Division of Geological & Geophysical Surveys

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ANALYSIS OF AN AQUIFER TEST AT SAINT PAUL ISLAND, PRIBILOF ISLANDS, ALASKA

by

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Division of Water
Alaska Hydrologic Survey

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ANALYSIS OF AN AQUIFER TEST AT SAINT PAUL ISLAND PRIBILOF ISLANDS, ALASKA

by James A. Munter and Roger D. Allely

INTRODUCTION

The City of Saint Paul, Alaska, is currently experiencing rapid growth as a result of the expansion of shore-based seafood processing in the community. The city relies entirely on ground-water wells for water supply, and requires increased water production to supply the seafood processing industry. The primary purpose of this report is to present the results of an aquifer test conducted at the City's Fredreka well field. The test results are used to estimate potential yield from existing wells and suggest pumping and well drilling strategies to ensure the availability of water in sufficient quantity and of acceptable quality to satisfy expected demands. Projected average demands for three new processing facilities and existing uses ranges up to 500,000 gallons per day, or 350 gallons per minute (gpm), during the seafood processing season. This is approximately double existing in-season demand.

LOCATION AND GEOLOGY

The City of Saint Paul is located on the southwest tip of Saint Paul Island of the Pribilof Islands in the Bering Sea off the southwest coast of mainland Alaska. Saint Paul Island is approximately 16 miles long and 9 miles wide and has a maximum land surface elevation of about 665 ft above sea level. The bulk of the island is comprised of a series of gently dipping olivine-basalt lava flows and scoriacious volcanic debris of Late Pleistocene age (Barth, 1956). The thickness of individual lava flows generally ranges from a foot to several tens of feet. Surface topography of Saint Paul Island exhibits volcanic features such as individual flow boundaries and volcanic cones in some areas. Volcanic rocks are discontinuously overlain by coastal dunes and marine deposits. Volcanic rocks are generally quite permeable as a result of fracturing of the volcanic rocks during transport and cooling. The scoriacious deposits are also highly permeable as a result of the coarse clast size. No integrated stream drainage network exists on the island. The high permeability of soils and rocks allow rapid infiltration of precipitation and snowmelt. Water resources of Saint Paul Island are generally described by Feulner (1980).

Four water supply wells currently provide water to the City (figure 1). The South and North wells are old wells for which very little information is available, but are reportedly 86 and 92 ft deep, respectively (Feulner, 1980). The 8-in.-diam Fredreka I and II wells are located approximately 3000 ft north of the North and South wells. Logs for the Fredreka wells are given in Appendix A. Previous tests on the wells (URS, 19871 indicated that the transmissivity of the aquifer was about 100,000 gpd/ft and that sustained yields of about 150 gallons per minute (gpm) could be obtained from each Fredreka well. To convert flow rates in this report from gpm to gallons per day, multiply gpm figures by 1440.

OVERVIEW OF TEST CONDITIONS

The primary objective of the aquifer test was to provide data for estimating the potential yield of the existing wells. Previous tests were not conducted at high enough rates or for long enough durations to stress the aquifer sufficiently. The test was originally planned to run for 5-10 days, pumping at a constant rate of 600 gpm from the Fredreka I well while monitoring drawdown in the Eureka and Fredreka II wells and nearby ponds. The maximum capacity of the test pump, however,

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[1] Alaska Department of Natural Resources. Division of Water, Alaska Hydrologic Survey, PO BOX 107005, Anchorage, Alaska 99510-7005

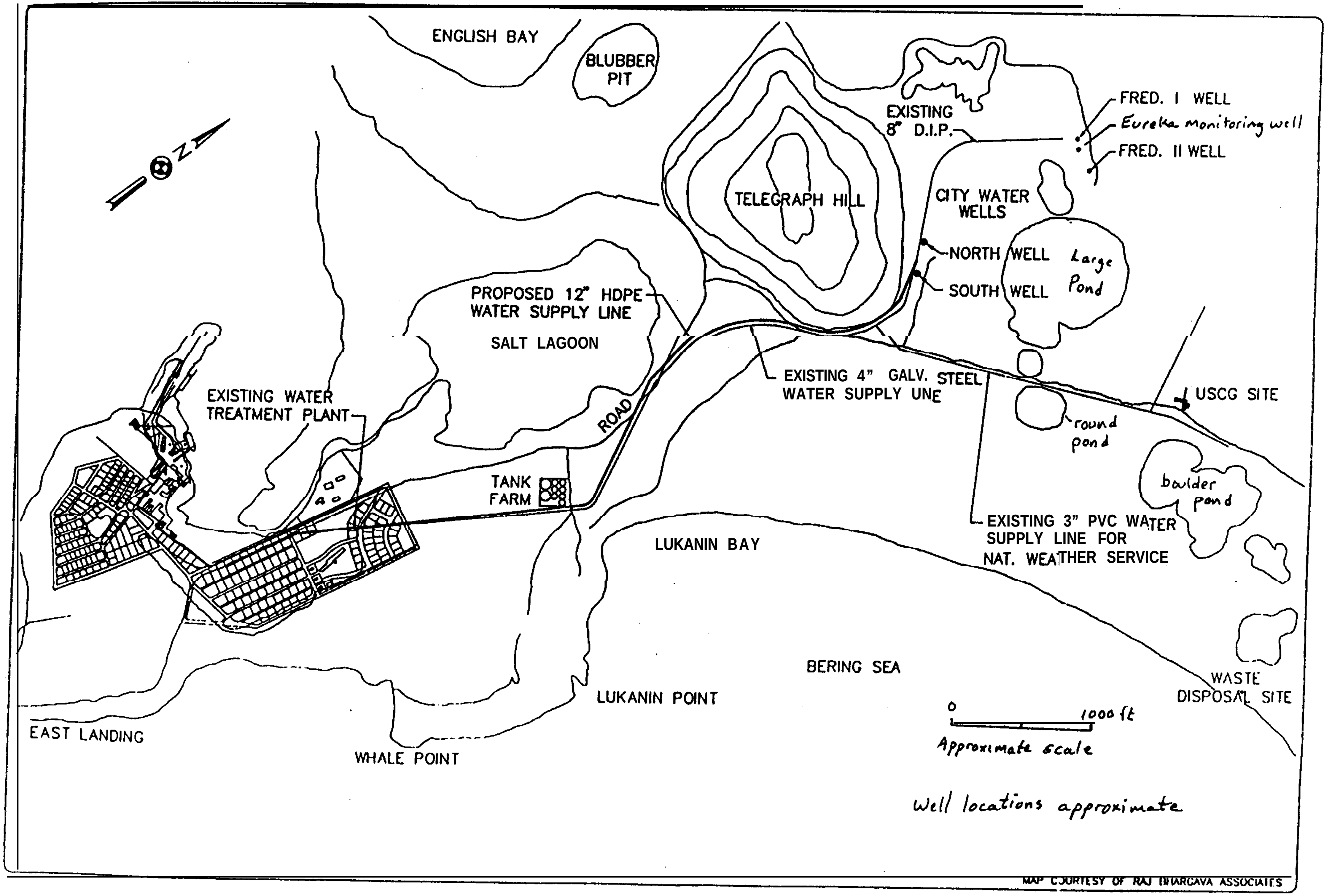

Figure 1. Location of water supply wells. Saint Paul Island Alaska (after B&M Consultants, Inc. 1992)

was found to be only about 500 gpm. This was the largest capacity submersible test pump that would fit into the well.

Pumping was initiated at 0930 hrs Alaska Daylight Time on May 15, 1993 and run continuously but at different rates until 2021 hrs on May 20, 1993. While pumping at 506 gpm, it was observed that the conductivity of the water steadily increased. After pumping at a steady rate for 24 hours and failing to achieve stable conductivity levels, the pumping rate was reduced in steps from 506 gpm to 300 gpm, to 199 gpm, to 98.5 gpm, and then increased to 197 gpm, and to 292 gpm. The purpose of these changes was to evaluate changes in water quality caused by different pumping rates.

Near the end of the test, at 1408 hrs on May 20, the pump in the Fredreka II well was turned on at a rate of 196 gpm for about 6 hrs to evaluate the effects of pumping both wells simultaneously. The pump was also turned on for 15 minutes on May 18 to purge the well and collect a water sample.

Four water samples from the Fredreka I well were collected for laboratory analysis of major dissolved ions at different times during the test. The purpose of these samples was to determine the differences in water chemistry that occur with different pumping rates. Water samples were also collected from the South well and the Fredreka II well to characterize and compare their water quality, Analytical results are given in Appendix 6.

Drawdown data were collected in the pumped well before, during and after the test with an electric water level indicator through a monitoring access tube installed in the well. A float-driven water level recorder was installed on the Eureka well (figure 1) on May 4, 1993, to record water levels before, during and after the test. A similar recorder was installed on the Fredreka II well from May 14 to May 18. A pressure transducer and water-level recorder were also installed on a large pond located southeast of the Fredreka wells (figure 1). Staff gages were installed and monitored daily on two ponds (round pond, and boulder pond, see figure 1). Weather records were obtained for the duration of the test from the National Weather Service station on St. Paul Island on May 21. Surveyed elevations of well heads are given in Appendix C.

RESULTS AND ANALYSIS

Drawdown Data

Figure 2 shows drawdown data collected at the pumped well during the test. The response of the water level to the different pumping rates is readily observable. In general, the amount of drawdown is small at each pumping rate, and drawdown stabilizes at each rate within a relatively short period of time. An analysis of drawdown data from the pumped well during the first 24 hrs of pumping by Cooper and Jacob's (1946) method shows that the aquifer response is nonuniform. Calculated transmissivity values range from 380,000 gpd/ft to 2,500,000 gpd/ft. Cooper and Jacob's (1946) method assumes that the aquifer is a confined homogeneous and isotropic porous medium filled with fresh water extending infinitely in all directions. Clearly, the aquifer tapped by the Fredreka wells does not exactly meet these conditions. The method *is* sufficiently applicable, however, to demonstrate that the transmissivity of the aquifer is quite high relative to most aquifers. Water-quality considerations (see below) indicate that more detailed quantitative flow modeling of the aquifer is not warranted at the present time.

