Division of Geological & Geophysical Surveys

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EVALUATION OF GROUND WATER AT A PROPOSED WASTEWATER DISPOSAL SITE, GAMBELL, ALASKA

by
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Division of Water
Alaska Hydrologic Survey

in cooperation with
Chuck Eggener Consulting Engineers,
Department of Environmental Conservation,
Village Safe Water Program,
and City of Gambell

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*Available in color at an additional cost

EVALUATION OF GROUND WATER AT A PROPOSED WASTEWATER DISPOSAL SITE, GAMBELL, ALASKA

by
James A. Munter[1]

ABSTRACT

The 1993 construction of a piped water and sewer system for the community of Gambell, Alaska, prompted an investigation into appropriate siting and design of a wastewater lagoon. A key consideration was to avoid contaminating a nearby school well. This investigation documents a dynamic groundwater system in permeable beach gravels strongly influenced by tides and storm surges. Ground-water flow directions are shown to change up to 180 degrees over the span of a few hours. Water quality beneath the proposed lagoon site ranges from brackish to saline. A "fast-perc" lagoon design is considered to have more advantages and fewer disadvantages than an alternate "slow-perc" design, including a lower potential for contaminating the nearby school well.

INTRODUCTION

The City of Gambell, Alaska, began construction of a community-wide piped water and sewer system during the summer of 1993. A major task of the project was to design and construct a facility for disposing of wastewater from the system. One option under consideration was to construct a percolation-type sewage lagoon to receive septic tank effluent.

The main goals of this investigation were to identify ground-water flow systems and ground-water quality beneath the proposed lagoon site and determine the probable effect of the percolation lagoon on those flow systems. Two major concerns with the proposed design were: 1) to avoid contamination of a nearby school well with leachate; and 2) to maintain a 4-ft separation distance between the bottom of the lagoon and the seasonal high water table.

The school well, located less than 1000 ft from the proposed lagoon site, tapped a shallow fresh-water aquifer. A conceptual model of ground-water flow in the area identified several factors that could possibly cause effluent from the lagoon to impact the well. These factors were: 1) the presence of highly permeable beach gravels throughout the area that could result in relatively fast ground-water travel times; 2) irregular occurrences of permafrost that could influence flow directions; and 3) reports of large storm-driven fluctuations in ground-water levels that could alter ground-water flow directions. As a result of these factors, the proposed lagoon site was selected to be as close to the coast as possible and as far from the school well as possible, and this investigation was initiated to further evaluate the site.

If ground water at the site were found to be brackish, the proposed lagoon might qualify for regulation as an "ocean discharge" with waiver of the 4-ft separation requirement. This condition was not assured in advance, however.

GEOLOGIC SETTING

The City of Gambell is situated on a gravel spit on the northwest tip of St. Lawrence Island in the northern Bering Sea (figure 1). Troutman Lake, located south of the city, is separated from the Bering Sea by a narrow gravel spit. The level of the lake is about 2 ft above mean lower low water. The lake is fed by Troutman Creek, a fresh water stream at its south end. Storm surges are reported to break over the spit periodically and cause the lake water to be brackish. The lake has no surface water outlet.

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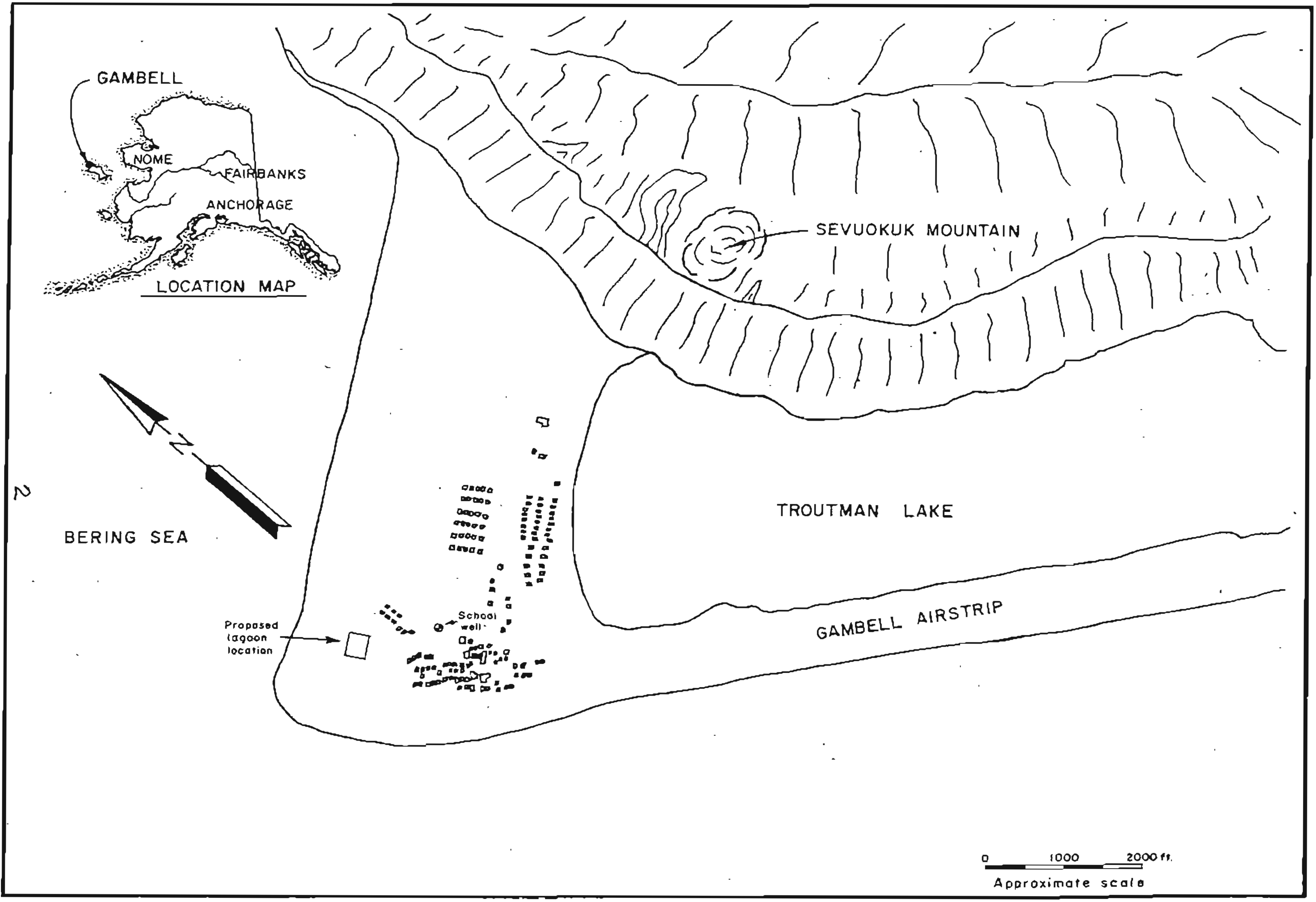
PO BOX 107005, Anchorage, AK, 99510-7005



Base credit: 7-19-80 Aerial photograph

Figure 1. *Map showing proposed wastewater lagoon location, Gambell, Alaska*

Sevuokuk Mountain lies about 1 mi east of the city, rising to an elevation of 614 ft above sea level. The mountain is comprised predominantly of quartz monzonite, a granitic rock type. Permafrost is discontinuous throughout the area, and is commonly found at depths of 7-10 ft (RZA, Inc, 1985). Annual precipitation at Gambell is about 16 inches (Phil Johnson Engineering, 1972).

Both fresh and brackish ground water has been found by several wells drilled in Gambell (Waller, 1959; RZA, Inc., 1985). Waller (1959) suggested that Troutman Lake probably discharges via ground water to the north. Shallow ground water is variably present because of the existence of shallow permafrost in some areas.

SCOPE AND METHODS

The scope of this investigation included drilling monitoring wells and soil borings, sampling water quality, performing slug tests and grain-size analyses for permeability determinations, measuring water levels to determine the response of the ground-water flow system to tidal fluctuations and analyzing the data.

Three monitoring wells were installed using a small custom-built track-mounted auger rig with a 20 horsepower motor and 4.25 in.-inside-diameter hollow-stem augers. Six additional soil borings were made using 2.25 in.-inside-diameter auger flights. Split spoon samples were taken at selected intervals. Wells were constructed with 2 in.-diameter PVC casing with silica sand fill around the screen, bentonite chip seals, and cemented 6 in.-diameter steel surface casing and locking well cap. Detailed logs of soil borings and wells are included in Appendix A.

Wells were purged with a hand operated piston-type purge pump and disposable polyethylene bailers prior to sampling. Samples were taken with bailers and nylon twine. A quality assurance plan is included as Appendix B.

Slug tests were conducted in the monitoring wells by sudden extraction of a 1.25-in. by 6.03-ft slug and measurement of water level response with a chalked steel tape. Data were analyzed by the method of Bouwer and Rice (1976). Representative soil samples were collected and shipped to a laboratory for permeameter and grain-size analyses.

Staff gages were installed in Troutman Lake and in a nearby pond to augment the wells for water-level data. Water level data were collected approximately every two hours through one twelve hour tidal cycle as determined from published tide tables.

Well, boring and staff gage elevations were surveyed relative to a brass cap (no. 50391 FAA 1940) located in the well point concrete pad on the west edge of Troutman Lake (Chuck Eggener Consulting Engineers, written commun., 1994). The mean lower low water elevation of the cap is 6.1 ft.

RESULTS AND INTERPRETATIONS

HYDROGEOLOGY

Well and borehole locations relative to the proposed lagoon location are shown in figure 2. The lagoon location was generally selected to be near an area already containing landfill waste and underlain by brackish ground water. A topographic map of the site based on point-survey measurements is shown in figure 3.

Most deposits in the study area were found to be highly permeable sands and gravels, with very minor amounts of silts and clays. Ice-bound permafrost was found to be distributed irregularly beneath most of the site, with generally less permafrost encountered in the seaward direction. A hydrogeologic cross section showing the general distribution of saturated sediments and permafrost is shown in figure 4. Ground water is observed to occur under both water table and confined conditions at the site. Permafrost is an effective confining layer in places, as demonstrated by soil boring hole SL-1. This boring reached the maximum depth capability of the rig without

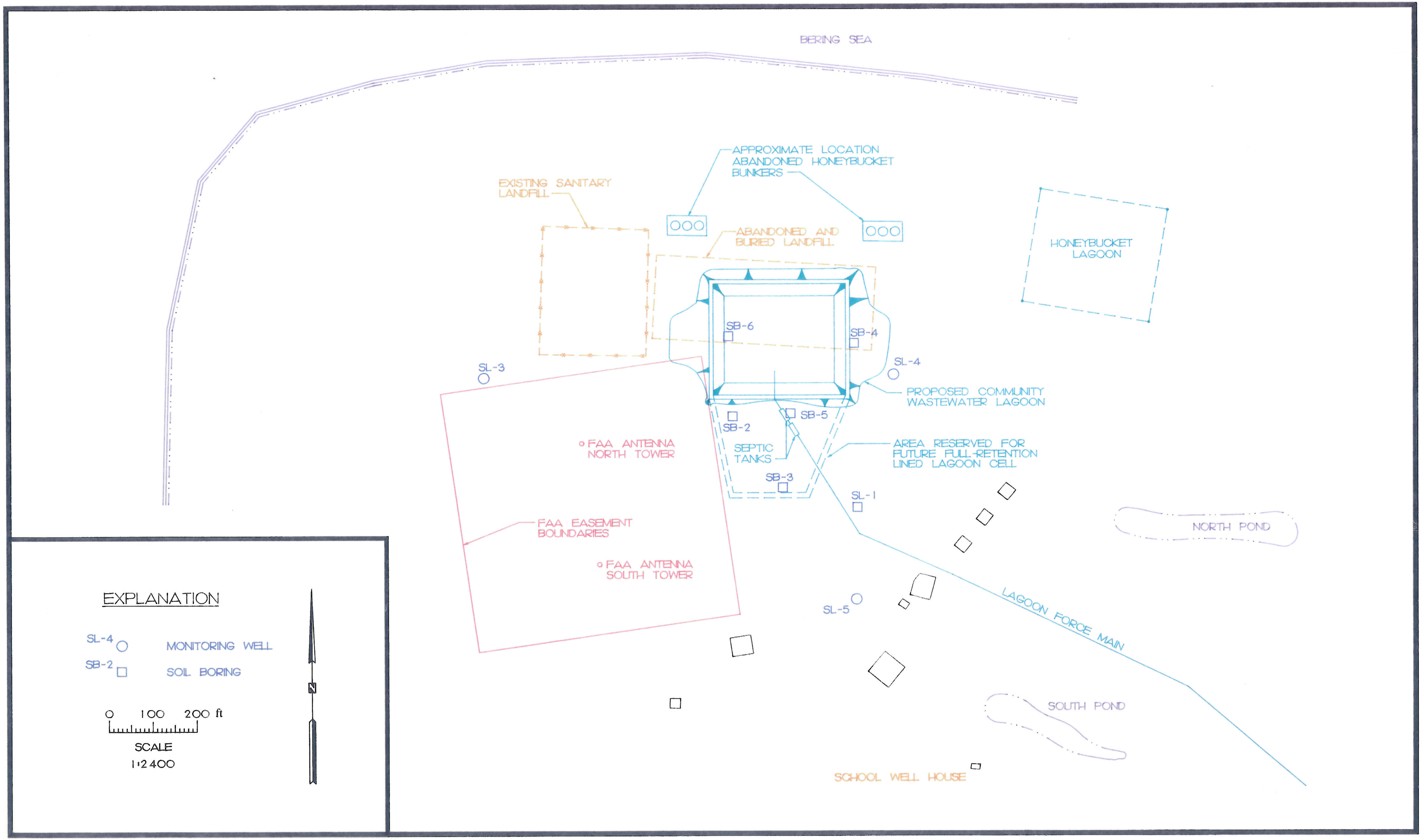


Figure 2 Locations of Soil Borings, Monitoring Wells, and Proposed Wastewater Lagoon

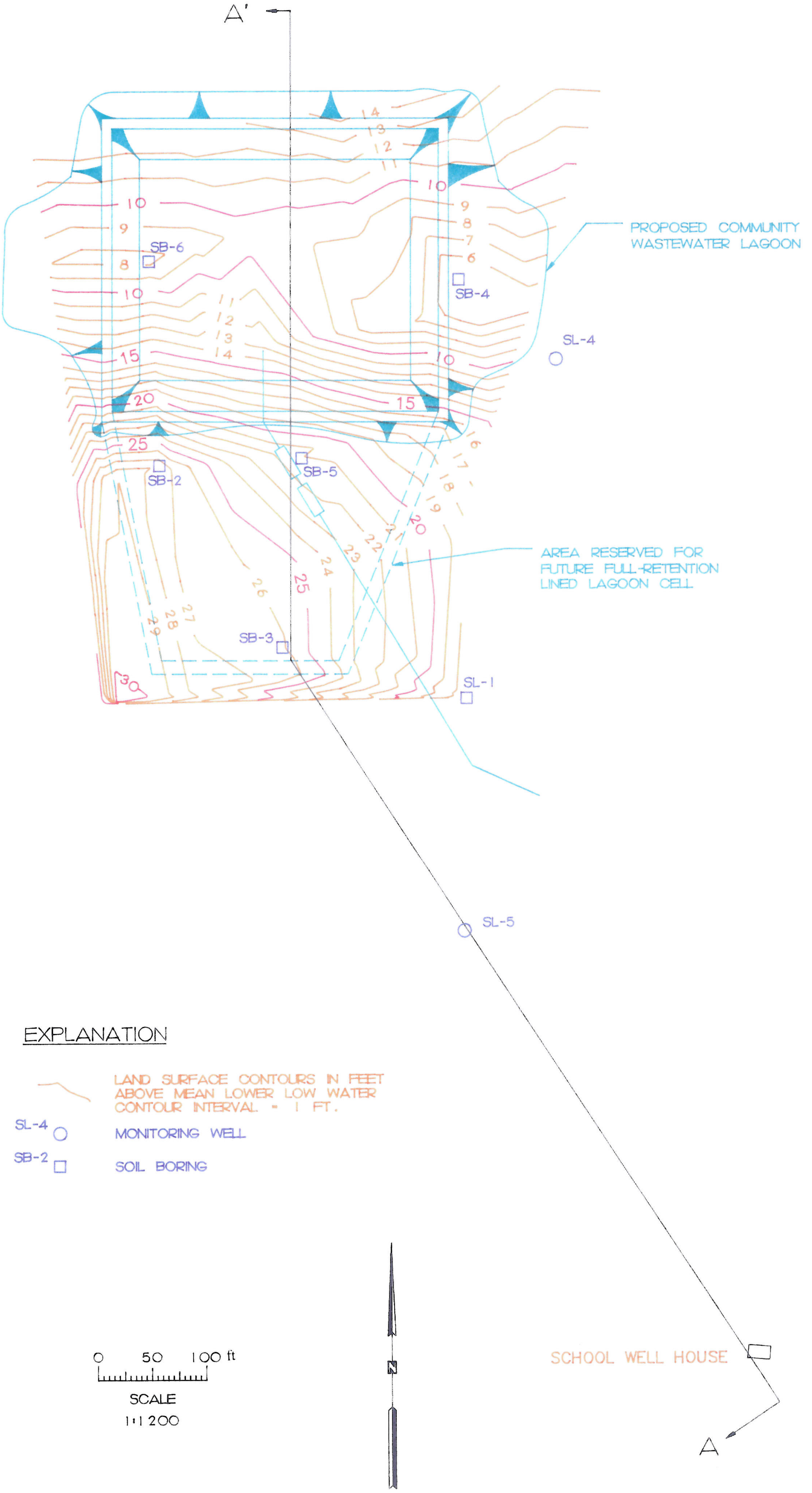


Figure 3 Lagoon Site Topography and Location of Cross Section A–A'

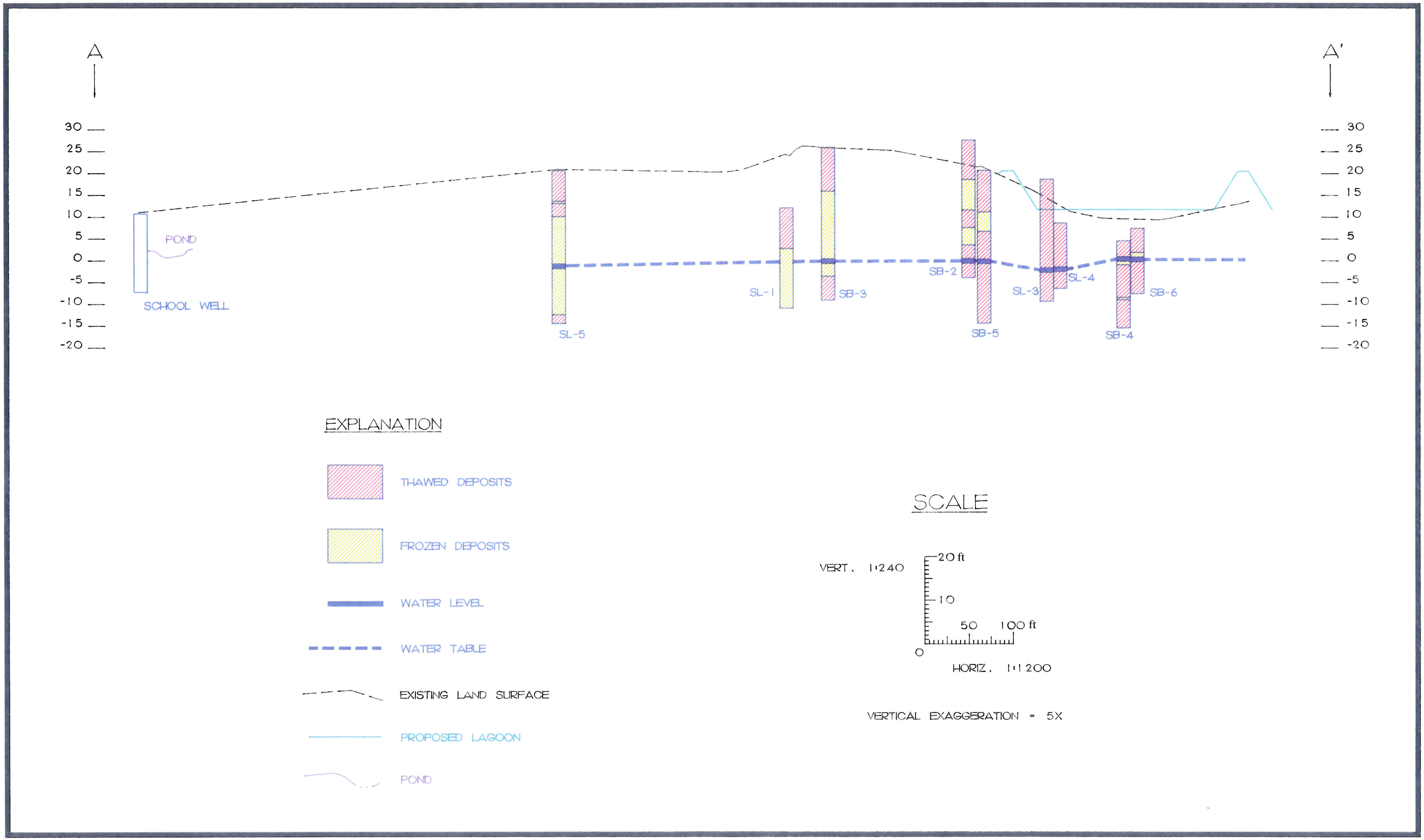


Figure 4 Hydrogeologic Cross Section A–A'. See Figure 3 for Location.

encountering water, even though the bottom of the hole was well below the potentiometric surface of the aquifer.

