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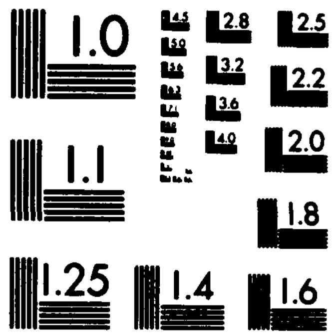

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PSDDA Reports

US Army Corps of Engineers
Seattle District

Puget Sound Dredged Disposal Analysis

Washington State Dept. of Natural Resources

PUGET SOUND SEDIMENT DEPOSITION ANALYSIS: PHASE I

Prepared by: Evans Hamilton, Inc.
Seattle, Washington

EPA
Region 10

ECOLOGY

PUGET SOUND SEDIMENT DEPOSITION ANALYSIS

FINAL REPORT

by

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INTRODUCTION

In Phase I of the Puget Sound Dredge Disposal Analysis (PSDDA), five Zones of Siting Feasibility (ZSFs), located in central Puget Sound, were evaluated for their suitability for the future disposal of dredged materials. The Phase I area covers central Puget Sound from the Narrows Bridge to Foulweather Bluff, Port Susan, and midway up Saratoga Passage. The Zones are located in Commencement Bay, Elliott Bay, Port Gardner, and Saratoga Passage (Figure 1).

Within each zone, preliminary disposal sites were located in areas where the tidal current energy was believed to be very low, because, under the Phase I "non-dispersive" philosophy, the primary goal was to choose sites where newly deposited dredged material generally would remain undisturbed. A number of checking studies were conducted in each ZSF to refine the disposal sites by identifying their gross physical and biological characteristics. A quantitative approach was required to confirm that the sites were situated within low energy or "depositional" environments where fine sediments naturally accumulate. A procedure was selected in which a statistical evaluation of physical characteristics of the sediments was carried out.

This procedure, termed "depositional analysis", is based on the fact that fine sediments and organic material settle out of the water column to the sea floor in areas of low energy. The method involves examining the sediment at each station located on a specific depth contour, and identifying areas of low energy through statistical evaluations of measures of organic content, grain size, and water content.

The methods used in the analysis were developed from observations made in southern California where the organic enrichment in the vicinity of municipal sewage outfalls was noted to be in direct proportion to distance from the discharge (Bascom, 1978). The concentration of organic material in the sediment decreased from the outfall in the direction of the alongshore current (Hendricks, 1976). Average values of 5 day biochemical oxygen demand measurements (BOD_5) along depth intervals were calculated and compared to the BOD_5 values at each station and the depositional patterns due to the discharge plume were elucidated. The grid of stations established around the outfall region showed that the greatest amount of organic material deposited at the depth of the outfall and dispersed forming an eliptical pattern with the outfall at one apex. It was postulated that the natural deposition of particulate material may occur in a somewhat similar manner. However, the use of BOD_5 as the sole indicator of deposition may not be adequate without a measure of grain size.

The depositional analysis was refined by adding the grain size, percent volatile solids, and percent water to the analysis for studies in Puget Sound. The technique was used during the Seahurst and Duwamish Head baseline studies to identify areas

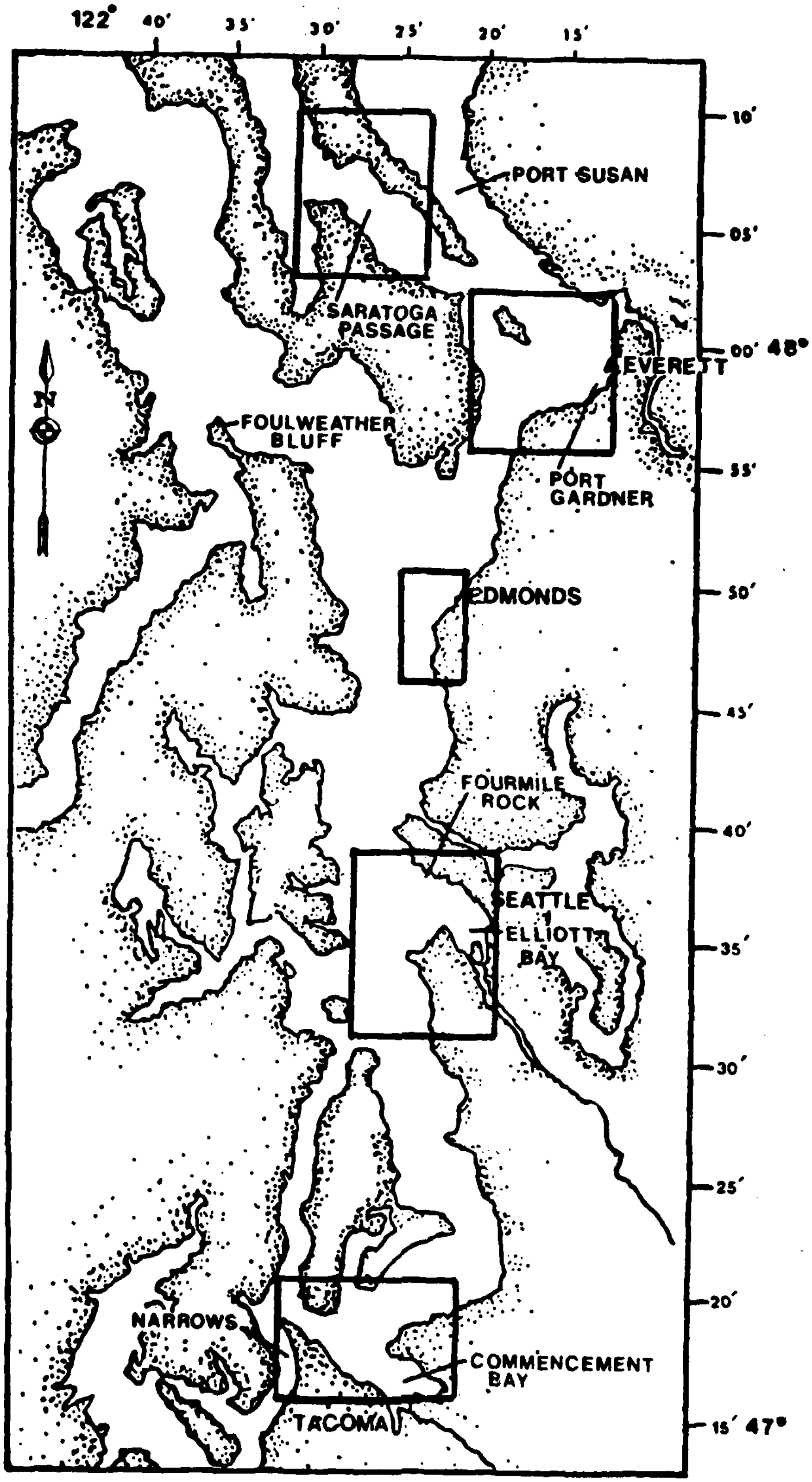


Figure 1. General location of the five ZSF's within Puget Sound. Also shown is a test sampling area located outside of a ZSF (Edmonds).

where the deposition of organic material from an outfall most likely would occur (Word et al., 1984a & b). A comparison was made of the percent volatile solids, five-day biochemical oxygen demand, percent water and median grain size of sediment samples taken from a number of stations located in the East Passage of central Puget Sound. Because of the natural depth dependent variation of these parameters, only samples taken at similar depths were statistically compared. Stations where sediment samples had high levels of organic material, high water content, and high percent clay were always found to be located in areas with low current speeds or tidal eddies. This correlation suggested that these areas were sediment sinks, or were depositional in nature. The fact that fine sediments tend to settle in low current areas is not surprising, but the significance of elevated values of the other parameters requires further explanation. A high level of volatile solids (% VS) indicates that a large percentage of the sediment by weight is volatile at 550°C. This volatile material consists of organic and inorganic solids. High BOD_5 values indicate the presence of a large amount of biologically available organic material. A high BOD_5 value is anticipated in sediments with high % VS but may not correlate with % VS if the organic material is not readily available to microorganisms. Large BOD_5 values suggest that organic material is accumulating rapidly through settlement, or that there is a large amount of biological activity generating organic material for microbial use. Percent water is a by-product of the volatile solids analysis, and a high percent water usually coincides with small sediment grain sizes.

None of the depositional analysis parameters independently provides complete assurance that an area is depositional. For instance, past studies have found that sediment grains between 0.1 and 0.5 mm sometimes are more easily eroded than sediments that are either larger or smaller (Moherek, 1978; Kendall, 1983). Therefore, if the selection of a depositional site depended solely on locating sediments with fine grain size and high percent clay, there is a possibility that an area of even lower energy could be overlooked. However, when at least one of the other parameters (volatile solids, BOD_5, or percent water) also indicates a low energy environment, the site may be labeled depositional with a high degree of confidence.

By examining existing bottom sediments through the depositional analysis methods, the end product of the Puget Sound basin's natural erosion and accretion process is being observed directly. The exact pathway by which the sediments arrived at a site may not be completely understood, but the knowledge that very fine sediments are accumulating greatly simplifies the task of predicting the fate of dredged material that is disposed at the site. If the disposal methods are selected to minimize the amount of material that is lost during its descent through the water column, and if the material's erodability characteristics are similar to those of the existing bottom sediments, the conclusion that the dredged material will also remain in place may be made with a high degree of certainty.

MATERIALS AND METHODS

STATION LOCATIONS

Sampling stations were located throughout each ZSF (Figure 2). Stations were placed on transect lines at similar depths (50, 100, 200, 300, 400, 500, 600, 700) so that a statistical comparison of the data at similar depths could be made.

Sixty one stations were sampled in Commencement Bay from 7 to 8 April 1986. From 9 April to 10 April thirty-four stations were sampled in Elliott Bay (seventeen in the inner Bay and seventeen at Four-Mile Rock). Seventy-two stations were sampled in Port Gardner on April 10, 11, and 14. Saratoga Passsage, with its twenty-four stations, was not sampled until the 24th of April because of high winds.

Nine additional stations were taken in an area between Elliott Bay and Port Gardner to test the technique outside of an embayment. Edmonds, Washington was selected because it is geographically centered between the two embayments, and because the bathymetry indicated that it was an uncomplicated sedimentary environment.

A total of two hundred and one stations were sampled for the study. Station locations, date and time of collection, number of replicates, and types of samples collected are presented in Appendix A.

NAVIGATION

To achieve accurate station positioning the following navigational aids were used:

1) LORAN C

2) Variable Range Radar Fixes using two to four targets

3) Mini-Ranger

4) Water depth

In Commencement Bay and Elliott Bay, variable range radar was used in conjunction with LORAN C coordinates providing a positioning accuracy of approximately 18.5 meters. Navigation using LORAN C in Port Gardner and Saratoga Passage was not possible due to strong interference in the area. Navigation in these two areas was therefore accomplished using a Mini-Ranger III System (MRS) which provided accurate positioning to within three meters.

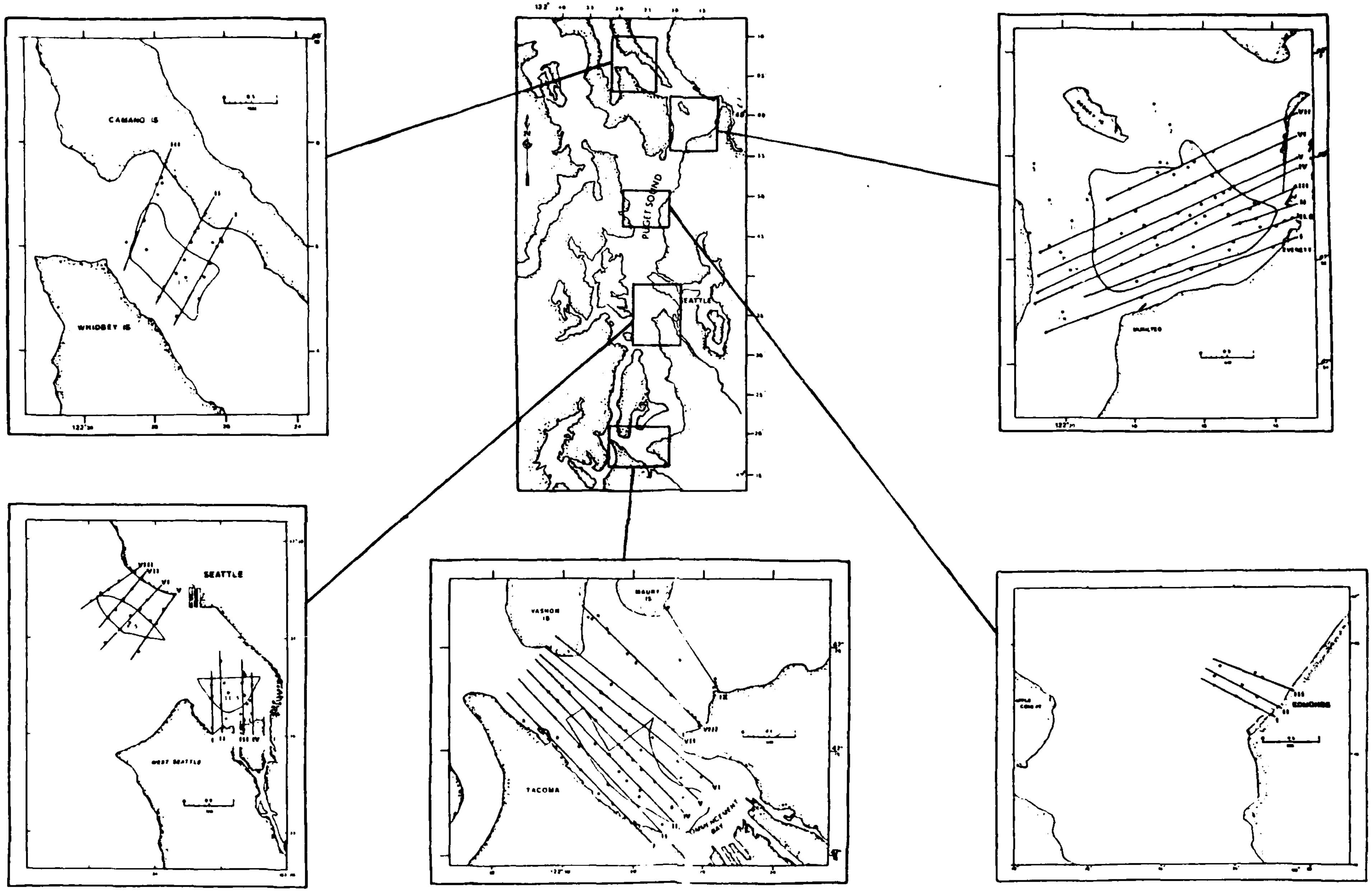


Figure 2. Transects (lines numbered with Roman numerals) and stations (dots) sampled within each ZSF (light line) and off Edmonds.

The water depth criterion used during this project for acceptable depth variation during replicate sampling was either 10% of the established depth or 20 feet, which ever was less. Depths were measured using recording paper and digital output fathometers.

FIELD SAMPLING PROCEDURES

Subtidal sediment samples were collected in a consistent, repeatable way with a 0.1 m^2 modified van Veen grab sampling device. Upon collection, the physical characteristics of the sediment were described and recorded for each sample. The recorded information included sediment texture and color, strength and type of odors, sampler penetration depth, degree of leakage or sediment surface disturbance, and any obvious abnormalities such as wood debris and biological structures (e.g., shells and tubes). Samples which showed excessive disturbance of the sediment surface were rejected. In addition, sediment samples were rejected if they did not meet the following minimum penetration depths:

1) 4 cm-coarse sand and gravel

2) 5 cm-coarse to medium sand

3) 7 cm-find sand

4) 10 cm-silt with sand or clay

FIELD METHODS FOR CHEMICAL ANALYSIS

Sediment samples for chemical analysis were handled by first removing the overlying water in the sampler. Water was drawn off using a vacuum suction device attached to the seawater system on the vessel. Since an undisturbed sediment surface was necessary, the physical description of the sediments was delayed until after the chemical samples were taken. At each station separate samples were collected for: 1) priority pollutant analysis; 2) grain size; and 3) total volatile solids and five-day biological oxygen demand.

Samples were taken from the upper two centimeters of the sediments using METRO's toxicant cookie cutter. The cookie cutter, an inverted stainless steel pan, was placed on the surface of the sediment, gently pushed into the sediment, and a flat plate slid just underneath the edge of the device. Material extending outside the device was sliced away and the material within the cookie cutter was transferred to an appropriately cleaned container.

Sample containers for priority pollutant analyses were prepared by Analytical Resources, Inc. using standard EPA procedures. The cookie cutters were rinsed with a solution of deionized organic-free water between replicates at a station and between stations. Handling devices for the collection of grain size, total volatile solids, and biochemical oxygen demand were also cleaned with deionized organic-free water, and sediments were placed into clean eight ounce glass jars.

Sediment samples for measurements of grain size and percent water were kept in a cool place until returned to the laboratory where they were refrigerated (4°C). Samples for priority pollutants, total volatile solids, and biochemical oxygen demand were stored on ice until returned to the laboratory where they were stored in freezers.

LABORATORY PROCEDURES

In 1985, the U.S. Environmental Protection Agency (Region X) established protocols for the examination of water, sediments and benthic infauna under the Puget Sound Estuaries Program (PSEP). These protocols, when used with those established in Standard Methods for the Examination of Water and Wastewater, are an extremely valuable guide to follow when conducting research in the marine environment. All procedures used in this study are those recommended for use by the above two manuals.

Priority Pollutants

Priority pollutant samples were not analyzed for this report. These samples were collected so that future analysis of the samples could be conducted if a need arose to investigate the presence of priority pollutants in the potential disposal sites. These samples are archieved at the laboratories of the Washington State Department of Natural Resources.

Percent Volatile Solids (% VS)

Percent volatile solids were determined by combustion at 550°C, once the samples were completely thawed and homogenized. A minimum of two replicates were conducted for each station.

Five-Day Biochemical Oxygen Demand (BOD_5)

The 5-day biochemical oxygen demand was determined following procedures in Standard Methods for the Examination of Water and Wastewater (1985) and in the PSEP protocols manual. These procedures were modified for using seawater as the dilution water. Seawater was collected at the Seattle Aquarium and filtered through three Baker Hydro Sand Filters (Model HRV-36; #20 white silica sand), two charcoal filters, and an ultraviolet sterilizer (Model L-150). The water was then incubated at 20°C in the dark and aerated for quality improvement. The 5-day demand of the seawater dilution blank did not exceed the recommended value of 0.20 mg/l throughout the study.

The microorganism seed culture was produced in the laboratory by continually aerating a three litre culture medium incubated at 20°C. The medium was initially composed of one liter of aquarium sand collected from the University of Washington School of Fisheries' saltwater aquarium gravity filter beds, and two liters of the supernatant of equal parts sand and saltwater. For the duration of the study the culture received 75 ml of salinity-adjusted METRO West Point Treatment Plant unchlorinated sewage effluent and 5 mg of Tetra-Min baby fish food every other day. Three times a week the seed culture was violently stirred and a portion transferred to a one liter glass jar where the particulates were allowed to settle and the supernatant was used in the BOD_5. A seed concentration of 1 ml per 0.3 liters of diluted sample was used.

In preparing the sediment sample for the 5-day test, the sample was allowed to thaw to room temperature and was homogenized. Four representative aliquots of the sample were weighed to within 10 mg of each other and then carefully transferred into incubation bottles. One milliliter of the seed culture was introduced into each bottle which was then filled with oxygen-saturated seawater. Care was taken when capping the bottles so that no air bubbles were introduced into the bottles. Two bottles were fixed immediately to measure the initial concentration of dissolved oxygen. The other two bottles were agitated for 10 seconds or until the sediment was completely suspended, and were placed in a darkened area and maintained at 20°C. The bottles were incubated for a period of five days, and were agitated daily to resuspend the sediments.