Figure 3 shows water level data collected at the Eureka well. Water level changes induced in the aquifer by the test are observed to be similar in magnitude to fluctuations observed before the test started. Water level fluctuations prior to and during the test exhibit an irregular daily cycle, which may be influenced by tides, recharge events or pumping. Pumping records obtained from the City of Saint Paul show no pumping of the Fredreka wells or North and South wells between May 4 and May 10, although records may not reflect actual pumping during this time. In general, the aquifer is observed to adjust rapidly to changes in the pumping rate at Fredreka I and II during the test. Fluctuations observed during the test appear to be influenced by pumping and natural factors.

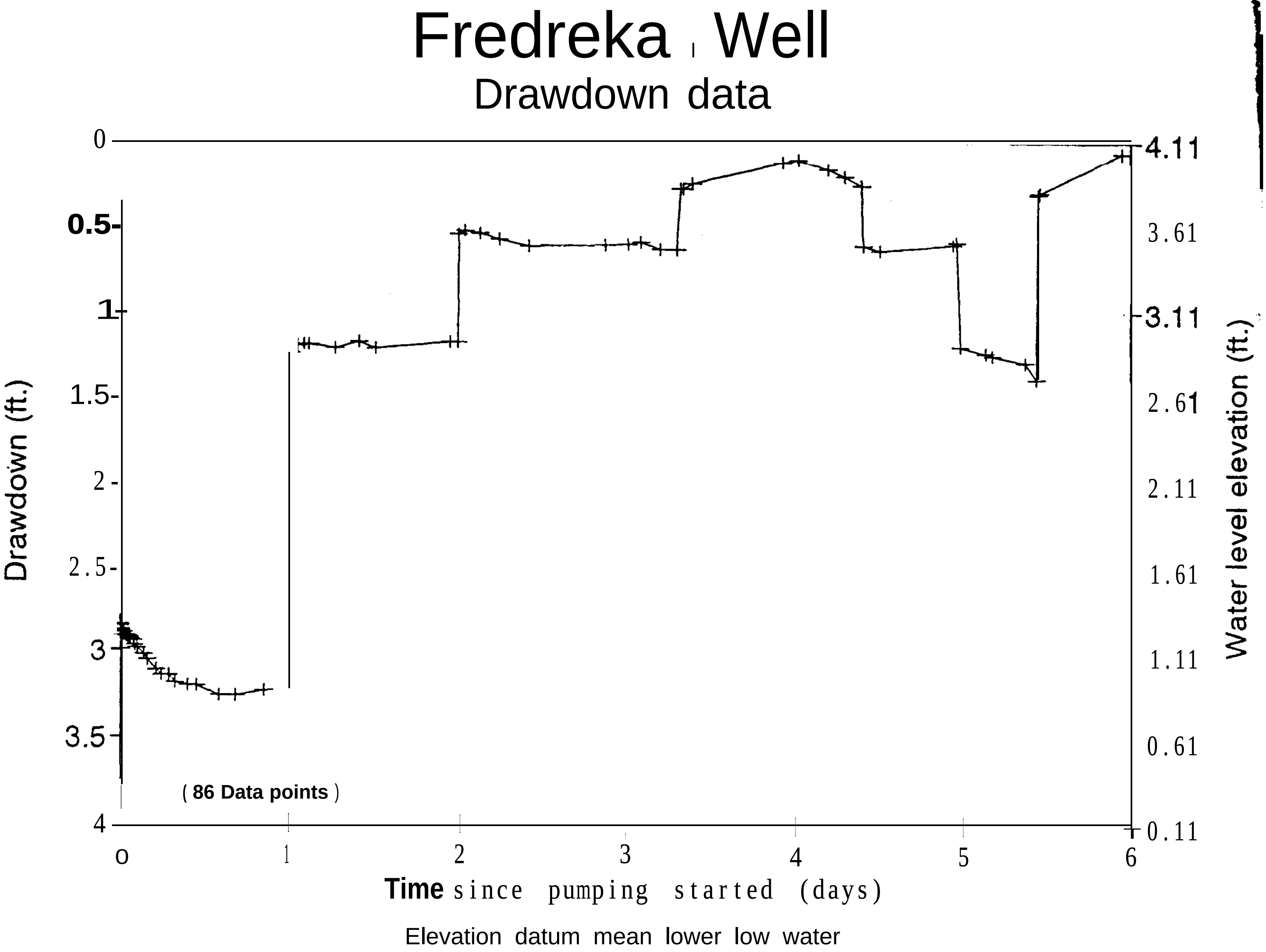

Figure 2. Graph showing drawdown data collected at the pumped well (Fredreka I)

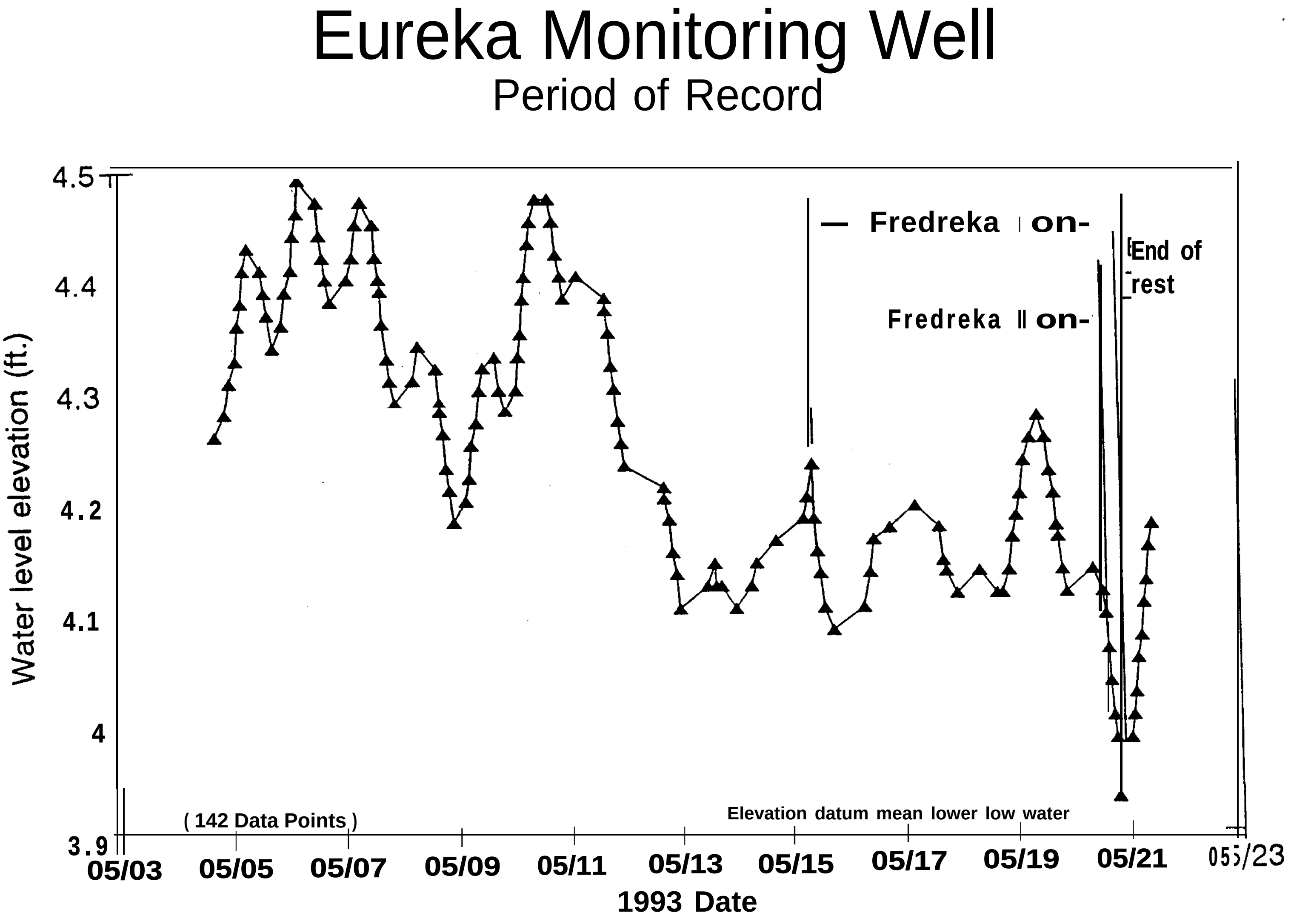

Figure 3. **Graph showing water-level data collected at the Eureka monitoring well.**

Analysis of the first 24 hrs of drawdown data collected at the Eureka well by the Theis (1935) method failed to yield reasonable values of transmissivity and storativity, indicating that the aquifer does not fit assumptions inherent in the method. The assumptions of the Theis (1935) model are essentially the same as those of the Cooper and Jacob (1946) model. Further analysis of the data has not been performed.

Figure 4 shows water-level data collected at the Fredreka II well. These data show trends very similar to those of the Eureka well.

Figure 5 shows water-level data collected at the large pond located southeast of the Fredreka wells. These data show no clear response of pond stage to pumping. A review of staff gage data collected at two other ponds similarly showed no clear response to pumping.

Water Quality

An important criteria in determining long-term yields of the Saint Paul Island aquifer is the maintenance of fresh-quality water supplies. Electrical conductivity and specific conductance, total dissolved solids (TDS), sodium, and chloride concentrations in water are important indicators of salt water content. The secondary drinking water standard for sodium and chloride is 250 mg/L, and for TDS is 500 mg/L. Electrical conductivity and specific conductance are gross indicators of TDS that are useful for reconnaissance purposes. Sodium and chloride concentrations in water commonly vary in parallel, so discussions in this report will focus on chloride to avoid redundancy.

URS (1987) reported the conductivity of water from the Fredreka wells between 325 microsiemens and 425 microsiemens during their initial testing of the wells. An analytical report obtained from the City of Saint Paul files reported chloride concentration of 71 mg/L from the North well on 12/13/83. A sample taken from the tap at the USPHS clinic on 7/27/85 showed a chloride concentration of 94 mg/L. Samples collected from the North and South wells between 1955 and 1979 yielded chloride concentrations ranging from 55 to 69 mg/L (Feulner, 1980). The data showed no clear increasing or decreasing trend with time.