A perched water table probably forms intermittently on top of permafrost. Soils were generally found to be wet just above the permafrost, although no perched water table was identified at the time of the field investigation.

The cross section is not a reliable indicator of ground-water flow directions because the water level measurements were taken during a period of significant water-level fluctuation.

Results of grain-size analyses and permeameter tests are given in Appendix C. Laboratory permeameter tests on two samples of gravel yielded permeability values of 26,000 ft/day and 16,000 ft/day.

Appendix D contains water-level data and data from slug tests conducted on wells SL-3 and SL-4. Well SL-5 was not tested because the well was suspected to contain contaminated water. Both tested wells exhibited rapid water-level response indicative of a relatively permeable aquifer. Analysis of data from well SL-4 yielded a calculated permeability value of 40 ft/day. The rapid response of the well and the small number of data points suggest that this number has a relatively low degree of confidence. Well SL-3 responded too rapidly to the slug removal to allow any quantitative estimate of permeability. Qualitatively, the permeability of the aquifer at SL-3 is probably greater than at SL-4.

The range of permeabilities from 40 ft/day to 26,000 ft/day as described above is typical of aquifers comprised of deposits ranging from clean sands to gravels (Freeze and Cherry, 1979, p.29). Considering the high energy depositional environment of the deposits at Gambell, the presence of highly permeable zones within the aquifer is reasonably concluded to be characteristic of the aquifer.

WATER QUALITY

Results of water quality analyses conducted on monitoring well water samples are contained in appendix E. The results show that water beneath the proposed lagoon site ranges from brackish to saline. In addition, water collected from well SL-5 was noted to have an unusual odor suggestive of diesel fuel contamination. The Alaska Department of Environmental Conservation was conducting an evaluation of possible diesel fuel contamination in Gambell during the course of this investigation, and no follow-up analyses for organic constituents were performed as part of this study.

WATER LEVELS

Figure 5 shows water level data collected during the study. Water levels were observed to change significantly. Water level fluctuations in wells SL-3 and SL-4 appear to correlate with tidal cycles. This confirms that the aquifer in this area is hydraulically connected with the Bering Sea, transmitting sea level changes relatively rapidly and efficiently.

Troutman Lake levels remained relatively unchanged through the observation period. Water levels in the pond and in SL-5 rose rapidly on 6/19/93, and slowly but steadily thereafter, showing no direct effect from tidal influences.

The observed water level changes in the pond and SL-5 occurred after local winds changed intensity and direction. Prior to June 22 light winds were from the southwest. During the night of June 21-22, winds became northerly and increased their intensity. Wind-generated waves began impacting the north shore of the Gambell spit, with breakers sending sea spray approximately 30 ft into the air.

GROUND-WATER FLOW SYSTEMS

Figures 6-9 show water-table contour maps based on water-level measurements made during the study. The maps

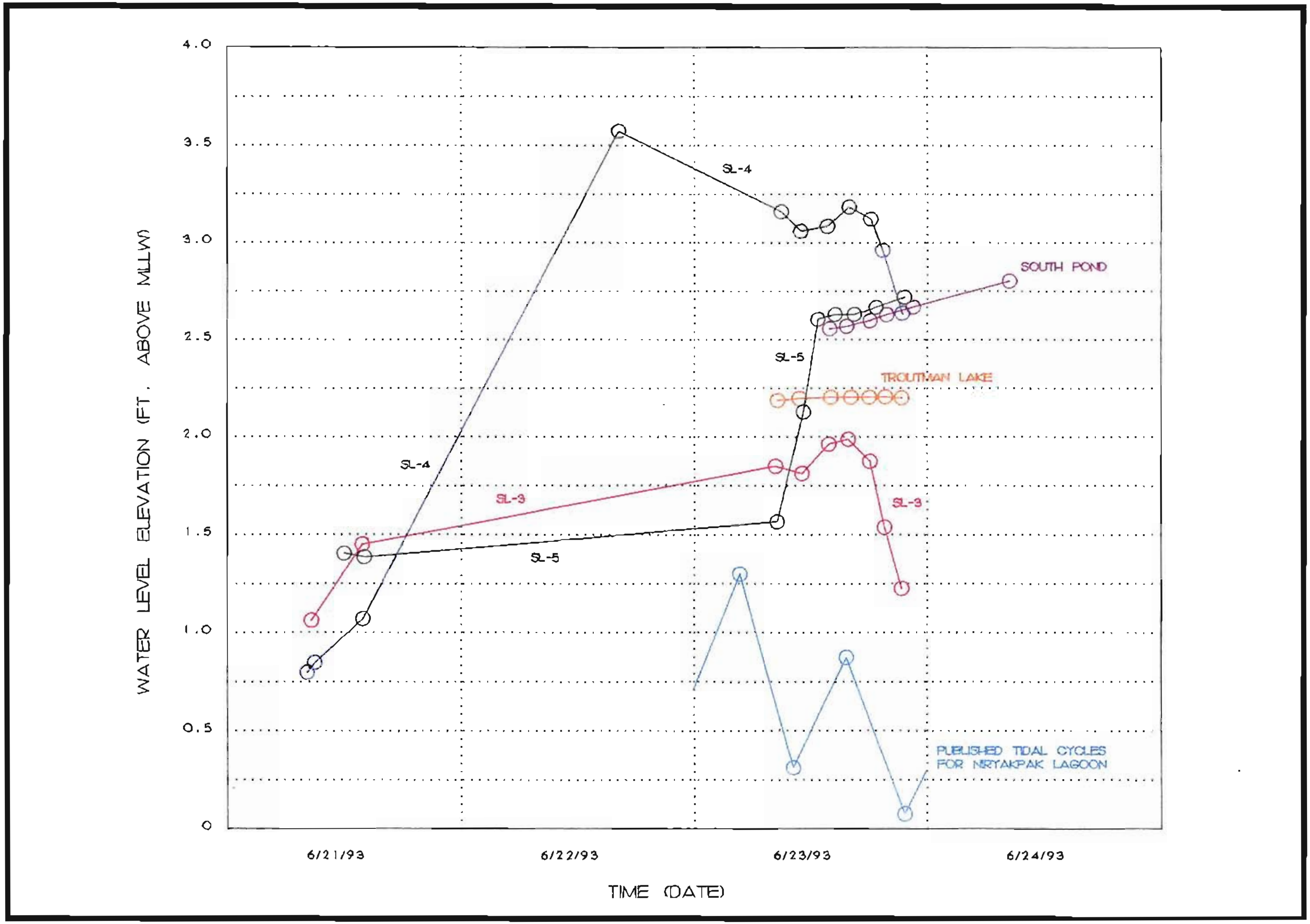
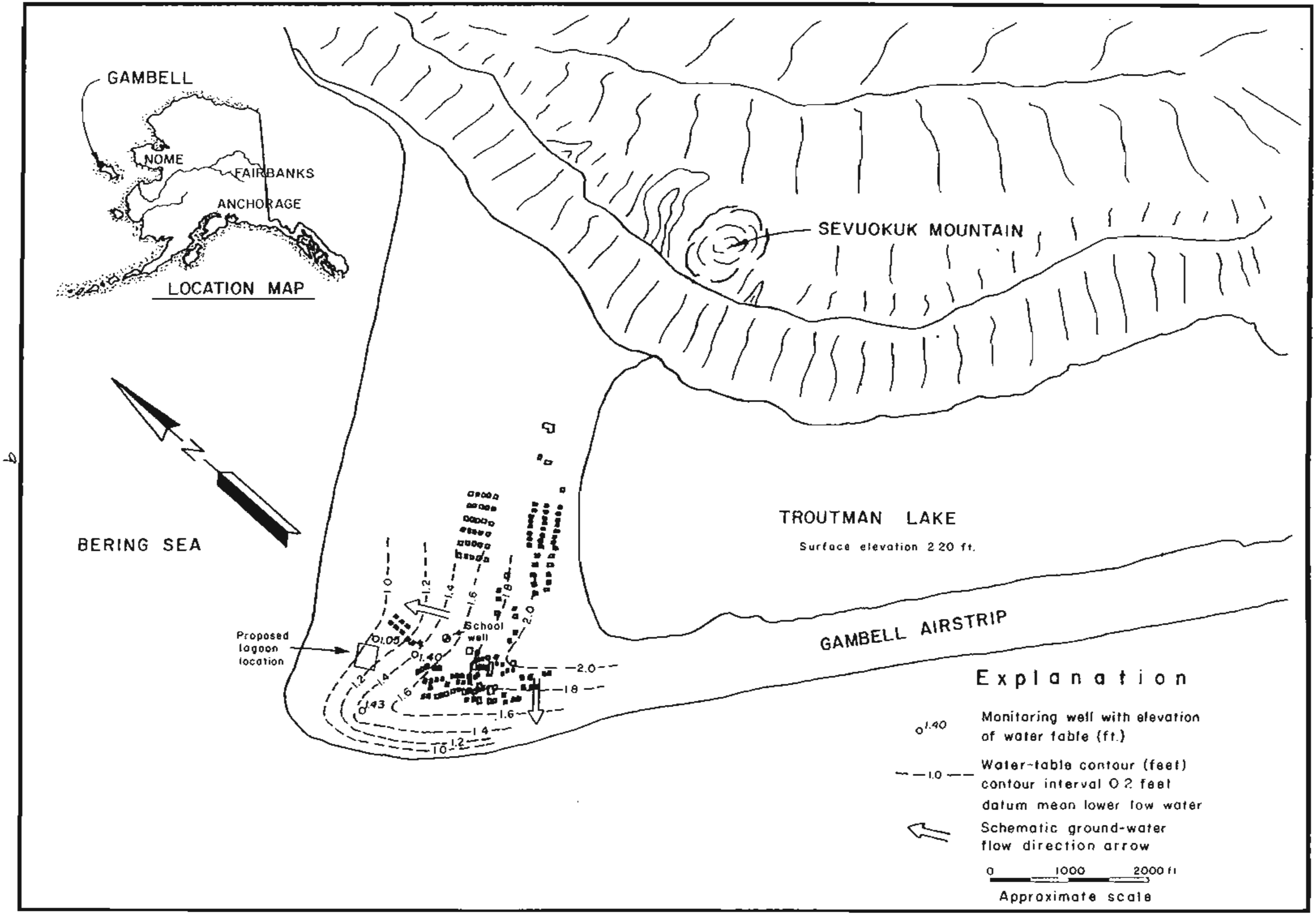
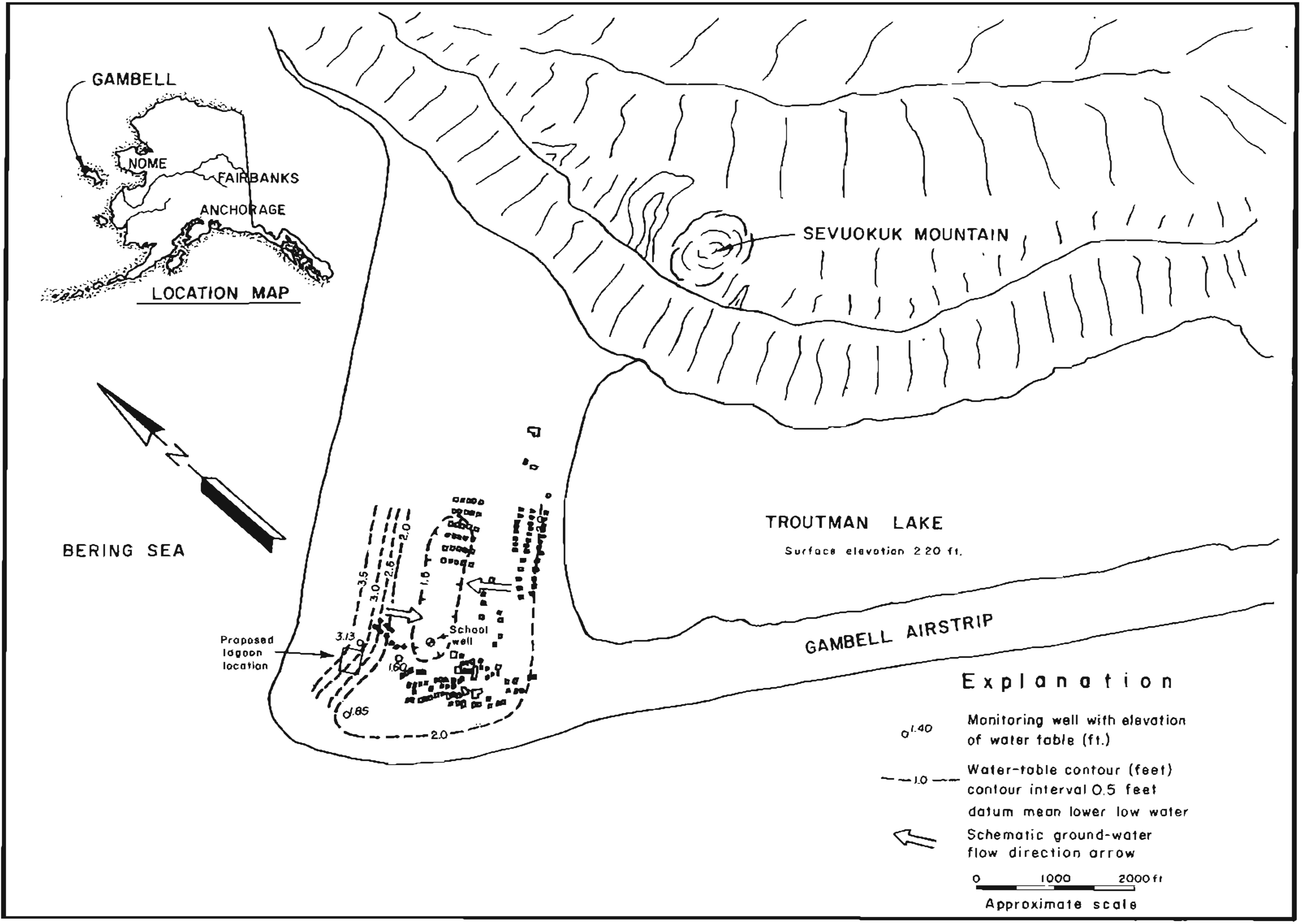


Figure 5 Observed Ground- and Surface- Water Levels



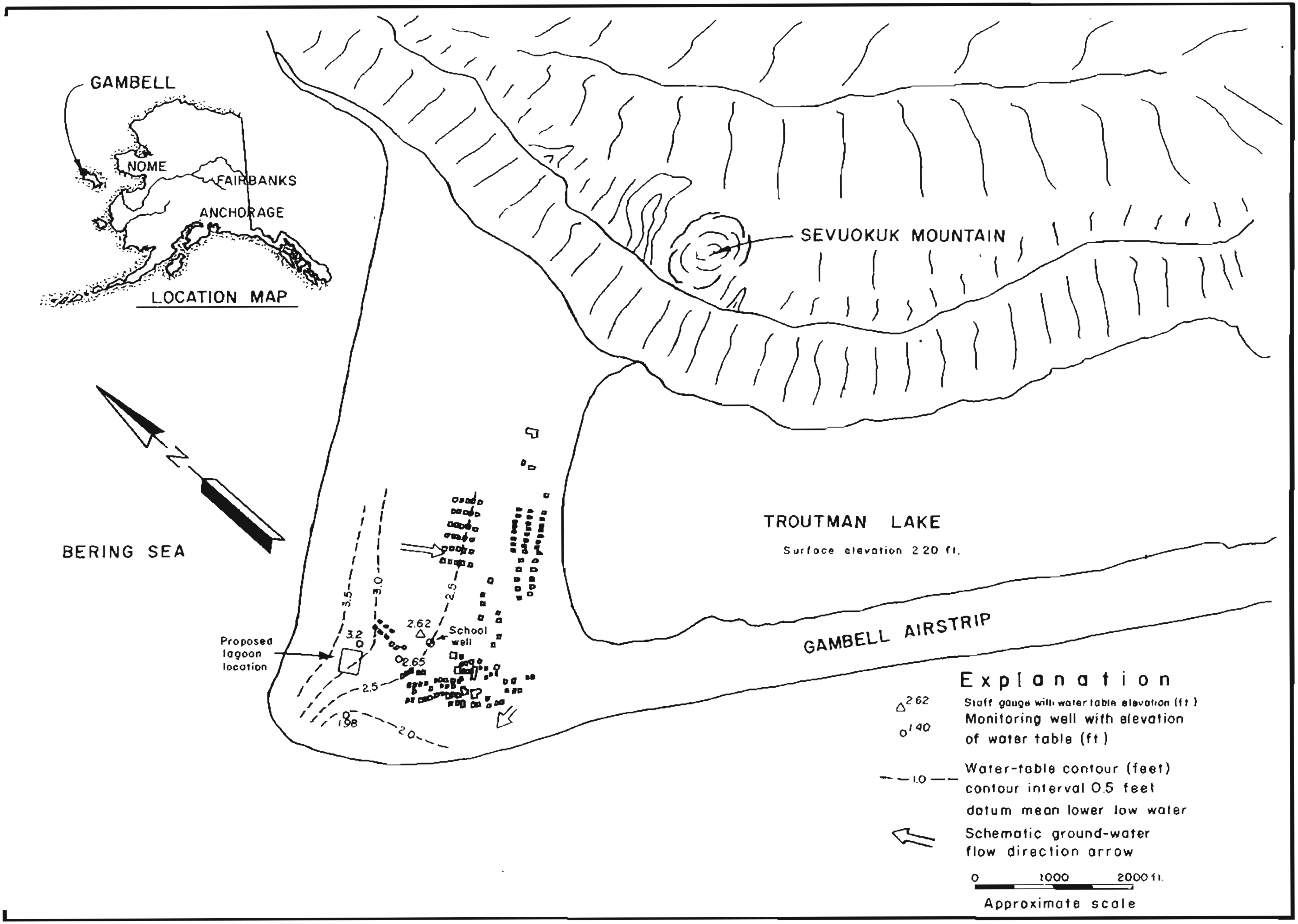
Base credit: 7-19-80 Aerial photograph

Figure 6. *Map showing water-table configuration at Gambell, Alaska, 1400 hrs., June 21, 1993*



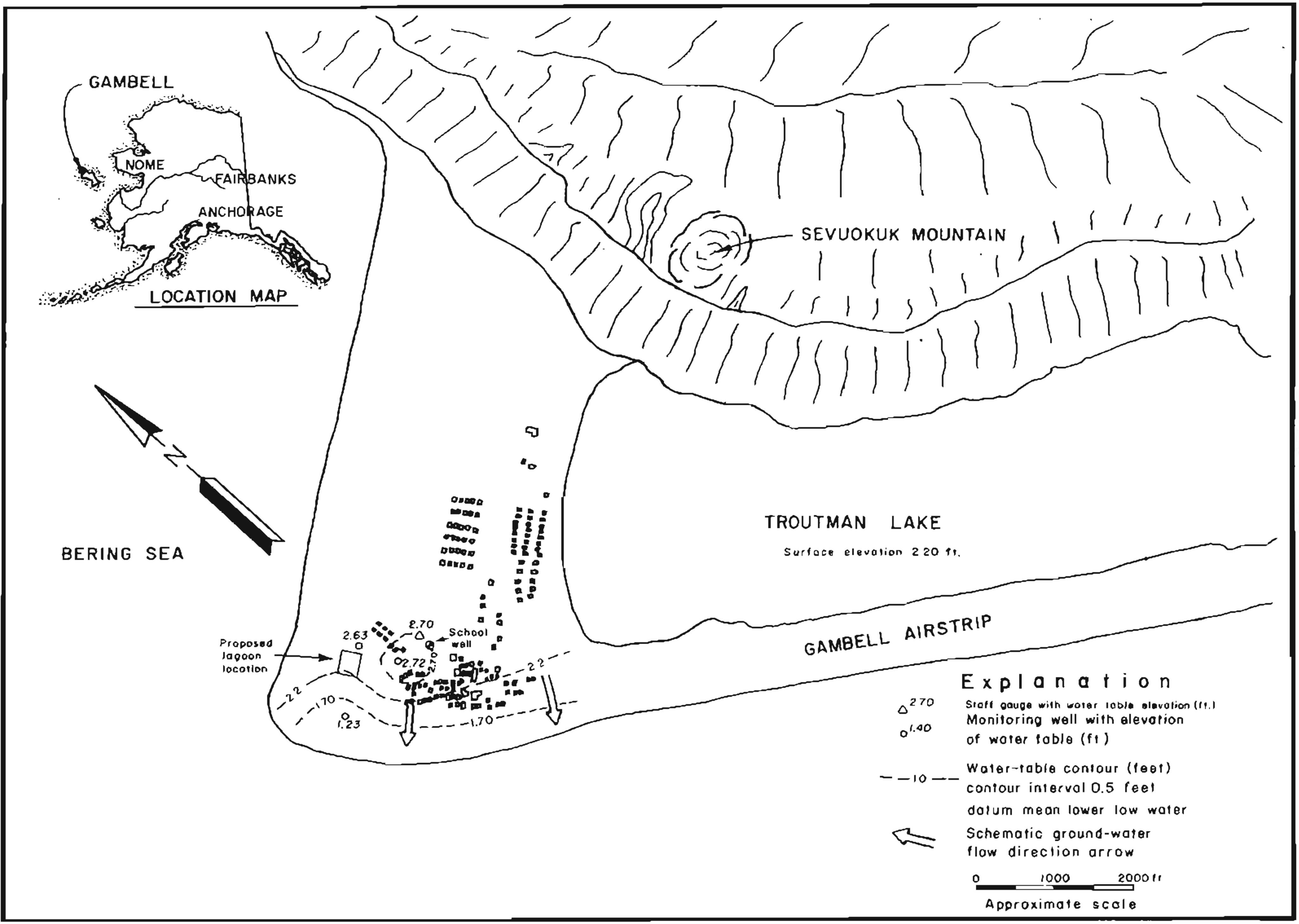
Base credit: 7-19-80 Aerial photograph

Figure 7. *Map showing water-table configuration at Gambell, Alaska, 0900 hrs., June 23, 1993*



Base credit: 7-19-80 Aerial photograph

Figure 8. *Map showing water-table configuration at Gambell, Alaska, 1600 hrs., June 23, 1993*



Base credit: 7-19-80 Aerial photograph

Figure 9. *Map showing water-table configuration at Gambell, Alaska, 2130 hrs., June 23, 1993*

are used to infer ground-water flow direction changes in response to tidal and wind-driven sea-level changes.