The 5-day BOD (milligrams of oxygen used per kilogram of sediment, dry weight) for each sample was calculated using the formula:

$$BOD_5 = \frac{(a-b)\ .3 \times 1000}{(g)(R)}$$

where,

a = initial dissolved oxygen concentration at time 15 minutes (mg/l)

b = dissolved oxygen concentration at time 5-day (mg/l)

g = grams of sediment added to each 0.3 liter test bottle

R = ratio of the dry to wet weight of the sediment sample (expressed as a decimal fraction)

Quality control of the dilution water, the effectiveness of the seed culture, and the technique of the analyst, were maintained by: 1) preparing dilution seawater controls (test blanks); 2) using control mixtures of glucose and glutamic acid (1:1) with a theoretical oxygen demand of 218 ± 11 mg/l; 3) preparation of several dilutions of seeded dilution seawater (seed control) with theoretical oxygen demand between 0.6 and 1.0 mg/l; 4) duplicate determinations made using sediment samples with low and high organic loads.

<u>Percent Water, Grain Size, and Percent Clay</u>

The refrigerated sediment samples were warmed to room temperature and homogenized. One aliquot was weighed, oven-dried ($103^{o} \pm 5^{o}C$), and weighed again for computation of percent water.

A second aliquot went through a stepwise procedure for sediment grain size determination. The grain size determinations were done based on methods modified from Plumb (1981), Krumbein and Pettijohn (1938), and Buchanan (1984). The sediment was wet sieved into two size fractions. Sediment larger than 62 um was air dried and further analyzed by dry sieving through a series of graded sieves into the following size categories using a Braun mechanical shaker: cobble (156-64 mm); gravel (64-2 mm); coarse sand (2-0.5 mm); and fine sand (0.5-0.062 mm). Sediments finer than 62 um were analyzed by wet pipetting techniques, and were classified as silt (0.062-0.004 mm); and clay (less than 0.004 mm). A computer program generated the median size class and the percentages of gravel, sand, silt, and clay.

DATA ANALYSIS

Percent volatile solids, biochemical oxygen demand, percent water content, grain size, and percent clay values were plotted and contoured for each ZSF.

The data for volatile solids were tested for normality at the depths where dredged material may be deposited. The frequency distribution of the data along the 400, 500, and 600 foot depth contours were plotted. These plots were then compared to their expected normal curves generated from the calculated mean and standard deviation. The Kolmogorov-Smirnov test for normal distributions was applied to the data to obtain a numerical indication of normality.

A statistical method was employed to determine if individual samples indicated a station to be more depositional in nature than other stations at a similar depth. The mean, standard deviation, 95% confidence interval (95% CI), and 1.96 standard normal deviate (1.96 SND) were calculated for BOD, % VS, and % water for each depth contour using data from all 201 stations (Word et al., 1984 a, b; Sokel and Roth, 1969). In addition, the volatile solids data from the Seahurst and Duwamish Head Baseline studies were added to the analysis to broaden the database. The original intent was to incorporate data for each parameter from the Seahurst and Duwamish Head Baseline studies. However, it became apparent during discussions with the personnel that conducted the work that protocols established in Standard Methods for the Examination of Water and Waste Water were not followed except in the analysis of volatile solids. Thus, the data used in this study incorporated only the Seahurst and Duwamish Head volatile solids data and not the BOD_5 and percent water data.

Those values falling beyond the 1.96 SND were considered outliers. They were temporarily removed from the data, and the computations performed again. Removal of the outliers decreased the variance and produced more realistic average values for the data. Once the final mean, 95% CI, and 1.96 SND were obtained for each depth contour, the individual data for each station sampled (including previously removed outliers) were then compared to the appropriate values. Individual values which fell outside of the 95% CI but inside the 1.96 SND were considered to be potentially depositional compared to other stations at that depth. Any values falling outside of the 1.96 SND were considered depositional in nature as compared to other stations at that depth.

Stations exceeding the 95% CI and the 1.96 SND were placed on a chart, and areas encompassed by the two levels were shaded.

The advantage of this technique is that the values of each parameter are averaged over a large geographic region. This gives a high degree of confidence that stations with sediments that exhibit abnormally high concentrations of the measured parameters are indeed indicative of a depositional environment.

RESULTS AND DISCUSSION

TESTS FOR NORMALITY

The frequency distribution for 400-600 ft depth intervals shows that the data do approximate a normal distribution (Figure 3). In each case the greatest skewness in the observed data occurs towards the greater volatile solids values. The results of the Kolmogorov-Smirnov test using a standard normal distribution are presented in Table 1. These results also indicate that the observed frequency distributions were normal. Since the data were normally distributed parametric statistics were used to calculate the depth interval means, variances, and confidence intervals.

DEPTH RELATED PATTERNS IN CONVENTIONAL CHEMISTRY

Average concentrations, standard deviations, coefficents of variation, 95% confidence intervals, and 1.96 standard normal deviate ranges for volatile solids, biochemical oxygen demand, and percent water at each depth sampled in the zones of siting feasibility are presented in Table 2. The data demonstrate that as station depth increased there was a corresponding increase in the percent volatile solids, percent water, and biochemical oxygen demand of the sediments (Table 2 and Figure 4). For these parameters an exponential regression equation produced coefficients of determination (r^2) that ranged from 0.89 to 0.90. This indicates that there is a strong relationship between the measured parameters and water depth. This is important because it verifies the assumption that depth related trends in the measured parameters are similar to those seen in the Seahurst and Duwamish Head Baseline Studies.

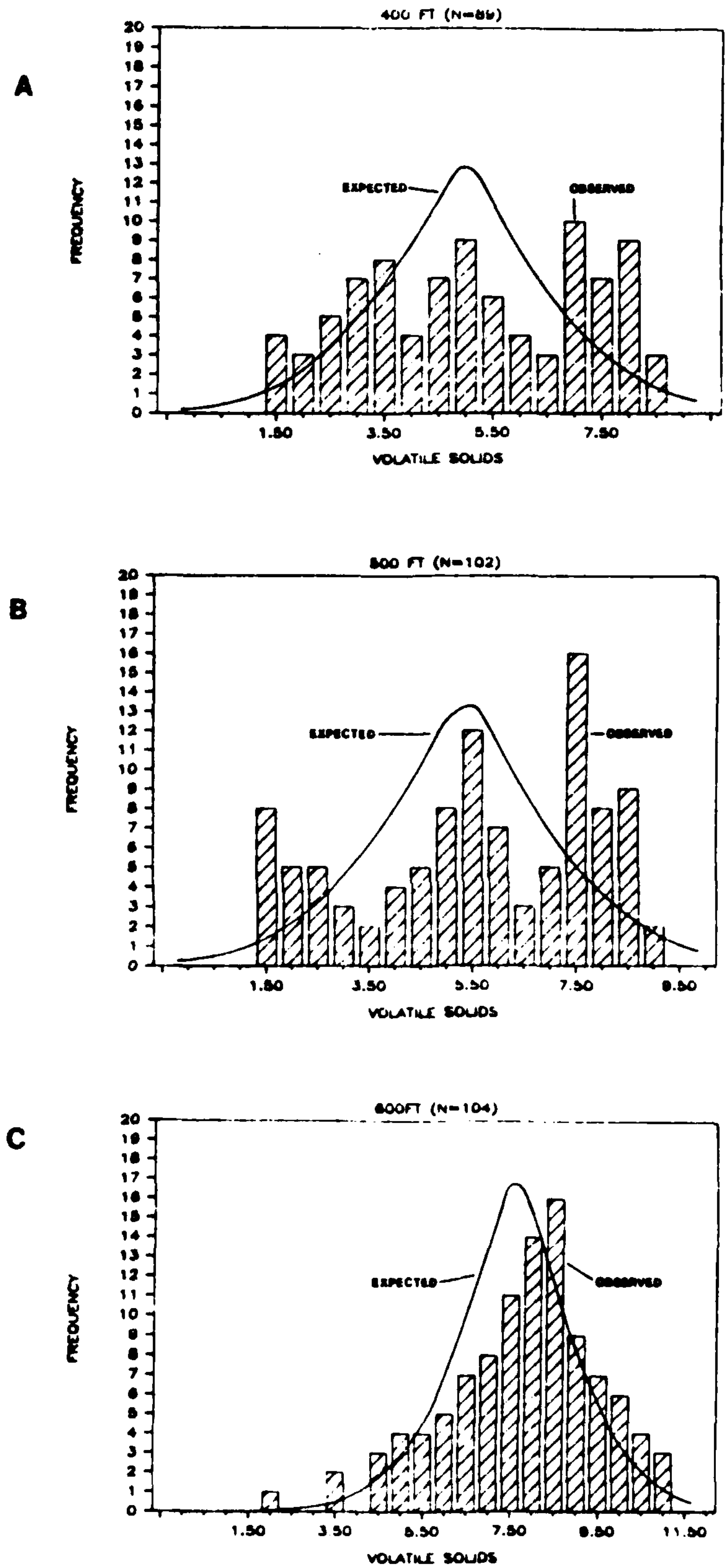


Figure 3. Comparison between the expected normal distribution and the observed distribution of frequency of occurrence versus percent volatile solids, for various depths: a) 400 ft, b) 500 ft, and c) 600 ft.

Table 1. Results of the Kolmogorov-Smirnov test for normality. The test was conducted on the percent volatile solids data.

	Depth 400	500	600
Maximum Difference	0.897	0.875	0.980
Probability (2-tail)	0.000	0.000	0.000

Table 2. Mean, standard deviation, and 95% CI and 1.96 SND intervals for conventional chemistry measures for each depth contour sampled. (N - number of samples, x - mean, S.D. - Standard Deviation, C.V. - Coefficient of Variation, SND - Standard Normal Deviate, CI - Confidence Interval)

Measurement Type	Depth (ft.) 50	100	200	300	400	500	600	700
Volatile Solids								
n	54	45	77	57	77	102	104	25
x	2.1	1.0	2.1	3.2	4.5	5.3	7.5	7.8
S.D.	2.6	0.2	1.5	1.3	1.8	2.2	1.7	1.8
C.V.	1.20	0.19	0.72	0.42	0.41	0.41	0.23	0.23
x + 95% CI	2.8	1.1	2.5	3.6	4.9	5.7	7.9	8.5
x - 95% CI	1.4	0.9	1.7	2.9	4.1	4.9	7.2	7.0
x + 1.96 SND	7.2	1.5	5.0	5.9	8.1	9.7	11.0	11.4
x - 1.96 SND	0	0.6	0	0.6	0.9	0.9	4.1	4.2
Biochemical Oxygen Demand								
n	20	67	40	80	46	93	42	2
x	476	377	444	591	694	718	881	955
S.D.	274	274	178	290	299	254	303	7.0
C.V.	0.57	0.47	0.65	0.47	0.43	0.35	0.34	0.007
x + 95% CI	596	420	534	653	780	770	972	964
x - 95% CI	355	335	354	529	607	667	789	945
x + 1.96 SND	1014	726	1013	1141	1281	1218	1475	968
x - 1.96 SND	0	28	0	40	106	219	286	941
Percent Water								
n	25	64	48	80	60	84	38	2
x	26.1	25.6	34.6	50.2	52.4	57.0	59.7	66.2
S.D.	8.2	4.4	10.0	13.5	13.2	10.1	5.7	0.07
C.V.	0.31	0.17	0.29	0.26	0.25	0.17	0.09	0.001
x + 95% CI	29.3	26.6	37.4	53.1	55.7	59.2	61.5	66.3
x - 95% CI	22.8	24.5	31.7	47.2	49.0	54.9	57.8	66.1
x + 1.96 SND	42.2	34.1	54.3	76.7	78.4	76.9	70.9	66.3
x - 1.96 SND	9.9	17.0	14.8	23.6	26.4	37.2	48.4	66.1

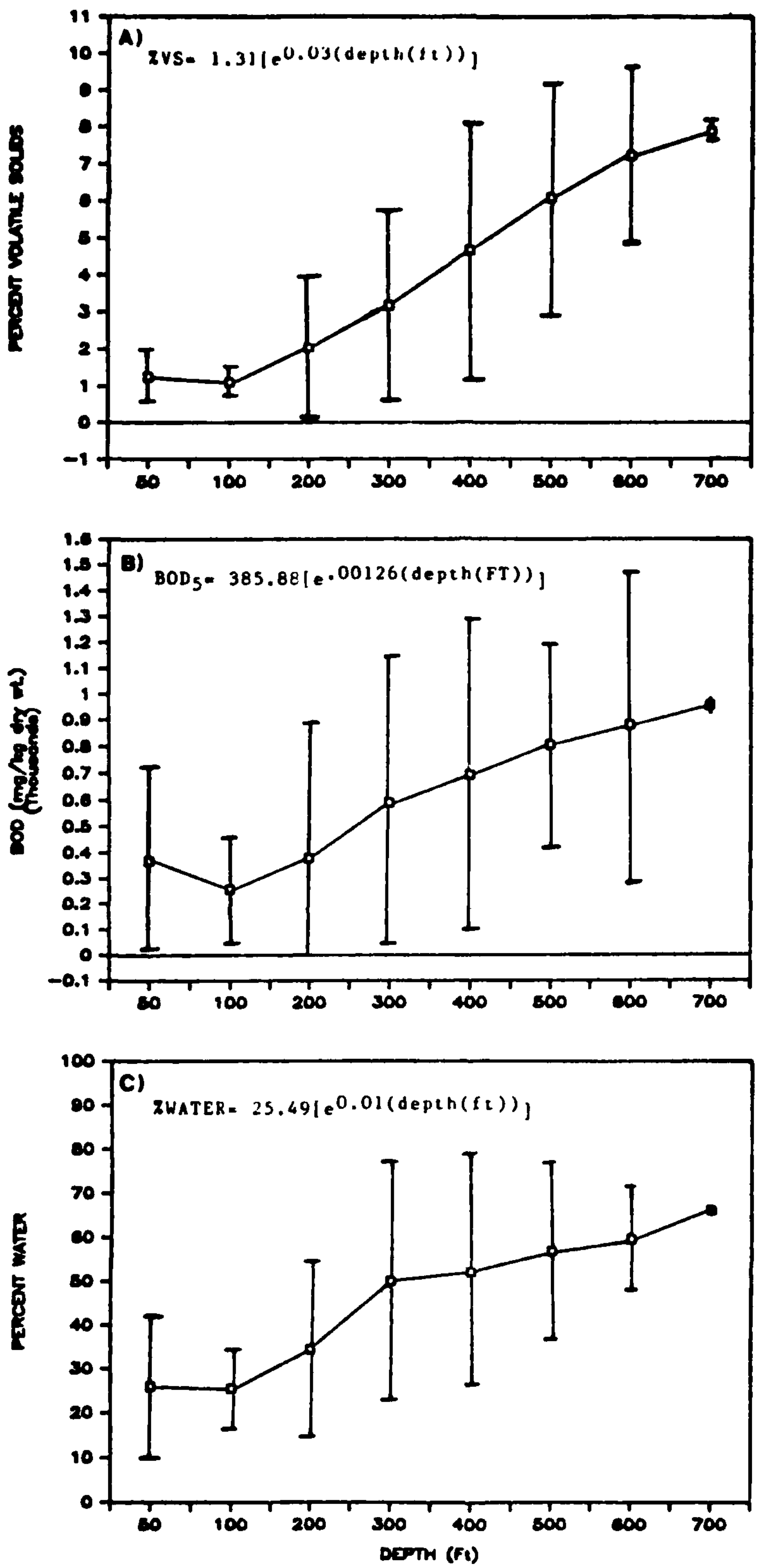


Figure 4. The mean (□) and 1.96 standard normal deviate values for percent volatile solids (A), five day biochemical oxygen demand (B), and percent water (C) for samples collected at 50, 100, 200, 300, 400, 500, 600, and 700 feet depth.

COMMENCEMENT BAY

Percent volatile solids in Commencement Bay ranged from 0.8% to 9.9%, and contours of these data show a tongue of >4% volatile solids extending from the central basin into the Bay (Figure 5). Stations having percent volatile solids in excess of the 95% CI were found extending from the west side of Commencement Bay across the ZSF to Brown and Dash Points. Values greater than 1.96 SND were found along Commencement Bay's southwest shoreline and near Vashon Island.

The five-day biochemical oxygen demand of the sediment in Commencement Bay displayed trends somewhat similar to %VS. A band of high BOD_5 sediment extended from the central basin into portions of the preliminary sites in the ZSF (Figure 6). Values within this band ranged from 892 mg/kg dry wt. to 1338 mg/kg dry weight. BOD_5 values decreased in the center of the Bay and increased again on the west side. Stations having BOD_5's in excess of the 95% CI also showed trends similar to those shown by the %VS. A band of these stations extended across the mouth of Commencement Bay from the west shore to Brown and Dash points and also were found further into the Bay. Values in excess of 1.96 SND were again found at two stations along the Bay's southwest shoreline.

The percent water of the Commencement Bay samples is contoured in Figure 7. The sediments of the central portion of the Bay, including most of the two preliminary sites were composed of 50% water. Only six stations have statistically significant elevations in percent water and none were elevated in excess of 1.96 SND. None of these six stations were in the ZSF.

The distribution of the median sediment grain size and percent clay content are presented in Figures 8 and 9, respectively. The median grain size covering most of the ZSF consisted of coarse to fine silt. Closer to Dalco Passage the sediments became significantly coarser. The central portion of the ZSF and the preliminary sites within it contained high percentages of clay (>15% by weight; Figure 9).

The results show that a low energy area extends from north of Browns Point across the mouth of Commencement Bay to the Bay's southwest shoreline approximately one-half the way between the head of the Bay and the tip of Point Defiance (Figure 10). This low energy area crosses portions of both preliminary sites, but appears to encompass more of the outer site. The highest levels (>1.96 SND) of %VS and BOD_5 are located immediately adjacent to the Bay's southwest shoreline in shallow water, but do not coincide with the Bay's areas of smaller grain sizes and higher clay content which lie within the band crossing the Bay's mouth. In summary, the outer preliminary site and the outer portions of the inner preliminary site appear to be more depositional in nature than other areas in the Bay.

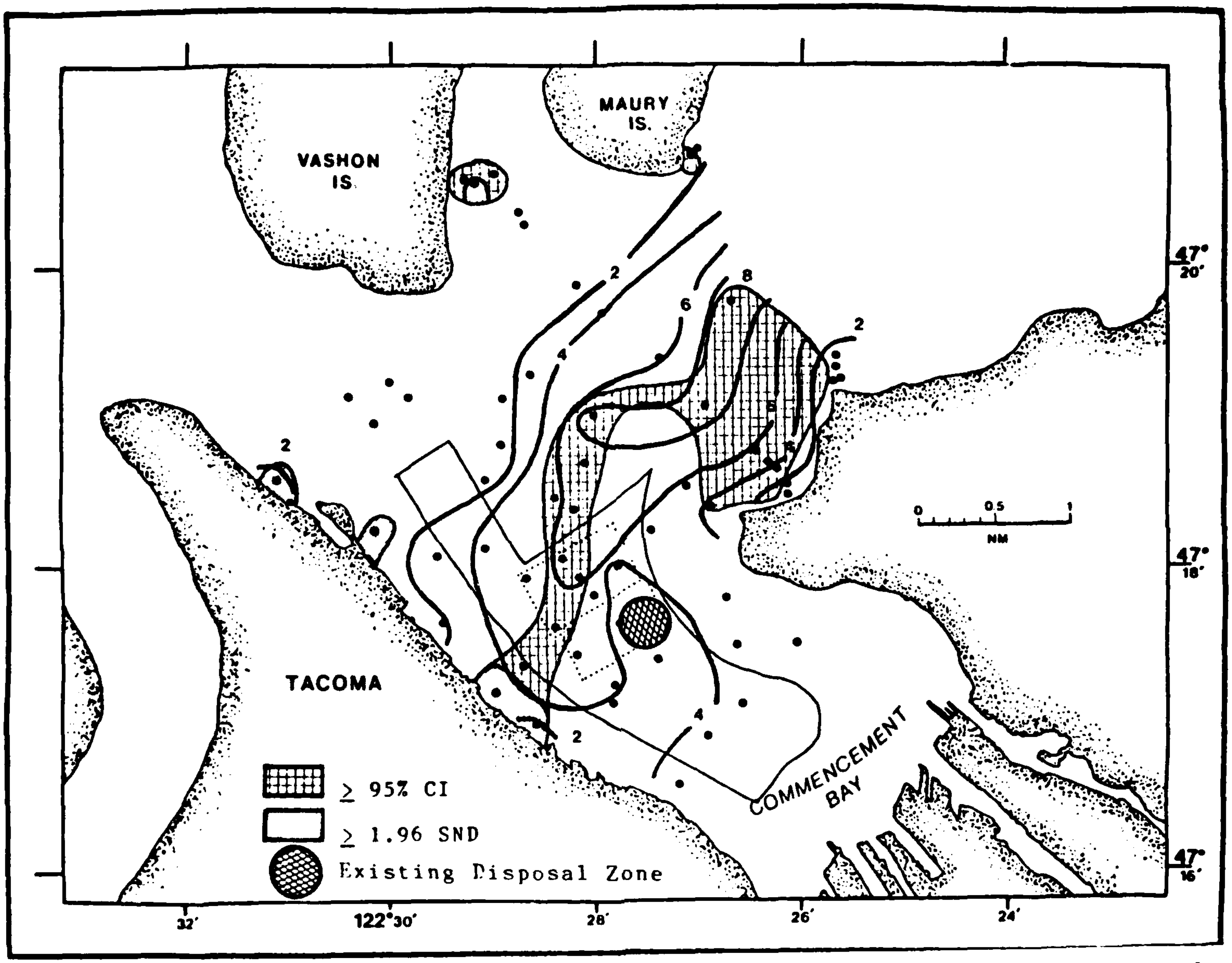


Figure 5. Contours of volatile solids content (percent) overlayed with areas where the percent volatile solids exceeded the 95% confidence interval and 1.96 standard normal deviate values.

