant hydraulic gradient (0.00115) was then used to calculate the average horizontal flow velocity, which is 0.0950 ft/day (34.67 ft/yr).

The average estimated K for wells open to the intermediate zone (0.50 ft/day, see Table 3) indicate that this zone is characterized by relatively low permeabilities. The average horizontal flow velocity for this zone is 0.0027 ft/day (0.9855 ft/yr).

Table 3

GROUNDWATER FLOW RATES

Average[a] Estimated Transmissivity (T) (Ft sq/day)	Average[a] Estimated Hydraulic Conductivity (K) (Ft/day)	Average Estimated Groundwater Flow Rate (V) (Ft/day)	(Ft/yr)
Shallow Zone			
57.87	23.15	0.0950	34.67
Intermediate Zone			
1.26	0.50	0.0027	0.9855
Deep Zone			
33.80	13.52	0.0019	0.6935

[a] Averages calculated ruing slug and pumping test results from March, 1990 aquifer testing (Ecology and hvironmnt, Inc., June 1990, Groundwater Flow Rate and Direction Determination Report Cor the Industrial Wastewater Treatment Plant, Naval Air Station. Pensacola, Florid.).

NOTE: Horizontal hydraulic gradients used for groundwater flow rate calculations: Shallow Zone 0.00115, Intermediate Zone 0.0015, Deep Zone 0.00004.

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The average estimated K for wells open to the deep zone (13.52 ft/day, see Table 3) indicate that this zone is moderately permeable. The average horizontal flow velocity for this zone is 0.0019 ft/day (0.6935 ft/yr).

CONCLUSIONS

Groundwater Flow Direction

Groundwater elevations in the shallow zone of the Sand-and-Gravel Aquifer underlying the IWTP mimic the peninsular topography, and groundwater flow occurs from the central portion of the site (i.e. the highest elevation) and radiates outward to the east, north, and west (i.e. the lowest elevations). Groundwater in the shallow zone probably discharges into Pensacola Bay and Bayou Grande.

Groundwater in the intermediate zone appears to flow to the east-northeast across the IWTP, probably discharging into Pensacola Bay.

Groundwater in the deep zone of the Sand-and-Gravel Aquifer underlying the IWTP appears to flow to the south, probably discharging into Pensacola Bay and/or the Gulf of Mexico.

Groundvater Plov Rates

The shallow zone of the Sand-and-Gravel Aquifer underlying the IWTP is characterized by a moderate permeability. The average estimated rate of groundwater flow calculated for this zone is 0.0950 ft/day (34.67 ft/yr).

The intermediate zone of the Sand-and-Gravel Aquifer underlying the IWTP possesses relatively low permeabilities. Consequently, the average estimated rate of groundwater flow calculated for this zone is also low at 0.0027 ft/day (0.9855 ft/yr).

The deep zone of the Sand-and-Gravel Aquifer underlying the IWTP is characterized by a moderate permeability. However, the horizontal hydraulic gradient in this zone is low. Therefore, the average estimated rate of groundwater flow calculated for this zone is low at 0.0019 ft/day (0.6935 ft/yr).

The Florida Professional Geologist Approval for this report is provided as Attachment A.

If there are any questions or comments concerning this report or other matters pertaining to the contract, please feel free to contact me or John Barksdale at (904) 435-8925, or Rick Rudy at (904) 877-1978.

Sincerely,

ECOLOGY AND ENVIRONMENT, INC.

John D. Barksdale for

Brian E. Caldwell
Project Manager

BEC/mv/528

CC: J. Wilcox; E & E--Buffalo/Central File UH7000
R. Rudy; E & E--Tallahassee/Central File UH7000
J. Barksdale; E & E--Pensacola
C. Tonolone; E & E--Buffalo

Attachment A

FLORIDA PROFESSIONAL GEOLOGIST SEAL

I hereby affix my seal to the 1991 Groundwater Flov Rate and Direction Determination Report for the Industrial Wastewater Treatment Plant, Naval Air Station, Pensacola, Florida, in accordance with Chapter 492 of the Florida Statutes and applicable rules and regulations developed pursuant thereto:

Name:	John D. Barksdale
License Number:	P.G. No. 1150
State:	Florida
Expiration Date:	July 31, 1992

John D. Barksdale

John D. Barksdale

6-25-91

Date