Figures 6-9 are based on water level measurements made during narrow intervals of time relative to the rate of water level fluctuations. Strictly speaking, the water-table maps are not true indicators of ground-water flow directions because ground water throughout the flow field is not of uniform density. Because of the magnitude of observed gradients, however, general flow conditions described below are thought to apply. Conversion of water-level data to equivalent fresh water head data is not warranted because the monitoring wells are all screened from the water-table to a depth of less than 10 ft below the water table.

Water level contours shown in figure 6 imply a general direction of ground-water flow from south to north across the sewage lagoon site. Wind conditions at the time of these measurements were generally light.

At the time of the water level measurements shown in Figure 7, the wind had increased significantly and had shifted to the north. Large waves were impacting the north shore of St. Lawrence Island, and a significant rise in water level was evident in well SL-3. A central depression in the water table between the shore and Troutman Lake is evident. The direction of ground-water flow beneath the site is from north to south at the time of these measurements.

Figure 8 shows that the central depression of the water table has largely disappeared within the span of seven hours. A pond appeared a few hours prior to the time of the figure 8 water-table map in a formerly dry closed swale. The direction of ground-water flow at the sewage lagoon site is still generally from north to south.

Figure 9 shows that water levels fell at SL-3 and SL-4 and rose slightly at SL-5 compared to figure 8. The drop in water levels coincides with tidal fluctuations (figure 5). A residual ground-water mound is evident southeast of the lagoon site, and inferred ground-water flow directions are southwesterly, although the gradient is relatively flat.

Two ponds appeared in formerly dry swales on June 23, 1993. The north pond (figure 2) was tested to have a specific conductance of 2600 umhos/cm, which is characteristic of brackish water while the south pond had a specific conductance of 475 umhos/cm, which is characteristic of fresh water. The north pond was observed to form earlier in the day than the south pond.

The onset of strong onshore winds is interpreted to have created a water table mound near the north shore of the Gambell spit that effectively blocked the flow of fresh ground water to the sea, creating a backwater effect that caused ground-water levels to rise and the ponds to form. The source of fresh water in the south pond is inferred to be from melting snow on the west flank of Sevuokuk Mountain. Rivulets of fresh water were observed descending the flank of the mountain during the field project and infiltrating into the spit deposits at the base of the mountain. The City of Gambell has installed and test pumped a series of shallow wells near the base of the mountain tapping the freshwater aquifer.

Fresh ground water diverted by the storm-induced water-table mound from flowing northward to the sea is inferred to flow south into the City of Gambell, contributing to the sudden rise in water levels observed in the ponds and well SL-5. Water in the northern pond is a mix between sea water and fresh water.

SEASONAL FACTORS

It has been reported by local residents that the low swale near SB-4 and SB-6 fills with standing salt water as a result of fall and early winter storms. Land surface elevation in that area is about 6-8 ft above MLLW. The standing water is interpreted to be the result of a high water table condition from severe seasonal storms. Fall and winter storms reportedly cause onshore winds on the north shore much more violent than those that were observed in June. These storms probably result in high ground-water levels at the swale as high as about 10 ft above MLLW.

PERCOLATION LAGOON EFFECTS

Two options have been identified for percolation lagoon design: 1) a "fast-perc" lagoon which would be designed with a highly permeable bed to achieve a maximum rate of percolation; and 2) a "slow-perc" lagoon, which would have a sand filter bed to slow percolation to achieve some treatment of the effluent waters in the unsaturated zone beneath the lagoon. Selection of an option is dependent, in part, on ground-water dynamics beneath the site. The major concern was to avoid contaminating a school well located about 900 ft southeast of the site. Key lagoon-design and ground-water dynamics issues relating to each of the options is provided below.

"FAST-PERC" OPTION

The "fast-perc" design option would include a 50,000 sq ft bottom area lagoon located at the north end of the study site. The lagoon would be designed such that water would not be retained. Wastewater would be discharged into an area where ambient ground-water is brackish to saline. Ground-water in the seaward direction from this site may also be contaminated by landfill or honeybucket disposal leachate.

Hydraulic conductivities reported in this report support design of a smaller lagoon. However, possible future environmental requirements and the availability of equipment prompted design and construction of a lagoon large enough for future splitting of the lagoon into separate lined and unlined cells.

"SLOW-PERC" OPTION

The "slow-perc" option would entail construction of a 70,000 sq ft bottom area lagoon. This size was selected to allow full retention of seven months accumulation of wastewater, assuming, under a worst-case scenario, that the bed of the lagoon would freeze during the winter. It was further assumed that all of the retained frozen wastewater would melt and infiltrate during a 30-day period in the spring. The lagoon would be located where the "fast-perc" lagoon was planned, except for a southward extension to provide for added bottom area and storage volume.

GROUND-WATER MODEL ANALYSIS

In order to evaluate the effects of each proposed lagoon design on ground water, an analytical ground-water model was applied to each lagoon scenario. The model was designed to estimate the height of the ground-water mound beneath infiltration basins (Hantush, 1967; Bouwer, 1978, p. 279-288). Inputs to the model are:

	"Fast-perc"	"Slow -perc"
Model inputs		
Lagoon infiltration area	50,000 sq ft	70,000 sq ft
aquifer horizontal hydraulic conductivity	2000 ft/day	2000 ft/day
aquifer thickness	20 ft	20 ft
fillable porosity	0.2	0.2
arrival rate at water table of water from lagoon	0.046 ft/day	0.23 ft/day
duration of infiltration	365 days	30 days
Model Outputs		
Water-table rise at center of infiltration basin	0.05 ft	0.23 ft

The thickness, fillable porosity, and hydraulic conductivity of the aquifer were estimated based on the hydrogeologic data collected during the field investigation. The arrival rate at the water table of water from the lagoon and the duration of recharge are based on probable operating scenarios for the respective lagoons.

The "fast-perc" lagoon is designed to trickle water to the water table at a relatively constant rate equal to the disposal rate of water in Gambell, which is estimated to be 17,050 gal/day, or 0.046 ft^3/day/sq ft of seepage area, or 0.046 ft/day.

The "slow-perc" design will result in a large volume (3.58 million gallons) of wastewater stored as ice at the end of a typical winter. Inputs to the model were specified to determine the response of the water-table after a 30 day period of ice melting and infiltration of all meltwater.

Calculated rises in the water-table beneath the center of the lagoon are 0.05 ft and 0.23 ft for the "fast-perc" and "slow-perc" options, respectively. Considering the possibility that the hydraulic conductivity estimate used in the calculations may be too high, calculations were also performed using a hydraulic conductivity of 200 ft/day, all else remaining constant. This resulted in calculated water-table rises of 0.36 ft and 1.6 ft for the "fast-perc" and "slow-perc" options, respectively.

ADVANTAGES AND DISADVANTAGES OF LAGOON DESIGNS

Detailed discussions of advantages and disadvantages of the alternate lagoon designs are given in Appendix F. To summarize, the "fast-perc" option is considered to have more advantages than the "slow-perc" option, and fewer disadvantages. Advantages of the "fast-perc" option include: efficient disposal of wastewater into an area with ground-water that is already nonpotable; relatively high flushing and dilution rates; greater distance between wastewater disposal and the school well; and less potential for migration of water from the lagoon area to the school well as a result of less ground-water mounding beneath the lagoon.

SUMMARY AND CONCLUSIONS

This study documents the presence of a dynamic ground-water flow system beneath a portion of the Gambell spit. Ground-water flows through highly permeable gravels deposited in a high energy beach environment. Probably as a result of storm events, brackish and saline ground-water occurs more than one eighth of a mile inland from the coast. Ground-water levels respond to tidal and storm stresses, resulting in highly variable ground-water flow systems and reversals of ground-water flow directions within periods of a few hours.

An analysis of different options for designing a percolation-type sewage lagoon results in the identification of several advantages of a "fast-perc" design compared to a "slow-perc" design. The primary advantage of the "fast-perc" design is a lower potential for contaminating a nearby school well, which is a key design criteria.

ACKNOWLEDGMENTS

Numerous individuals assisted with this project, including Jane Dale, Chuck Eggener, and Dave Ulvestad with Chuck Eggener Consulting Engineers, and Roger Allely with the Alaska Hydrologic Survey. Steve Eng with the Village Safe Water Program and Chuck Eggener provided helpful review comments.

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APPENDIX A

Soil boring and monitoring well logs

SB-1

SOIL BORING LOG

CE 2
CHUCK EGGENER
CONSULTING ENGINEERS

PROJECT AND LOCATION GAMBELL SEWAGE LAGOON/LOCATION LIFT STATION
ELEVATION AND DATUM
DRILLER STEVE WOODSTOCK/Ambler Exploration
DATE STARTED 1:35 PM 6/17/93
DATE FINISHED 3 PM 6/17/93
DRILLING EQUIPMENT & BIT SIZE ~5¼" Ambler Rambler custom built rig on tracks ~20hp 2¼" ID × 4¼" OD Hollow stem
DEPTH DRILLED 25.2'
CASING DEPTH
CASING DEPTH
NO. SOIL SAMPLES
METHOD
WATER LEVEL 8'
MEAS. PT. Ground surface
SCREEN SETTING SIZE DEPTH
SCREEN SETTING SIZE DEPTH
DRILLER'S helper Levine Oozeva
HYDROGEOLOGIST Jim Munter

DEPTH (FEET)	SOIL DESCRIPTION BORING NO. 1	SAMPLES	FROZEN	STANDARD PENETRATION RESISTANCE 140 BLOWS PER FOOT (150 LB. HAMMER, 30" DROP)
5	0-5 Grey fine gravel, no fines poorly graded some coarse sand GP-SP Very clean, moist well rounded ↓			
10	5-8 AA, slightly coarser, very clean 8-10 Grey coarse sand, no fines well rounded SP, Mostly igneous rock fragments			
15	moist. Rig chattered @ ~8ft: possible ice lense/top permafrost easy drilling some fine gravel, med sand 10-12 Drills rougher/slower returns a.a.	Approx { 8' 10' frozen top		
20	slightly coarser SP-GP 12 aa w' ice in returns, cobble @ 13' good returns more dense			
25	@ 14' SP w' some fine gravel, med sand little to no fine sand 15-17 No ice in returns, ice at 17' higher ice content SP-GP, no fines			
30	very rough ~~at 17.5~~ -ice lense no ice 18.5' high ice cobble @ 19' high ice content Trace ice @ 20', high sidewall cave in? 20-25 Rig still chattering like frozen, ice returns	I Split spoon 2" OD 25-25.2		
35	sinkhole developing under rig GP-SP smoother @ 22': 22.5' 23' no ice 23' piece of cloth recovered. ice @ 24ft water level @ 8' on a-rod 1430 hrs			
40	(awml rod) 25- setup for SS 25-25.2 ~2" recovery, SP, some fine sand on top, ice fragment, trace - some gravel subrounded			50 blows/1.75"

LEGEND

I	2.0" O.D. SPLIT SPOON SAMPLER	P	SAMPLER PUSHED
II	3.0" O.D. UNDISTURBED SAMPLER	%	MOISTURE CONTENT
G	GRAB SAMPLE INTERVAL	*	SAMPLE NOT RECOVERED

SB-2 **SOIL BORING LOG**

CE 2 CHUCK EGGENER CONSULTING ENGINEERS

PROJECT AND LOCATION: GAMBELL SEWAGE LAGOON TOP OF KNOLL 50' from FAA Bdry stake

ELEVATION AND DATUM: (surveyed) Land Surface = 27.75' above MLLW

DRILLER: STEVE WOODSTOCK

DATE STARTED: 6/18/93

DATE FINISHED: 6/18/93

DRILLING EQUIPMENT & BIT SIZE: 5¼" 2¼" ID hollow stem auger flights Ambler Rambler

DEPTH DRILLED: 31.5'

CASING: DEPTH / DEPTH

NO. SOIL SAMPLES: 1

METHOD: 2" split spoon

WATER LEVEL: see p. 2

MEAS. PT.

SCREEN SETTING: SIZE / DEPTH / SIZE / DEPTH

DRILLER'S Helper: Levine Oozeva

HYDROGEOLOGIST: Jim Munter

DEPTH (FEET)	SOIL DESCRIPTION BORING NO. 2 Page 1 of 2	SAMPLES	FROZEN	STANDARD PENETRATION RESISTANCE NO BLOWS PER FOOT (140 LB. HAMMER, 30" DROP)				
5	0-5 Fine gravel, dk grey, well rounded up to 1¼" GP, clean, little to no sand v. loose moist - Beach ridge deposit trace-some coarse gravel, thawed, no fines							
	5-9 a.a 8-9 sample wet							
10	9-10 Frozen fine gravel a.a GP trace coarse sand, trace ice, no fines		Thawed 9' — Frozen					
	10-11 drills like ice, no ice returns, wet GP 4 lam							
	12-13 ice returns, trace dry Some coarse sand							
15	13-15 more ice, rougher drilling, possibly thin ice lenses GP a.a.		16 — Thawed 18-20 - - -					
	15-16 a.a		—					
20	16-18 Thawed - drills very smooth, trace ice in returns, prob. cave	I 20' 20'9"	20 Frozen	20' 24/6"	60/3"-	refusal		
	18-20 drilled stiffer possible silt? split spoon: 20' depth is silt plug?		24 Thaw	25' 6/6"	12/6"	14/6"		
25	20-20.7 Frozen coarse sand SP trace fine gravel ice content ~ 30% trace fine sand, some med sand subrounded - subangular little to no silt							
30	20.7-22.5 - slight rough drilling - no returns from 6.7 22.5-24 rough spot - still frozen 24 - smooth drilling - thawed? - bit plug fell 25 2" at break plug moist sand - 6" up							
35	25-26+ 1.1' recovery, SP, med-coarse sand, subrounded, damp, ... some fine sand, trace fine gravel 1-3% silt							
40	thawed							

LEGEND

trace < 14%
some = 14-28%

est. 22' × 170' to bottom of swale to N

[illegible]

1	2.0" O.D. SPLIT SPOON SAMPLER	P	SAMPLER PUSHED	
U	3.0" O.D. UNDISTURBED SAMPLER		% MOISTURE CONTENT	
G	GRAB SAMPLE INTERVAL	•	SAMPLE NOT RECOVERED	

SOIL BORING LOG

SB-2 (cont.)

CE 2 CHUCK EGGENER
CONSULTING ENGINEERS

PROJECT AND LOCATION: Gambell Sewage Lagoon Top of Knoll

ELEVATION AND DATUM:

DRILLER: Steve Woodstock

DATE STARTED: 6/18

DATE FINISHED: 1120 6/18

DRILLING EQUIPMENT & BIT SIZE:

DEPTH DRILLED: 31.5

CASING DEPTH:

CASING DEPTH:

NO. SOIL SAMPLES: 1 permanent sieve

METHOD: 2" split spoon

WATER LEVEL: 27.63'

MEAS. PT.: Top flange 0.30 ft

SCREEN SETTING SIZE: DEPTH:

SCREEN SETTING SIZE: DEPTH:

~~DRILLER~~ = 27.33 below ground surface @1115

HYDROGEOLOGIST: Jim Munter

DEPTH (FEET)	SOIL DESCRIPTION BORING NO. 2 Page 2	SAMPLES	FROZEN	STANDARD PENETRATION RESISTANCE BLOWS PER FOOT (140 LB. HAMMER, 30" DROP)				
	26.1-30 drills v smooth plug wet 1.9' on bottom fine sand SP? seal 30-1.9: 28.1' - seal 1.45' of sample recovery split spoon 30-31 brown fine sand 0.1-0.2 mm poorly graded subround to well rdd, SP wet aeolian? somewhat cohesive trace to no silt Sharp contact @30.95' 31-31.5 GW - Well graded fine gravel brown, some sand, trace silt subrounded Thawed 25+2.63 0.30 ft stickup TD = 31.5	Took a bagged sample 30-31 SB2-1	Thawed TD 31.5	30' 7/6"	23/6"	26/6"		
5								
10								
15								
20								
25								
30								
35								
40								

LEGEND

I	2.0" O.D. SPLIT SPOON SAMPLER	P	SAMPLER PUSHED
II	3.0" O.D. UNDISTURBED SAMPLER	%	MOISTURE CONTENT
G	GRAB SAMPLE INTERVAL	•	SAMPLE NOT RECOVERED

SB-3 **SOIL BORING LOG**

CE2 CHUCK EGGENER
CONSULTING ENGINEERS

PROJECT AND LOCATION GAMBELL SEWAGE lagoon SE corner - 50' in both sides

ELEVATION AND DATUM est 2' below SB 2 SURVEYED LAND SURFACE: 26.16' (MLLW)

DRILLER Steve Woodstock

DATE STARTED 1530 6/18/93

DATE FINISHED 1700 HRS 6/18/93

DRILLING EQUIPMENT & BIT SIZE 2¼" ID hollow auger / 5¼" bit

DEPTH DRILLED 35'

CASING DEPTH

DEPTH

NO. SOIL SAMPLES 1

METHOD Auger cuttings

WATER LEVEL 26.02 — 25.72 below land surface

MEAS. PT. Top of Auger @ +0.30ft

SCREEN SETTING SIZE DEPTH

SIZE DEPTH

DRILLER #2 Levine Oozeva

HYDROGEOLOGIST Jim Munter

DEPTH (FEET)	SOIL DESCRIPTION BORING NO. 3	SAMPLES	FROZEN	STANDARD PENETRATION RESISTANCE BLOWS PER FOOT (~~180~~ 140 LB. HAMMER, 30" DROP)				
	0-5 V. loose cs sand - fine gravel SP-GP little to no fines subrounded to rounded, dk grey, moist							
5	5-10 loose dk grey fine gravel, GP, sandy (coarse), some medium sand little to no fines, wet, ~~thawed~~	Shovel Sampled SB3-I -10	Thawed					
10	10-15 Frozen GP trace sand, very poorly graded, trace ice @ 12' very soft ice drilling, only slight chatter		10' — Frozen					
15	15-20 cs sand - fine gravel GP-SP frozen, trace med sand, little to few fines (< 3%) Frozen, wet							
20	20-25 a a drills little soft ice except last ½' 25-26 a.a ~~26-28~~ drills soft, prob thawed 30 3.6 26.4'							
25	28-29.5 hard- ice frozen 29.5-30 v. soft, thawed 3.6' water on a rod							
30	30-31 split spoon 1.0 recovery, 2" pebble in mouth well graded ~~sandy~~ gravelly sand SW, subangular to rounded trace fine sand, little to no fines trace gravel wet, thawed		29.5 — Thawed	30' 43/6"	27/6"	25/6"		
35	31-35' SWL 26.02 drills smooth - thawed No returns							
40	35' TD							

LEGEND

I	2.0" O.D. SPLIT SPOON SAMPLER	P	SAMPLER PUSHED
II	3.0" O.D. UNDISTURBED SAMPLER	%	MOISTURE CONTENT
G	GRAB SAMPLE INTERVAL	•	SAMPLE NOT RECOVERED

SB 4

SOIL BORING LOG

CE2 CHUCK EGGENER
CONSULTING ENGINEERS

PROJECT AND LOCATION Gambell Sewage Lagoon NE corner in swale		ELEVATION AND DATUM Surveyed Land Surface = 4.71' (MLLW)	
DRILLER Steve Woodstock		DATE STARTED 1800 6/18/93	DATE FINISHED 1900 6/18/93
DRILLING EQUIPMENT & BIT SIZE 2'4" JD Hollow Stem / 5¼" bit Amber Rambler		DEPTH DRILLED 20'	
CASING	DEPTH	NO. SOIL SAMPLES 1	METHOD OFF AUGER FLIGHT
	DEPTH	WATER LEVEL. 4'1¾" (4.15')	MEAS. PT. Top of auger @ ground level
SCREEN SETTING	SIZE / DEPTH	DRILLER #2 Levine Oozeva	
	SIZE / DEPTH	HYDROGEOLOGIST Jim Munter	