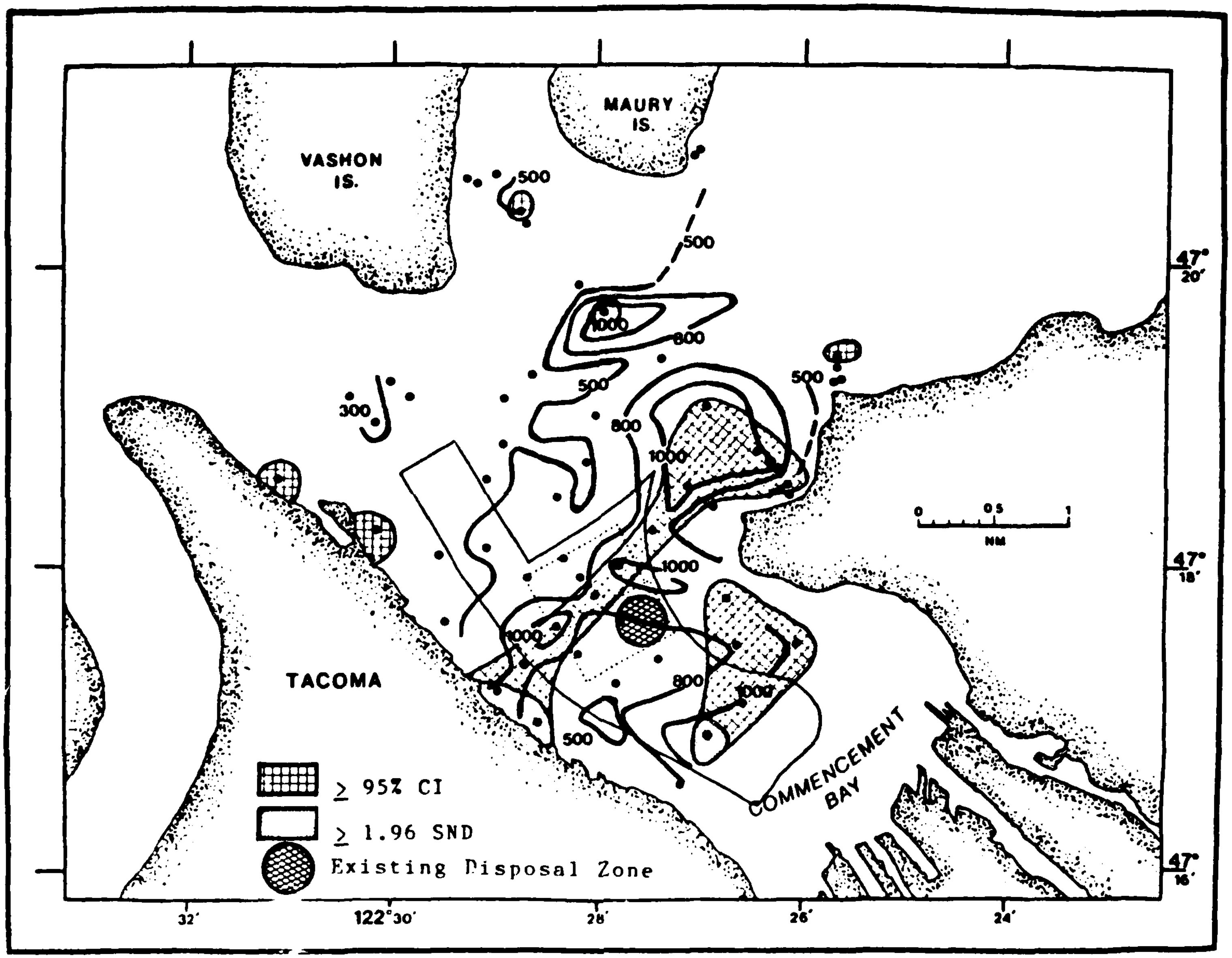


Figure 6. Contours of five day biochemical oxygen demand (mg/kg dry weight) overlayed with areas where the biological oxygen demand exceeded the 95% confidence interval and 1.96 standard normal deviate values.

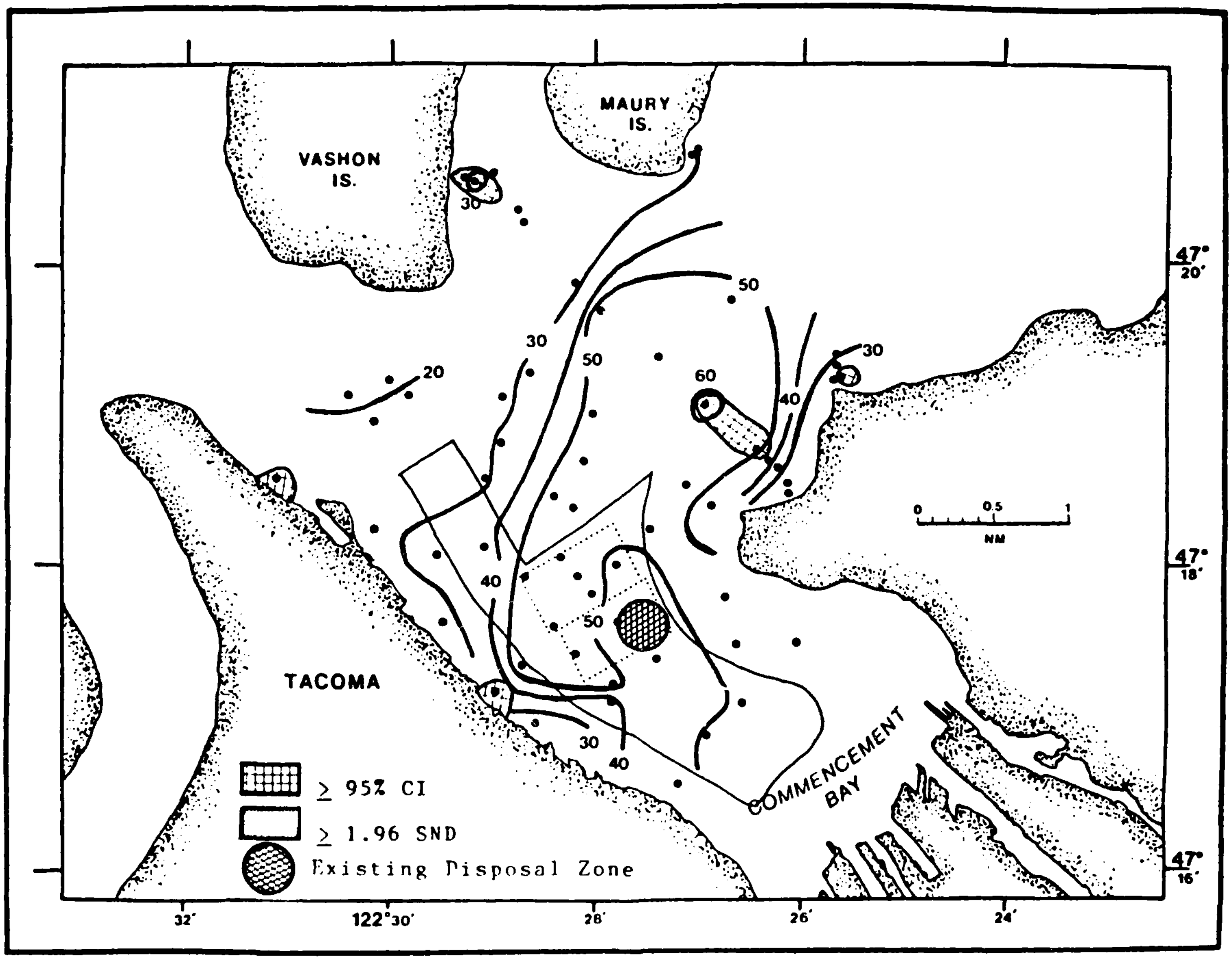


Figure 7. Contours of water content (percent) overlayed with areas where the percent water exceeded the 95% confidence interval and 1.96 standard normal deviate values.

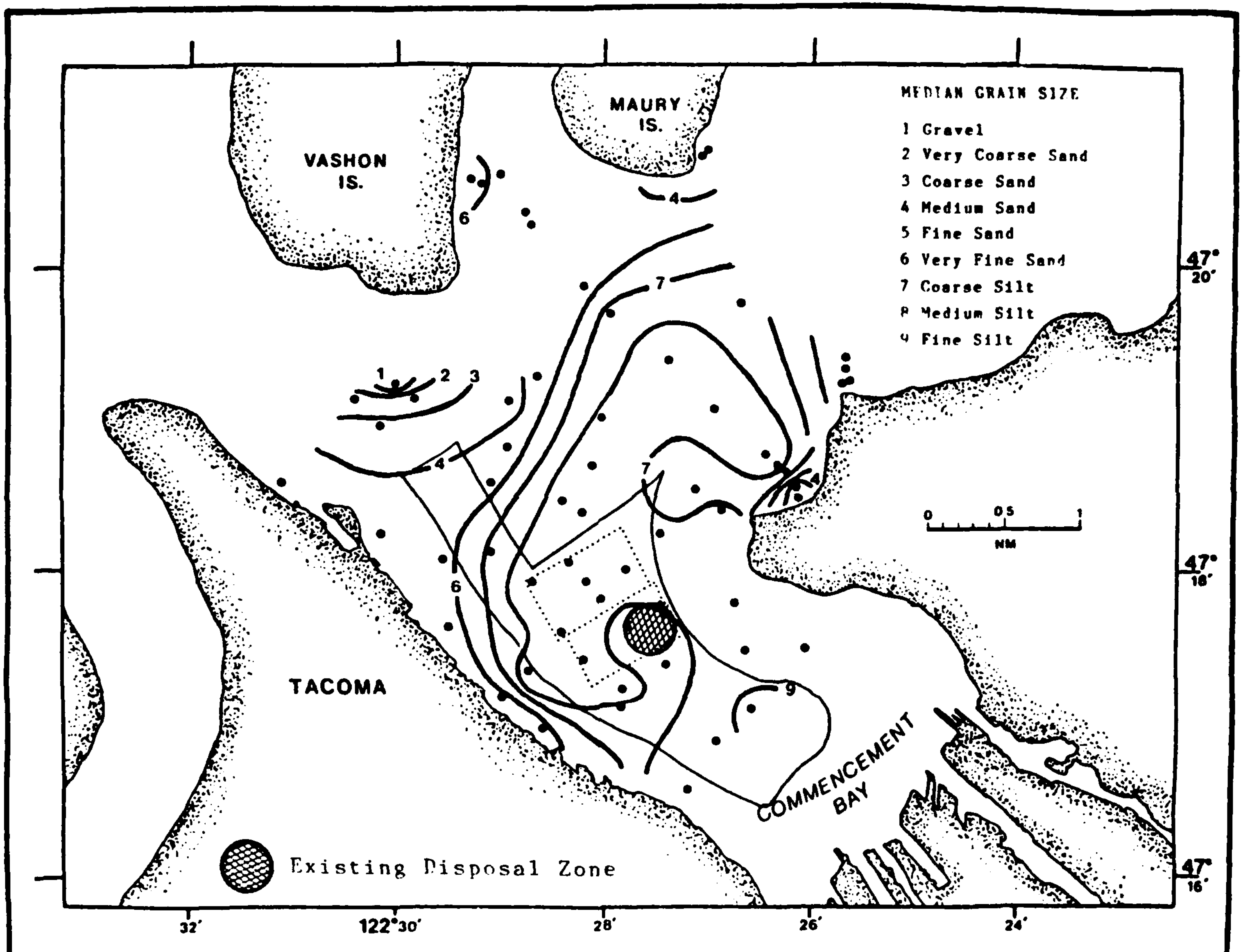


Figure 8. Contours of median grain size. Numbers corresponding to median grain sizes are shown in legend.

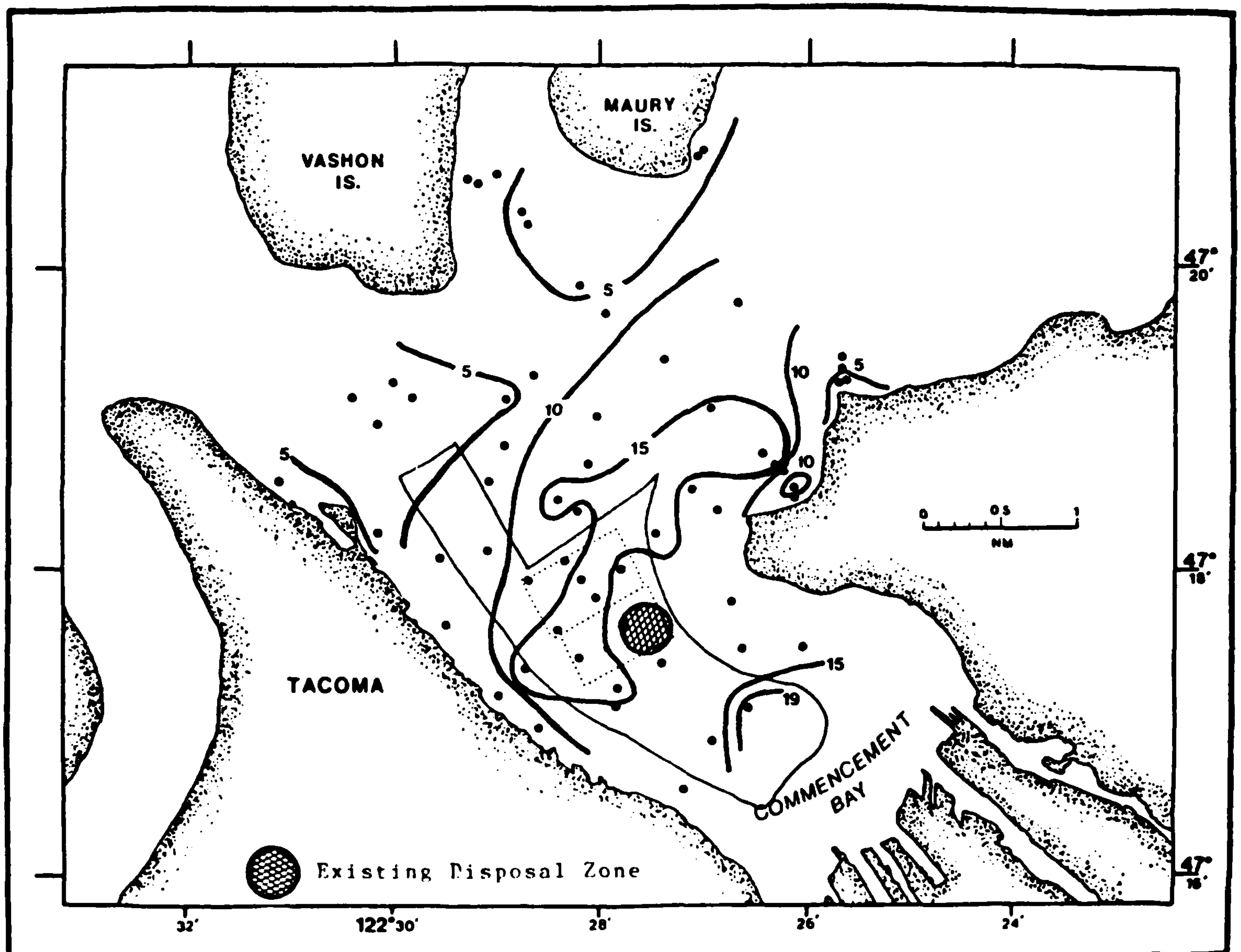


Figure 9. Contours of clay content (percent). No statistical computations were conducted on percent clay.

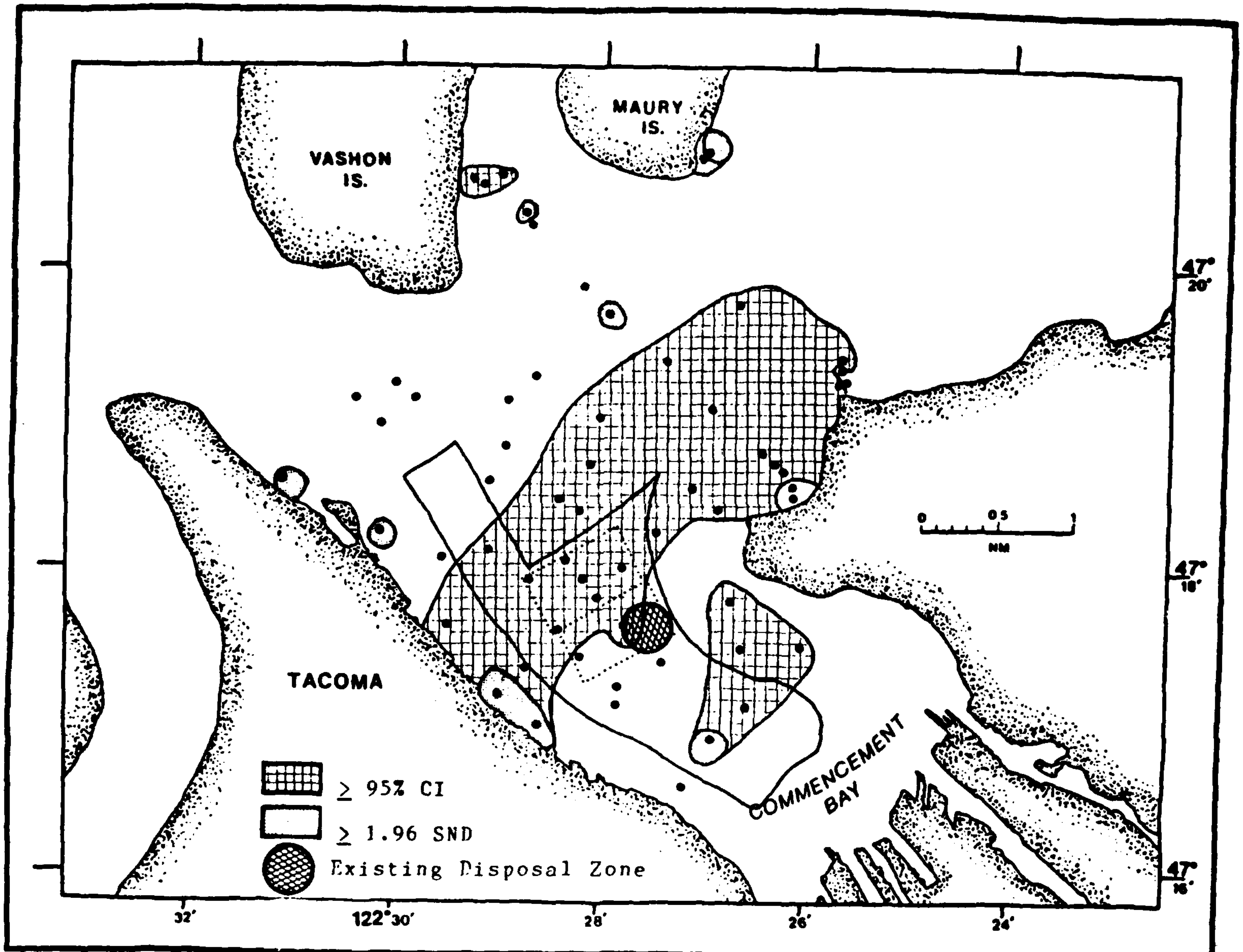


Figure 10. Areas where at least one parameter (percent volatile solids, biochemical oxygen demand, or percent water) exceeded the 95% confidence interval or the 1.96 standard normal deviate.