Figure 6 shows a plot of specific conductance of water from the Fredreka I well during the test. The initial value of specific conductance is 327 micromhos/cm (at 25'C), and specific conductance can be seen to vary directly with pumping rate throughout the test.

Figure 7 shows a plot of specific conductance of water collected at the Fredreka II well during the late-test pumping of that well. The conductivity is observed to rise more rapidly than at the Fredreka I well, and to approach stabilization at a higher level.

Figure 8 shows the relationship between specific conductance and chloride content for all water analyses, and figure 9 shows the relationship between specific conductance and total dissolved solids for all analyses. All water samples collected during the test are well below the drinking water standards for both chloride (250 mg/LI and total dissolved solids (500 mg/L). The relationships show that specific conductance is a good indicator of chloride concentration and total dissolved solids. Extrapolation of the data suggests that a conductivity of approximately 1000 micromhos/cm (at 25'C) will result in exceedance of the drinking water standards for chloride and total dissolved solids.

At the end of the first 24 hrs of pumping at 506 gpm, the water from Fredreka I well exhibited a slight but noticeable salty taste. Fifty three minutes after reducing the pumping rate to 300 gpm, a water sample was taken (GW2). By this time, the specific conductance of the pumped water had declined from 556 micromhos/cm (at 25'C) to 513 micromhos/cm (at 25'C) and the salty taste of the water was barely discernible. The highest chloride value detected in the Fredreka I well, 117 mg/L was obtained at this time.

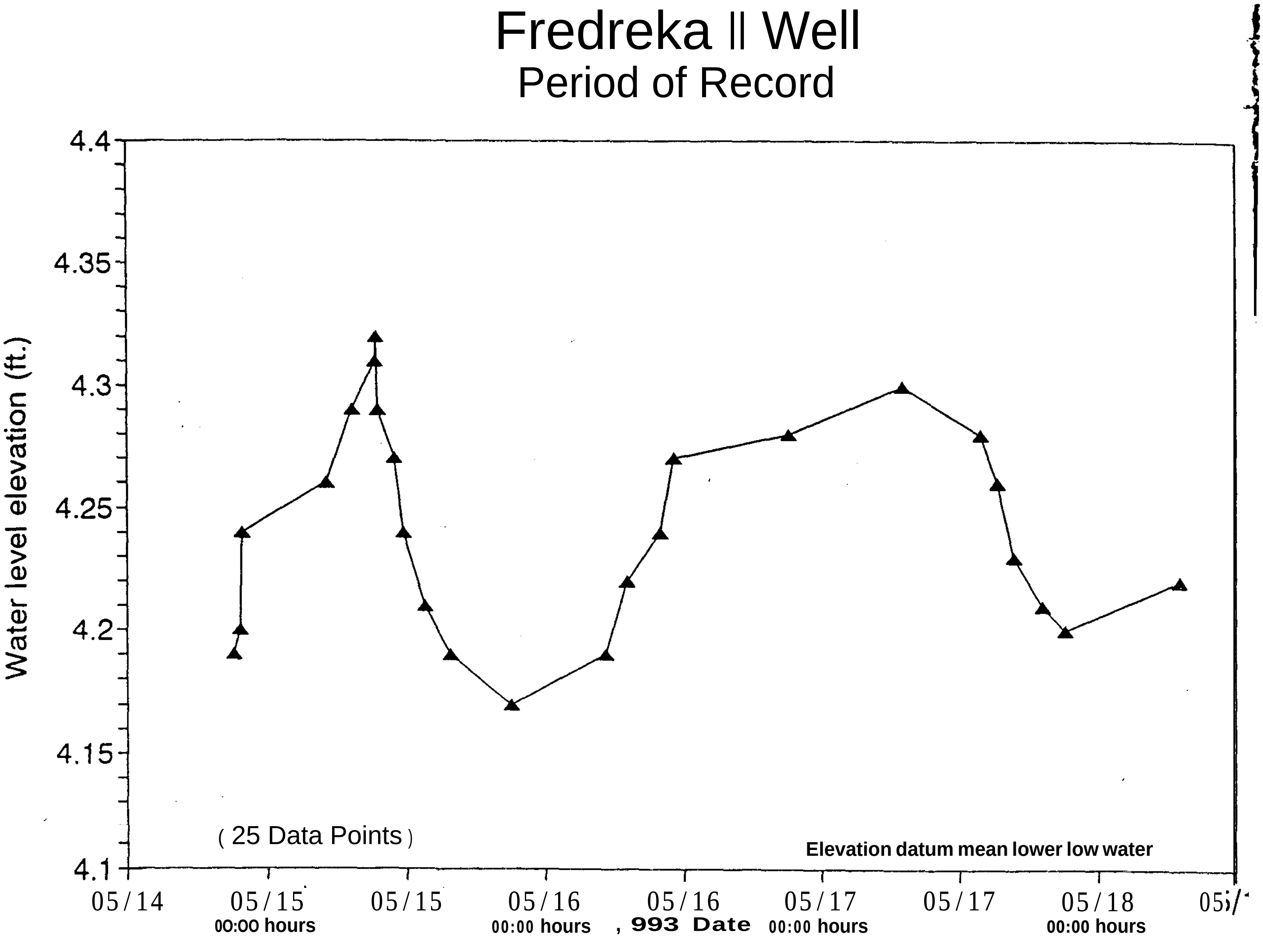

Figure 4. Graph showing water-level data collected at the Fredreka II well.

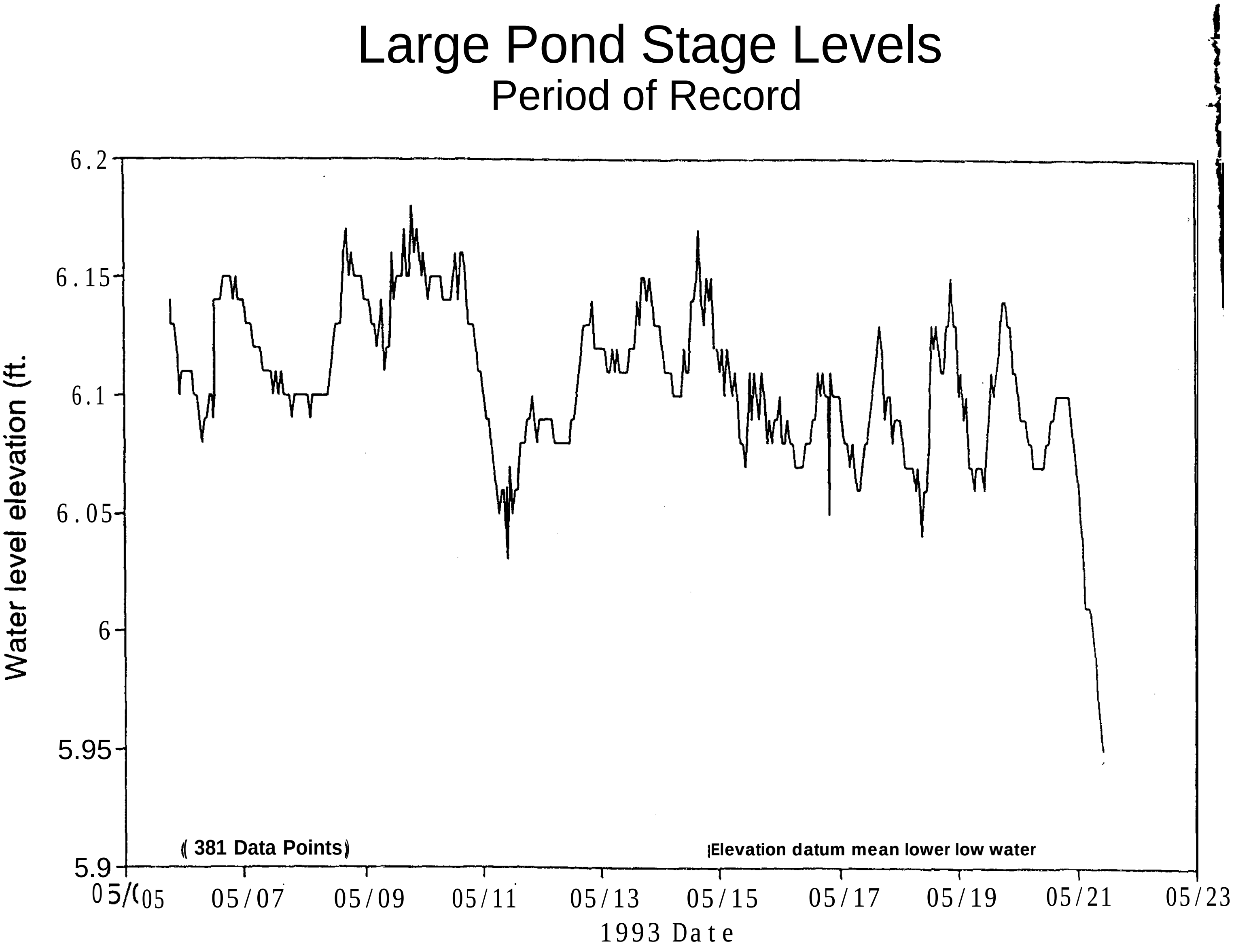

Figure 5. Graph showing water-level data collected at large pond located southeast of the Fredreka II well. See Figure 1 for location of pond.