DEPTH (FEET)	SOIL DESCRIPTION BORING NO. 4	SAMPLES	FROZEN	STANDARD PENETRATION RESISTANCE 140 BLOWS PER FOOT (~~160~~ 140 LB. HAMMER, 30" DROP)				
	0-4 GP v. loose sandy fine gravel, little-no fines sand coarse, well rounded trace fine-med. sand dk grey, wet at bottom	- 2	Thawed					
5		SAMPLE SB4-1	4 FROZEN					
	4-5 a.a. frozen, trace ice returns	- 5	5.5	Heave in auger				
10	5-5.5 frozen a.a.		Thawed	32/6"	13/4"	8/6"		
	5.5-10 drills very soft & smooth - prob thawed slightly coarser gravel		13 FROZEN 13.5					
15	10-11 split spoon - 1 ft recovery fine gravelly & cs sand SP dk grey trace medium sand, saturated no ice subrounded - well rounded 6'-1'10¼": 4'1¾" below		Thawed					
20			20.0					
	11-13 a.a. fine gravel w/ sand GP well rounded							
25	13-13.5 ice lense a.a.							
	13.5-15 thawed a.a							
30	15-20 fine gravel w/ cs sand GP grading downward to fine gravel w/ coarse gravel and cs sand, GP. Well rounded, wet							
35								
	TD 20'							
40								

LEGEND

I	2.0" O.D. SPLIT SPOON SAMPLER	P	SAMPLER PUSHED
II	3.0" O.D. UNDISTURBED SAMPLER	%	MOISTURE CONTENT
G	GRAB SAMPLE INTERVAL	•	SAMPLE NOT RECOVERED

SB-5

SOIL BORING LOG

CE2 — CHUCK EGGENER CONSULTING ENGINEERS

PROJECT AND LOCATION ~140' east of SB 2 GAMBELL SEWAGE LAGOON East side midpoint / top edge of slope

ELEVATION AND DATUM (est) ~5' below SB2 SURVEYED LAND SURFACE = 21.04' (MLLW)

DRILLER Steve Woodstock

DATE STARTED 8 Am 6/19/93

DATE FINISHED 10 30 hrs 6/19/93

DRILLING EQUIPMENT & BIT SIZE 2¼" ID Hollowstem / 5¼" bit Amber Rambler

DEPTH DRILLED 35 ft

CASING DEPTH

CASING DEPTH

NO. SOIL SAMPLES 1

METHOD 2 Split spoons composite

WATER LEVEL 20.8

MEAS. PT. Top of Augers +0.7 ft als

SCREEN SETTING SIZE DEPTH

SCREEN SETTING SIZE DEPTH

DRILLER #2 Levine Oozeva 20.1 ft below ground surface

HYDROGEOLOGIST Jim Munter

DEPTH (FEET)	SOIL DESCRIPTION BORING NO. 5	SAMPLES	FROZEN
	0-5 v loose, dk brown fine gravel, GP some cs sand, trace fine-med sand, little to no fines, moist, well rounded thawed		Thawed
5	5-7.0 a.a.		
	7-9.5 loose cs sand, SP, with fine gravel trace fine-med. sand subangular-sub rounded, thawed moist to almost wet in lower part, little to no fines		9.5 —
10	9.5-10 a.a except frozen, drills rough		Frozen
	10-14 sandy fine gravel GP, harder @ 10.5 little to no fines, no visible rain returns, wet		14 —
15	14-15 a.a. drills soft - thawed?		Thawed
20	15-20 a.a drills smooth - thawed, moist split spoon 0.9 ft recovered	I SB5-1	▽
	20-20.9 sandy fine gravel, GW, sand fine-cs trace silt, trace cs gravel wet, saturated thawed gravel rounded, sand subangular-rounded Took sample SB5-1		
25	Second split spoon - starts @ 20.2 (collapsed hole) a.a except trace coarse gravel at bottom 0.3 ft (up to 1" dia. 0.9' recovered wet - added to SB5-1 bag		
30	20.9-25 drills smooth except @ 23-23.3 - ice lense?.		
35	25-30 a.a fairly smooth, slight grinding		
40	30-35 a.a no change in drilling TO 35 ft marginal - {21.01 / 20.90} @ live 21.5 - 7 7/8" sharp 20.8 } 8-9 min		

STANDARD PENETRATION RESISTANCE BLOWS PER FOOT (~~150~~ 140 LB. HAMMER, 30" DROP)

20'	11/6"	20/6"	18/6"
	5/6"	9/6"	12/6"

LEGEND

I	2.0" O.D. SPLIT SPOON SAMPLER	P	SAMPLER PUSHED
II	3.0" O.D. UNDISTURBED SAMPLER	%	MOISTURE CONTENT
G	GRAB SAMPLE INTERVAL	*	SAMPLE NOT RECOVERED

SB6

SOIL BORING LOG

CE2 CHUCK EGGENER CONSULTING ENGINEERS

PROJECT AND LOCATION GAMBELL SEWAGE LAGOON NW corner in swale center 200' from [illegible] (soil) landfill cover		ELEVATION AND DATUM SURVEYED LAND SURFACE = 7.74' (MLLW)	
DRILLER steve Woodstock		DATE STARTED 1115 hrs 6/19/93	DATE FINISHED 1220 hrs 6/19/93
DRILLING EQUIPMENT & BIT SIZE 2¼" ID Hollow stem/5¼" bit		DEPTH DRILLED 15 ft	
CASING	DEPTH	NO. SOIL SAMPLES 1	METHOD shovel & auger
	DEPTH	WATER LEVEL . 7.15 → 6.65 below ground	MEAS. PT. Tip of auger +0.5ft
SCREEN SETTING	SIZE / DEPTH	DRILLER #2 Levine Oozeva	
	SIZE / DEPTH	HYDROGEOLOGIST Jim Munter	

DEPTH (FEET)	SOIL DESCRIPTION BORING NO. 6	SAMPLES	FROZEN	STANDARD PENETRATION RESISTANCE BLOWS PER FOOT (~~180~~ 140 LB. HAMMER, 30" DROP)
	0-5 Coarse sand, SP, w trace fine gravel dk brown, some fine to med sand little to no fines, wet near bottom Sample SB6-1 Subrounded-rounded	SB6-1	thawed 5.5 — Frozen 7 —	
5	5-7 fine gravel w/ sand GP rough 5.5-7 seasonal frost? No ice in return, wet, trace shell fragments			
10	7-10 soft drilling fine-cs gravel GP up to 1½" trace ice in cuttings wet rounded gravel trace-some sand little to no fines		Thawed	
15	10-15 a.a. well rounded, oblate, up to 2"		TD 15 —	
20	8.5 · 1'4¼" @ 1046 8.0 - 0'10¼" @ 1047 8.0 - .85ft = 7.15			
	TD15'			
25				
30				
35				
40				

LEGEND

I	2.0" O.D. SPLIT SPOON SAMPLER	P	SAMPLER PUSHED
II	3.0" O.D. UNDISTURBED SAMPLER		% MOISTURE CONTENT
G	GRAB SAMPLE INTERVAL	-	SAMPLE NOT RECOVERED

GROUND—WATER MONITORING WELL LOG

SL - 1

LOG OF WELL SL- 1

CE2 CHUCK EGGENER
CONSULTING ENGINEERS

PROJECT AND LOCATION GAMBELL SEWAGE lagoon 60' SW of small W. house

ELEVATION AND DATUM Land surface = 17.30 ft above MLLW (surveyed)

DRILLER Steve Woodstock

DATE STARTED 1700 hrs 6/18/93

DATE FINISHED 6/18/93

DRILLING EQUIPMENT & BIT SIZE 4"4" Hollow stem 8.5" bit Mobile Rambler 7" OD flights

DEPTH DRILLED 23

None ~~CASING~~

~~DEPTH~~ field Elev ~ 3' below SB2 (estimate)

DEPTH

NO. SOIL SAMPLES 1

METHOD Auger returns/ shovel

WATER LEVEL None

MEAS. PT.

SCREEN SETTING

SIZE

DEPTH

DRILLER

SIZE

DEPTH

HYDROGEOLOGIST Jim Munter

DEPTH (FEET)	ELEV. (FEET)	DESCRIPTION	CONDUC-TIVITY	DEPTH (FEET)	CASING	REMARKS
		0-4 ft GP dk grey fine-med gravel well rounded, trace sand little to no fines gravel up to 2"				
		4-5 a.a., grading as if frozen, no ice in returns				
		5-9 aa drills smooth	thawed			
		8-9 GW fine gravel with sand, med-cs trace fine sand & coarse gravel wet - drills rough ice?	8' —			
		9-10 GP, fine gravel, trace med-cs sand well rounded, took sample **SL1-1** trace cs gravel, little no fines no ice visible, drills rough, ice?	frozen			
		10-15 aa GP 1st visible ice @ 12 ft smoother 13-14 fine gravel w/sand				
		15-20 aa, caving around borehole @ surface 15'. hard turning augers - ice lens or cobbles?				
		20-23 aa. 22' secured a rod end recirculating cuttings. still drills rough very slow advance				
		TD 23 ft No well installed -	23 ↓			

GROUND-WATER MONITORING WELL LOG

LOG OF WELL SL-2

CE 2 CHUCK EGGENER
CONSULTING ENGINEERS

PROJECT AND LOCATION GAMBELL SEWAGE LAGOON NW corner 95' from landfill corner 7' from old mon. well			ELEVATION AND DATUM Land surface Approx 12' above MLLW (from 2' CE Topo (1"=50')	
DRILLER Steve Woodstock			DATE STARTED 1300 hrs mob 6/19/93	DATE FINISHED 1400 6/19/93
DRILLING EQUIPMENT & BIT SIZE 4 1/4" ID Hollow stem 8 1/2" bit 7" flights			DEPTH DRILLED 10'	
CASING	DEPTH		NO. SOIL SAMPLES	METHOD
	DEPTH		WATER LEVEL	MEAS. PT.
SCREEN SETTING	SIZE	DEPTH	DRILLER #2 Levine Ooseva	
	SIZE	DEPTH	HYDROGEOLOGIST Jim Munter	

DEPTH (FEET)	ELEV. (FEET)	DESCRIPTION	CONDUCTIVITY	DEPTH (FEET)	CASING	REMARKS
		0-5 fine gravel, GP, w' cs sand, v. dk brown, damp well rounded, little-no fines, trace debris-old diaper @ 2' few bits of landfill float. Thawed				
		5-10 a.a., more debris, plastic garbage bag @ 7,' wet 8-10 ft. (ice in plug, bottom 1.5' wet)				
		TD 10' stop drilling, clean rig, move to new site				

GROUND–WATER MONITORING WELL LOG

SL-3 LOG OF WELL SL-3
Page 1 of 2

CE 2 CHUCK EGGENER
CONSULTING ENGINEERS

PROJECT AND LOCATION GAMBELL SEWAGE LAGOON NW of FAA & SW of landfill

ELEVATION AND DATUM (est) ~10 ft below SBZ SURVEYED 21.89 @ TOC / Land surface = 18.49

DRILLER Steve Woodstock

DATE STARTED 1600 Hrs 6/19/93

DATE FINISHED 1530 6/20/93

DRILLING EQUIPMENT & BIT SIZE 4¼ ID Hollow stem/7" OD flights 8.5" bit

DEPTH DRILLED 28'

CASING ~~DEPTH~~ TYPE 2" ID / 2¼" OD - 3 x 5' Threaded PVC +0.1' - 14.9'

CASING DEPTH 6" steel - ≈6' stickup, +3.40' - 2.60'

NO. SOIL SAMPLES 0

METHOD

WATER LEVEL 0836 Hrs 6/21/93 20.83

MEAS. PT. TOP OF STEEL CASING = +3.40' a/s

SCREEN SETTING SIZE 20 slot 2×5' sections 8-12 silica sand 12-25' →

DEPTH 14.9-25.2 (inc. 0.3' endcap) 3/4 of 100 lb bag

DRILLER #2 Levine Oozeva

⇒ SWL = 17.43' b/s

~~SIZE~~ GROUT TO 2' b/s surface w/ Bentonite chips

~~DEPTH~~ 1¼ bag (50 lb bag)

HYDROGEOLOGIST Jim Munter

DEPTH (FEET)	ELEV. (FEET)	DESCRIPTION	CONDUC-TIVITY	DEPTH (FEET)	CASING	REMARKS
		0- 3 med-cs sand SP, brn, subang-subrdd moist, trace cs sand & fine gravel little to no fines 3-5 cs sand w/ fine gravel, SP, wet no-few fines 5-8, a.a. slightly coarser at bottom 8-10 fine gravel, GP with cs sand some fine-med sand subrdd-rounded wet, drills softer 10-15 cs sand SP w/ fine gravel, some med sand little to no fines wet subang.-subrd +rounded 15-20 drills smooth-med-cs sand SP, w/ trace fine gravel, fine sand little to no fines - possible large sidewall sloughing 20-25 a.a. w/ trace shell fragments SWL 20 - 1.26 = 18.74 - 0.4 = 18.34 0.4 ft stickup ~inside auger 25-28 fine gravel, GP, w/ cs sand, some fine-med sand TD 28' pulled back 3' to ~~set~~ well Bottom 6½ ft of auger has fine to cs sand w/ trace gravel on flights, SW trace silt				Enviroplug™ Medium Sodium bentonite chips for grout ¼"-1" Left cap on & buried @ +0.5 ft overnight 6/20/93 pushed steel casing & set concrete Added 2.5' to stickup of PVC inside steel TOC - Top PVC = 0.80' TOC - Top grout = 3.52 TOC - Top mounded dirt = 3.20 cement approx. 1.5' thick

GROUND-WATER MONITORING WELL LOG

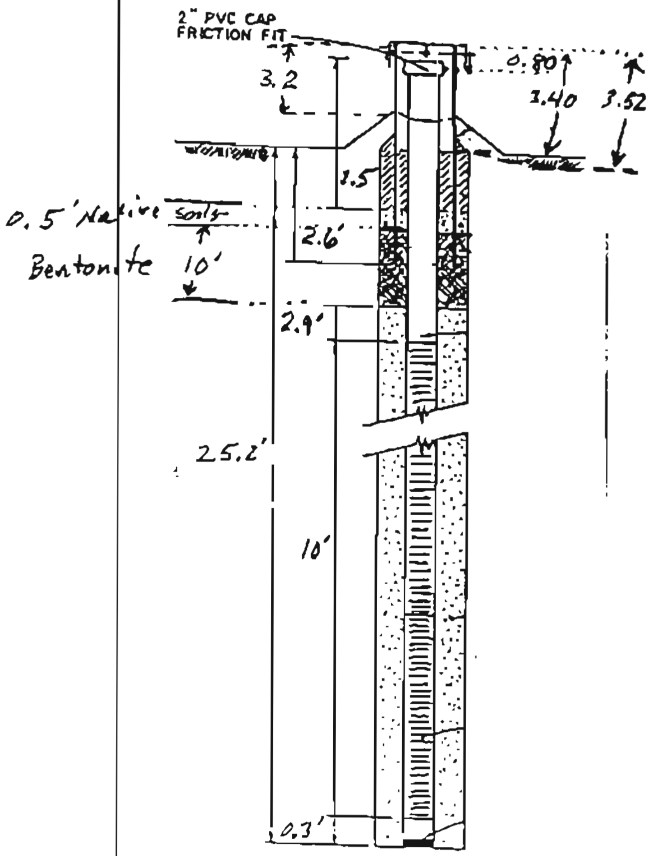
SL-3 page 2 of 2

LOG OF WELL SL-3

CE2 CHUCK EGGENER CONSULTING ENGINEERS

PROJECT AND LOCATION Gambell Sewage Lagoon		ELEVATION AND DATUM	
DRILLER		DATE STARTED	DATE FINISHED
DRILLING EQUIPMENT & BIT SIZE		DEPTH DRILLED	
CASING	DEPTH	NO. SOIL SAMPLES	METHOD
	DEPTH	WATER LEVEL	MEAS. PT.
SCREEN SETTING	SIZE / DEPTH	DRILLER	
	SIZE / DEPTH	HYDROGEOLOGIST	

DEPTH (FEET)	ELEV. (FEET)	DESCRIPTION	CONDUC-TIVITY	DEPTH (FEET)	CASING	REMARKS
		WELL DIAGRAM				



GROUND-WATER MONITORING WELL LOG

LOG OF WELL SL- 4

CE 2 CHUCK EGGENER CONSULTING ENGINEERS

PROJECT AND LOCATION GAMBELL SEWAGE LAGOON NE corner 75' E of line w/ D, 12's

ELEVATION AND DATUM 11.35' surveyed / land surface ~3' above SB4 Top steel casing / = 8.75' (MLLW

DRILLER Steve Woodstock

DATE STARTED 1230 6/20/93

DATE FINISHED 1530 6/20/93

DRILLING EQUIPMENT & BIT SIZE 4¼" ID Hollow stem

DEPTH DRILLED 15'

CASING

DEPTH +2.05-4.95 2" ID 2¼ OD threaded PVC schedule 40

~~DEPTH~~ silica sand 8-12 1¼ bag (100 lb) 3'5"-15' / 6'×6" steel casing

NO. SOIL SAMPLES 0

METHOD

WATER LEVEL 0810 hrs 6/21/93 10.58 ft

MEAS. PT. TOP OF STEEL CASING = +2.6' als

SCREEN SETTING

SIZE .020 in slot 2" ID

DEPTH 4.95-14.95 w' 0.3' endcap

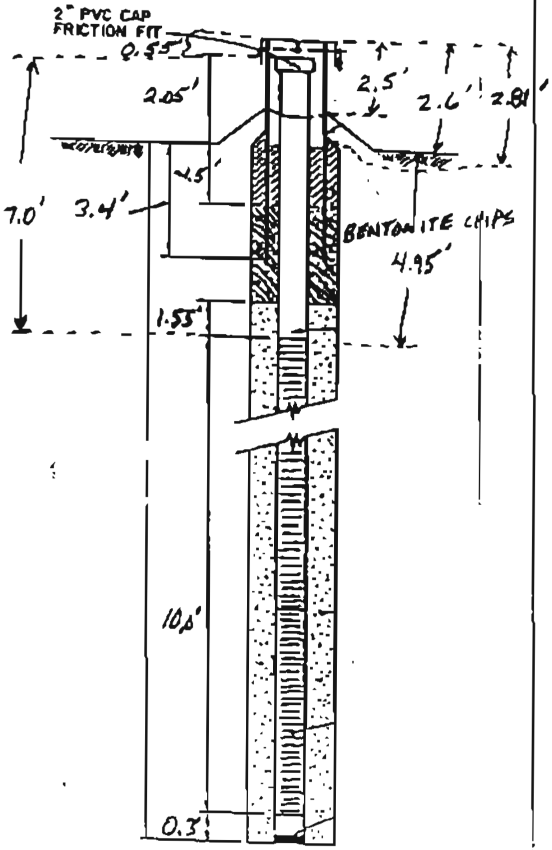
~~SIZE~~ bentonite chips 1'-3'5"

~~DEPTH~~

DRILLER Levine Oozeva

→ SWL = 7.98' bls

HYDROGEOLOGIST Jim Munter

DEPTH (FEET)	ELEV. (FEET)	DESCRIPTION	CONDUCTIVITY	DEPTH (FEET)	CASING	REMARKS
		0-5 finegravel, dk Brown, GP w' cs sand trace fine-med sand little to no fines damp, thawed. Thin ice @ ~5'? 5-10 aa, wet at 7' fewer sand, trace cs grvl 10-15 aa, with cs sand, 2 ice frags - cocoanut? smooth drilling. wet, well rounded U.L. 9'-8⅞", 1257; 9'-8¼", 1258; 9'-8½", 1300 w' 4" stickup 				Drove 2' 5" of steelcasing 1400 6/20 • left site Drive later w' end loader Pushed casing • set concrete ½ bag 1530 hrs TOC - Top PVC = 0.55' TOC - grd lvl = 2.6 ft TOC - cont = 2.81' TOC - Top dirt mound = 2.5'

GROUND-WATER MONITORING WELL LOG

SL-5 LOG OF WELL SL-5 Page 1 of 2

CE 2 CHUCK EGGENER CONSULTING ENGINEERS

PROJECT AND LOCATION GAMBELL SEWAGE LAGOON Upgradient well	ELEVATION AND DATUM 23.25' Top steel Csg (surveyed) ~ = SL-1 Land Surface = 20.30 MLLW datum
DRILLER Steve Woodstock	DATE STARTED 1600 6/20/93
	DATE FINISHED 6/21/93
DRILLING EQUIPMENT & BIT SIZE 2¼" ID Hollow stem pilot hole	DEPTH DRILLED 27.6'
CASING see p.2 DEPTH	NO. SOIL SAMPLES 0
	METHOD
CASING DEPTH	WATER LEVEL 1347 Hrs 6/21/93 21.85
	MEAS. PT. TOP OF STEEL CASING = 2.95' als ⇒ 18.90' bls
SCREEN SETTING see p.2 SIZE	DEPTH
	DRILLER #2 Levine Oozeva
SIZE	DEPTH
	HYDROGEOLOGIST Jim Munter