INNER ELLIOTT BAY

Sediment samples were collected and analyzed from inner Elliott Bay and from Fourmile Rock. Both the inner Elliott Bay and Fourmile Rock ZSF's are shown in Figures 11-16, however for clarity the results for inner Elliott Bay will be discussed first.

The volatile solids concentrations in the inner bay increased with increasing water depth and distance down the submarine canyon off the west waterway of the Duwamish River (Figure 11). Low values near 1% were found immediately off the west waterway, and values increased to 7% at the base of the canyon. Values of 7% were also found at the outer stations on Transects III and IV. Most stations in the inner bay showed enhancements in volatile solids greater than the 1.96 SND level. Exceptions occurred at the following stations: EB II.5 A-220, EB III A-100, and EB IV B-200; these three stations exceeded the 95% CI but not the 1.96 SND level. These stations are located in the southern portion of the preliminary site within the inner bay ZSF.

The five-day biochemical oxygen demand of the sediments at the inner bay ZSF ranged from 300 to over 700 mg/kg dry weight (Figure 12). Values increased with depth and down the submarine canyon. High values were also found along both sides of the bay. Elevations beyond the 95% CI were found in a horseshoe pattern with Stations III A-100 and II.5 A-220, located in the center of the horseshoe, remaining below the 95% CI. Station II.5 A-220 lies in the south side of the preliminary site within the inner bay ZSF.

Percent water values followed the patterns previously described for %VS and BOD_5. The data indicate that the percent water in the inner bay sediments increased with depth from less than 40% at the mouth of the west waterway to over 60% at the base of the submarine canyon (Figure 13). All but one station (III A-100) had percent water values in excess of the 95% CI level. These stations covered the entire preliminary site. Stations with percent water in excess of 1.96 SND were found only outside the ZSF near the south shoreline of Elliott Bay.

The median grain size in the inner bay ranged from coarse sand, located at the station closest to the west waterway, to coarse silt, located offshore in deeper water (Figure 14). The percent clay in most of the inner bay ZSF and preliminary site was from 9 to 12% with values increasing with increasing water depth. Most of the preliminary site within the ZSF contained very fine sands or smaller grain sizes, and the eastern portion of the preliminary site exceeded 12% clay content (Figure 15).

A review of the measured parameters indicates that the entire inner bay ZSF is a depositional area (Figure 16). Station A-200, located in the preliminary site, is in the region where an experimental disposal site was located in 1976, and results here may be biased by previous experimental dumps.

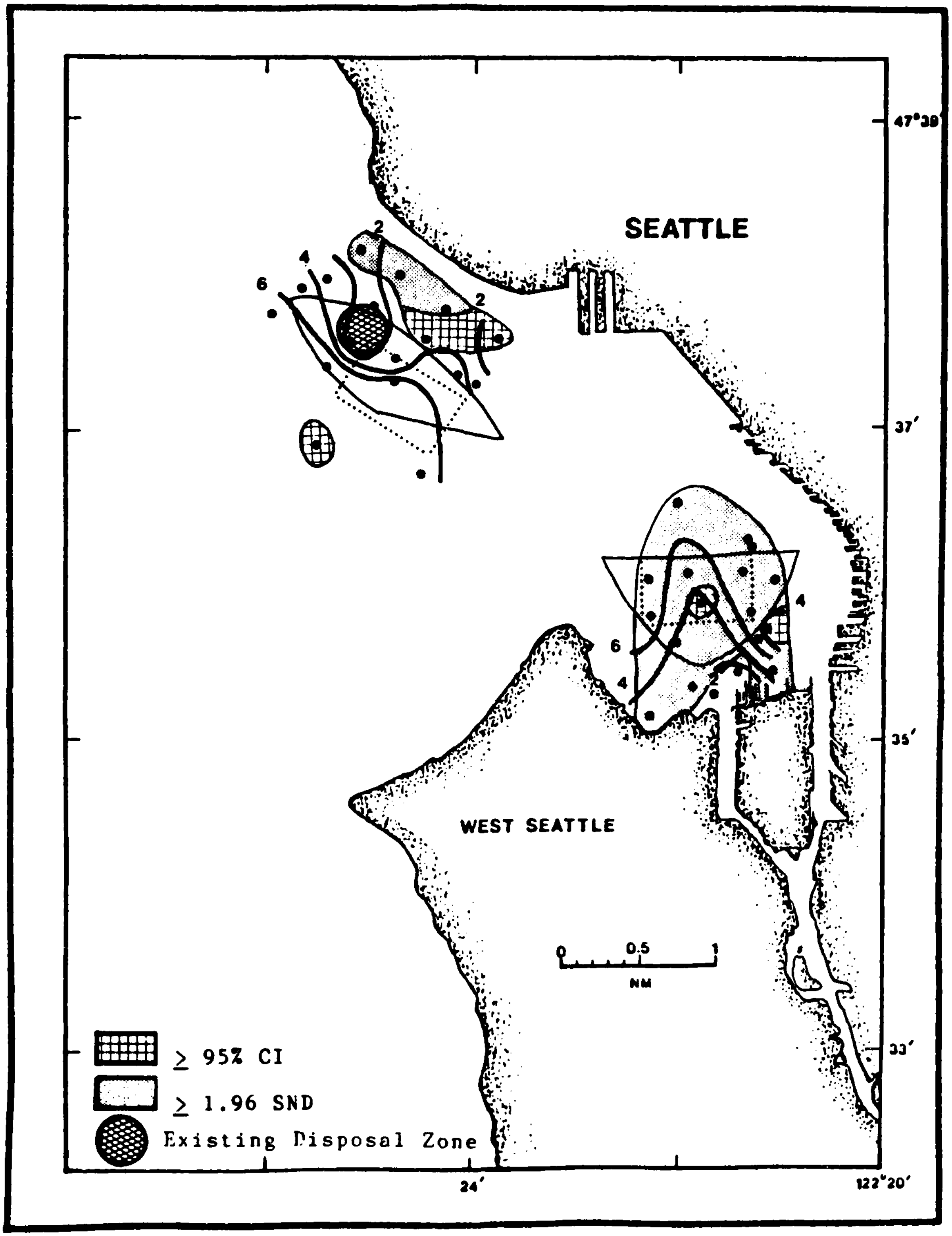


Figure 11. Contours of volatile solids content (percent) overlayed with areas where the percent volatile solids exceeded the 95% confidence interval and 1.96 standard normal deviate values.

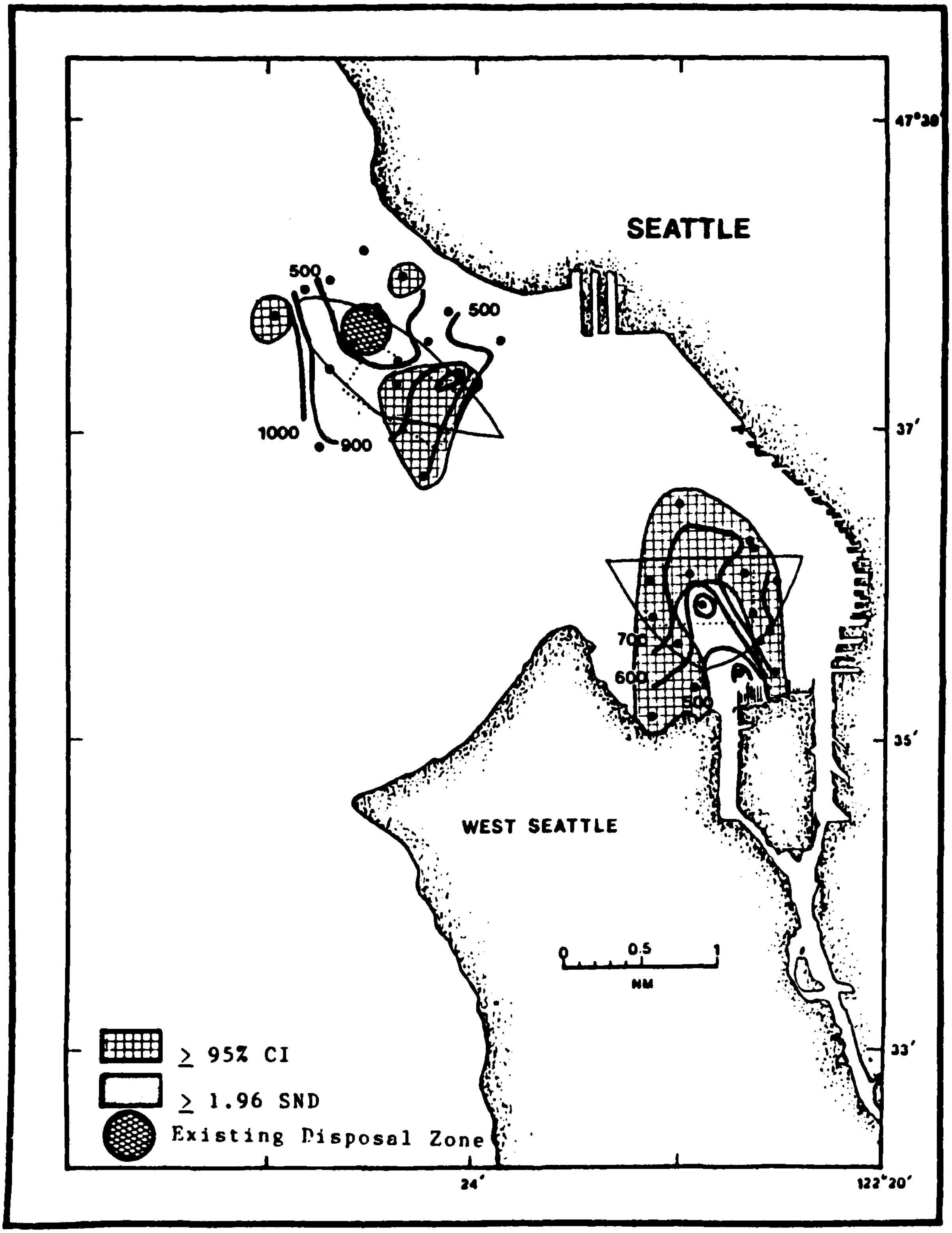


Figure 12. Contours of five-day biochemical oxygen demand (mg/kg dry weight) overlayed with areas where the biological oxygen demand exceeded the 95% confidence interval and 1.96 standard normal deviate values.

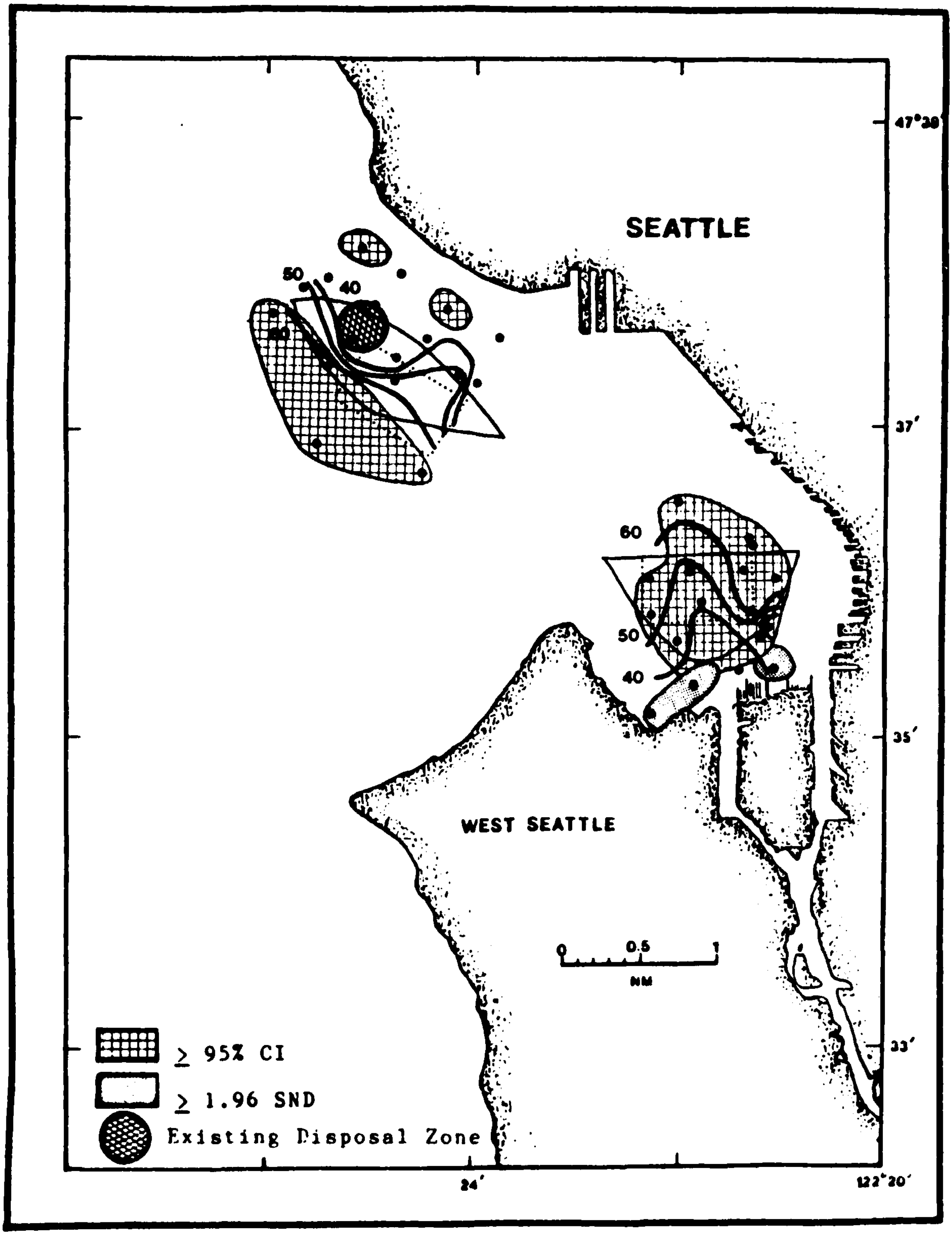


Figure 13. Contours of water content (percent) overlayed with areas where the percent water exceeded the 95% confidence interval and 1.96 standard normal deviate values.

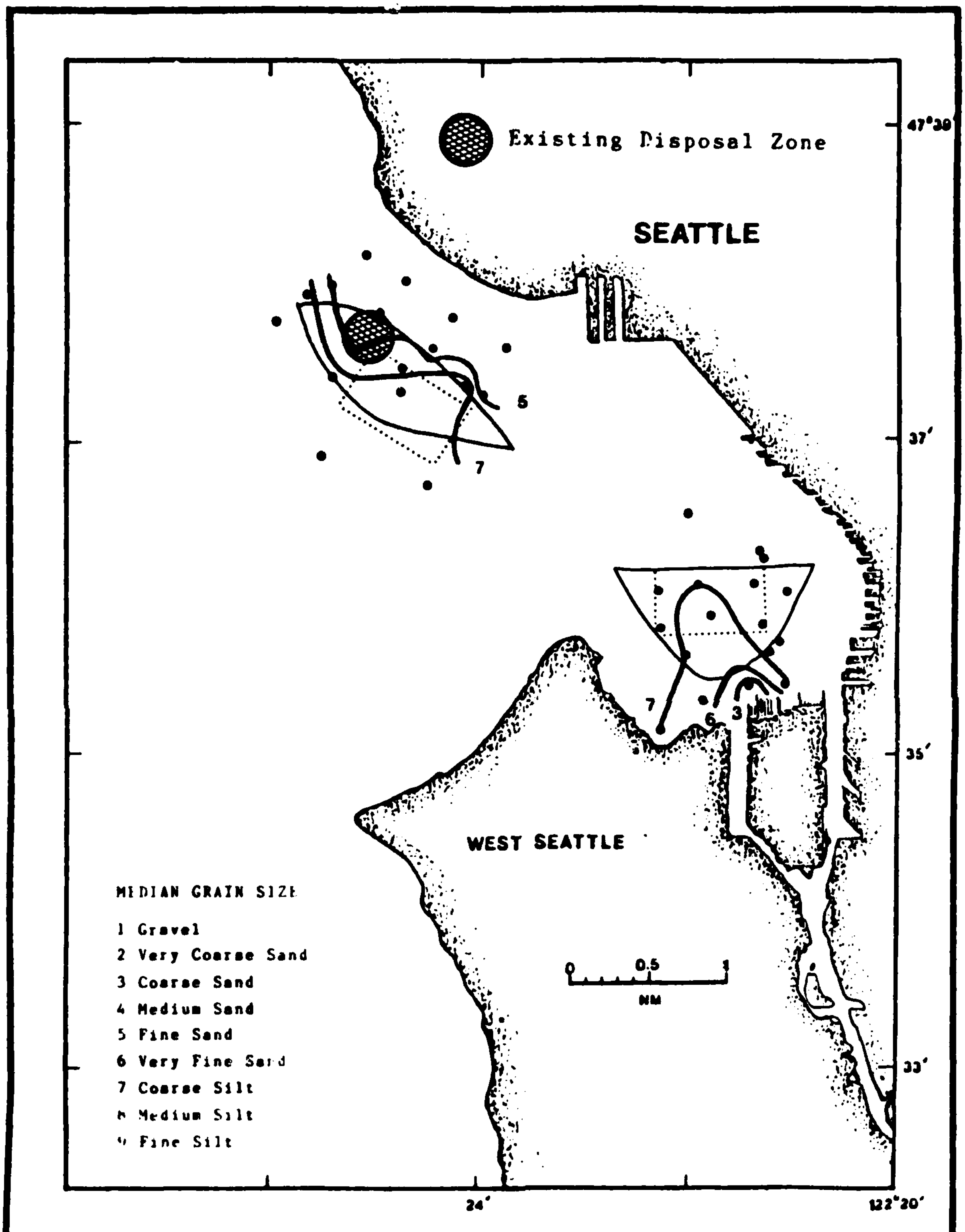


Figure 14. Contours of median grain size. Numbers corresponding to median grain sizes are shown in legend.