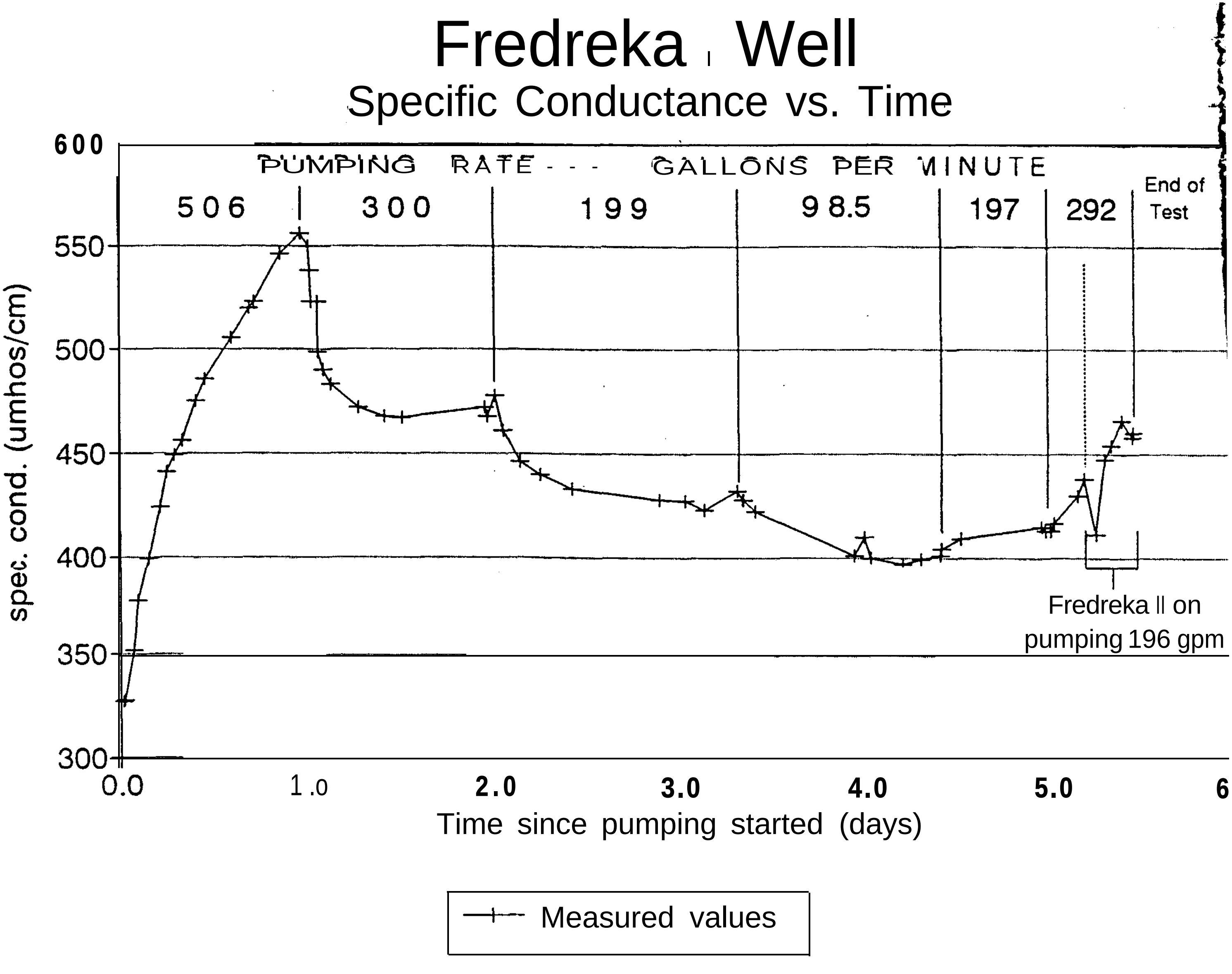

Figure 6. Graph showing specific conductance (at 25°C) data collected at the pumped well (Fredreka I). Average pumping rate was 196 gpm.

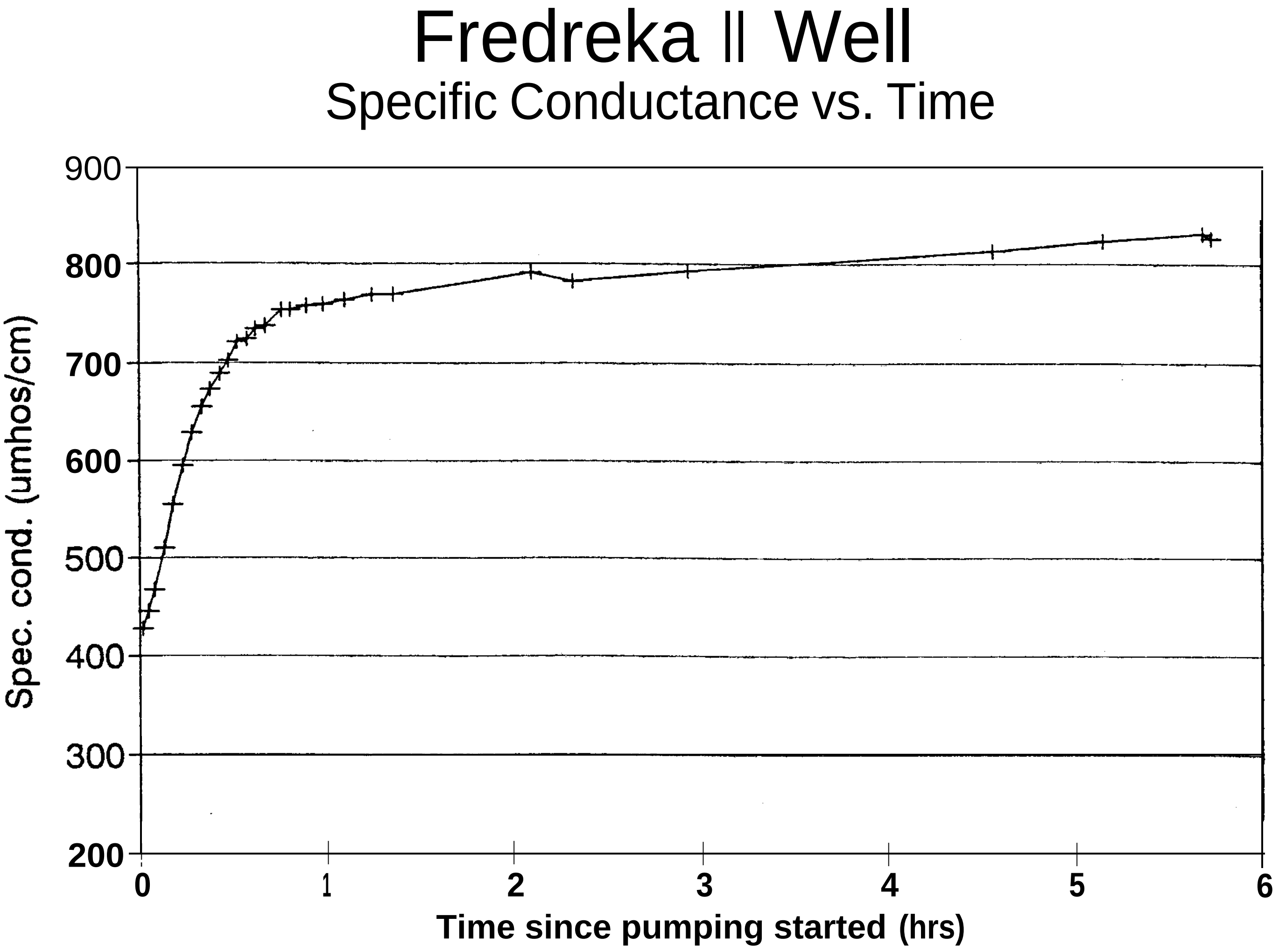

Figure 7. Graph showing specific conductance (at 25°C) data collected at the Fredreka II well.

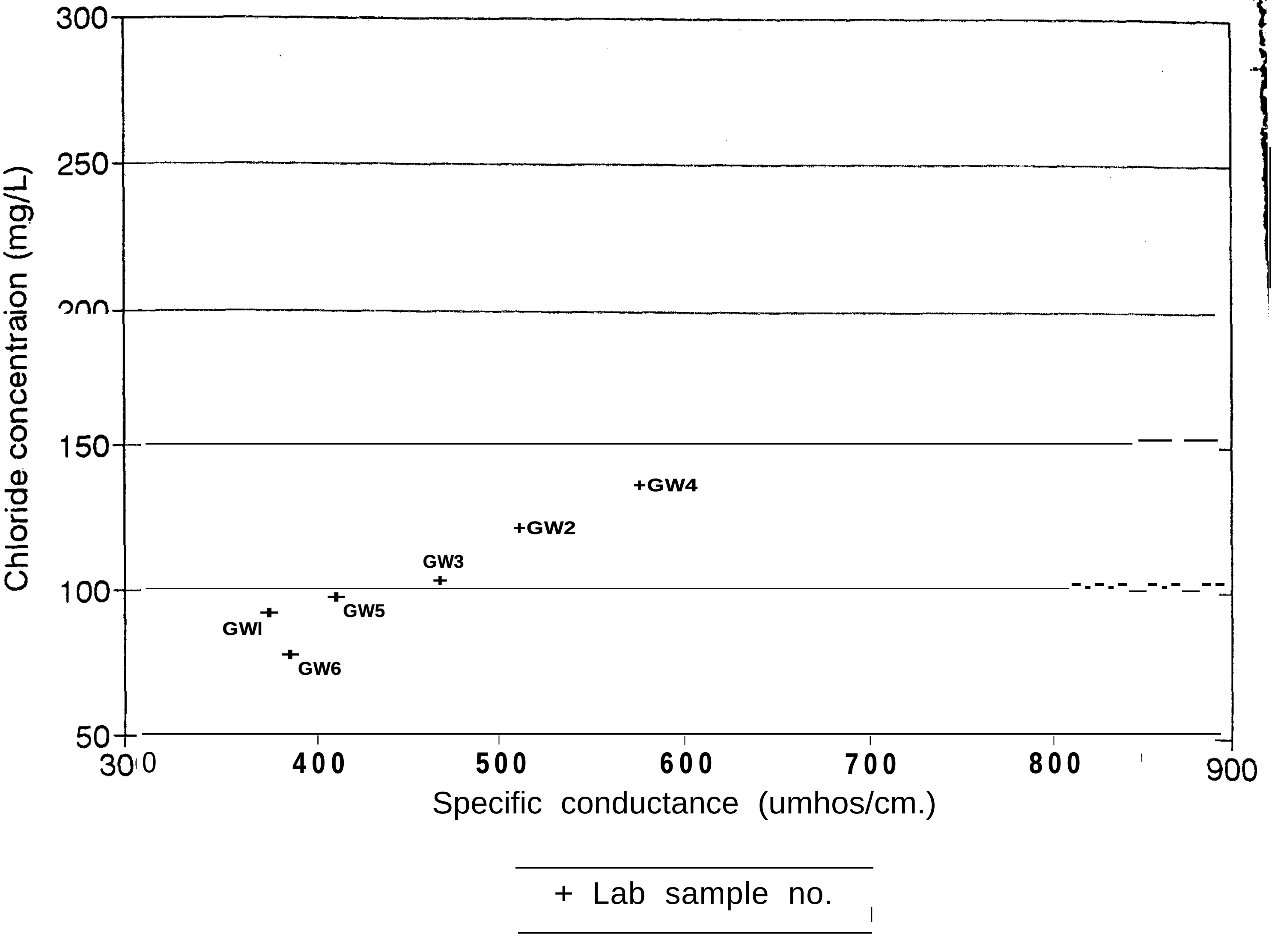

Figure 8. Plot showing specific conductance (at 25'C) and chloride concentrations of samples GWI through GW6 (see Appendix B).