DEPTH (FEET)	ELEV. (FEET)	DESCRIPTION	CONDUCTIVITY	DEPTH (FEET)	CASING	REMARKS
		0-3 fine gravel, GP, well rounded, trace cs grv., brn, moist-wet trace sand, thawed				
		3-5 fine gravel with cs sand GP-SP, trace fine-med. sand, grey, moist, thawed				
		5-10 fine gravel, GP, brn, with some sand well rounded, moist-wet, possible ice lense at 7-7.5 otherwise thawed little to no fines. Sand mostly med-cs	Thawed			
		10-10.5 a.a. 10.5-11.0 - ice lense - top of pf 11-12 - softer 12-14 - harder - ice lenses 14-14.5 softer 14.5-15 harder a.a. wet, grayish pulled rod, hole dry pulled back 6' - dry @ 9'	10.5 — Frozen			
		Drilled to 10.5 ft (15'1¼" - 4.5'), pulled rod still dry - No perched W.T. waited ~5 min				
		15-20 aa except grey, ice lense @ 16 Softer 17-19, hard [illegible], fine visible ice somewhat finer at [illegible] GP-SP Samples wet				
		20-25 Very rough - high ice ? or larger gravel driller says drills like cobbles - can feel teeth bit ~ every revolution @ 25' Pulled rod - 25'3½" - 8" stickup - dry - rod went klunk on rock at bottom	31 — Thawed			
		25-30 Very rough drilling - cobbles ?, some root fibers in cuttings cuttings aa, sloughing				
		30-35 intermittent soft & hard, bottom PF @ 31' ?				
		W.L. sand cobbles stickup 1307 21' - 2.5" · 20'9½" - 9" · 20' ½" 1733 2? - 10¾" 1817 21 · 11⅞"				Pulled augers at 1818

GROUND-WATER MONITORING WELL LOG

LOG OF WELL SL-5 page 2 of 2

CE 2 CHUCK EGGENER CONSULTING ENGINEERS

PROJECT AND LOCATION GAMBELL SEWAGE LAGOON/Upgradient well

ELEVATION AND DATUM

DRILLER Steve Woodstock

DATE ~~STARTED~~ Continued 6/21

DATE FINISHED 1330 6/21

DRILLING EQUIPMENT & BIT SIZE 4¼" ID Hollow stem

DEPTH DRILLED 27.6

CASING DEPTH +1.0-17.3' 2" ID sch 40 + 20' (-1.72' top cut)

CASING DEPTH 6⅝" ID 16 5/800 steel casing +2.8' - 3.2'

NO. SOIL SAMPLES 0

METHOD

WATER LEVEL 21.85

MEAS. PT. Top of Steel Casing

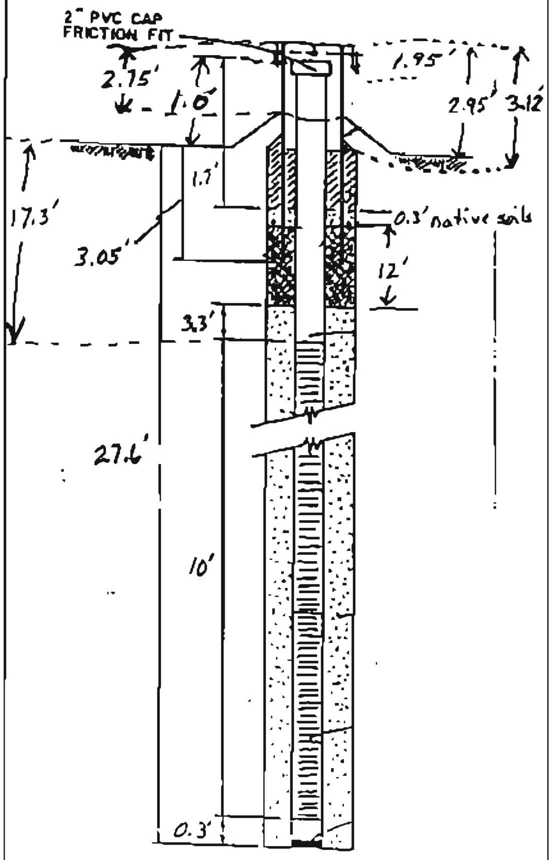
SCREEN SETTING SIZE .020" x 10' + 0.3' cap 180 lbs 8-12 silica sand 14'-27' DEPTH 17.3' - 27.6'

SCREEN SETTING SIZE Enviroplug medium benton. chips 2 bags 2' - 14' ~~DEPTH~~

DRILLER #2 Levine Oozeva

HYDROGEOLOGIST Jim Munter

DEPTH (FEET)	ELEV. (FEET)	DESCRIPTION	CONDUCTIVITY	DEPTH (FEET)	CASING	REMARKS
		0-10' drills smooth - following pilot hole 10-12' a a 12-15' chatter - in permafrost 15-20' a a except smooth 16-18', soft @ 20' bit plug fell 1' 20-23 rough - bit catches freq. 23-25 very slow + rough 30.4 - 2.8 27.6' TD @ 25' 1020 hrs W.L. 25.00 - 4'4¼ 20'7¾" 6" stickup 20' 1¾" 25-27.6 very slow + rough. Refusal at 27.5				Portland cement grout outside 6" casing 3.1' - 4.8' below TOC TOC - cement = 3.12' TOC - grd lvl = 2.95' TOC - Top PVC = 1.95' TOC - Top Mound = 2.75'



APPENDIX B
Quality assurance plan

A Quality Assurance Project Plan for
Gambell Sewage Lagoon Groundwater Dynamics Investigation

Principal Investigator:

James A. Munter
Hydrogeologist
Alaska Hydrologic Survey
Division of Water
Department of Natural Resources
State of Alaska

James A. Munter 16-June-93
Signature Date

PROJECT DESCRIPTION

Site History

The proposed site of the Gambell Sewage Lagoon is near the City of Gambell on St. Lawrence Island, Alaska. The location of the site is latitude 63 degrees, 47 minutes, 1 second north, longitude 171 degrees, 45 minutes, 53 seconds west. Although the site is currently undeveloped and has no known prior site history, the proposed lagoon site is adjacent to an area that has historically been used as a landfill by the city of Gambell. A scope of work for the project is available from the author of this report upon request.

Project Objectives

The goal of the project is to evaluate the suitability of the site for hosting a percolating-type sewage lagoon. In addition to evaluating the suitability of the soils and aquifer to physically accommodate the expected influx of fluids, an objective of the study is to determine whether or not existing groundwaters at the site are naturally potable. The proximity of the site to the coast suggests that water may be brackish as a result of periodic storm surges. An additional objective is to document the pre-development nitrate concentrations in groundwater at the site. Water will be sampled and on site measurements of temperature and specific conductance will be made. Water samples will be sent to a laboratory for analysis of nitrate, chloride and total dissolved solids.

Approach

A suite of three samples will be collected from four wells shown on figure 1. Wells will be constructed according to specifications shown in figure 2. The wells will be constructed according to the specifications shown in the drilling contract (Appendix A). Each well will be purged with a hand operated piston-type pump for one hour or until sediment-free water is obtained, whichever occurs first. Samples will be obtained with a disposable polyethylene bailer after purging at least 4 casing volumes of water. Samples will be preserved according to USEPA (1983) and packed and shipped via Alaska Airlines Goldstreak courier service to the Alaska Division of Water laboratory in Fairbanks, Alaska, where all analyses will be conducted. A field data form (figure 3) will be filled out for each suite of samples.

PROJECT ORGANIZATION AND RESPONSIBILITIES

As a result of the relatively small scope of this project, only a few personnel are involved. Their roles are shown below.

James A. Munter
Project Manager, QA officer, Field Supervisor and Sampler

Jim Vohden
Lab Director, analyst

Howard Grey Associates
Drilling Contractor

Name 1
Name 2
Drillers

QUALITY ASSURANCE OBJECTIVES AND CRITERIA FOR DETERMINING PRECISION, ACCURACY, COMPLETENESS, REPRESENTATIVENESS AND COMPARABILITY OF DATA

Quality assurance requirements for analyses are shown in Table 1 below.

Parameter	Method	Precision (RPD)	Accuracy (% recovery)	Completeness
Chloride	300.0	+/-20%	80-120	95
Nitrate + nitrite	353.2	+/-20%	80-120	95
Total Dissolved Solids	160.1	+/-20%	80-120	95

Percent Recovery (%R) is calculated as follows:

$$\%R = \frac{(SSR - SR)}{(SA)} \; X \; 100$$

where:

SSR = spiked sample amount
SR = sample amount
SA = amount of spike added

Relative Percent Difference (RPD) is calculated as follows:

$$RPD = \frac{|D_2 - D_1|}{(D_1 + D_2)/2} \; X \; 100$$

where:

D_1 = first sample result
D_2 = second sample result

SAMPLING PROCEDURES

Sampling procedures used will follow general guidelines contained in Nielsen (1991).

SAMPLE CUSTODY

Sample containers obtained from the lab will be transported using common carriers to the field and back to the lab. Shipping and receiving documents will be kept with project files.

CALIBRATION PROCEDURES AND FREQUENCY AND TRACEABILITY OF STANDARDS

The field specific conductance meter will be calibrated in accordance with manufacturer specifications. Laboratory equipment is calibrated according to standard operating procedures described in USEPA (1983).

ANALYTICAL PROCEDURES

Analytical procedures are shown in Table 1.

DATA REDUCTION, VALIDATION AND REPORTING

Standard operating procedures described by APHA (1989) regarding data reduction, validation and reporting will be followed.

INTERNAL QUALITY CONTROL CHECKS

One set of field blanks will be collected using standard sampling equipment and deionized water. One set of field duplicates will be collected.

PERFORMANCE AND SYSTEM AUDITS

The Alaska Division of Water laboratory participates in performance evaluations conducted by the US Environmental Protection Agency and the US Geological Survey. These consist of the lab analyzing blind samples for certain chemical constituents and is conducted on a biannual basis.

PREVENTIVE MAINTENANCE

Maintenance of field and laboratory equipment generally follows manufacturers suggestions.

SPECIFIC STANDARD OPERATING PROCEDURES USED TO ASSESS DATA PRECISION, ACCURACY, REPRESENTATIVENESS AND COMPARABILITY

Data precision and accuracy will be determined using the equations described previously. Data completeness will be calculated as a percent of useable data of all possible data. Data representativeness and comparability will be evaluated by determining whether or not total dissolved solids for any specific sample is within the range given by the following relationship Hem (1985, p.67):

$0.55 \times \text{specific conductance} \leq \text{TDS} \leq 0.75 \times \text{specific conductance}$

Also, chloride concentration will be compared to TDS concentration to ensure that it is less.

CORRECTIVE ACTION FOR OUT-OF-CONTROL SITUATIONS

The project manager will be notified in writing of any measurement system found to be out-of-control, and will initiate corrective action. Appropriate corrective actions may include remeasuring, reanalyzing or recollecting a sample. If this is not feasible, the results will be discarded or used with cautionary statements.

QUALITY ASSURANCE REPORTING

Any quality assurance evaluations will be reported in writing to the project manager.

REFERENCES CITED

American Public Health Association, American Water Works Association, Water Pollution Control Federation, 1989, Standard methods for the Examination of Water and Wastewater, 17th edition: APHA, AWWA, WPCF, Washington, D.C.

Hem, J.D., 1985, Study and interpretation of the chemical characteristics of natural water, Third Edition: U.S. Geological Survey Water-Supply Paper 2254, 263 p.

Nielsen, David M., editor, 1991, Practical Handbook of Ground-water Monitoring: Chelsea, Michigan, Lewis Publishers, Inc. 717 p.

USEPA, 1983, Methods for chemical analysis of water and wastewater: Cincinnati Ohio, U.S. Environmental Protection Agency.

37

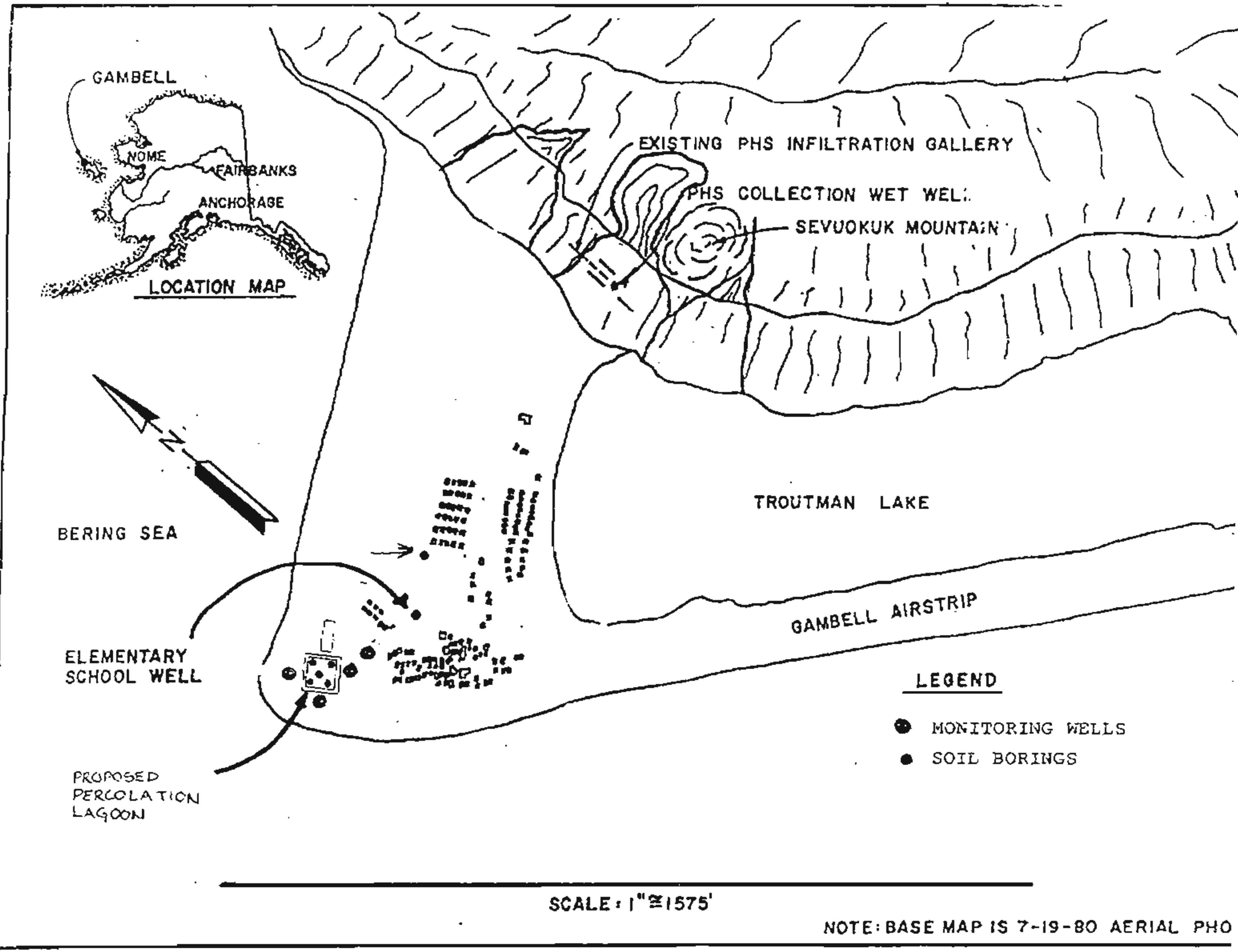
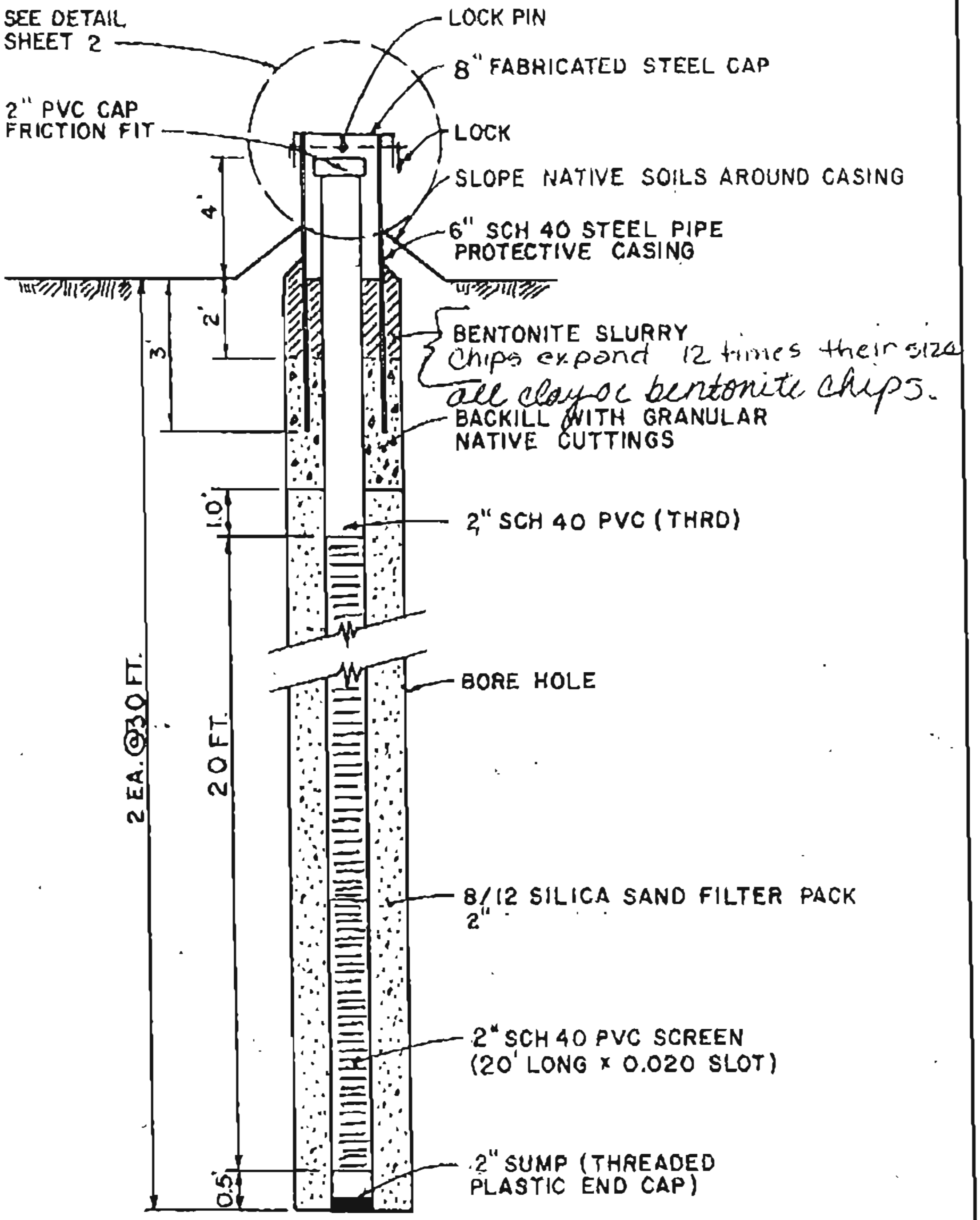


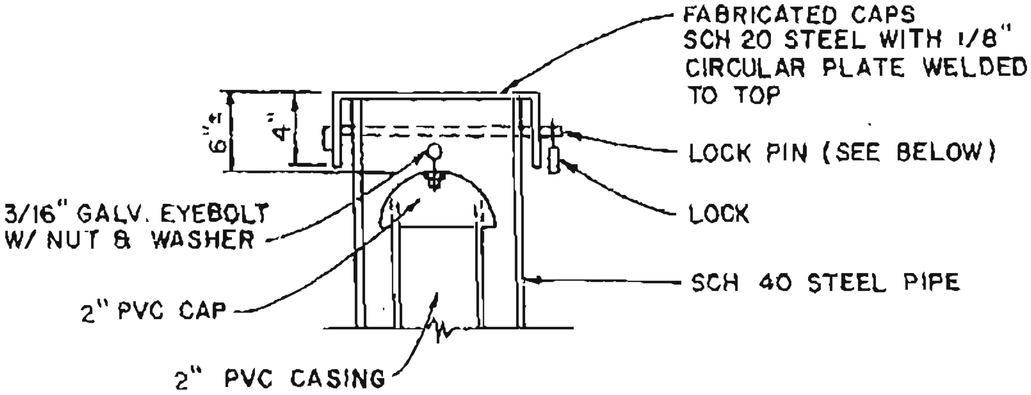
Figure 1. Location of proposed sewage lagoon.



NOTE: PLASTIC MATERIALS TO BE THREADED/FLUSH
IN ACCORDANCE WITH ASTM F 480-88.

LAGOON SITE GROUNDWATER MONITORING WELLS	NO SCALE SHEET 1 OF 2

Figure 2. Proposed monitoring well construction detail.

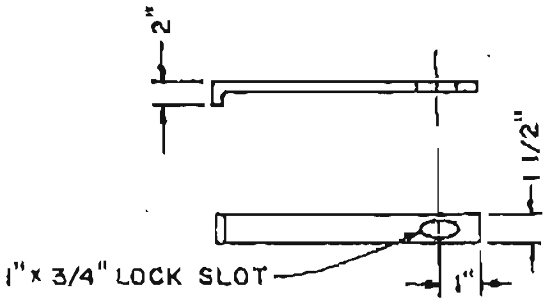


NOTE: CAP & CASING SLOTTED TO ACCOMMODATE LOCK PIN

LOCKING COVER DETAIL

SCHEDULE OF DIMENSIONS

MARK	QUANT.	DIMENSION
CAP	4	8" DIAMETER
PIN	4	10:5" LENGTH



NOTE: FABRICATE LOCK PINS
FROM 1/4"x 1 1/2" STEEL STRAP.

LOCK PIN DETAIL

LAGOON SITE
MONITORING WELL DETAIL

NO SCALE

SHEET 2 OF 2

Figure 2. Proposed monitoring well construction detail (cont.).