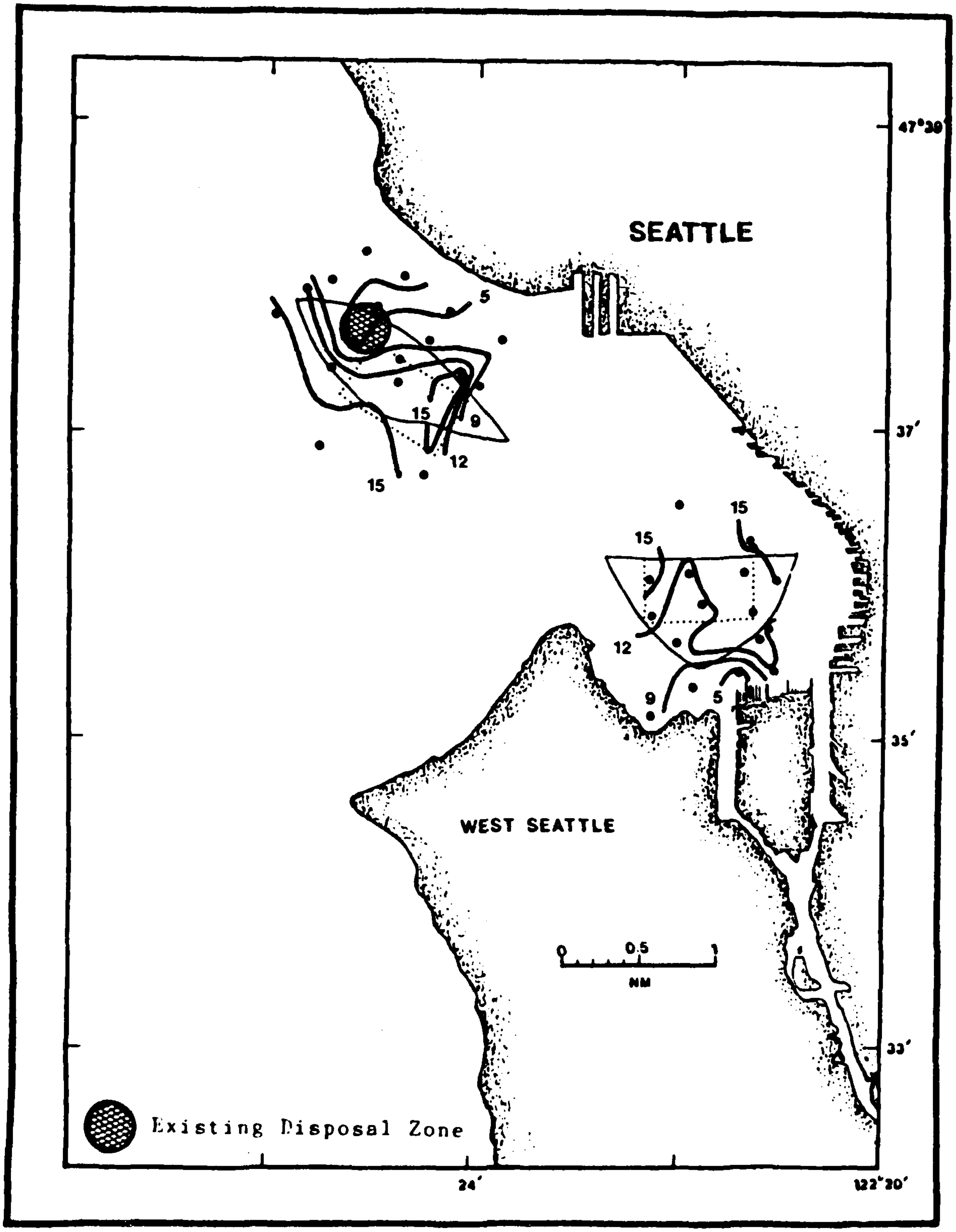


Figure 15. Contours of clay content (percent). No statistical computations were conducted on percent clay.

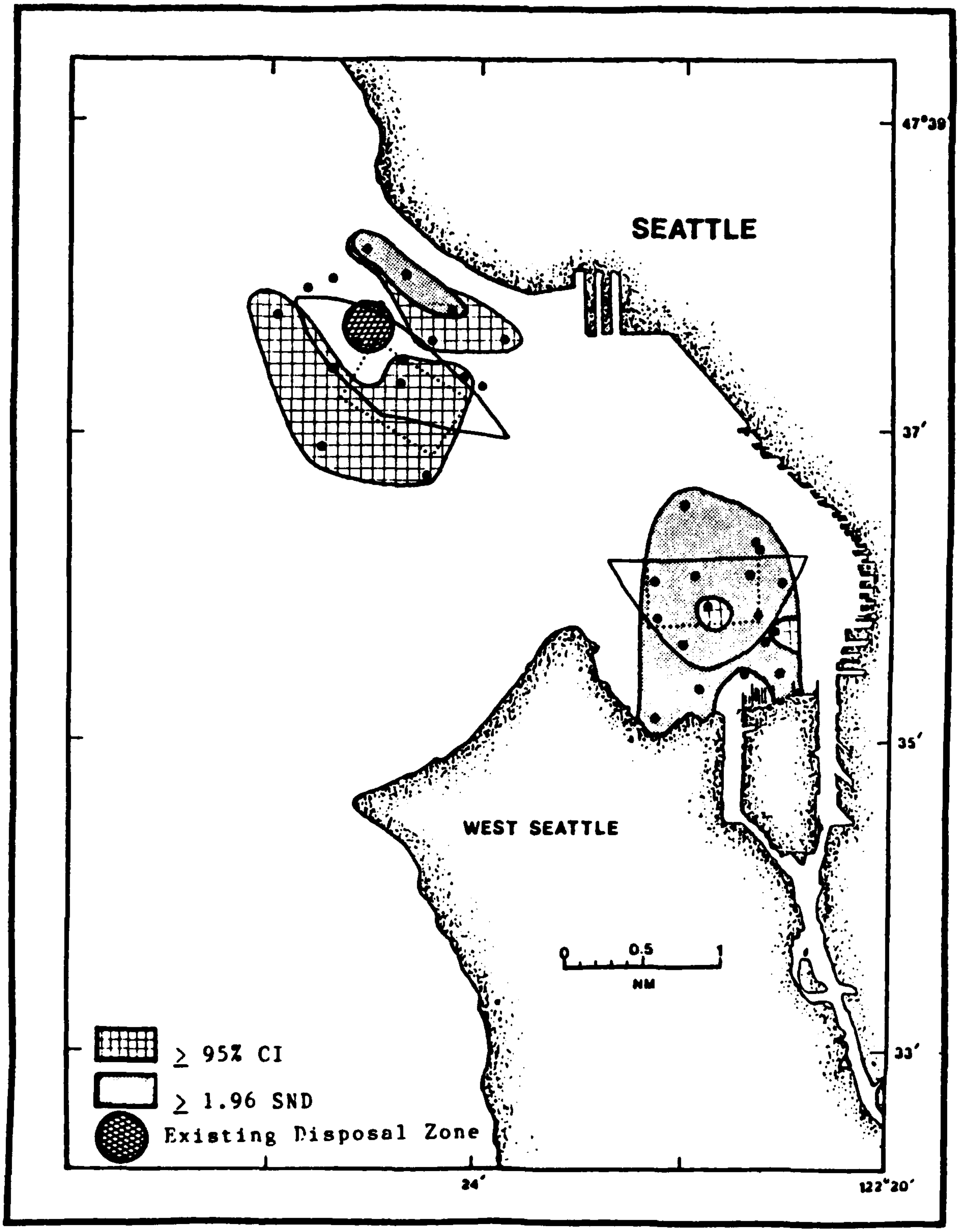


Figure 16. Areas where at least one parameter (percent volatile solids, biochemical oxygen demand, or percent water) exceeded the 95% confidence interval or the 1.96 standard normal deviate.

FOURMILE ROCK

The range of volatile solids values at the Fourmile Rock disposal site was 1.6% to 7% (Figure 11). A tongue of sediment with low volatile solids extended from the northern inshore stations into the ZSF and slightly into the northwest corner of the preliminary site. All stations at a depth of 100 ft. on Transects VI, VII, and VIII exceeded the 1.96 SND and stations V A-100, VI B-300, and VI D-600 were elevated beyond the 95% CI.

Five-day biochemical oxygen demand values at Fourmile Rock ranged from less than 500 at the inshore stations to over 1000 at the deep stations. As with the volatile solids data, a tongue of sediment with low BOD_5 values were found to extend into the ZSF and preliminary site from the northern inshore stations (Figure 12). Five stations fell above the 95% CI for BOD_5, while none exceeded the 1.96 SND. The eastern half of the preliminary site contained the elevated BOD_5's.

Percent water values at the Fourmile Rock site were similar to the inner bay site, and ranged from less than 40% to over 60%. The band of lower percent water sediments is broader than seen in the % VS and BOD_5 measurements (Figure 13).

The median grain size distribution at Fourmile Rock ranged from fine sand at the shallow stations along all transects to coarse silt at all deeper stations (Figure 14). Sediment in the preliminary site consisted of predominantly coarse silt. The percentage clay increased with increasing water depth but showed a high level (15%) along the southeast edge of the preliminary site (Figure 15). A tongue of sediment with low percent clay (5%) extended from inshore into the ZSF along Transect VII, approximately the same location where low %VS and BOD_5 were found.

The parameters for Fourmile Rock indicate that an area of very low energy lies along the 100 foot depth contour from Transect VI through VIII, and an area of slightly higher energy occurs at stations located at 500 ft. and deeper on all the Fourmile Rock transects (Figure 16). The group of four stations at the northern end of the ZSF all had %VS, BOD_5, and % water less than expected for the depth interval on which they were located. This appears to be the area where the existing disposal site is located. Information obtained from the Washington State Department of Ecology indicates that most of the recently disposed material had a high organic content. If so, the sediment at the disposal site should have had at least a high %VS. The fact that the data do not show a high %VS in that area indicates that the organic material may have been carried away from the existing disposal site by the slightly higher tidal currents found in this area. Therefore, the Fourmile Rock site probably is less depositional than the inner Elliot Bay site.

PORT GARDNER

Volatile solids concentrations in the Port Gardner ZSF ranged from under 2 to over 8% (Figure 17). The preliminary #1 site in the central portion of the ZSF had concentrations of 6 to near 8%. The range in the preliminary #2 site on the southern edge of the ZSF was from 2 to 5%. Values increased with increasing water depth and were greater in northern Possession Sound (>8%). Elevations above the 95% CI were found at most of the stations in the ZSF. Five stations along the northeast margin of the ZSF and three stations in line with the entrance to the Everett Marina exceeded the 1.96 standard normal deviate.

Five-day biochemical oxygen demand values in the preliminary site ranged from 700 to 900 mg/kg dry wt. (Figure 18). Values increased closer to Possession Sound where the highest values in the study were found. Overall, the BOD_5 ranged from 200 mg O_2/kg dry wt north of Gedney Island to 1500 mg O_2/kg dry wt in Possession Sound. BOD_5 values in excess of the 95% CI were found in the easternmost, central, and western portions of the ZSF. Stations where values exceeded the 1.96 SND were found at the entrance to Possession Sound and at two stations on the eastern margin of the ZSF.

The water content in the sediment increased with depth (Figure 19). The sediment in the preliminary #1 site contained water in excess of 60%. The percent water in the preliminary #2 site varied between 40 and 60%. Elevations above the 95% CI show a distribution similar to that seen in the BOD_5 with the elevations principally occurring in the easternmost, central and western margins of the ZSF.

The distribution of sediment types in the ZSF is presented in Figure 20. The predominant sediment type found in most of the ZSF was medium and fine silt with some fine and very fine sands located along the ZSF's northeastern and southern sides. Percent clay in the ZSF ranged from 10-20% with the preliminary #1 site being higher in clay content than the preliminary #2 site (Figure 21).

The composite figure for Port Gardner (Figure 22) shows areas of very low energy at the entrance to Possession Sound and on the eastern edge of the ZSF in a band between the 50 and 300 feet depth contours. All stations in the central portion of Port Gardner were found to contain high levels of BOD_5, volatile solids, and percent water, as well as a large percentage of clay with a grain size of medium to fine silt. This combination indicates that a large portion of the bay is low in energy and that the ZSF is located in one of the most depositional areas in the bay.

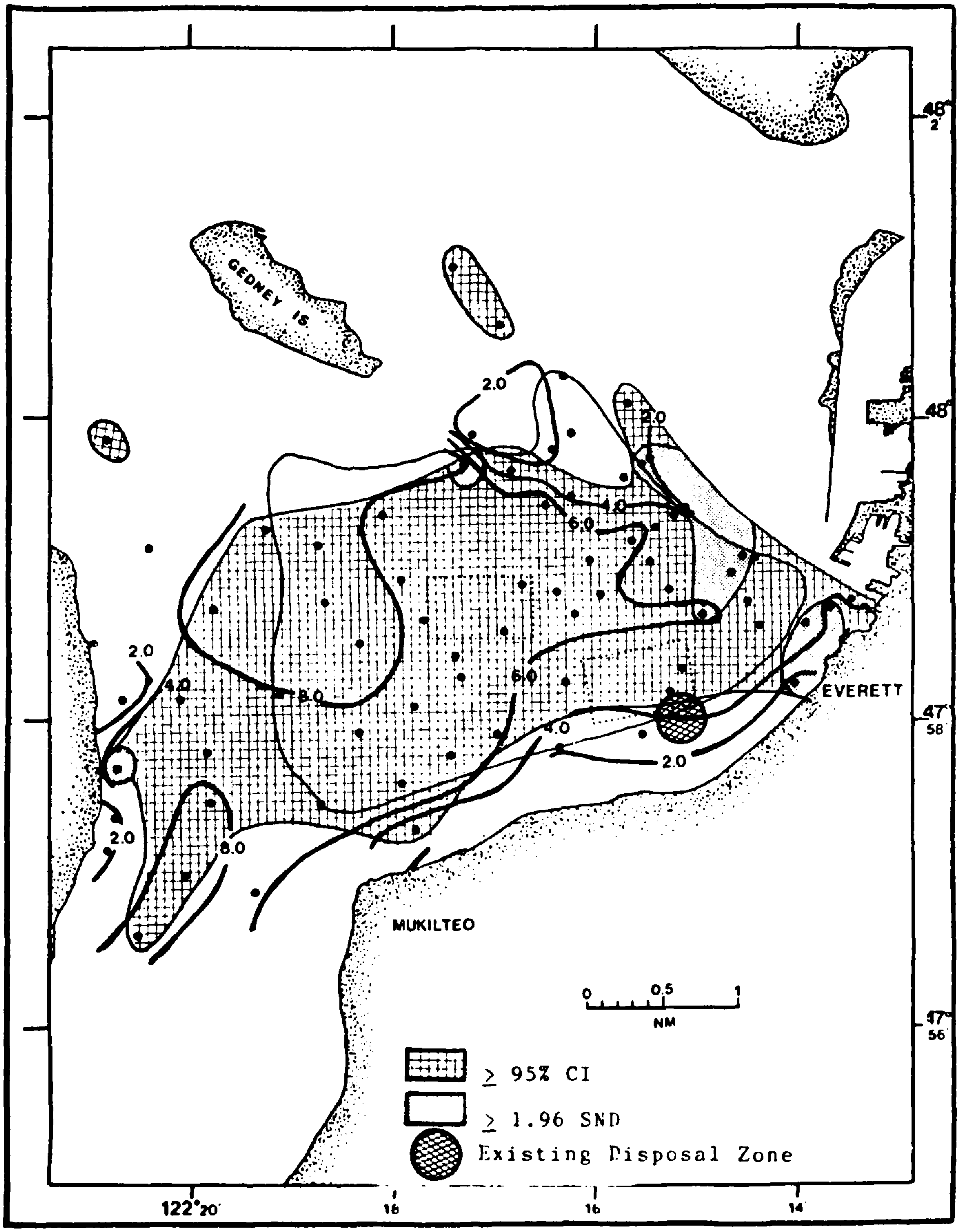
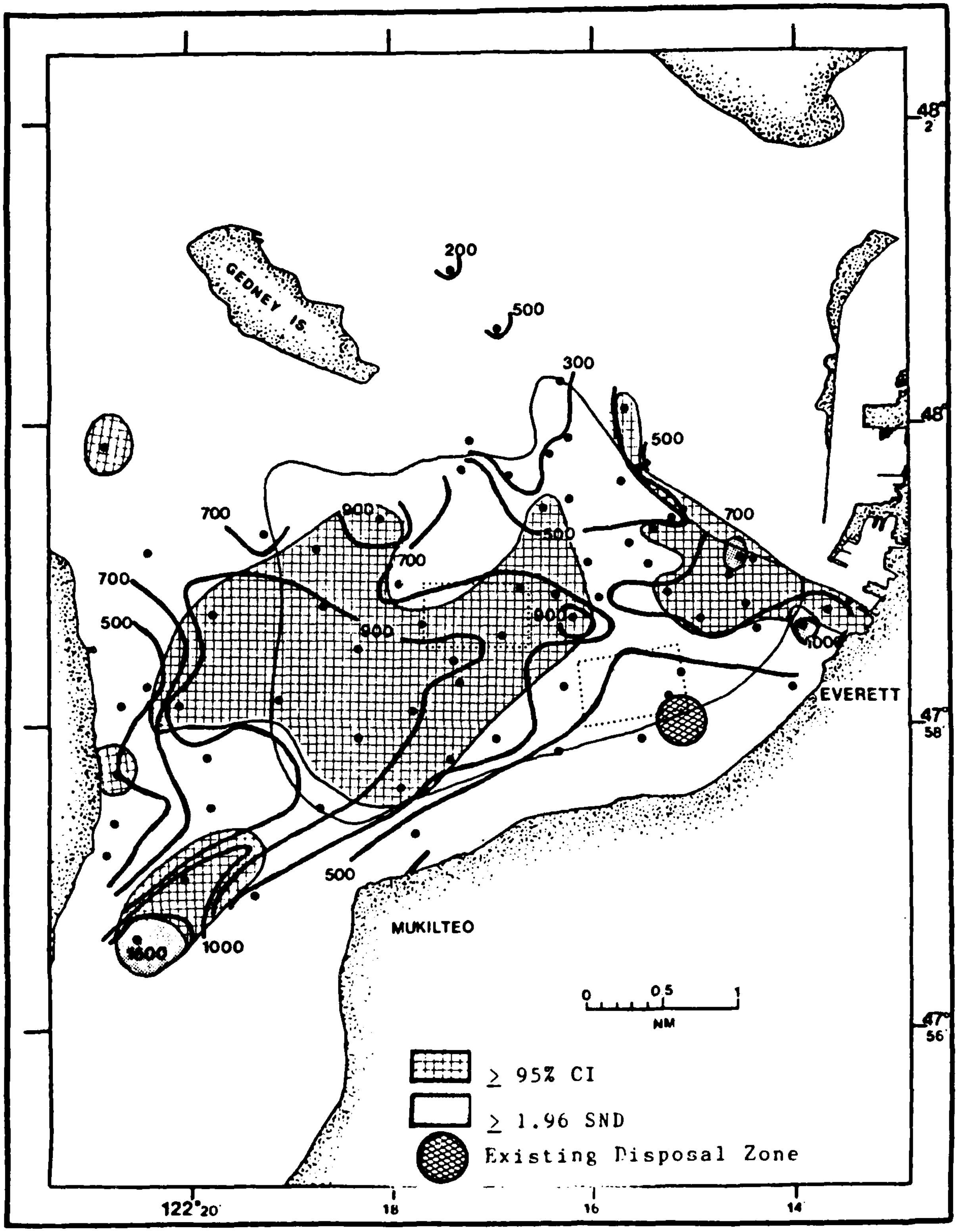


Figure 17. Contours of volatile solids content (percent) overlayed with areas where the percent volatile solids exceeded the 95% confidence interval and 1.96 standard normal deviate values.



Figurc 18. Contours of five-day biochemical oxygen demand (mg/kg dry weight) overlayed with areas where the biological oxygen demand exceeded the 95% confidence interval and 1.96 standard normal deviate values.