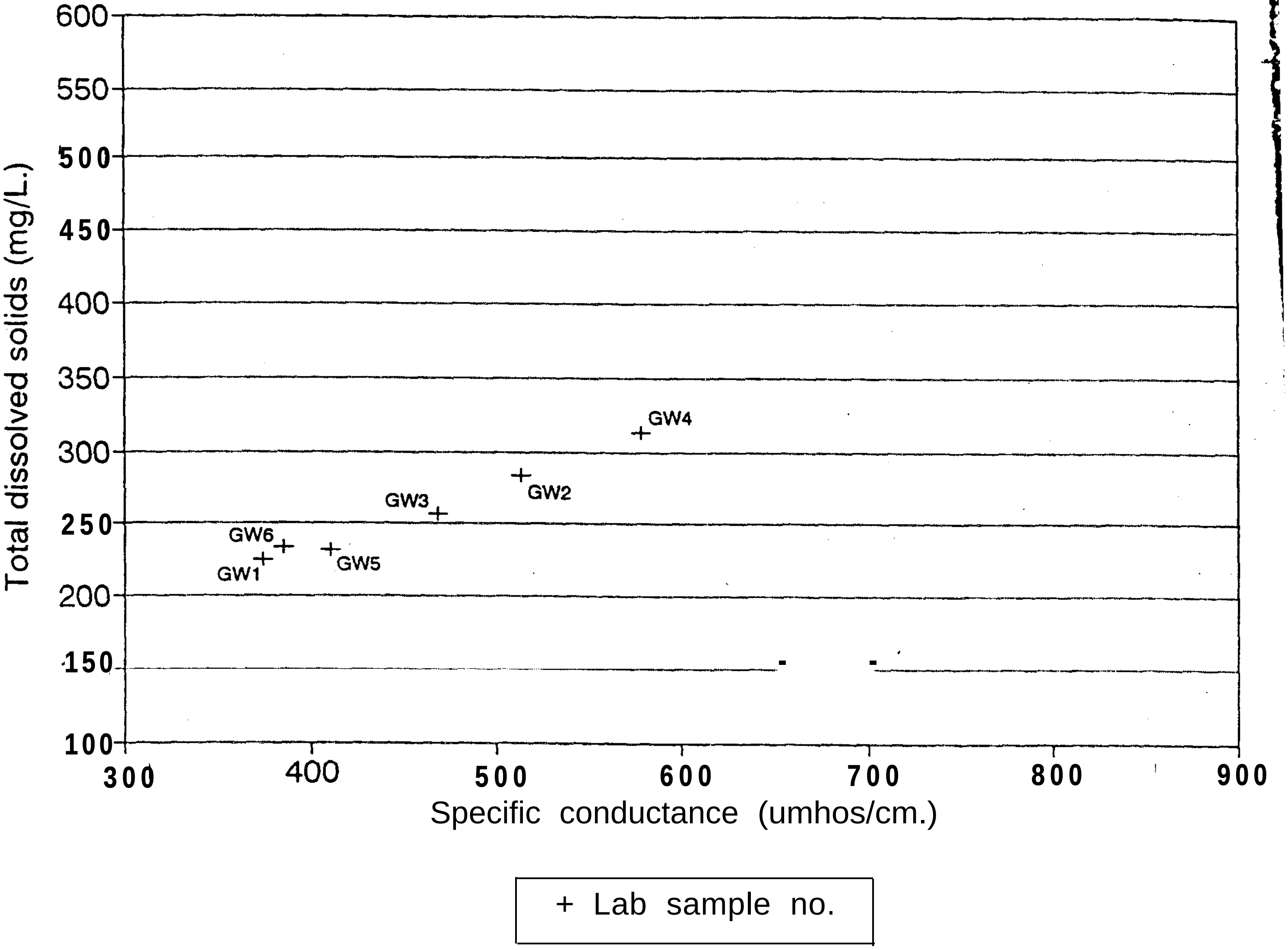

Figure 9. Plot showing specific conductance (at 25'C) and total dissolved solids of samples GW1 through GW6 (see Appendix B).

In contrast, a sample of water from the Fredreka II well taken after 15 minutes of purging at about 200 gpm exhibited a specific conductance of 579 micromhos/cm (at 25'C) and a chloride content of 132 mg/L, yet did not taste noticeably salty. In fact, no clear salty taste was detected subsequent to pumping at a rate of 196 gpm for almost 6 hrs with specific conductance values as high as 831 micromhos/cm (at 25'C). This would correspond to an estimated chloride concentration of about 190 mg/L, although no samples were taken of that water. Other dissolved constituents in the water may be responsible for taste differences.

The specific conductance of water in the South well was tested at 332 micromhos/cm (at 25'C) within 4 minutes of pump startup, and again after 23 hours of pumping at 57 gpm. The specific conductance was observed to increase to 386 micromhos/cm (at 25'C) after almost a day of pumping.

Recharge

A comparison of the precipitation records and the water level records obtained from the Eureka well show a relationship between a 4-hr rainfall event on May 18 and a subsequent rise in water levels. A total of 0.4 in. of rain fell during the event. The time difference between the midpoint of the event and the peak ground-water level is about 20 hrs. This indicates that the aquifer receives recharge near the well field relatively rapidly.

Source of Salt Water

A conceptual model of the ground-water flow systems at St. Paul Island has fresh water from precipitation and snowmelt infiltrating to the water table through scoriacious debris and into fractures and vesicles in the volcanic rocks. The fresh water follows a relatively shallow ground-water flow path to discharge areas near the coast or beneath the sea. Beneath the fresh water is a mixing zone where water becomes increasingly saline with depth, eventually approaching the salinity of seawater. The freshwater aquifer is sustained by the density difference between fresh and saline water, the stratified nature of the lava flows, and recharge. A relatively thick mixing zone may exist because of the high transmissivity (and possibly high dispersivity) of the aquifer and the transient stresses induced by tides, intermittent recharge, and pumping.

Mean tide level at Saint Paul Island is 1.95 ft above mean lower low water (Appendix C). Although water levels at the pumped well dropped below this level early in the test (fig. 2), water levels in the Eureka and Fredreka II wells remained 2.0 to 2.5 ft above this level throughout the test (figs. 3, 4). This indicates that sea water intrusion from the coast is not a credible explanation for the rise in salt content in the pumped water. Rather, the increase in specific conductance, chloride, and total dissolved solids is indicative of upconing. Upconing is the rise of salt water from deeper parts of an aquifer as a result of pumping from a well. The amount of upconing is generally related to pumping rate, as was observed, and is generally reversible, as was also observed. The source of the salt water is probably relict seawater, as the rocks present at St. Paul Island are generally low in soluble salt minerals. The percentage of seawater that is required to mix with pure water to yield the quality of water observed during the test is less that 1 percent.

AQUIFER YIELD AND DEVELOPMENT

The primary objective of the aquifer test was to provide data for estimating the potential yield of existing wells. The test results show that at pumping rates up to 300 gpm, water levels stabilize within a few hours. Long-term changes in water level at this rate of pumping are expected to be slight. As a result of the high transmissivity of the aquifer, the potential yield of the aquifer is more limited by the dissolved salt content of the water than by the amount of water that can be produced. The level of dissolved salts in the water that is acceptable to water users is poorly defined.

TDS, sodium and chloride are three water quality parameters related to upconing or sea-water intrusion for which water-quality standards exist (TDS = 500 mg/L, sodium and chloride = 250 mg/L). For discussion purposes, it is suggested that the guideline for chloride concentration of treated and blended water be made approximately equal to 110 mg/L, which is probably below most people's taste threshold. Most users could probably not distinguish waters with chloride concentrations varying between 71 and 110 mg/L. Water-quality requirements of seafood processors are unknown. Provision of blended water exceeding 110 mg/l chloride to residential users incurs a risk of perceptible deterioration of palatability.

The procedure for estimating the potential yield of existing wells requires: 1) determining theoretical well yields that could have been obtained at the time of the test to yield blended water meeting the guideline described above; 2) evaluating factors beyond the scope of the test that might influence long-term pumping and water quality.

Theoretical Aauifer Yield Under Test Conditions

During test conditions, water could theoretically have been mixed in the following proportions to have achieved a blended water approximately matching the guideline. Values shown below for the Fredreka II well are estimates.

	Pumping rate (gpm)	Specific conductance (umhos/cm at 25'C)	TDS mg/L	Chloride (mg/L)
Fredreka I	300	465	250	100
Fredreka II	100	630	340	150
South + North	82	386	233	77
Theoretical total	482			

Estimated blended chloride concentration using above ratios: 106 ma/L.