Page ___ of ___

STATE OF ALASKA - DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
PO BOX 772116, EAGLE RIVER AK 99577-2116
(907) 696-0070

WATER QUALITY FIELD NOTES - GROUND WATER

Location/Project: ________________ Date: ________

Collected by: ________________

Well Owner: ________________ Weather Conditions: ________

Use of Well: ________________

Sampling Equipment (for measuring water level, purging, sampling and filetering. include model if appropriate): ________________

Well Name: ________________

Pipe top elevation (MSL)	
Reference elevation if different	Time sample withdrawn
Measured depth to water (ft)	Field temperature (°C)/time
Correction	Field conductivity (uncorrected)/time
Total depth to water (ft)	Field conductivity (slope corrected)
Water elevation (MSL)	Field pH (std. units)/time
Depth to bottom of well (ft)	Color (Y/N)
Volume H_2O in well (gal)	Odor (Y/N)
Volume to be purged (4Xvol.in well)	Turbidity (Y/N)
Time purging begun	Sample Field filtered? (Y/N)
Time purging completed	Well cap and lock replaced? (Y/N)
Purged dry? (Y/N)	

Analysis:						
Bottle:	unfiltered, well-mixed	unfiltered, acidified	field-filtered, acidified	field-filtered, unacidified		
volume (ml):						
preservative:						

Alkalinity: Sample Size ____ml; H_2SO_4 ____ (factor ___) instruments ________

Titer added (digits) pH Calculations

COMMENTS: ________________

Figure 3. Water quality field note form

APPENDIX B-1

Drilling Contract

CITY OF GAMBELL

REQUEST FOR QUOTATION

Introduction

The City of Gambell is requesting quotations from qualified geotechnical drilling companies to provide a drill rig operated to perform the following tasks for the City of Gambell.

1. Install four each 2" groundwater monitoring wells to a maximum depth of 30 feet with a 4.25" I.D. hollow stem auger. • 10 FT BELOW WATER TABLE
   <4 5/8" I.D. — O.D. 10">
2. Drill up to six geotechnical test borings with a 3.25" I.D. hollow stem auger to a maximum depth of 50 feet. Holes must be sampled at 5-foot intervals to a maximum depth of 30 LF, using 1.25" I.D. split spoon sampler.
   • SOIL DOWN TO WATER TABLE

All holes will be drilled on the west side of the community within 1/2 mile of the center of town. The work will be performed under the direction of the City's consultant hydrogeologist during late June 1993. A recent drill log from a nearby hole is attached. The Owner will furnish the materials listed later in this solicitation. All other materials shall be furnished by the Contractor. The Owner shall transport the Contractor's drill rig, tools and appurtenances to Gambell on its chartered DC-6 at no cost to the Contractor. All equipment offered under this solicitation must fit through the side cargo door of a DC-6. The Owner anticipates the DC-6 will depart from the Palmer airport. Equipment must be to delivered to the freight carrier by June 11, 1993. Drilling must begin by June 15, 1993.

If a skid-mounted drill rig is provided, the Owner shall help the driller move and set up the rig at the various drill sites.

The Owner will also provide room and board for a maximum of two personnel from the drilling company and a four-wheeler and trailer for their use.

Fuel is available for purchase from the Gambell Native Store.

The Contractor shall be paid under four bid items:

1. Mobilization/Demobilization, which shall include transporting the rig, drill stem, tools and appurtenances, and the Owner-furnished materials (to be picked up by the Contractor at a maximum of two sites in Anchorage) to the Palmer airport. In addition, mobilization/demobilization shall include transporting drilling personnel to and from Gambell and getting the drill rig and appurtenances out of Gambell at the end of the drilling program. The Owner will load the drill rig onto a commercial carrier at the Contractor's direction. Mobilization/demobilization shall be paid lump sum.

2. Monitoring Wells. All labor, equipment and fuel required to install the monitoring wells in accordance with the attached plans and specifications shall be paid for per-lineal-foot of PVC casing installed below the ground surface. The anticipated depth is 30 feet.

3. Geotechnical Drilling. Geotechnical drilling shall be paid per hour. Geotechnical drilling shall include time logged moving the rig between holes, boring, soil sampling and performing other drill services directed by the hydrogeologist. Drilling will be paid from the time the auger bites soil on the first geotechnical boring to the time tools are withdrawn from the final boring. Breakdown time will not be paid for. For purposes of payment, time will be rounded to the nearest 1/2 hour.

4. Standby Time. Standby time shall be paid hourly when the equipment, materials and personnel are prepared to drill or move the rig but are not directed to do so for the convenience of the hydrogeologist. Standby time shall not be paid when driller's equipment is not operational.

Owner-Furnished Items

4 ea.	2" female bottom plug, Sch. 40
8 ea.	2" x 5' 0.020 screen PVC, Sch. 40
4 ea.	2" x 10' 0.020 screen PVC, Sch. 40
6 ea.	2" x 10' blank PVC pipe, Sch. 40
4 ea.	2" slip-on top cap, Sch. 40
2 ea.	50# sack Bentonite grout
20 ea.	1 sack of 8/12 silica sand
4 ea.	casings—7'-6" long, 6" diameter.
4 ea.	caps—8" diameter, 4" height
4 ea.	lock pins

The Work

The drilling contractor shall provide all labor, materials (other than those listed above), equipment, supervision, and expertise to construct the wells in accordance with the information provided in this solicitation. Workmanship shall conform to industry standards for quality construction of permanent monitoring wells. Wells and geotechnical borings shall be drilled straight and casing installed plumb. The wells and geotechnical borings will be installed by boring with a hollow stem auger. The monitoring well casing and sandpack will be placed inside the hollow stem. Additional sand will be added to the annular space between the plastic screen and the stem of the auger as the auger is removed. After the screen pack is placed, the annular space between the drill hole and the casing shall be backfilled with 3/4" minus granular cuttings placed in a manner which will prevent against future settlement of the column.

The 2" well casing shall be centered inside the 6" steel surface protective casing as shown on the drawings. Bentonite and slurry shall be handled and installed in accordance with the manufacturer's recommendations.

Any materials needed for the construction which are not identified above, with the exception of the locks, shall be furnished by the contractor at no additional cost to the Owner.

Our intent is to construct quality wells which will prove to be serviceable for several decades. Bidders must provide details on their equipment and the construction methods they propose to use.

Commercial Terms

Quotes will be received by Jane Dale, CE2 Engineer until 5:00 p.m., May 20, 1993.

Payment will be made within fourteen (14) days of completion of the work and receipt of a properly documented billing.

Labor Rates

Contractors are reminded that Alaska Department of Labor wage rates apply to work done under this solicitation.

Fees

The City of Gambell will pay for any storage fees at the Palmer airport. All other fees shall be included in the bid.

Rejection of Bids

The City of Gambell reserves the right to accept or reject any and all bids, and to waive any and all technicalities it deems appropriate, and to rebid as it deems necessary and proper.

Acceptance of Bidder's Offer

The bidder's firm price shall be construed as its offer, pursuant to the bid document to be accepted by the City of Gambell. The City of Gambell's acceptance of the bidder's offer shall be by issuance of purchase order. The Uniform Commercial Code as adopted by the State of Alaska shall control. The laws of the State of Alaska shall govern the rights and obligations of all parties.

Bid Delivery Date

All bids shall be faxed to the office of Chuck Eggener Consulting Engineers (fax number (907) 349-1015) no later than 5:00 p.m. May 20, 1993, with a follow-up copy to be mailed to:

Chuck Eggener Consulting Engineers/City of Gambell
P.O. Box 232946
Anchorage, AK 99523-2946

APPENDIX C
Grain-size analyses and permeameter test results

ALASKA
T E S T L A B
A Division of DOWL, Incorporated

ALASKA'S *ONLY*
AASHTO ACCREDITED
CONSTRUCTION
MATERIALS LABORATORY

Chuck Eggener Consulting Engineers
P.O. Box 232946
Anchorage, Alaska 99523-2946

W.O.#A25618
June 30, 1993

Attention: Ms. Jane Dale

Subject: Particle-Size Analysis
Gambell Water Project

Dear Ms. Dale:

The particle-size distribution of your soil was measured in the laboratory. The published methods for this test are:

- ASTM C 117, "Material Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing;"
- ASTM C 136, "Sieve Analysis of Fine and Coarse Aggregates;"
- ASTM D 422, "Particle Size-Analysis of Soils;"
- AASHTO T-11, "Material Finer Than 75-µm Sieve in Mineral Aggregates;"
- AASHTO T-27, "Sieve Analysis of Fine and Coarse Aggregates;"
- AASHTO T-30, "Mechanical Analysis of Extracted Aggregate;"
- AASHTO T -88, "Particle Size Analysis of Soils;" and
- AK DOT/PF ATM T-7, "Sieve Analysis of Fine and Coarse Aggregates."

Alaska Testlab's standard procedure is in conformance with these standards, with the following descriptions:

- The coarse fraction of non-extracted soils is not washed unless the coarse particles appear to be significantly coated with fines;
- The fine fraction of the soil is *always* washed;
- The plus 3-inch fraction is not routinely included in the test due to the large sample mass required for a representative sample; The estimated percentage of plus 3 inch material in the sample is shown on the test report; and
- The mass of the coarse and fine test fractions are reported.

The soil is classified in accordance with ASTM D 2487, "Classification of Soils for Engineering Purposes (Unified Soil Classification System)." The frost classification is identified in accordance with Corps of Engineers and Municipality of Anchorage (MOA) procedures.

The permeability of your soil was determined in accordance with ASTM D2434, "Permeability of Granular Soils."

The test results are attached. If you have any questions regarding the test procedures or the results, please call.

Sincerely,
ALASKA TESTLAB

Howard K. Weston, P.E.
Technical Director

4040 B STREET • ANCHORAGE • ALASKA • 99503-5858 • 907/562-2000 • FAX 907/563-3953

ALASKA
TESTLAB
A Division of DOWL, Incorporated

4040 B Street Anchorage, Alaska 99503
(907) 562-2000 FAX (907) 563-3953

Client: Chuck Eggener Consulting Engineers

Project: Gambell Water Project

Location: SL1-1, Submitted by Client

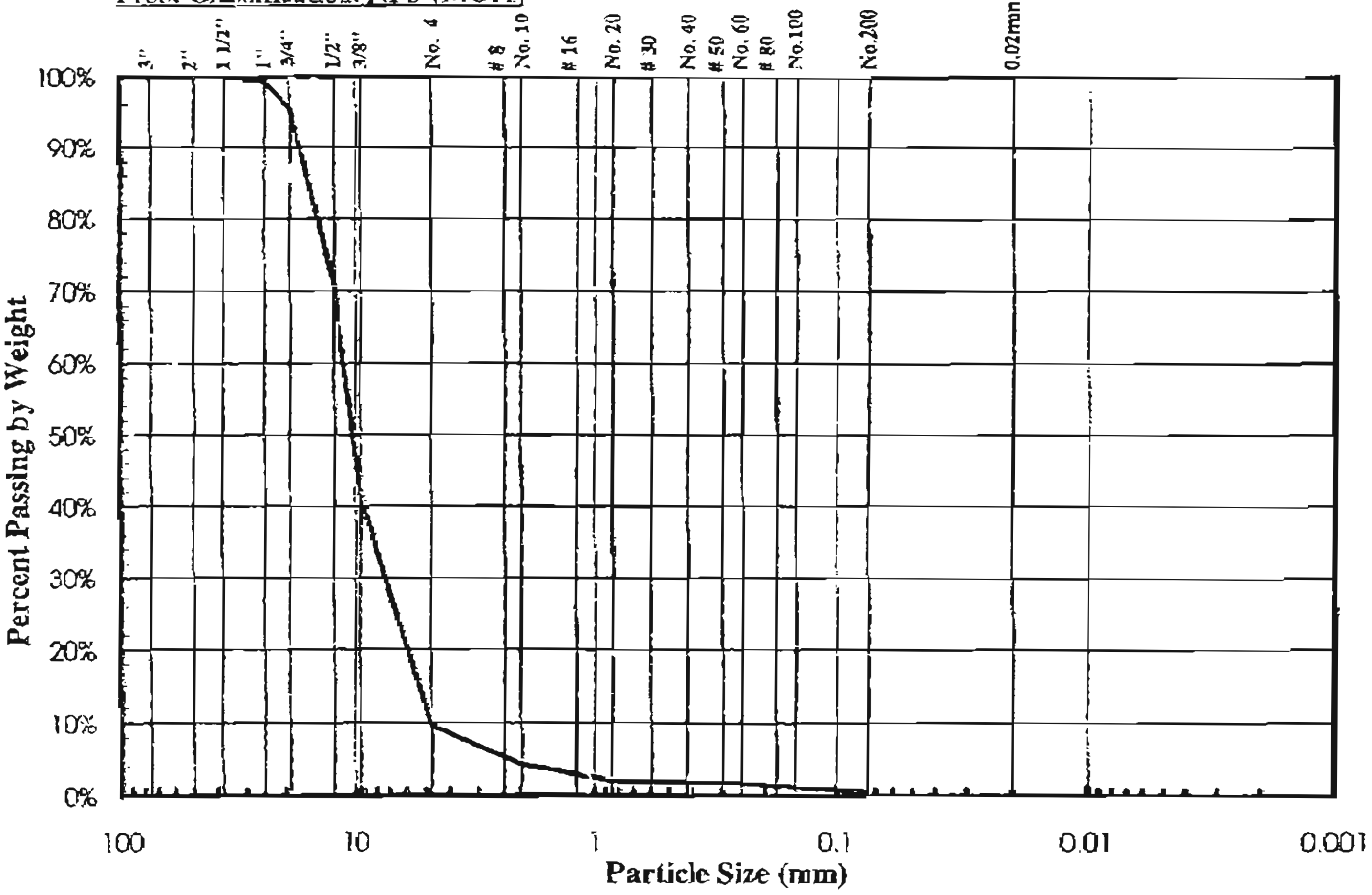
PARTICLE-SIZE DISTRIBUTION

W.O. A25518
Lab No. 629
Received: June 25, 1993

Permeability = 9.3 cm/sec

Engineering Classification: Poorly Graded GRAVEL , GP

Frost Classification: NFS (MOA)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"	100%	
1"	99%	
3/4"	95%	
1/2"	71%	
3/8"	42%	
No. 4	10%	
Total Wt. of Coarse Fraction = 22075g		
No. 8		
No. 10	4%	
No. 16		
No. 20	2%	
No. 30		
No. 40	2%	
No. 50		
No. 60	2%	
No. 80		
No.100	1%	
No.200	0.7%	
Total Wt. of Fine Fraction = 123.2g		
0.02 mm		

ALASKA TESTLAB
A Division of DOWL, Incorporated

4040 B Street Anchorage, Alaska 99503
(907) 562-2000 FAX (907) 563-3953

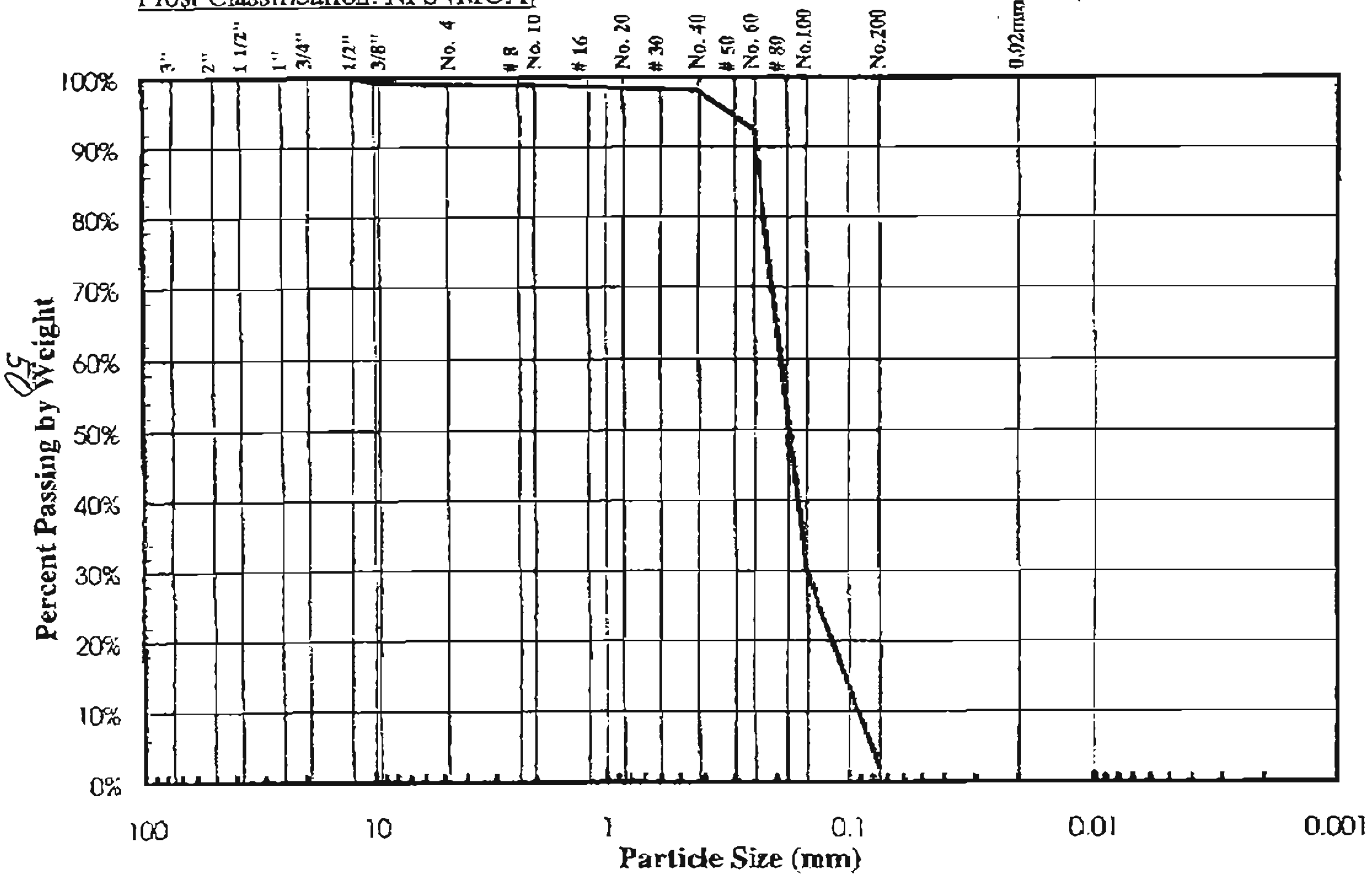
Client: Chuck Eggener Consulting Engineers
Project: Gambell Water Project

Location: SB2-1, Submitted by Client

PARTICLE-SIZE DISTRIBUTION

W.O. A25618
Lab No. 630
Received: June 25, 1993

Engineering Classification: Poorly Graded SAND , SP
Frost Classification: NFS (MOA)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"		
1/2"	100%	
3/8"	99%	
No. 4	99%	
Total Wt. of Coarse Fraction = 5212g		
No. 8		
No. 10	99%	
No. 16		
No. 20	98%	
No. 30		
No. 40	98%	
No. 50		
No. 60	92%	
No. 80		
No.100	30%	
No.200	2.2%	
Total Wt. of Fine Fraction = 127.8g.		
0.02 mm		

ALASKA
T E S T L A B
A Division of DOWL, Incorporated

4040 B Street Anchorage, Alaska 99503
(907) 562-2000 FAX (907) 563-3953

Client: Chuck Eggener Consulting Engineers

Project: Gambell Water Project

Location: SB3-1, Submitted by Client

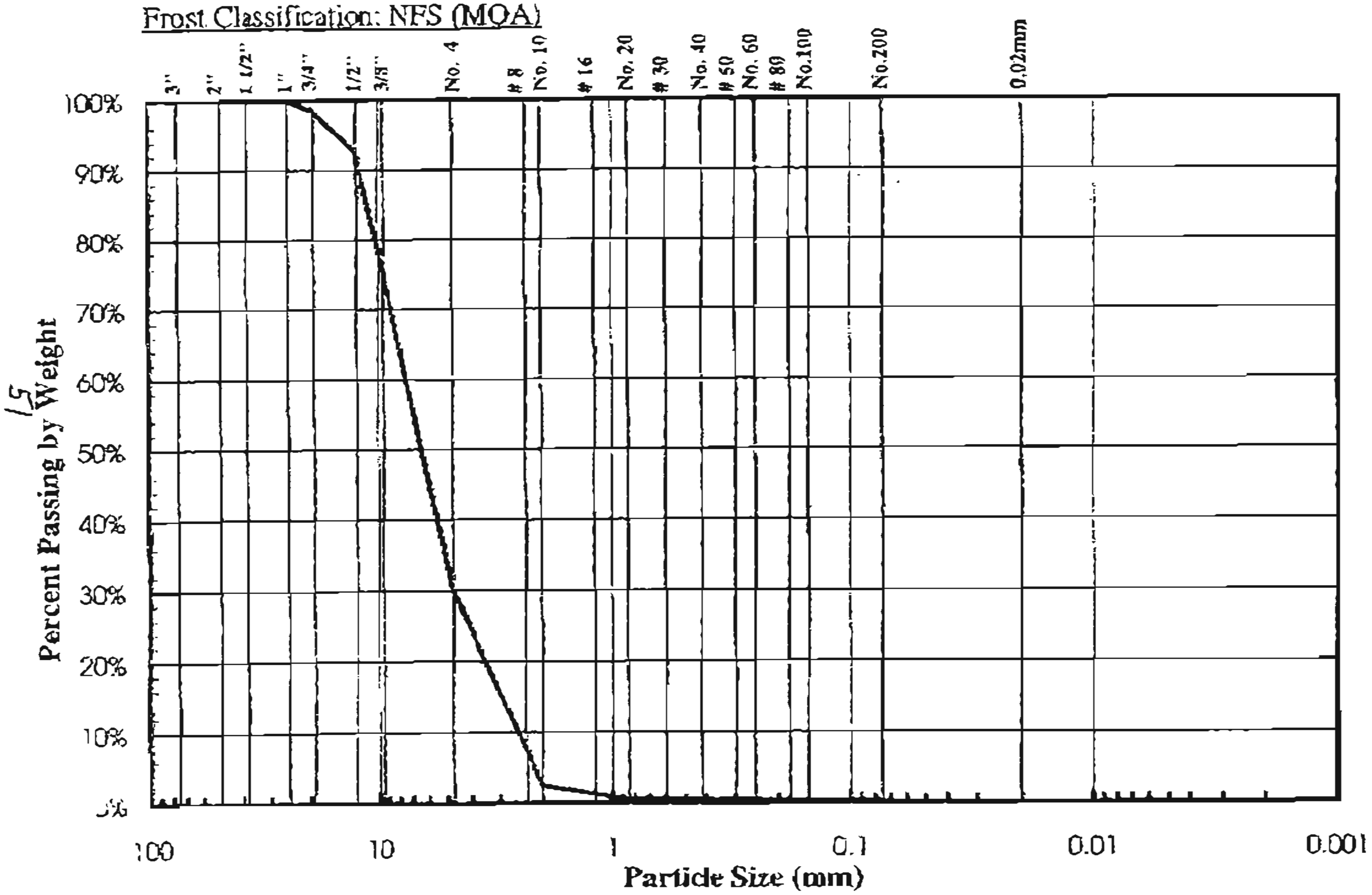
PARTICLE-SIZE DISTRIBUTION

W.O. A25618
Lab No. 631
Received: June 25, 1993

Permeability = 5.5 cm/sec

Engineering Classification: Poorly Graded GRAVEL with Sand, GP

Frost Classification: NFS (MOA)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"	100%	
3/4"	98%	
1/2"	93%	
3/8"	76%	
No. 4	30%	
Total Wt. of Coarse Fraction = 16333g		
No. 8		
No. 10	2%	
No. 16		
No. 20	0%	
No. 30		
No. 40	0%	
No. 50		
No. 60	0%	
No. 80		
No.100	0%	
No.200	0.2%	
Total Wt. of Fine Fraction = 127.6g		
0.02 mm		