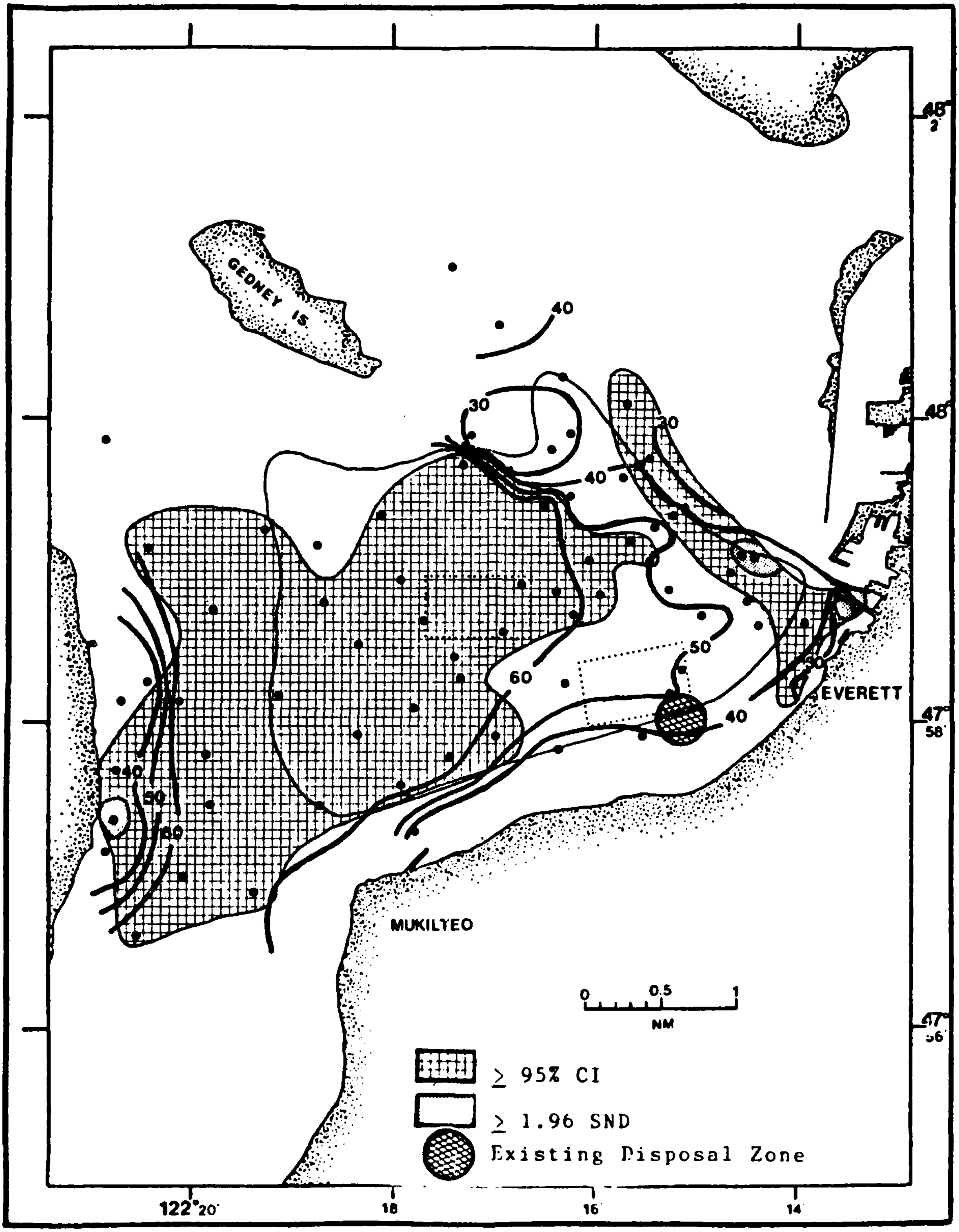


Figure 19. Contours of water content (percent) overlayed with areas where the percent water exceeded the 95% confidence interval and 1.96 standard normal deviate values.

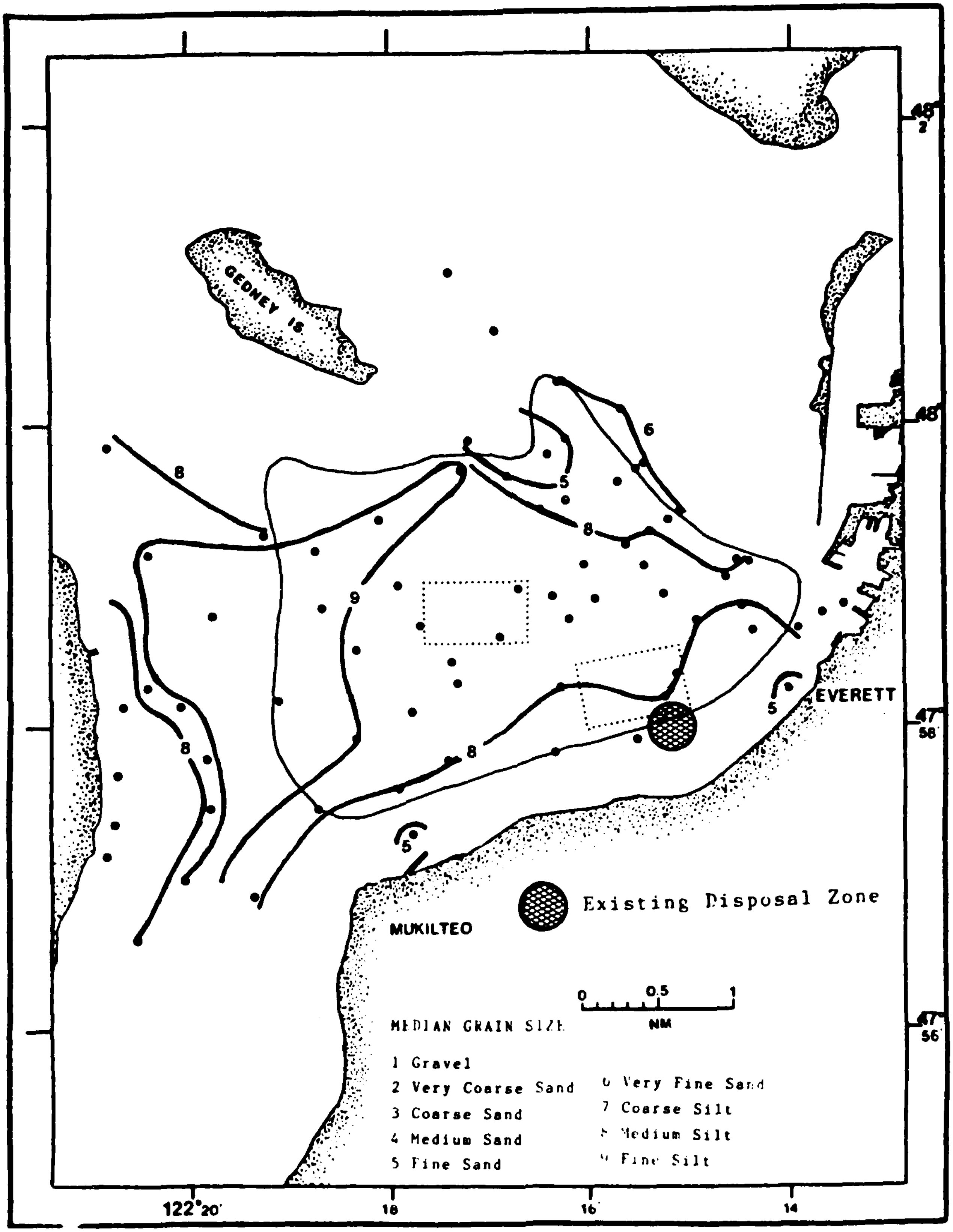


Figure 20. Contours of median grain size. Numbers corresponding to median grain sizes are shown in legend.

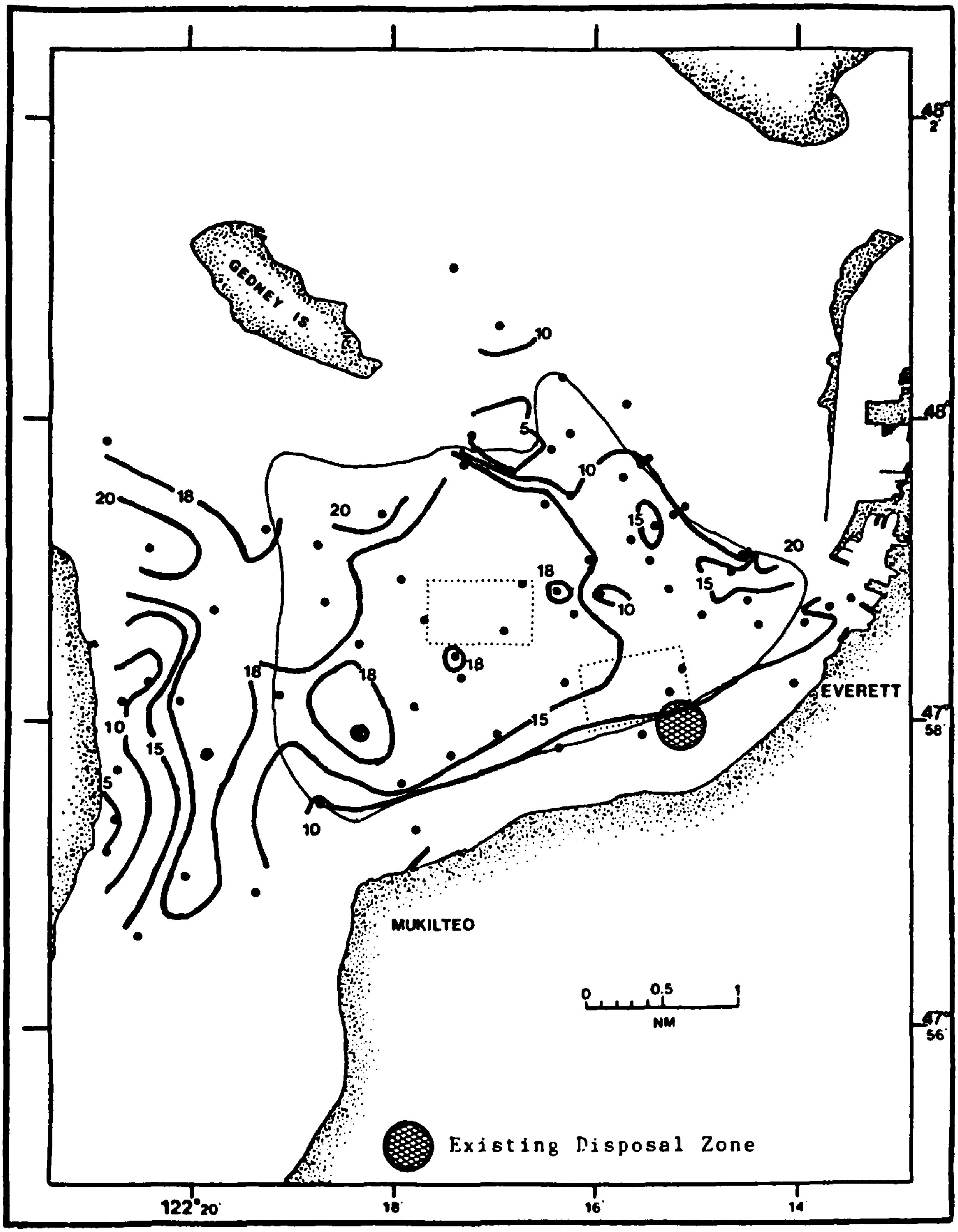


Figure 21. Contours of clay content (percent). No statistical computations were conducted on percent clay.

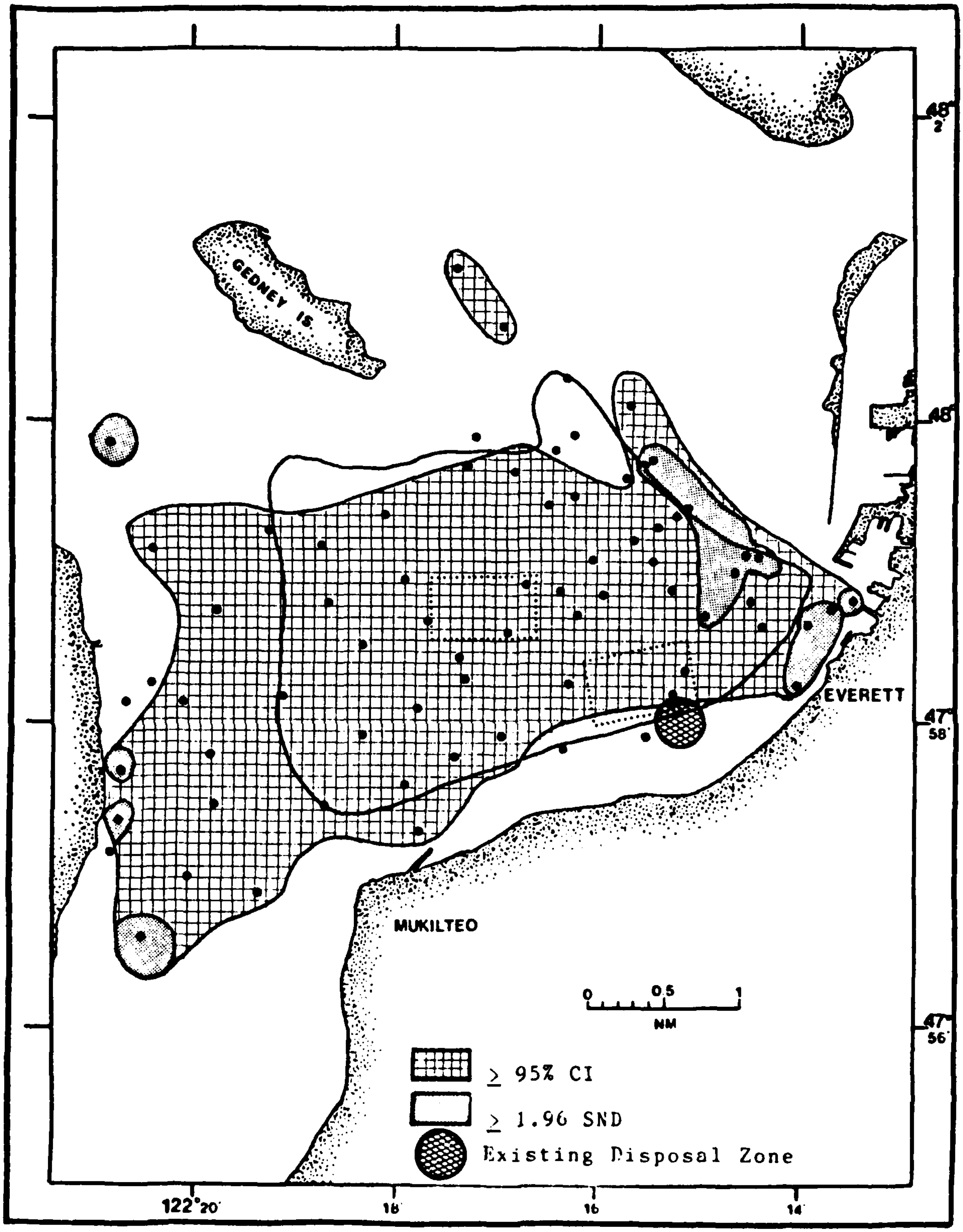


Figure 22. Areas where at least one parameter (percent volatile solids, biochemical oxygen demand, or percent water) exceeded the 95% confidence interval or the 1.96 standard normal deviate.

SARATOGA PASSAGE

The percent volatile solids in the Saratoga Passage ZSF ranged from under 2% to over 8% (Figure 23), with the greatest values found in the preliminary site. Elevations above the 95% CI were found at most of the stations within the ZSF, and four of the seven stations in the ZSF were elevated above the 1.96 SND interval.

Five-day biochemical oxygen demand values ranged from under 300 to over 1000 mg/kg dry wt. (Figure 24). The highest levels were found at the east and west ends of the ZSF. Values in the preliminary site ranged from 700 to 1000 mg/kg dry wt. Values exceeded the 95% CI at three stations on transect III on the west end of the ZSF and at four stations in and around the preliminary site. One station, located just outside the preliminary site, had BOD_5 values in excess of 1.96 SND.

Percent water values (Figure 25) showed very similar trends to those seen in the %VS and BOD_5. The highest values (60 to 70%) were found in the preliminary site. Elevations beyond the 95% CI were found in the central portion of the ZSF encompassing the preliminary site.

The sediment type found in the ZSF was predominantly medium to fine silt (Figure 26). Stations along the margins of Camano and Whidbey Islands had sediments consisting of fine sand. The percent clay in the ZSF ranged from approximately 10% to over 15% with the higher percentages occurring in the preliminary site (Figure 27).

Based upon all parameters studied, a large depositional area exists within the Saratoga Passage ZSF (Figure 28). The area extends from Elger Bay southward into the central part of the Passage. Current measurements taken just south of the preliminary site by the National Ocean Survey confirm that this is an area of low current energy.

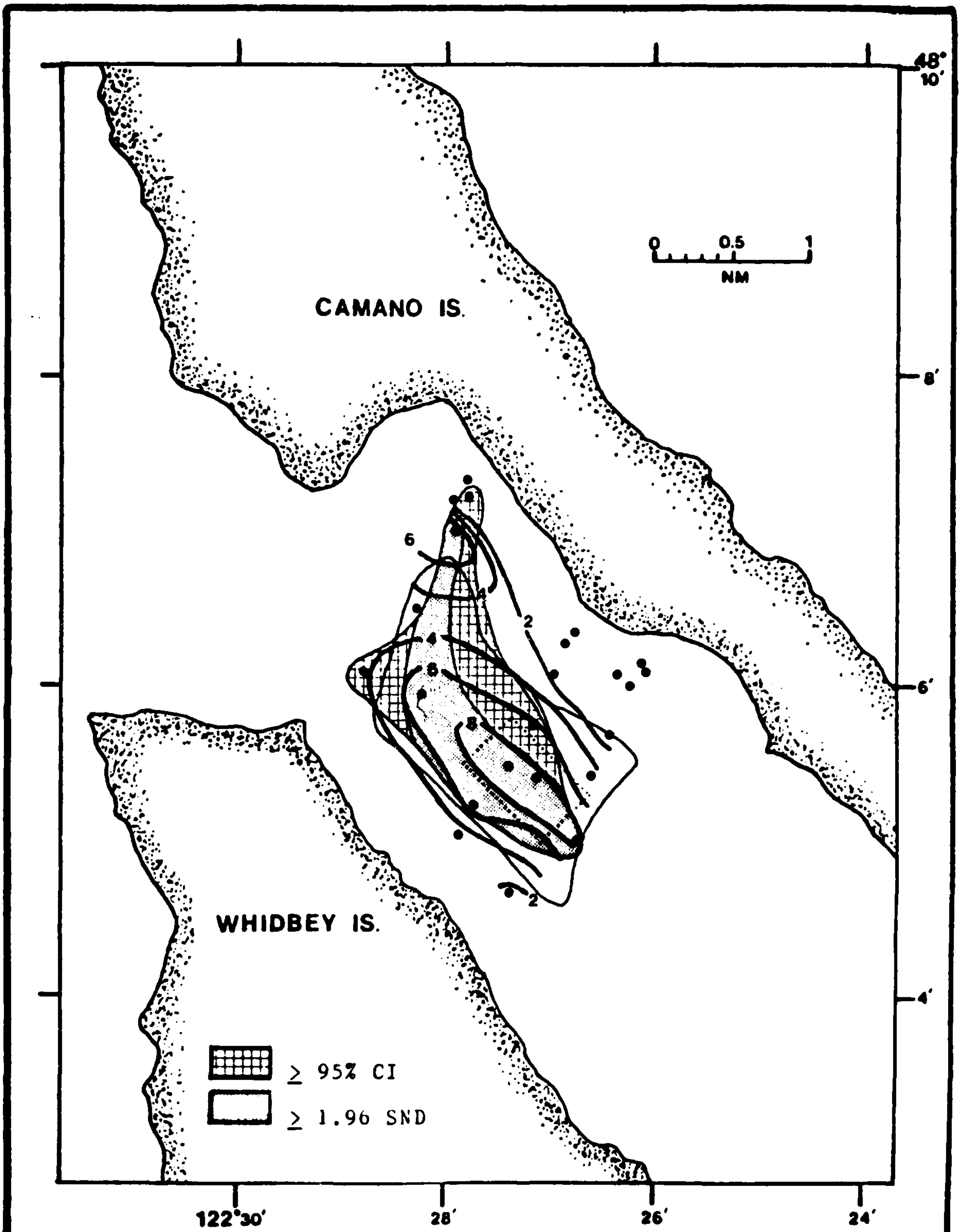


Figure 23. Contours of volatile solids content (percent) overlayed with areas where the percent volatile solids exceeded the 95% confidence interval and 1.96 standard normal deviate values.