Lona-term Potential Yield of Existino Wells

Estimates of the long-term potential yield of existing wells are influenced by seasonal considerations and uncertainties in extrapolating the results of the aquifer test to long-term pumping. Water quality in the aquifer may vary significantly from season to season. The low-' recharge time of year is during the winter as a result of low average precipitation and storage of precipitation as snow. The low-recharge time of year is expected to result in a low amount of available fresh water because of the aquifer's rapid response to recharge. In general, concentrations of dissolved ions in pumped water would tend to increase during seasons of low recharge and decrease during seasons of high recharge.

The test described in this report was performed at a relatively low-recharge time of year. On average, the lowest precipitation month on Saint Paul Island is April, with March and May also typically low. At the time of the test, however, snowmelt was largely complete, and some recharge from snowmelt had probably occurred.

The aquifer test showed that the mixing zone of fresh and salt water responds dynamically to pumping at rates of 500 gpm, whether from one or two wells. Even though the test demonstrated the capacity of the Fredreka wells to yield up to 500 gpm, water quality did not stabilize during the test. This means that dynamic readjustment of the mixing zone was underway during the duration of the test. Long-term projections of TDS or chloride content of water pumped from the Fredreka I well at a rate of 500 gpm would be highly uncertain. Even at lower pumping rates, long-term shifts in the mixing zone may occur, and long-term extrapolations of test results contain some uncertainty.

As described above, estimates of long-term potential yield of the aquifer at Saint Paul Island contain some uncertainty. The theoretical aquifer yield of 482 gpm calculated above should be considered the upper limit of possible potential yield estimates because of seasonal factors and possible long-term changes in the mixing zone as a result of pumping. Further quantitative techniques for modeling long-term yields are beyond the scope of this report. Qualitatively considering the factors described above, the total long-term sustainable yield of the four existing production wells that can be achieved without a deterioration of water quality below the 110 mg/L chloride guideline is estimated to be about 300 gpm or 400,000 gallons per day. This estimate is thought to be conservative to a degree consistent with the uncertainties. Cumulative well pumpage at some times of the year may be sustainable above this level because of high seasonal recharge.

Operationally, optimum water quality could probably be achieved by pumping the Fredreka I well at a steady rate of about 220 gpm and either the North or South well at a rate of about 80 gpm. The Fredreka II well, because it produces water of slightly higher specific conductance, should be used as a backup source of water. The actual mix of water from each well needed to minimize chloride concentrations in the delivered water should be determined from actual production and monitoring experience after water use increases.

Additional Wells

Feulner (1980) estimated that a large well field in the southeastern part of Saint Paul Island could yield “roughly” one million gallons per day (about 700 gpm). Additional wells should be drilled to achieve that objective. Considering the effects of upconing, additional wells should generally be drilled at a more inland location than the current wells, and with a minimum 1000 ft well-to-well spacing. The expected yield of each additional well should not exceed 200 gpm in order to maintain water quality. If more than two additional wells are drilled and operated near the Fredreka wells, the fresh-water yield of each well could drop because of well interference.

CONCLUSIONS

The aquifer test provided conclusive evidence that the aquifer tapped by the Fredreka wells is highly permeable and contains a relatively large reservoir of water that can be tapped. The aquifer responds rapidly (within hours) to recharge events. The aquifer response to pumping is nonuniform, indicating that irregularly distributed fractures and void spaces in the volcanic rocks govern flow. Given the geologic setting, however, this is not unusual. The range of calculated transmissivity values, 380,000 - 2,500,000 gpd/ft, indicates that transmissivity is significantly higher than the 100,000 gpd/ft value previously reported.

Each Fredreka well appears to be able to sustain flow rates of 200-500 gpm, however water quality constraints are likely to preclude continuous pumping at high rates.

The dissolved solids content of the water from all the wells appears to increase with pumping rate. Even modest increases in pumping can result in small but measurable increases in dissolved solids. The two Fredreka wells exhibit significantly different water quality responses to increased pumping.

Total pumping from all wells at the time of the test of about 480 gpm is estimated to yield a blended water quality not significantly different than historic production. This water is characterized by chloride concentrations less than half of the drinking water standard of 250 mg/L.

Considering seasonal factors and the possibility of depletion of fresh water, a conservative estimate of long-term sustainable yield from the four existing wells is 300 gpm, or 400,000 gpd. Optimal distribution of this yield among the four wells should be done as additional &formation is obtained from increased production and monitoring.

Sustainable yield greater than 300 gpm may be possible during wetter times of the year. Furthermore, short-term peak production rates may exceed 300 gpm at any time, however, reversible increases in dissolved solids concentrations will occur.

ACKNOWLEDGMENTS

The authors thank the City of Saint Paul for funding and logistical support for this project. R & M Consultants and Anchorage Well and Pump Service also assisted with the test. Charlie Sloan, Frank Rast, and Michael D. Dahl provided helpful review comments.

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RZA

RITTENHOUSE-ZEMAN & ASSOCIATES, INC.
Geotechnical & Hydrogeological Consultants

SOIL OR ROCK DESCRIPTION

DRILLED BY: MW Drilling
DRILLING METHOD: Air Rotary
REFERENCE ELEVATION:
CASING:
GROUND:

Silty overburden with cobbles

Basalt BOULDERS and silt

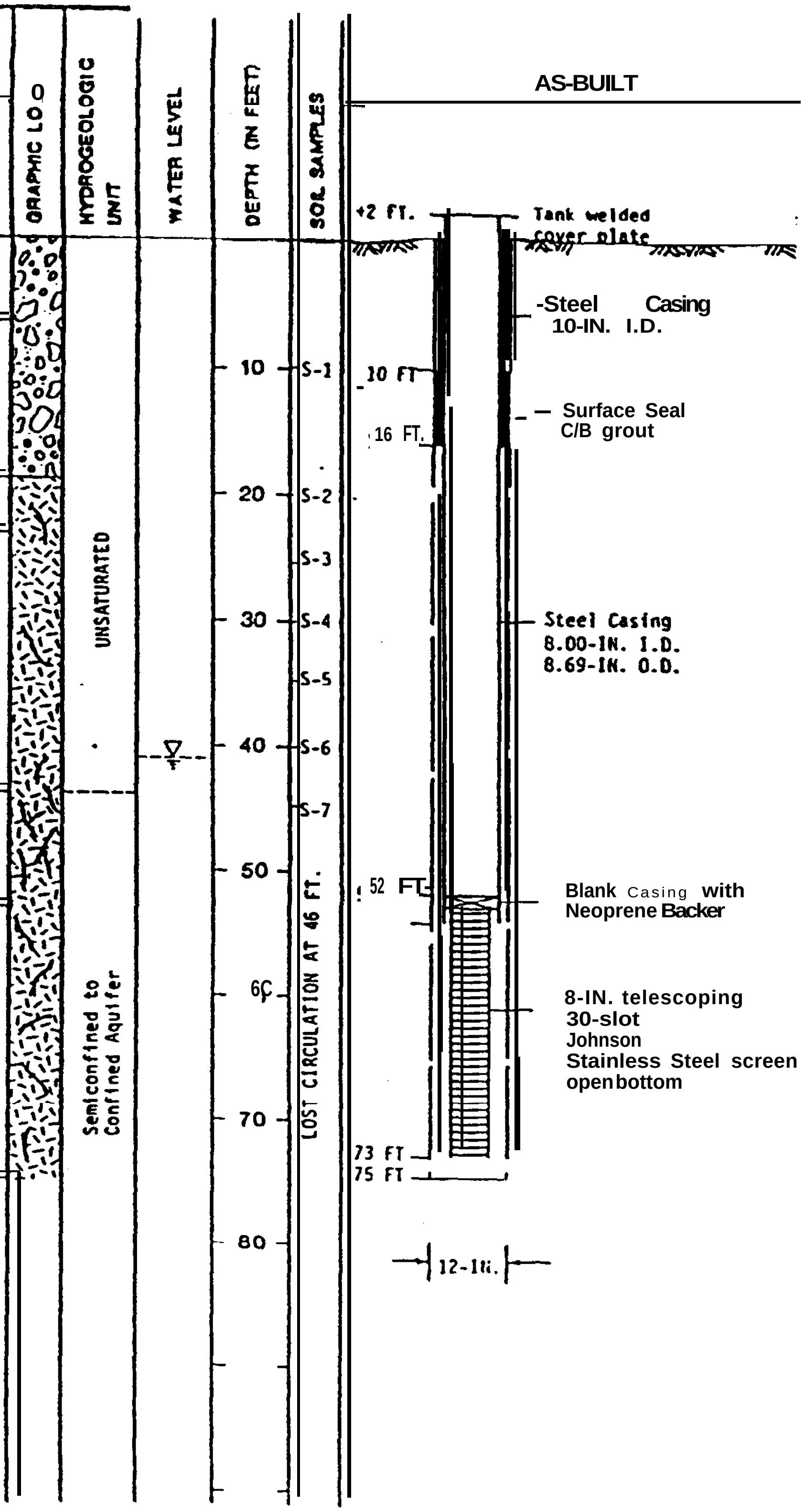
BASALT; gray. weathered, dry

BASALT: black, fine-grained mafic crystals

BASALT; fractured
Lost return of cuttings

BASALT - drilling action indicated less fractures

Total Depth 75 FEET



URS
Corporation
Anchorage Alaska

City of
St. Paul
Water Supply
Analysis Study

Well Fredreka Boring Log & As-Builts

RZA
RITTENHOUSE-ZEMAN & ASSOCIATES, INC.
Geotechnical & Hydrogeological Consultants

SOIL OR ROCK DESCRIPTION

DRILLED BY: M-W Drilling, Inc.
DRILLING METHOD: Air Rotary
REFERENCE ELEVATION:
CASING:
GROUND:

Moist, brown, silty, peaty, fine SAND with abundant basalt boulders.