ALASKA TESTLAB
A Division of DOWL, Incorporated

4040 B Street Anchorage, Alaska 99503
(907) 562-2000 FAX (907) 563-3953

Client: Chuck Eggener Consulting Engineers

Project: Gambell Water Project

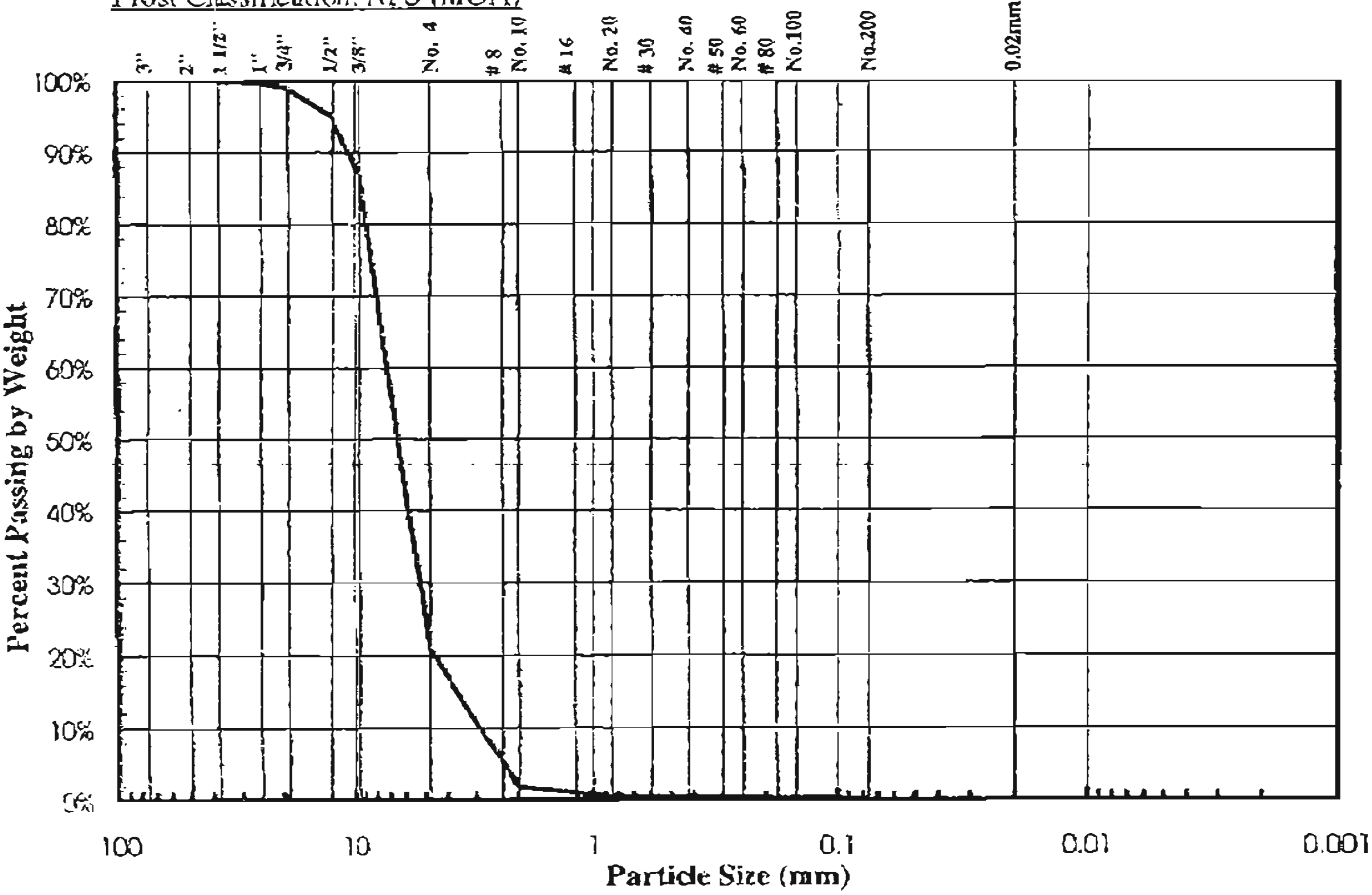
Location: SB4-1, Submitted by Client

PARTICLE-SIZE DISTRIBUTION

W.O. A25618
Lab No. 632
Received: June 25, 1993

Engineering Classification: Poorly Graded GRAVEL with Sand, GP

Frost Classification: NFS (MOA)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"	100%	
1"	100%	
3/4"	99%	
1/2"	95%	
3/8"	87%	
No. 4	21%	
Total Wt. of Coarse Fraction = 15345g		
No. 8		
No. 10	2%	
No. 16		
No. 20	0%	
No. 30		
No. 40	0%	
No. 50		
No. 60	0%	
No. 80		
No.100	0%	
No.200	0.1%	
Total Wt. of Fine Fraction = 156.2g		
0.02 mm		

ALASKA TESTLAB
A Division of DOWL, Incorporated

4040 B Street Anchorage, Alaska 99503
(907) 562-2000 FAX (907) 563-3953

Client: Chuck Eggener Consulting Engineers

Project: Gambell Water Project

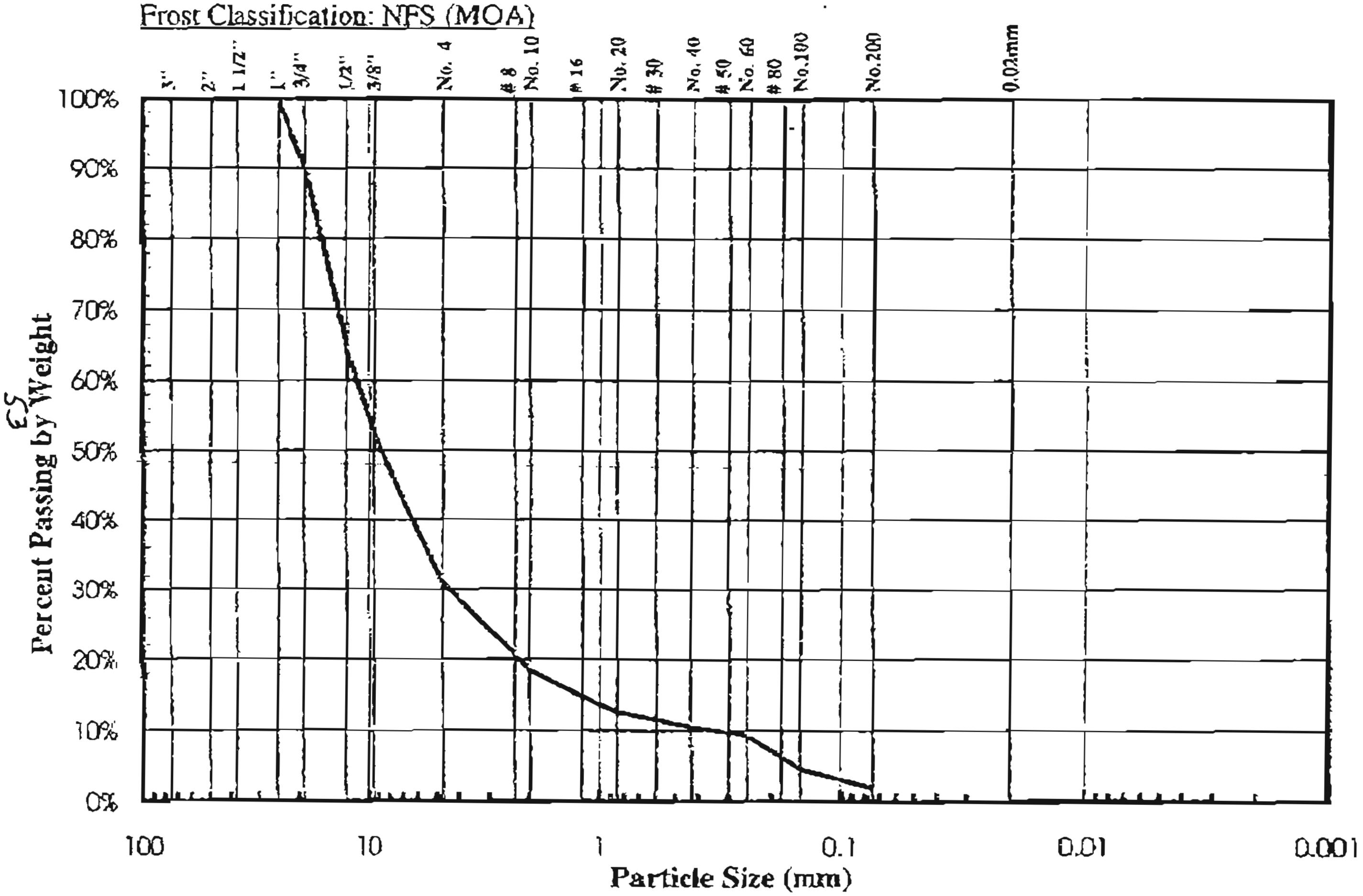
Location: SB5-1, Submitted by Client

PARTICLE-SIZE DISTRIBUTION

W.O. A25618
Lab No. 633
Received: June 25, 1993

Engineering Classification: Poorly Graded GRAVEL with Sand, GP

Frost Classification: NFS (MOA)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"	100%	
3/4"	90%	
1/2"	64%	
3/8"	53%	
No. 4	31%	
Total Wt. of Coarse Fraction = 1163.4g		
No. 8		
No. 10	18%	
No. 16		
No. 20	13%	
No. 30		
No. 40	10%	
No. 50		
No. 60	9%	
No. 80		
No.100	5%	
No.200	2%	
Total Wt. of Fine Fraction = 184.1g		
0.02 mm		

ALASKA TESTLAB
A Division of DOWL, Incorporated

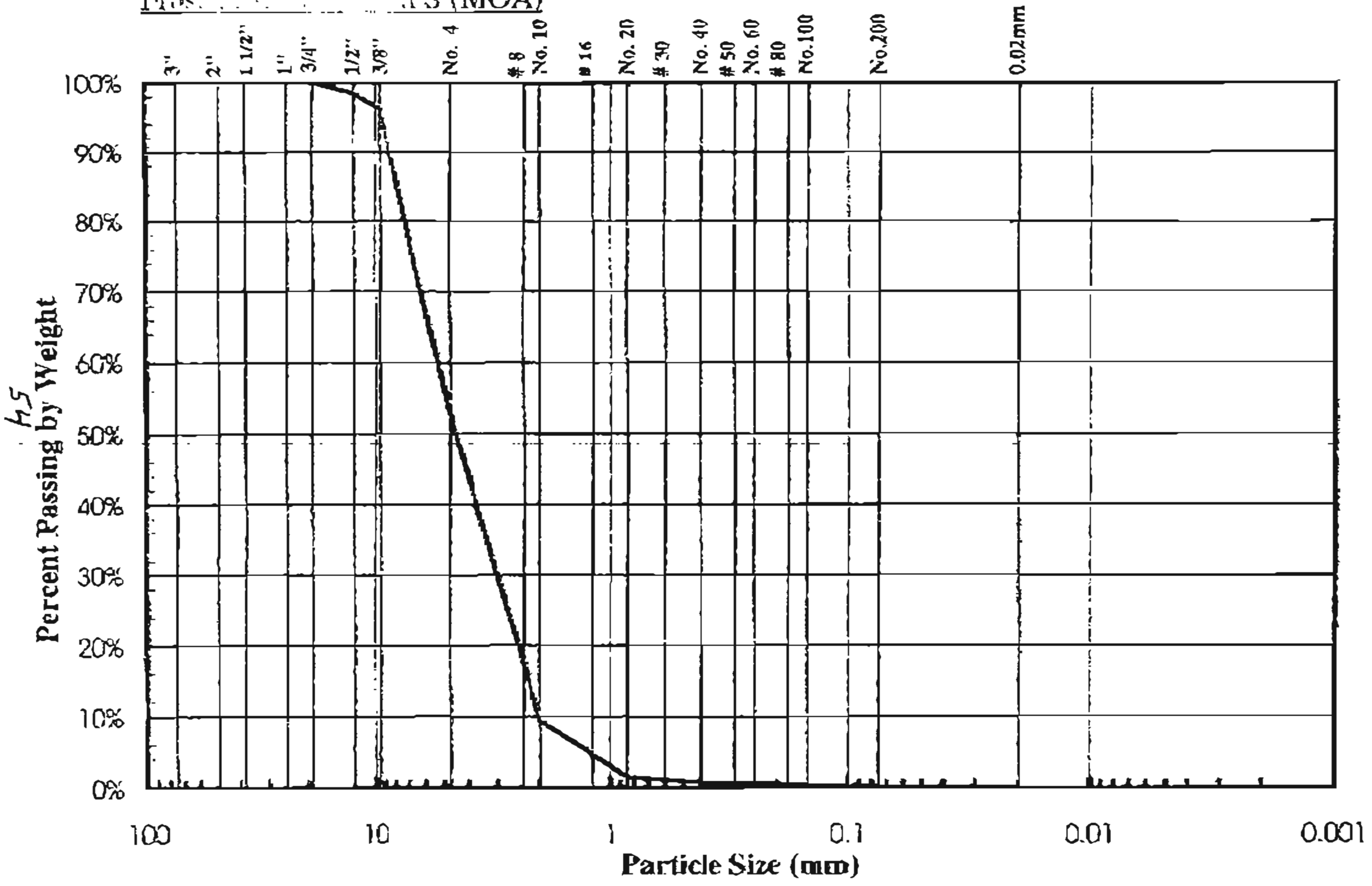
4040 B Street Anchorage, Alaska 9950[illegible]
(907) 562-2000 FAX (907) 563-3953

Client: Chuck Eggener Consulting Engineers
Project: Gambell Water Project
Location: SB6-1, Submitted by Client

PARTICLE-SIZE DISTRIBUTION

W.O. A25618
Lab No. 634
Received: June 25, 1993

Engineering Classification: Poorly Graded SAND with Gravel, SP
Fros[illegible] S (MOA)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test =~0%		
3"		
2"		
1 1/2"		
1"		
3/4"	100%	
1/2"	99%	
3/8"	96%	
No. 4	53%	
Total Wt. of Coarse Fraction= 14335g		
No. 8		
No. 10	9%	
No. 16		
No. 20	2%	
No. 30		
No. 40	1%	
No. 50		
No. 60	1%	
No. 80		
No.100	0%	
No.200	0.2%	
Total Wt. of Fine Fraction = 136.1g		
0.02 mm		

APPENDIX D

Water-level and slug test data

WATER LEVEL DATA

Monitoring well SL-3

Location -- NW of F.A.A./SW of landfill/City of Gambell

Measuring point (m.p.) -- top of steel casing

Measuring point elevation (mllw[1]) - - 21.89 feet

Height of measuring point above land surface -- 3.40 feet

Measuring equipment -- steel tape.

Depth to water below m.p.	Date	Time	Elevation of water level (from mllw)
20.82	06/21/93	08:36	1.07
20.82	06/21/93	08:39	1.07
20.43	06/21/93	14:06	1.46
20.48	06/21/93	14:34	1.41
20.04	06/23/93	09:20	1.85
20.09	06/23/93	11:27	1.80
19.93	06/23/93	13:42	1.96
19.90	06/23/93	15:27	1.99
20.06	06/23/93	17:23	1.83
20.32	06/23/93	19:14	1.57
20.57	06/23/93	21:19	1.32

---

[1] Mean lower low water datum

WATER LEVEL DATA

Monitoring well SL-4

Location -- NE corner of sewage lagoon near large barrel dump/City of Gambell

Measuring point (m.p.) -- top of steel casing

Measuring point elevation (mllw[1]) -- 11.35 feet

Height of measuring point above land surface -- 2.6 feet

Measuring equipment -- steel tape.

Depth to water below m.p.	Date	Time	Elevation of water level (from mllw)
10.57	06/21/93	08:10	0.78
10.57	06/21/93	08:16	0.78
10.56	06/21/93	08:25	0.79
10.55	06/21/93	08:46	0.80
10.29	06/21/93	13:58	1.06
10.30	06/21/93	14:25	1.05
7.75	06/22/93	16:00	3.60
8.20	06/23/93	09:10	3.15
8.30	06/23/93	11:16	3.05
8.30	06/23/93	11:19	3.05
8.24	06/23/93	13:34	3.11
8.18	06/23/93	15:20	3.17
8.20	06/23/93	17:13	3.15
8.21	06/23/93	17:16	3.14
8.39	06/23/93	19:08	2.96

---

[1] Mean lower low water datum

WATER LEVEL DATA

Monitoring well SL-5

Location -- Southeast of Lagoon site near V.S.W. office/City of Gambell

Measuring point (m.p.) -- top of steel casing

Measuring point elevation (mllw[1]) - - 23.25 feet

Height of measuring point above land surface -- 2.95 feet

Measuring equipment -- steel tape.

Depth to water below m.p.	Date	Time	Elevation of water level (from mllw)	Comments
21.87	06/21/93	13:31	1.38	
21.86	06/21/93	13:34	1.39	
21.85	06/21/93	13:47	1.40	
21.86	06/21/93	14:16	1.39	
21.65	06/23/93	08:59	1.60	
21.13	06/23/93	11:08	2.13	
21.12	06/23/93	11:10	2.14	
20.60	06/23/93	13:13	2.65	poor measurement
20.64	06/23/93	13:19	2.61	good measurement
20.63	06/23/93	15:11	2.63	poor measurement
20.60	06/23/93	15:15	2.65	v. good reading
20.57	06/23/93	17:05	2.68	
20.58	06/23/93	17:08	2.67	
20.56	06/23/93	19:03	2.69	
20.54	06/23/93	21:09	2.71	

---

[1] Mean lower low water datum

WATER LEVEL DATA

South Pond/City of Gambell

Location -- Southernmost swale between VSW office and red and white communication tower

Survey point -- top of steel rebar

Survey point elevation (mllw[1]) - - 3.70 feet

Staff gauge "0" elevation (mllw) -- 1.39 feet

Measuring equipment -- yardstick fastened to rebar driven into pond bottom

Time	Date	Staff gauge reading (inches)	Elevation of water surface (from mllw in feet)	Conditions	Comments
14:45	06/23/93	14.50	2.60	slight ripple	First noticed water in swale
15:40	06/23/93	14.69	2.61	" "	either 1130 or 1330 hrs
17:36	06/23/93	15.00	2.64		
19:26	06/23/93	15.38	2.67		
21:33	06/23/93	15.75	2.70		
18:13	06/24/93	17.00	2.81		

---

[1] Mean lower low water datum

WATER LEVEL DATA

Troutman Lake

Gauge Location -- 100 feet east of brackish water well and 10 feet offshore at north end of Troutman Lake

Survey point -- top of rebar, which is 0.96 ft below top of yardstick staff gauge

Survey point elevation (mllw[1]) - - 2.90 feet

Staff gauge "0" elevation (sea level datum) -- 0.86 feet

Measuring equipment -- yardstick fastened to rebar driven into lake bottom

Time	Date	Staff gauge reading (inches)	Elevation of water surface (from mllw in feet)	Comments
10:04	06/22/93	16.00	2.19	slight ripples, wind from N (offshore)
10:07	06/22/93	15.94	2.19	slight ripples, wind from N (offshore)
09:36	06/23/93	16.06	2.20	calm -- light rain
11:36	06/23/93	16.25	2.21	calm, light rain, wind from north
14:03	06/23/93	16.25	2.21	slight ripples -- wind more easterly
16:34	06/23/93	16.13	2.20	
17:31	06/23/93	16.13	2.20	wind from east -- light to moderate
19:21	06/23/93	16.25	2.21	wind from east -- slight ripples
21:27	06/23/93	16.13	2.20	light wind from east

---

[1] Mean lower low water datum

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Slug Dim.
1¼" x 6.03'

Volume = 0.0514 ft³

SLUG TEST
RECOVERY RATE TEST

Site SL-4
Date 6-22-93
Well Number

Water level before evacuation (nearest 0.1 ft below top of casing)

Well location

Weather conditions

BY: Jim Munter
BRIAN AKLIN

Initial: pH (units)

Conductance (umhos/cm*)

Temperature (°C)

Recharged: pH (units)

Conductance (umhos/cm*)

Temperature (°C)

clock Time or

of slug

steel tape

	Time from evacuation	Water level (nr. 0.1 ft)		Calculated recharge rate (volume/time)			
				SWL	residual drawdown		Comments
	Hold 1559	9 - 1.24 =		7.76			
	wet	1.24					
	Hold 1600	8		7.76			
	wet	.24					
	Slug in 1603						
	Hold 1604	8	-	7.75			
	wet	.25					
	Hold 1605	8	0.24	7.76			"STATIC"
TRIAL #	wet	.24	wet	SWL			
1	Hold 19 sec	Held 8.6	- 0.84	7.76	0.00		
	wet	.84					
2	8 sec	.800	0.23	7.77	0.01		
3	9 sec	8.50	0.71	7.79	0.03		
4	9 sec	8.00	0.20	7.80	0.04		
STATIC	Hold 1619	8.00	0.25	7.75	-		
5	8 sec	8.00	0.22	7.78	0.02		
6	15 sec	8.00	0.25	7.75	-0.01		
7	12 sec	8.00	0.25	7.75	-0.01		

The test is finished when the water level has recovered to its pre-evacuation level.