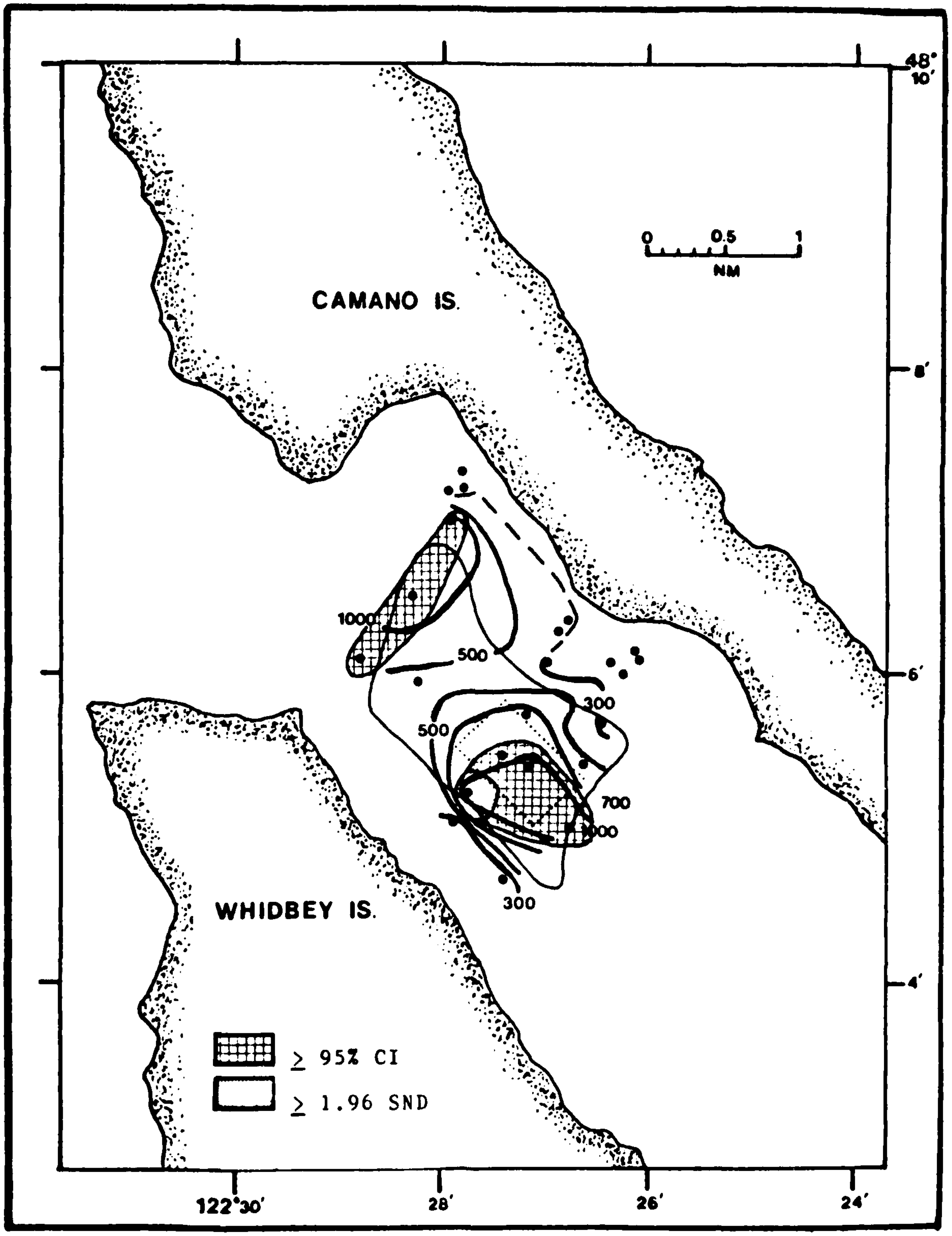


Figure 24. Contours of five-day biochemical oxygen demand (mg/kg dry weight) overlayed with areas where the biological oxygen demand exceeded the 95% confidence interval and 1.96 standard normal deviate values.

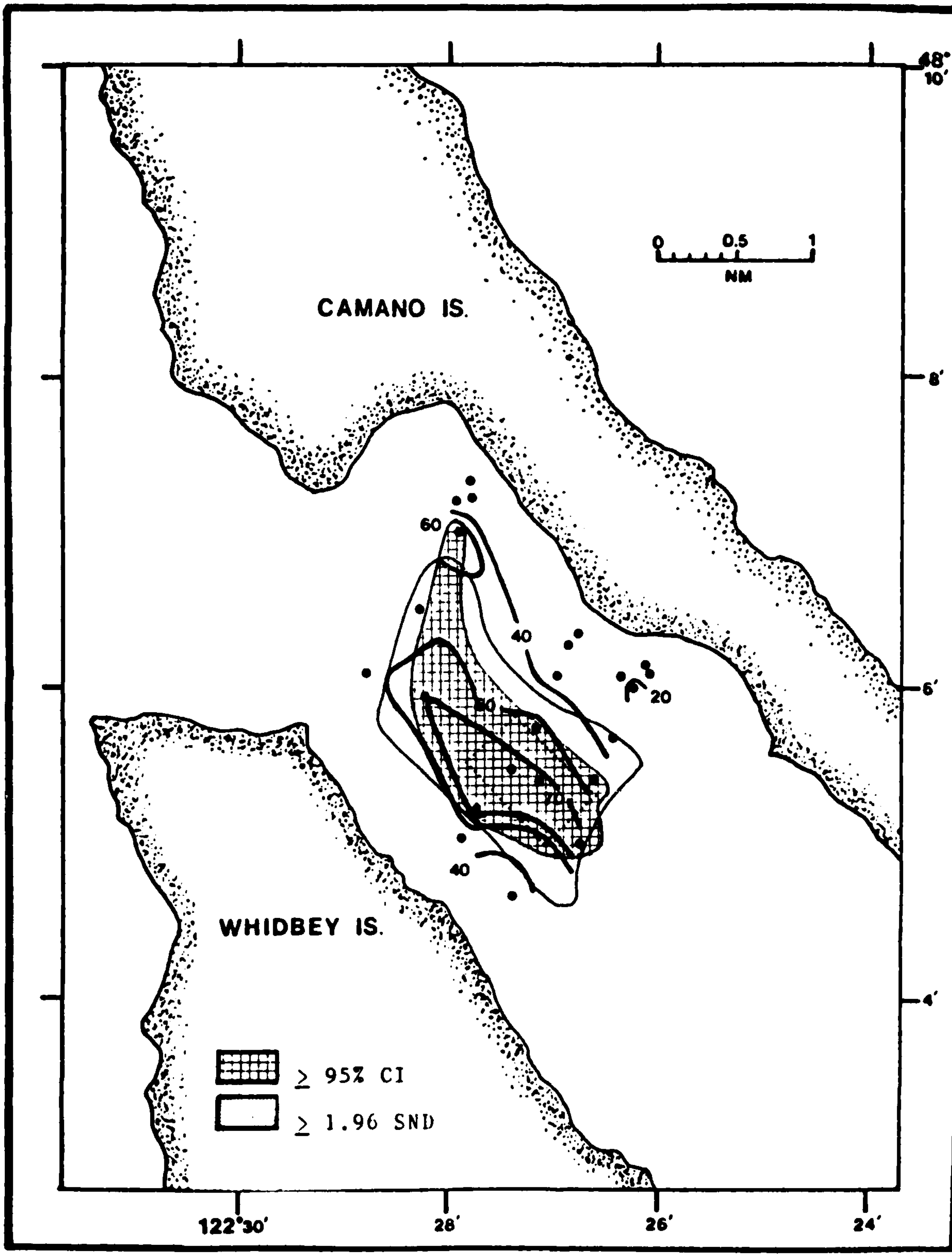


Figure 25. Contours of water content (percent) overlayed with areas where the percent water exceeded the 95% confidence interval and 1.96 standard normal deviate values.

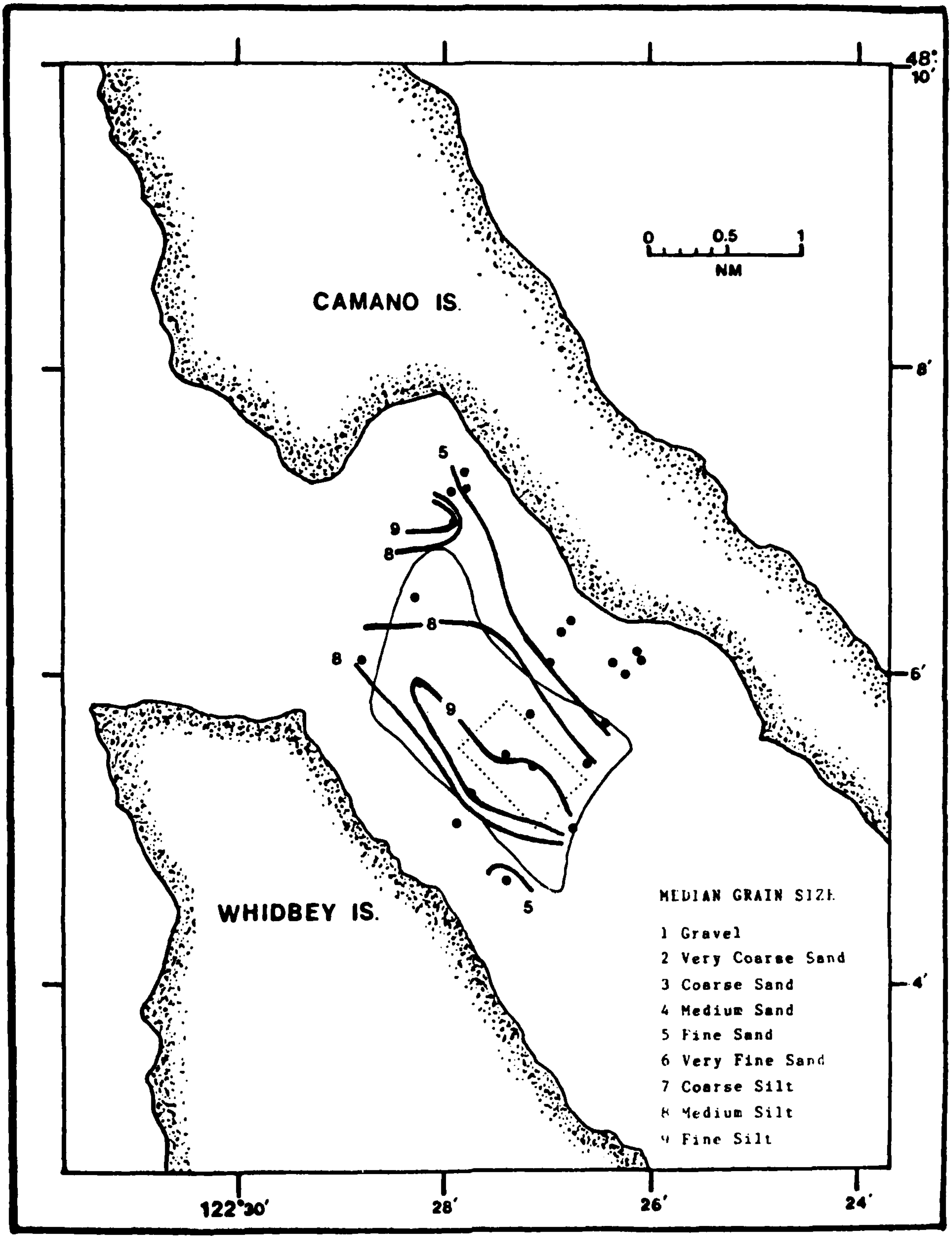


Figure 26. Contours of median grain size. Numbers corresponding to median grain sizes are shown in legend.

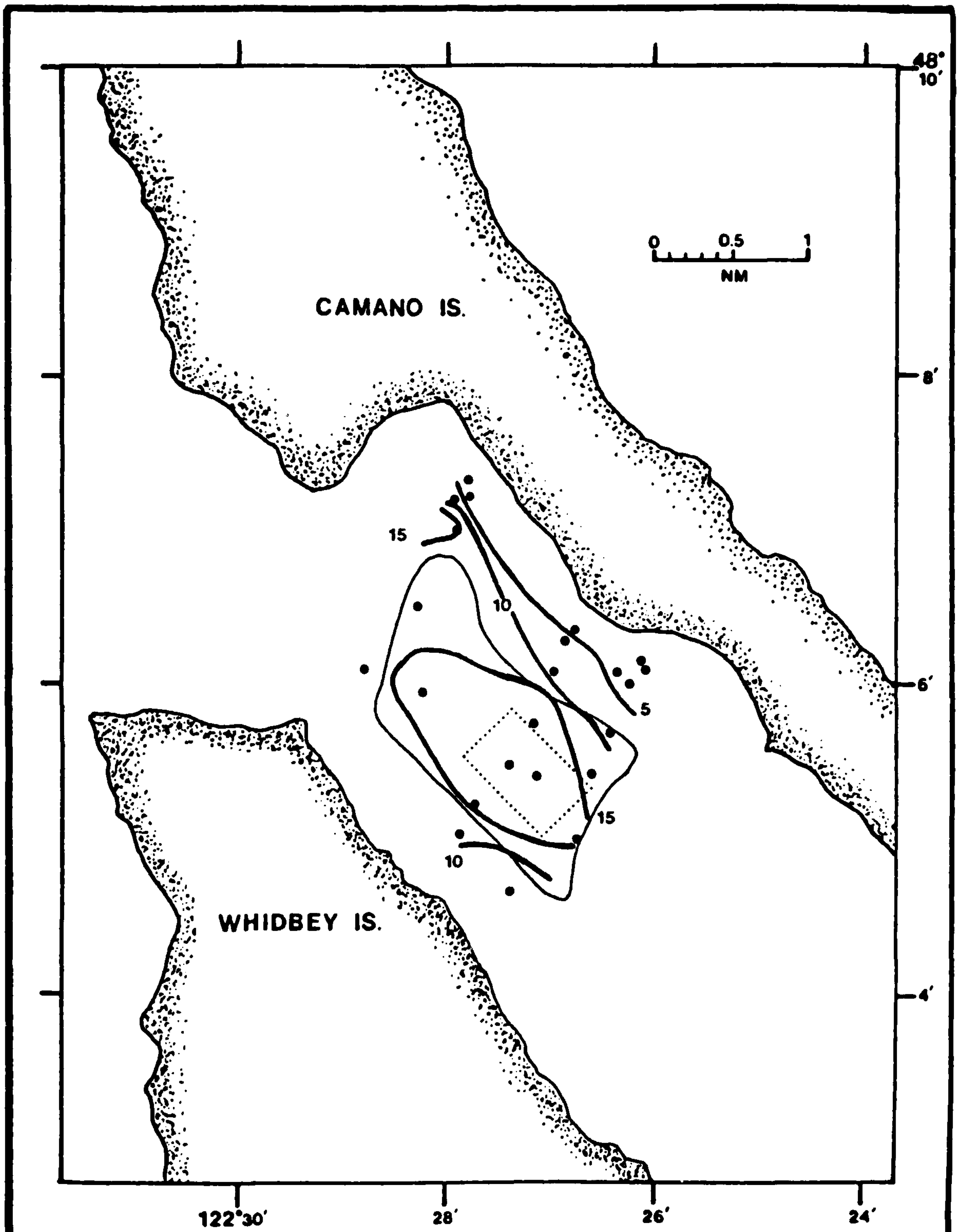


Figure 27. Contours of clay content (percent). No statistical computations were conducted on percent clay.

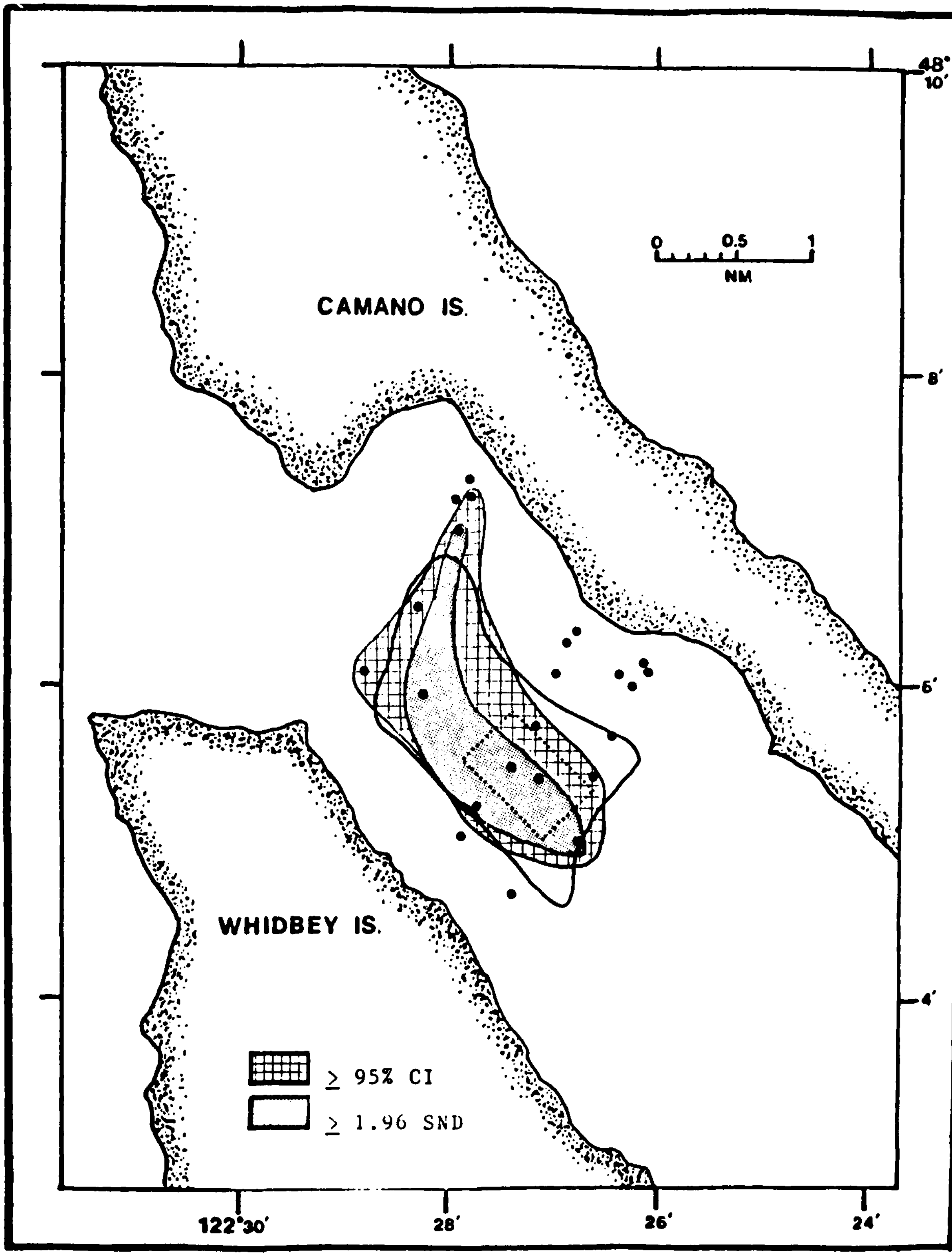


Figure 28. Areas where at least one parameter (percent volatile solids, biochemical oxygen demand, or percent water) exceeded the 95% confidence interval or the 1.96 standard normal deviate.

EDMONDS

Nine stations were established off Edmonds to examine sediment conditions in an area not being considered as a site for the disposal of dredged material. The percent volatile solids ranged from less than 2% to slightly greater than 4% (Figure 29). Values did increase with depth but not as rapidly as in Elliott and Commencement Bays. All stations along the 100 foot contour showed an increased percentage of volatile solids over the 95% level, and Stations I A-100 and II A-100 exceeded the 1.96 SND level.

Five-day biochemical oxygen demand values ranged from 198 to 875 mg/kg (Figure 30). Values increased with increasing depths. Station II B-100 had BOD_5 values in excess of the 95% CI as did Station III C-500.