Basalt BOULDERS; black, dry

BASALT: gray to black, dry

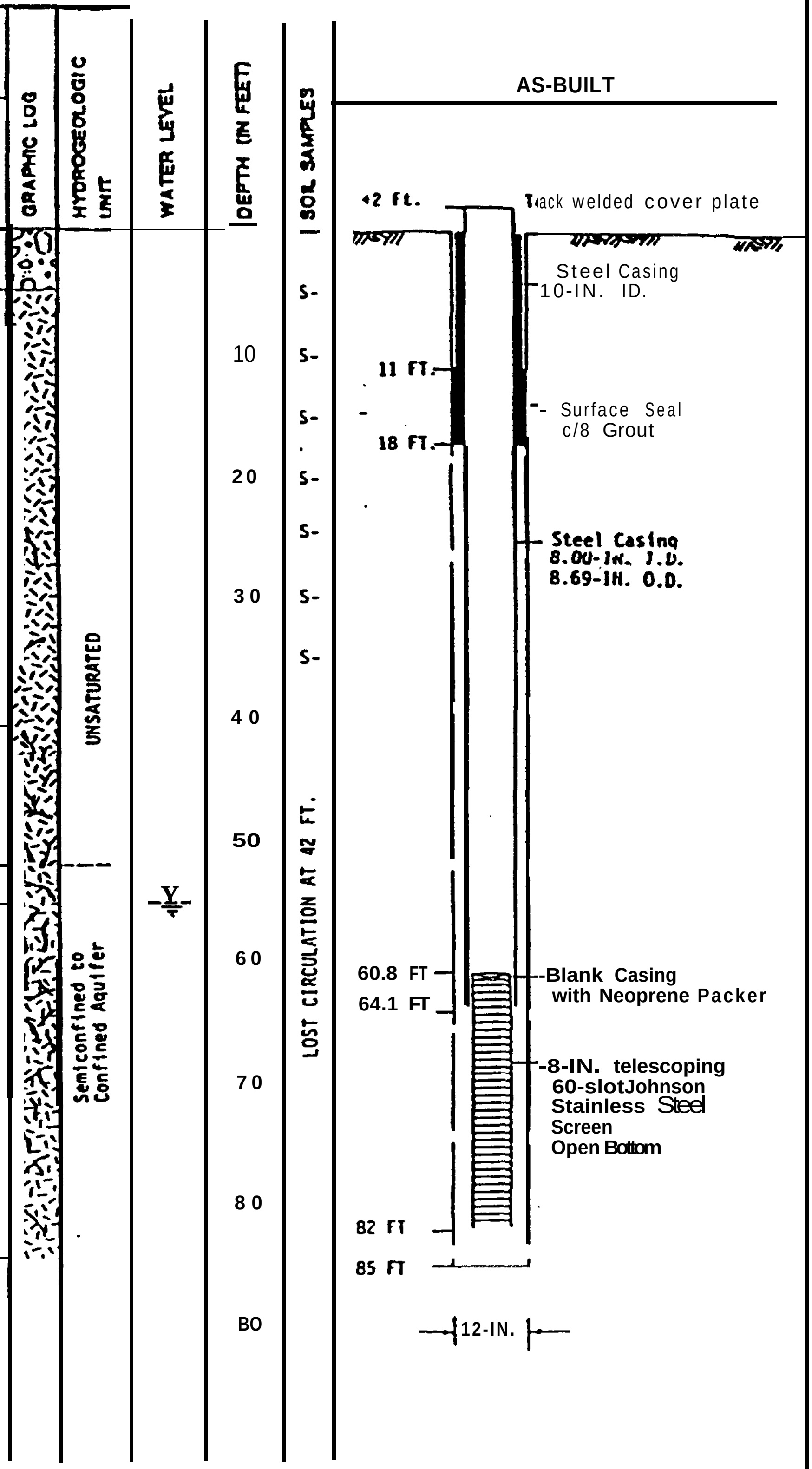
BASALT; fractured
Lost return of cuttings

BASALT - drilling action indicated fractured ~~rock~~

BASALT - drilling action indicated heavily fractured rock

BASALT - drilling action Indicated less fractures

Total Depth 85 FEET



URS Corporation Anchorage Alaska	City of St. Paul Water Supply Analysis Study	**Well Fredreka II Boring Log & As-Builts**

RZA

RITTENHOUSE-ZEMAN & ASSOCIATES, INC.

Geotechnical & Hydrogeological Consultants

SOIL OR ROCK DESCRIPTION

DRILLED BY: M-W Drilling, Inc.
DRILLING METHOD: Air-Rotary
REFERENCE ELEVATION:
CASING:
GROUND:

Moist, **brown, silty.** peaty. fine SAND with abundant basalt **boulders**

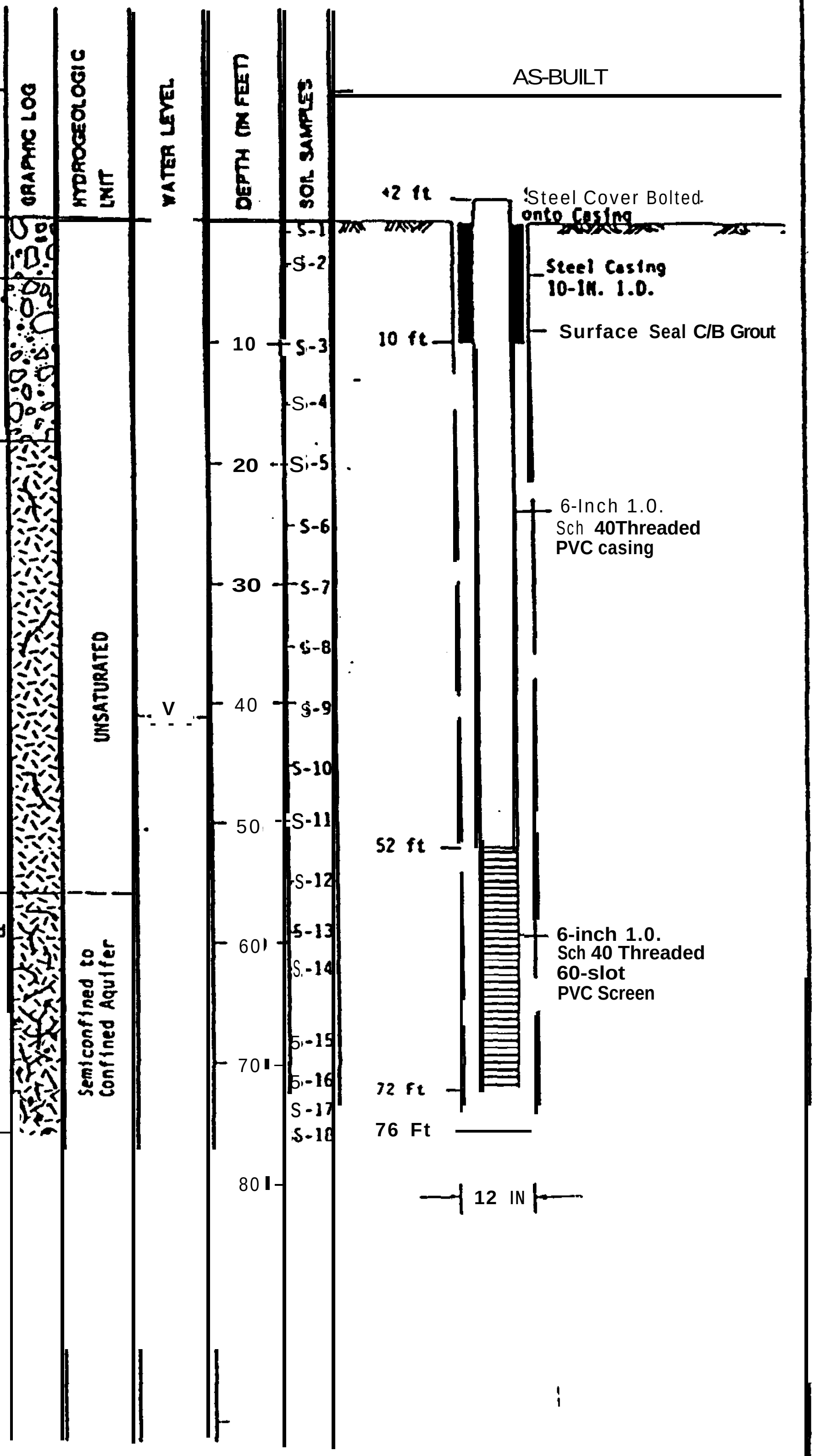
Basalt BOULDERS and moist, gray-brown, clayey, silty, *fine SAND. Basalt* fresh and locally vesicular

BASALT; **black,** fresh, fine-grained with Scattered very ***fine olivine grains.***

BASALT: gray-black. fine-grained fractured, fresh to slightly weathered locally oxidized Becomes **highly weathered, vesicular and limonitic** below 62 feet (Flow Bottom?)

Becomes silty below 75 feet.

Total Depth 76 FEET.