* Conductance should be temperature-corrected to 25°C

Mean response:

t	residual dd
9.5 sec	0.025 ft

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RECOVERY RATE TEST

Site GAMBELL SEWAGE LAGOON
Date 6-24-93
Well Number SL-3

Water level before evacuation (nearest 0.1 ft below top of casing)

Well location NW of FAA towers, SW of landfill

Weather conditions ~45° clear, lt NE wind

Staff: Jim Munter
Dave Ulvestad

Initial: pH (units)

Conductance (umhos/cm*)

Temperature (°C)

Recharged: pH (units)

Conductance (umhos/cm*)

Temperature (°C)

Clock Time	Time from evacuation	Water level (nr. 0.1 ft)	~~Calculated recharge rate (volume/time)~~	
19:39		Held / wet - 21.20/0.25	20.95	STEEL TAPE
19:40		21.5 - 0.54 =	20.96	
19:43		21.02	} hard to get good	E-TAPE
19:45		20.77	reading	E-TAPE *
21:50		21.4 - 0.42 =	20.98	STEEL TAP
21.56		21.4 - 0.41 =	20.99	
#1	:29 sec	22.0 - 0.99	21.01	
#2	:18 sec	22.0 - 0.99	21.01	
20:06	~~:28~~	21.50 - 0.47 =	21.03	STEEL TAPE
#3	:19 sec	22.0 - -.96	21.04	
	~~:14 sec~~	~~22.2~~	too wet in casing to read	
			Quit	
			Note: static level was falling	
			significantly during test	

The test is finished when the water level has recovered to its pre-evacuation level.

* Conductance should be temperature-corrected to 25°C

19:54 PUT SLUG IN WELL

* QUESTIONABLE READING

APPENDIX E
Water quality analyses

Explanation of sample codes

GW-1	Well SL-5
GW-2	Well SL-4
GW-3	field blank
GW-4	Well SL-3
GW-5	Well SL-3 (field duplicate)

State of Alaska
Department of Natural Resources / Division of Water
WATER QUALITY LABORATORY
209 O'Neill University of Alaska Fairbanks Fairbanks, Alaska 99775 (907)474-7713

Client: DNR/DOW – Eagle River

Submitted By: Jim Munter

Date Submitted: 26 June 93

Sample	Date	Time	TDS	Nitrate + Nitrite	Chloride
GW1	21 June 93	17:48	3600	0.05	2120
GW2	22 June 93	13:12	6000	0.74	3530
GW3	23 June 93	14:30	<DL	<DL	<DL
GW4	24 June 93	10:51	15000	4.46	7030
GW5	24 June 93	10:51	15400	4.49	6940
Units			mg/L	mg/L as N	mg/L
EPA Method			160.1	353.2	300.0
Detection Limit			0.1	0.02	0.01
Date of Analysis			28 June 93	16 July 93	17 July 93
RPD			4.6	2.7	0.0
% Recovery			–	106	107

Approved By ______________________ Date 27JUL93

Jim Vohden, Chemist

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WATER QUALITY FIELD NOTES - GROUND WATER

Location/Project: Gambell Sewage Lagoon Date: 6/24/93

Collected by: Jim Munter

Well Owner: City of Gambell Weather Conditions: lt rain/dry ~45° windy

Use of Well: Monitoring well

Sampling Equipment (for measuring water level, purging, sampling and filetering. Include model if appropriate): 1½" 30" polyethylene disposable bailer + nylon twine 0-23 gal cap.

Well Name: Field Dup (well SL-3)

Pipe top elevation (MSL)

Reference elevation if different TOC

Measured depth to water (ft) 21.00-0.43 = 20.57

Correction

Total depth to water (ft)

Water elevation (MSL)

Depth to bottom of well (ft) 28.6 (TOC)

Volume H_2O in well (gal) 1.5 gal

Volume to be purged (4Xvol.in well) 6 gal

Time purging begun 1016 hrs 26 bailers

Time purging completed 1045 hrs

Purged dry? (Y/ [✓ N])

Time sample withdrawn 1051

Field temperature (°C)/time 3.1°C @ 1104

Field conductivity (uncorrected)/time 23300 µmhos/cm

Field conductivity (slope corrected) 22,000 µmhos/cm

Field pH (std. units)/time

Color (Y/ [✓ N])

Odor (Y/ [✓ N])

Turbidity (Y/ [✓ N])

Sample Field filtered? (Y/ [✓ N])

Well cap and lock replaced? ([✓ Y] /N)

(643) GW-5B GW-5A (633) GW-5C (626)

Analysis:	TDS	Nitrate+Nitrite			Chloride	
Bottle:	unfiltered, well-mixed	unfiltered, acidified	~~field filtered, acidified~~	~~field filtered, unacidified~~		
volume (ml):	500 ml	250 ml			500 ml	
preservative:	None	Sulfuric acid			None	

Alkalinity: Sample Size _____ml; H_2SO_4_____ (factor____) Instruments

Titer added (digits) pH Calculations

COMMENTS:

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WATER QUALITY FIELD NOTES - GROUND WATER

Location/Project: Gambell Sewage Lagoon Date: 6-24-93

Collected by: Jim Munter

Well Owner: City of Gambell Weather Conditions: lt rain ~45°, windy - gust ~1030 hrs

Use of Well: Monitoring

Sampling Equipment (for measuring water level, purging, sampling and filetering. Include model if appropriate): 1 1/2" × 30" disposable polyethylene bailer + nylon cord (0.23 gal capacity)

Well Name: SL-3

Batt = 12.2 volts

Pipe top elevation (MSL)	6/23/93		
Reference elevation if different		Time sample withdrawn	1048-1054 = 1051
Measured depth to water (ft)	21.00 - 0.43 = 20.00	Field temperature (°C)/time	3.1°C @ 1104 hrs
Correction	20.57	Field conductivity (uncorrected)/time	23300 (233 on 200k)
Total depth to water (ft)		Field conductivity (slope corrected)	22,000 µmhos/cm Hach on 20K
Water elevation (MSL)		Field pH (std. units)/time	
Depth to bottom of well (ft)	(TOC) 28.6	Color	(Y/[✓ N])
Volume H_2O in well (gal)	1.5 gal	Odor	(Y/[✓ N])
Volume to be purged (4Xvol. in well)	6 gal	Turbidity	(Y/[✓ N])
Time purging begun	1016 26 bailers	Sample Field filtered?	(Y/[✓ N])
Time purging completed	1045	Well cap and lock replaced?	([✓ Y]/N)
Purged dry?	(Y/[✓ N])		

(642) GW-4B GW-4A (636) GW-4C (631)

Analysis:	TDS	Nitrate+Nitrite			chloride	
Bottle:	unfiltered, well-mixed	unfiltered, acidified	field-filtered, acidified	field-filtered, unacidified		
volume (ml):	500 ml	250 ml			500 ml	
preservative:	None	Sulfuric acid			None	

Alkalinity: Sample Size ______ ml; H_2SO_4 ______ (factor ___) Instruments ______

Titer added (digits) pH Calculations

Comment: Landfill fire started ~1040 hrs
well variably downwind

Purge: Water slightly turbid at
beginning, cleared up quickly

COMMENTS:

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WATER QUALITY FIELD NOTES - GROUND WATER

Location/Project: GAMBELL SEWAGE LAGOON / Field blank　Date: 6/22/93

Collected by: Jim Munter

Well Owner: 　Weather Conditions: 50° windy p cloudy

Use of Well:

Sampling Equipment (for measuring water level, purging, sampling and filetering. Include model if appropriate): 250 ml polyethylene bailer (disposable) & nylon cord

Well Name: Cubitainer / 5 gal

Pipe top elevation (MSL)

Reference elevation if different　Time sample withdrawn 1430 hrs

Measured depth to water (ft)　Field temperature (°C)/time 19.6°c

Correction　Field conductivity (uncorrected)/time 19 µmhos/cm (2k scale)

Total depth to water (ft)　Field conductivity (slope corrected)

Water elevation (MSL)　Field pH (std. units)/time

Depth to bottom of well (ft)　Color (Y/N) N

Volume H_2O in well (gal)　Odor (Y/N) N

Volume to be purged (4Xvol.in well)　Turbidity (Y/N)

Time purging begun　Sample Field filtered? (Y/[✓ N])

Time purging completed　Well cap and lock replaced? (Y/N)

Purged dry? (Y/N)

(639) GW3B　GW3 A (632)　GW3C (629)

Analysis:	TDS	Nitrate+Nitrite			chloride	
Bottle:	unfiltered, well-mixed	unfiltered, acidified	~~field-filtered, acidified~~	~~field-filtered, unacidified~~	unfiltered well-mixed	
volume (ml):	250 ml	125 ml			250 ml	
preservative:	None	Sulfuric Acid			None	

Alkalinity: Sample Size _____ml; H_2SO_4_____ (factor___) Instruments

Titer added (digits)　pH　Calculations

Used 1gal distilled water bottle for sample compositer, triple rinsed w/ distilled & triple rinsed w/ deionized water

COMMENTS:

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WATER QUALITY FIELD NOTES - GROUND WATER

Location/Project: GAMBELL SEWAGE LAGOON/NE corner well Date: 6-22-93

Collected by: Jim Munter

Well Owner: City of Gambell Weather Conditions: Windy, p. Sunny 45-50°

Use of Well: Monitoring

Sampling Equipment (for measuring water level, purging, sampling and fiIetering. Include model if appropriate): 1½" polyethylene bailer (~250 ml capacity) 30" long w/disposable nylon cord/purge + sample

Well Name: SL-4

Pipe top elevation (MSL) 0.55' TOC-Top PVC / 2.4' TOC-grd lvl / 2.5' TOC - Top mound

Reference elevation if different 2.81' - TOC - [illegible] Time sample withdrawn (1310-1314) 1312 hrs

Measured depth to water (ft) Field temperature (°C)/time 4.9@1328

Correction Field conductivity (uncorrected)/time 10150 (1010-1045) unstable

unwtd steel tape Total depth to water (ft) 9.00 - 0.71 = 8.29 @ 1295 hrs Field conductivity (slope corrected) 9,800 µmhos/cm on 20k scale (101 on 200k scale)

Water elevation (MSL) 9.31' Field pH (std. units)/time

Depth to bottom of well (ft) 17.6' (TOC) Color (Y/[✓ N]) slight clear

Volume H_2O in well (gal) 1.5 gal Odor (Y/N) N

Volume to be purged (4Xvol.in well) 6 gal Turbidity (Y/[✓ N]) slight clear

Time purging begun 1254 hrs 22 bailers full Sample Field filtered? (Y/N) N

Time purging completed 1308 Well cap and lock replaced? ([✓ Y]/N)

Purged dry? (Y/N) N

	GW2B (440)	GW2A (634)			GW2C (427)	
Analysis:	TDS	Nitrate + Nitrite			Chloride	
Bottle:	unfiltered, well-mixed	unfiltered, acidified	field-filtered, acidified	field-filtered, unacidified	unfiltered well mixed	
volume (ml):	250 ml	125 ml			250 ml	
preservative:	None	Sulfuric acid			None	

Alkalinity: Sample Size _____ ml; H_2SO_4 _____ (factor ___) Instruments _____

Titer added (digits) pH Calculations

Purge: Water moderately turbid at start, cleared up, little if any sand bailed

COMMENTS:

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DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
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(907) 696-0070

WATER QUALITY FIELD NOTES - GROUND WATER

Location/Project: GAMBELL SEWAGE LAGOON Date: 6-21-93

Collected by: Jim Munter

Well Owner: City of Gambell Weather Conditions: Sunny, 50° windy

Use of Well: Monitoring

Sampling Equipment (for measuring water level, purging, sampling and filetering. Include model if appropriate): Hydrolab / Hand powered PVC piston-type purge pump, polyethylene disposable bailer & nylon cord

Well Name: SL 5

Pipe top elevation (MSL)

Reference elevation if different

Measured depth to water (ft) (TOC) 21.86'

Correction

Total depth to water (ft) 21.86'

Water elevation (MSL)

Depth to bottom of well (ft) 31.5 (TOC)

Volume H_2O in well (gal) 1.6 gal

Volume to be purged (4Xvol.in well) 6.5

Time purging begun 1551 hrs / Approx every 5 min

Time purging completed 1740

Purged dry? [✓ Y]/N / 639 635 628

Time sample withdrawn 1740-1754

Field temperature (°C)/time 4.8° 1754

Field conductivity (uncorrected)/time 558 / 1759 hrs

558 on 20 scale

Field conductivity (slope corrected) 5380 µmhos/cm

Field pH (std. units)/time

Color (Y/N) slight cloudy

Odor (Y/N) Y - possible slight weathered diesel fuel

Turbidity (Y/N) Yes

Sample Field filtered? (Y/N) N

Well cap and lock replaced? (Y/N) Y

	GW-1B	GW-1A			GW-1C	
Analysis:	Total Diss Solids	Nitrate+Nitrite			Chloride	
Bottle:	unfiltered, well-mixed	unfiltered, acidified	~~field-filtered, acidified~~	~~field-filtered, unacidified~~	unfiltered well mixed	
volume (ml):	250	100 ml			250 ml	
preservative:	NoNE	Sulfuric Acid			None	

Alkalinity: Sample Size ______ ml; H_2SO_4 ______ (factor ____) Instruments ____________

Titer added (digits) pH Calculations

COMMENTS: Purge helper Levine Oozeva

APPENDIX F
Advantages and disadvantages of sewage lagoon options

JM

STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF WATER

ALASKA HYDROLOGIC SURVEY

WALTER J. HICKEL, GOVERNOR

P.O. Box 772116
Eagle River, Alaska 99577-2116
Phone: (907) 696-0070
Fax: (907) 696-0078

July 8, 1993

Jane Dale, Engineer
Chuck Eggener Consulting Engineers
PO BOX 232946
ANCHORAGE AK 99523-2946

Dear Ms. Dale:

As you have requested, I am providing you a summary of the advantages and disadvantages of the various sewage lagoon options for Gambell with respect to ground-water impacts only. Obviously, other factors affect siting that are not considered here. My comments are based on our recent field investigations and must be considered preliminary pending preparation of the final project report.

The options considered in this analysis are:

1. Construction of a "slow-perc" wastewater lagoon at the top of the hill between the VSW office in Gambell and the FAA towers extending northward into the swale near the old landfill. This lagoon would be designed with a 70,000 sq ft bottom area and be capable of retaining 7 months of wastewater during subfreezing conditions;

2. Construction of a "fast-perc" lagoon at the bottom of the hill close to the old landfill. This option would be constructed with a 50,000 sq ft bottom area and designed to not retain water;

3. Construction of a lined retention lagoon with periodic pumping out to sea;

All options described above would be designed to accommodate wastewater from a septic tank used to achieve primary treatment and separation of septic wastes.

First, I would like to review some key findings of our investigation. Full explanation and documentation of these findings is beyond the scope of this letter.

1. Ground water through out the area is found in highly permeable aquifers consisting of sand and gravel from old beach deposits. In the southern part of the "slow perc" lagoon site, permafrost confines the main aquifer. A secondary perched aquifer may form locally and perhaps only seasonally on top of

permafrost. Under the swale near the old landfill, permafrost is mostly or totally absent, and does not materially affect ground-water flow.

2. Ground-water flow directions are influenced greatly by large coastal ground-water level changes caused by wind-driven surf action. Annual water level fluctuations of 9-11 ft are expected beneath the "fast-perc" site, from a high of approximately 9-10 ft above MLLW to a low near MLLW. Ground-water beneath the swale also responds dynamically to tides, however these are lower-magnitude effects;

3. The specific conductance of water in the vicinity of Gambell and the lagoon sites varies from 460-23,000 micromhos/cm, indicating water quality varies from fresh to saline. Most water beneath the lagoon sites appears to be brackish, and may be contaminated with diesel fuel.

The advantages and disadvantages of the three options are described below.

OPTION 1 - "SLOW PERC" LAGOON

Advantages

1. Compared to option 2, this option would provide superior treatment of the wastewater in the unsaturated zone before the water contacts ground water, thereby reducing the potential for ground-water contamination;

2. Compared to option 3, this option may not result in significant impairment of ground water because ground water beneath the site is already non-potable.

Disadvantages

1. Compared to option 2, this option increases the risk that wastewater will flow southeastward into the community of Gambell because wastewater percolation would occur closer to the community and over a larger area. Wastewater could contaminate the school well or nearby ponds that occasionally form. The actual risk of this occurring is difficult to assess. Brackish ground water in the vicinity of well SL-5 does not appear to travel to the school well on a regular basis because the school well is fresh most of the time.

2. Compared to option 2, this option is more likely to have a large slug of thawing wastewater enter the aquifer in the spring. This slug slightly increases the possibility of contaminated ground water affecting the school well. After 30 days of melting and infiltrating a seven-month accumulation of frozen wastewater and drifted snow, a water table mound 0.2-1.5 ft high is calculated to form beneath the site. Superimposed on a flat water table which is expected to occur intermittently beneath the site in the spring, this creates the potential for flow towards the school well.

3. Compared to option 3, this option will probably require fill in the swale under the north end of the site to approximately the 10 ft elevation contour. This is expected to be above the fall high water level caused by storm-induced high water levels. The purpose of the fill would be to keep all potentially contaminated ground-water below the local land surface.

4. This option will require more extensive destruction of permafrost compared to option 2. This increases uncertainty in the prediction of ground-water responses and could lead to unexpected results. Unexpected results could be adverse, such as creation of a perched water table flowing towards the City of Gambell, or positive, such as creation of an effective permafrost barrier against ground-water flow towards the City. Effective monitoring of ground-water response to wastewater loading will be much more difficult as a result.

OPTION 2 - "FAST PERC" LAGOON

Advantages

1. This option would most efficiently dispose of the wastewater into an area with brackish to saline ground water. Ground water in the predominant downgradient direction, towards the coast, may already be contaminated by landfill or honeybucket disposal leachate.

2. High permeabilities of soils in this area and strongly fluctuating gradients result in relatively high dilution and flushing rates. Flushing and dilution rates are likely to be highest nearest the coast.

3. The fluctuating water table beneath this site will result in regular wetting of the vadose zone with ground water mixed with wastewater. This may help aerate the water and further promote subsurface degradation of waste products.

4. Being farther from the school well; this option is less likely to contaminate that well than option 1.

5. The potential for the spread of contamination into the City is reduced by minimizing the volume of thawing wastewater in the spring, such as is inherent in the design of this option. Continuous disposal of wastewater from the lagoon for 1 yr is estimated to create a water table mound less than 0.1 ft high.

Disadvantages

1. Water influent to the aquifer may contain unacceptably high concentrations of constituents typical of domestic wastewater. Applicable wastewater disposal regulations should be consulted to evaluate this factor.

2. Compared to option 3, this option has a slight probability to contaminate the school well and nearby ponds. As a result of the distances and gradients

involved and the preferred orientation of beach ridges and probably also the aquifer transmissivity in the area, contamination of the school well is not considered likely.

3. Compared to option 3, this option will probably require fill in the swale under the north end of the site to approximately the 10 ft elevation contour. This is expected to be above the fall high water level caused by storm-induced high water levels. The purpose of the fill would be to keep all potentially contaminated ground-water below the local land surface.

OPTION 3 - RETENTION LAGOON

Advantages

1. Properly constructed and maintained, this option should not result in significant risks to local ground-water resources.

Disadvantages

1. Any leaks in the liner could result in uncontrolled ground-water contamination.

Please let me know if you would like further information.

Sincerely,

James A Munter (gw)

James A. Munter
Hydrogeologist