URS Corporation Anchorage Alaska	City of St. Paul Water Supply Analysis Study	Well Eureka Boring Log & As-Builts

Appendix B

Water Quality Analyses

Explanation of sample codes

Sample date	Sample time	Well sampled	Sample identification	Specific Conductance (umhos/cm at 25'C)
15 May 1993	1220 hrs	Fredreka I	GW1	375
16 May 1993	1023 hrs	Fredreka I	GW2	513
17 May 1993	0850 hrs	Fredreka I	GW3	468
18 May 1993	1350 hrs	Fredreka II	GW4	579
19 May 1993	0916 hrs	Fredreka I	GW5	410
19 May 1993	1524 hrs	South Well	GW6	386

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/Division of Water – Eagle River

Submitted By: Jim Munter

Date Submitted: 24 May 1993

Sample	Flouride	Chloride	Nitrate	Phosphate	Sulfate
GWl	0.20	91.5	0.71	<DL	14.4
GW2	0.24	117	0.91	<DL	22.0
GW3	0.23	102	1.0	<DL	20.6
GW4	0.33	132	1.2	<DL	28.2
GW5	0.24	97.2	0.99	<DL	17.2
GW6	0.23	77.0	0.44	0.64	10.7
Units	mg/L	mg/L	mg/L as N	mg/L as P	mg/L
EPA Method	340.2	300.0	300.0	300.0	300.0
Detection Limit	0.01	0.01	0.02	0.1	0.01
RPD	5.5	8.3	5.7	9.0	3.9
% Recovery	94	109	96	92	104

“Approved By ______________________ Date 8JUNE93

Jim Vohden, Chemist

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/Division of Water – Eagle River

Submitted By: Jim Munter

Date Submitted: 24 May 1993

Sample	Calcium	Magnesium	Sodium	Potassium
GW1	8.89	7.60	50.1	4.27
GW2	11.2	10.0	67.4	5.17
GW3	10.6	9.19	60.6	4.74
GW4	9.88	8.53	80.3	5.24
GW5	7.72	6.92	55.4	4.09
GW6	12.2	7.58	52.6	5.21
Units	mg/L	mg/L	mg/L	mg/L
EPA Method	AES 0029	AES 0029	AES 0029	258.1
Detection Limit	0.01	0.01	0.1	0.01
RPD	2.8	1.2	3.2	6.5
% Recovery	99	101	96	105

Approved By

Jim Vohdcn, Chemist

Date 8JUNE93

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/Division of Water – Eagle River

Submitted By: Jim Munter

Date Submitted: 24 May 1993

Sample	Silica	Carbonate	Bicarbonate	Total Dissolved Solids
GW1	27.3	21.3	41.3	225
GW2	25.8	24.6	50.0	283
GW3	27.0	20.8	42.2	256
GW4	25.2	24.7	41.1	314
GW5	26.1	17.5	35.6	232
GW6	28.5	39.5	80.4	233
Units	mg/L as Si02	mg/L as CO3	mg/L as HC03	mg/L
EPA Method	AES 0029	**	**	**
Detection Limit	0.01			
RPD				
% Recovery				

** by calculation as per USGS I-1751-78.

Approved By

Jim Vohden, Chemist

Date 11 June 93

MEMORANDUM

R & M CONSULTANTS, INC.

To: Frank Rast
From: Michael Schoder
Subject: 1993 St. Paul Aquifer Test Surveys
Date: June 28, 1993
Job No: 351050

R&M completed the surveying services at St. Paul Island in support of the water aquifer testing during our May, 1993 field trip in accordance with your request. This task was comprised of establishment of MLLW elevations on four existing well casings, a new monitoring well casing and establishing temporary benchmarks near several ponds or lakes which were being monitored during the aquifer testing.

Vertical control surveys were performed utilizing third-order differential leveling techniques to establish Mean Lower Low Water (MLLW) elevations on the project points. The basis of elevation utilized for the vertical datum was National Ocean Service(NOS) tidal benchmark "K-946-4212" established by NOS in 1976. The value utilized for this benchmark was provided by the National Oceanic and Atmospheric Administration (NOAA) for Tidal Station 946 4212, Village Cove, St. Paul Island, Bering Sea, publication date 12/13/89. NOAA's data is based upon a 1 month series tidal observation performed in November 1977. The following tidal datums are correlated by NOAA for St. Paul:

Highest Observed Water Level (11/02/77) = 4.9 Feet
Mean Higher High Water (MHHW) = 3.27 Feet
Mean High Water (MHW) = 2.93 Feet
Mean Tide Level (MTL) = 1.95 Feet
Mean Low Water (MLW) = 0.97 Feet
Mean Lower Low Water (MLLW) = 0.00 Feet
Lowest Observed Water Level (11/14/77) = -0.6 Feet

Benchmark "K-946-4212" =26.93 Feet

The survey level loops were closed within third-order tolerances, and the observations adjusted for loop closures. The following two pages present the results of the vertical surveys.

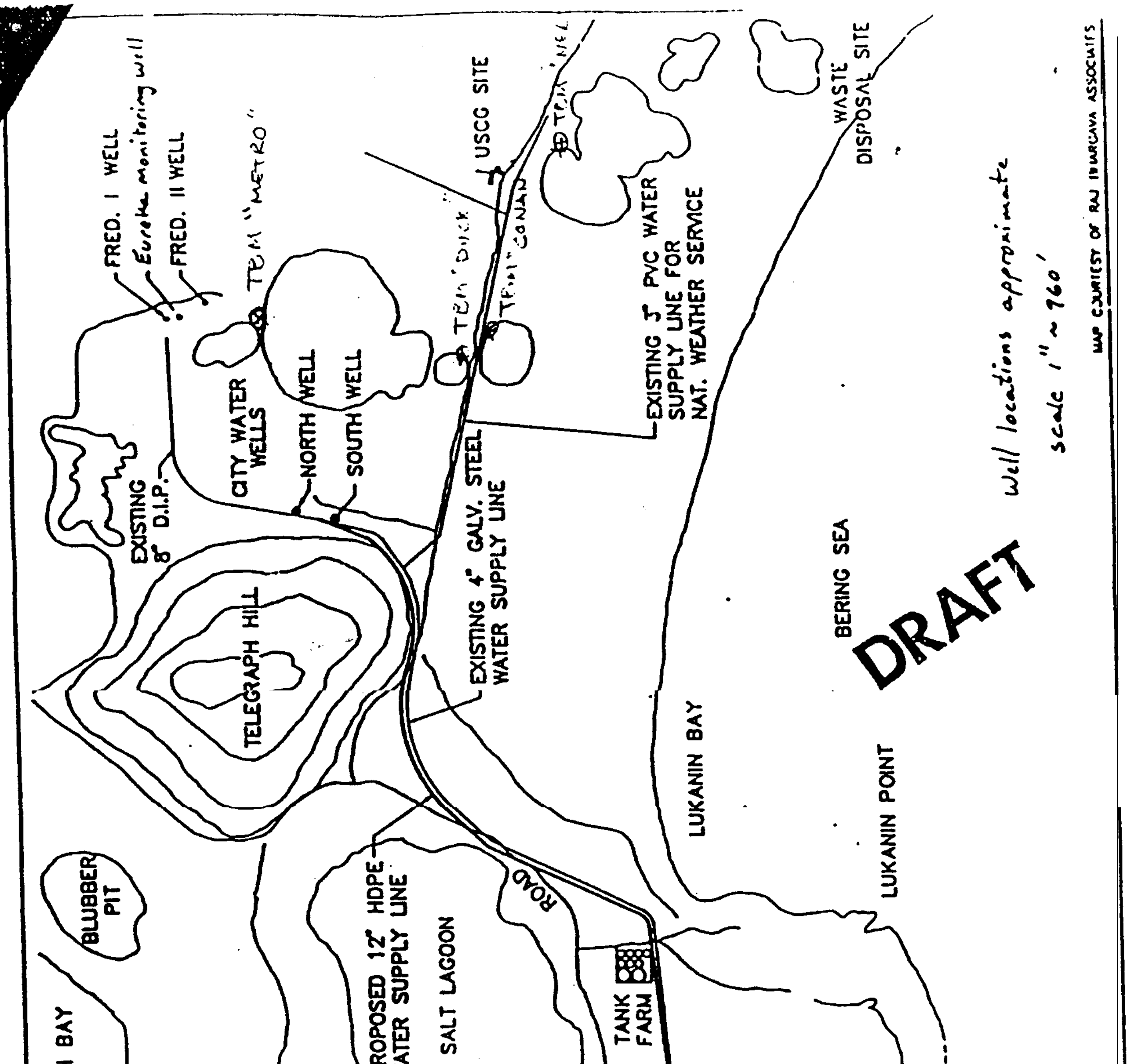
The following values were determined for well reference datums **at** the existing well sites:

MLLW **Elevation**	**Description**
02.22'	North Well - Southwest corner of concrete pad for well pump motor foundation.
81.74'	North Well - Finish floor of concrete slab of north well building adjacent to pump motor foundation monitoring point.
60.62'	South Well - Northwest corner of concrete pad for well pump motor foundation.
79.64'	South Well - Finish floor of concrete slab of south well building adjacent to pump motor foundation monitoring point.
40.74'	Fredreka I - Top of well casing
45.94'	Fredreka I - Finish floor of concrete pad of pumphouse building.
63.67'	Fredreka II - Top of well casing
61.05'	Fredreka II - Finish floor of concrete pad of pumphouse building.
46.03'	Eureka Monitoring Well - Top of well casing on east side.*

*See 1/7/94 memo (p. 30)

Four temporary benchmarks (TBMs) were established for use in monitoring of the waterbodies near the well sites. The general location of the TBMs are shown on the attached annotated copy of Figure 1. The TBMs and values established are described as follows:

MLLW Elevation	Description
8.69'	TBM "METRO" - 5/8" X 30" rebar, top set 0.10' above ground, approximately 30' northerly of water edge near DNR staff gauge on large pond southerly of Fredreka wells.
9.37'	TBM "DUCK" - Mark on top of 3' diameter rock boulder, at southerly edge of small pond, immediately northerly of Polovina Road.
9.23'	TBM " CONAN" - 5/8" X 30" rebar, top set 0.10' above ground, at toe of slope of Polovina road, at northerly edge of small pond.
11.67'	TBM "NERD" - 5/8" X 30" rebar, top set 0.10' above ground, on westerly shore of pond across Polovina Road approximately 0.2 mile northerly from the USCG Loran station.



Well locations approximate
scale 1" ~ 960'

MAP COURTESY OF R&J IHNARUAVA ASSOCIATES

Figure 1. Location of water supply wells, Saint Paul Island, Alaska. (after R&M Consultants, Inc., 1993)

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MEMORANDUM

R & M CONSULTANTS, INC.

To: Frank Rast
From: Michael Schoder
Subject: 1993 St. Paul Aquifer Test Surveys
Date: January 7, 1994
Job No: 351050

I have reviewed our survey field notes in response to your request to verify the elevation which we provided for the Eureka Monitoring well at St. Paul Island. The elevation of 46.03' which we provided was taken at a PK spike which we set in the easterly edge of a 10" diameter concrete filled casing pipe. At the time of survey, monitoring equipment was installed on the top of the PVC casing extending above the concrete filled outer casing, which prevented us from observing a measurement to the top of the PVC casing. It was understood that the DNR monitoring personnel would make this measurement after dis-assembling the monitoring equipment. I have attached a copy of the field notes for this site for your reference. Please contact me if you have any additional questions.