Percent water values at the Edmonds stations ranged from 25% to 60% (Figure 31). The contour plots show the 25% interval is discontinuous and is bisected by sediments containing 30% water. The same two stations (II B-100 and III C-500) that showed significant elevations in BOD_5 also contained percent water in excess of the 95% CI.

Sediment grain size plots are presented in Figure 32. On transects located at either end of the study area the sediment graded from fine sand to medium silt with increasing water depth. On the transect located in the center of the study area, the innermost station consisted of unusually fine silt. All inshore stations had relatively low values of clay (<5%), and the amount of clay increased with depth (Figure 33). Therefore, only a small portion of the Edmonds site appears to have sediments that are characteristic of a low energy environment (Figure 34).

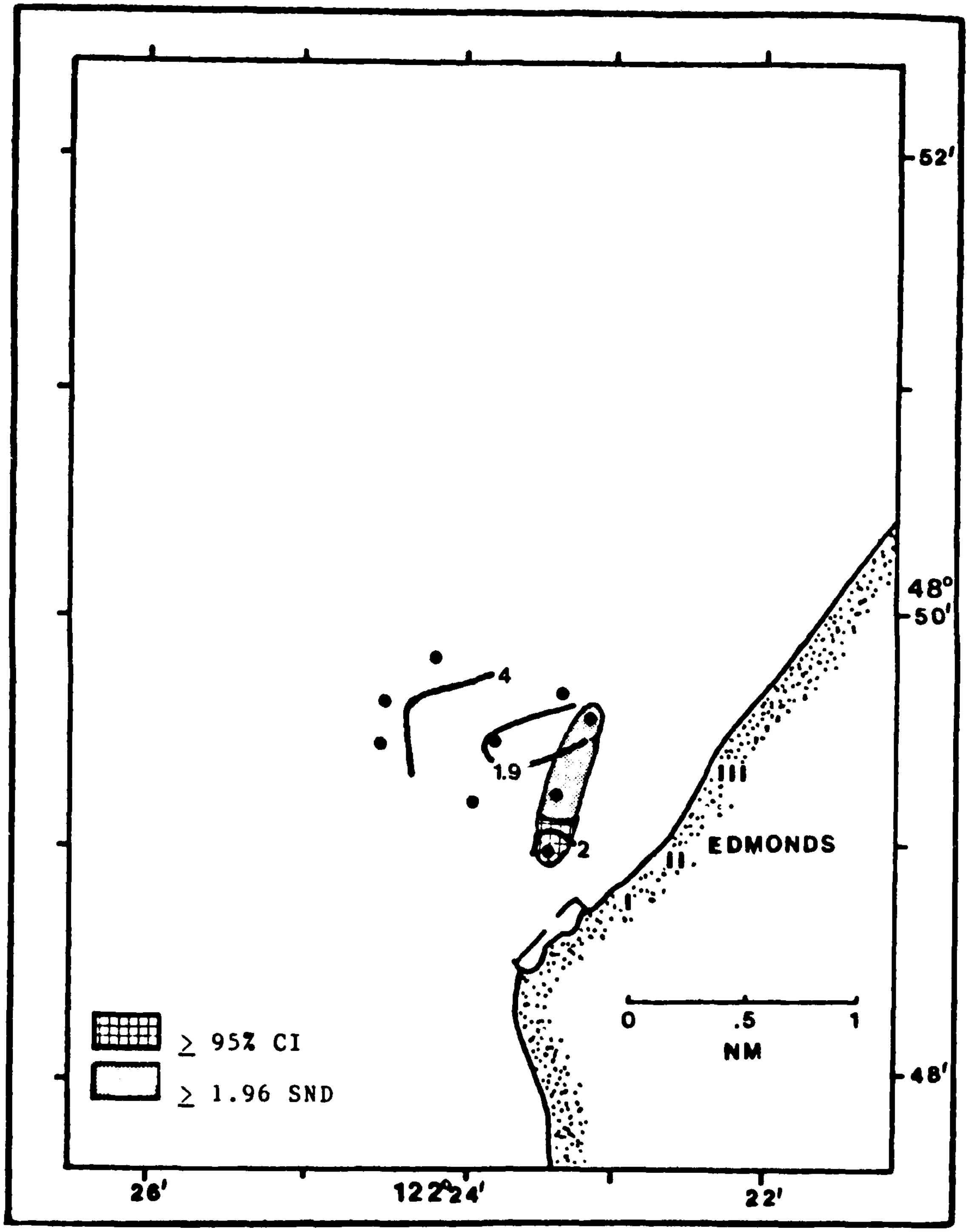


Figure 29. Contours of volatile solids content (percent) overlayed with areas where the percent volatile solids exceeded the 95% confidence interval and 1.96 standard normal deviate values.

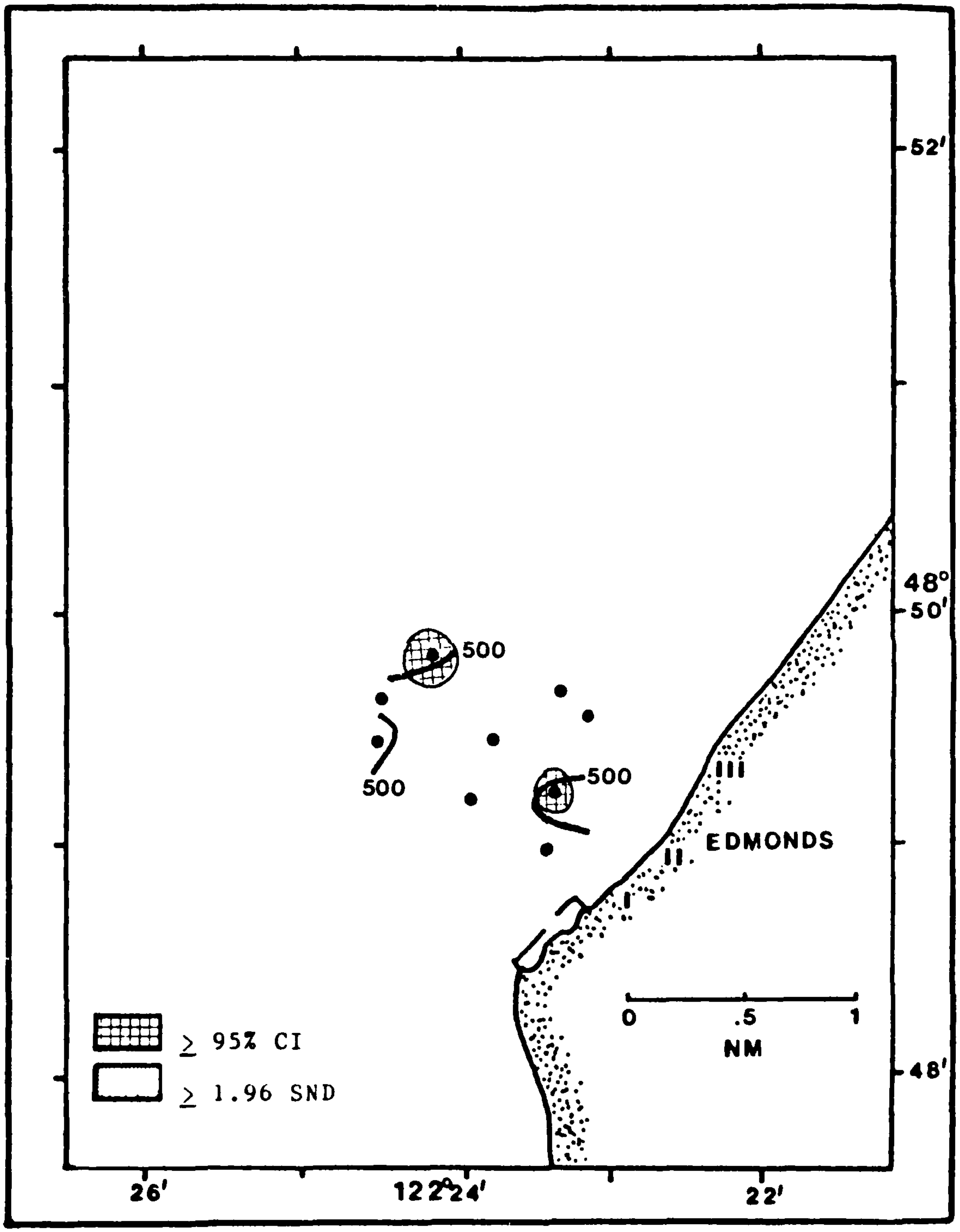


Figure 30. Contours of five day biochemical oxygen demand (mg/kg dry weight) overlayed with areas where the biological oxygen demand exceeded the 95% confidence interval and 1.96 standard normal deviate values.

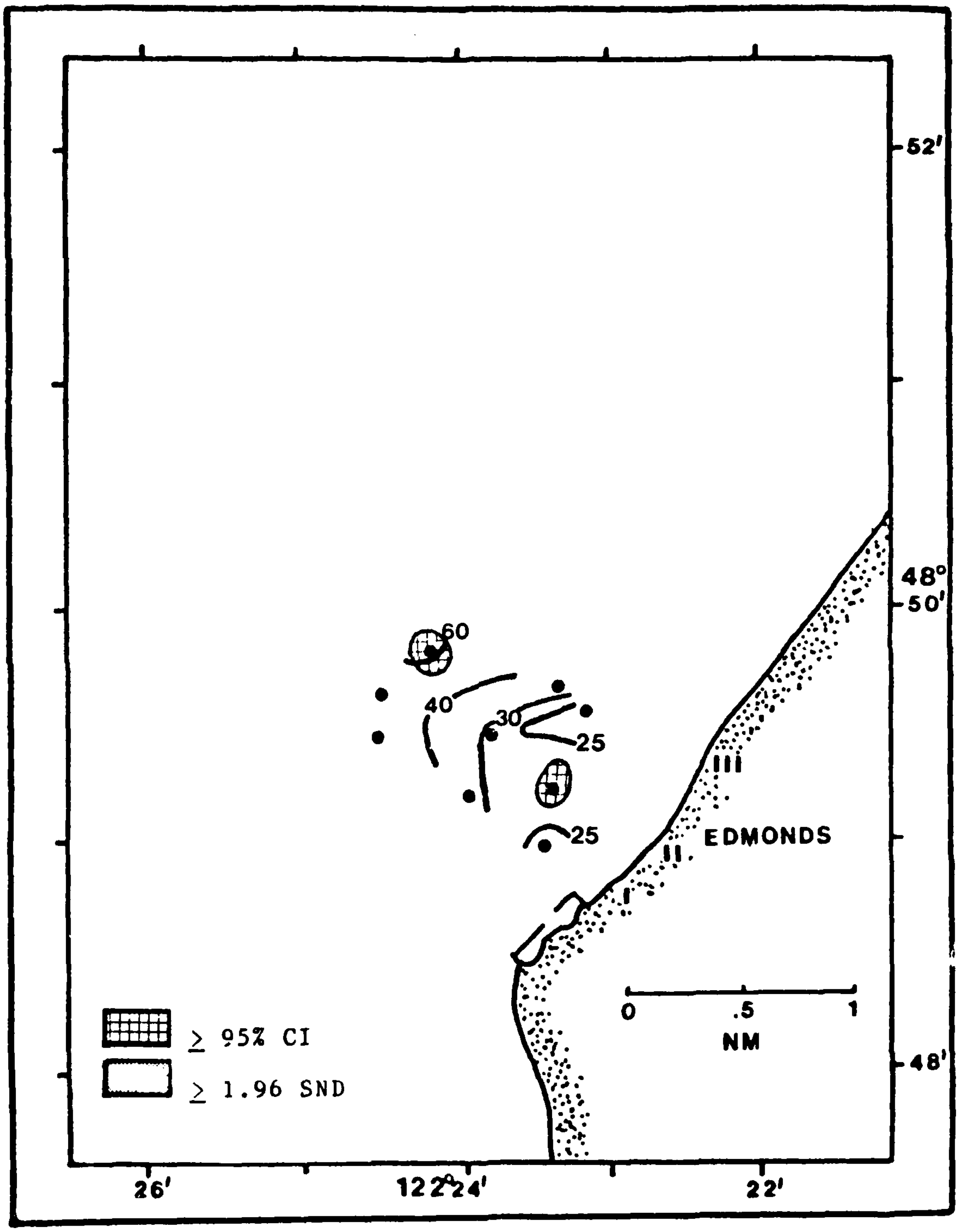


Figure 31. Contours of water content (percent) overlayed with areas where the percent water exceeded the 95% confidence interval and 1.96 standard normal deviate values.

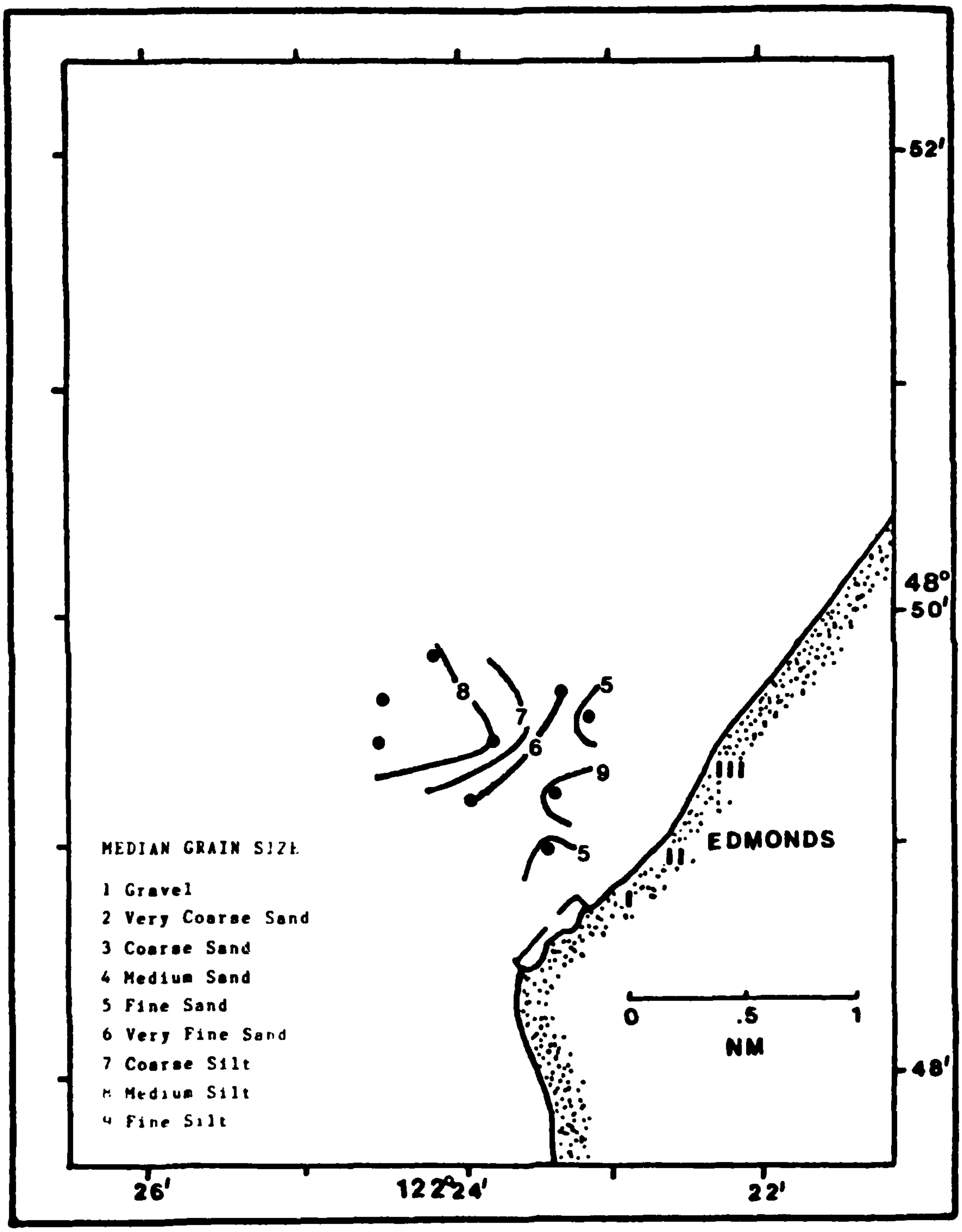


Figure 32. Contours of median grain size. Numbers corresponding to median grain sizes are shown in legend.

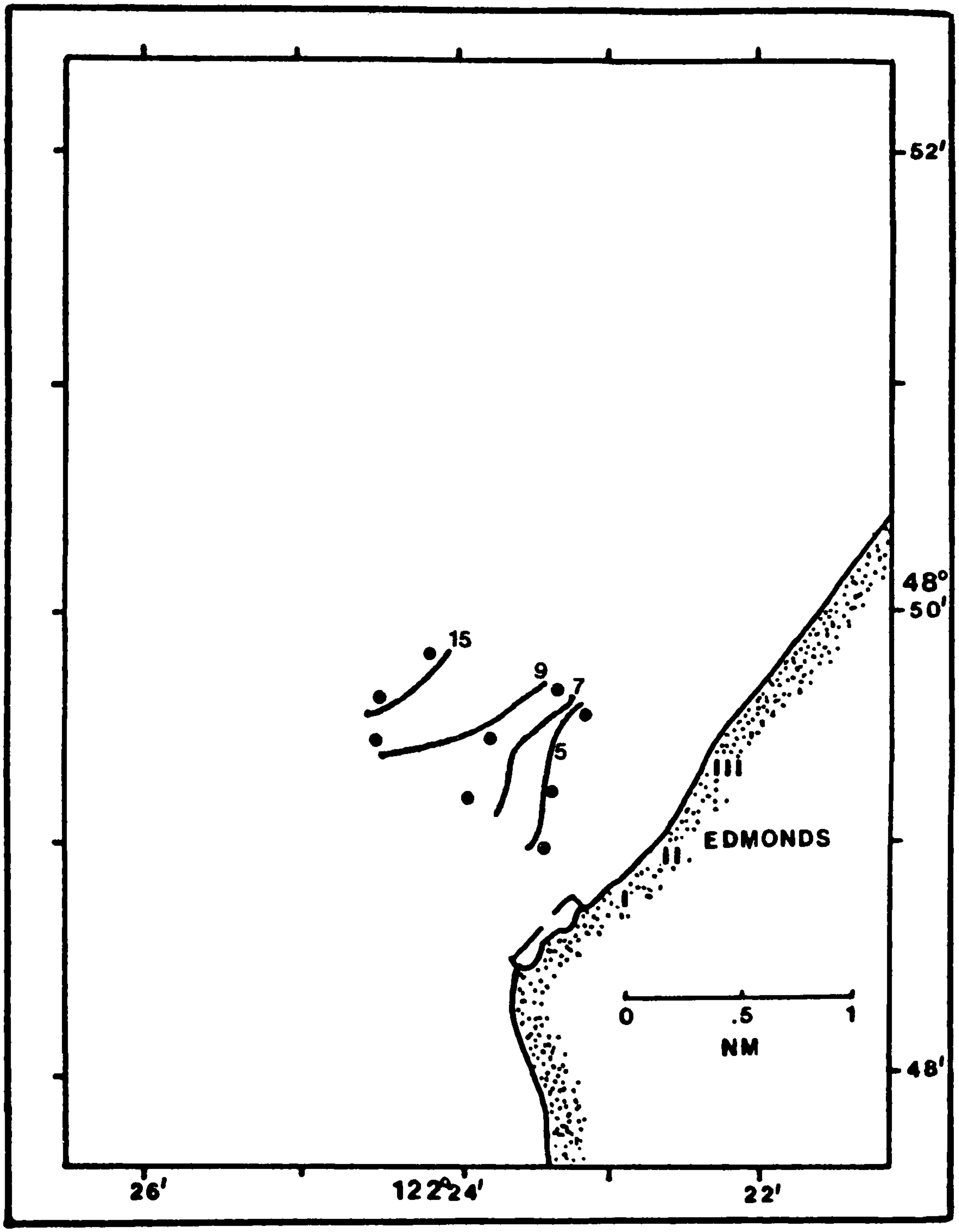


Figure 33. Contours of clay content (percent). No statistical computations were conducted on percent clay.

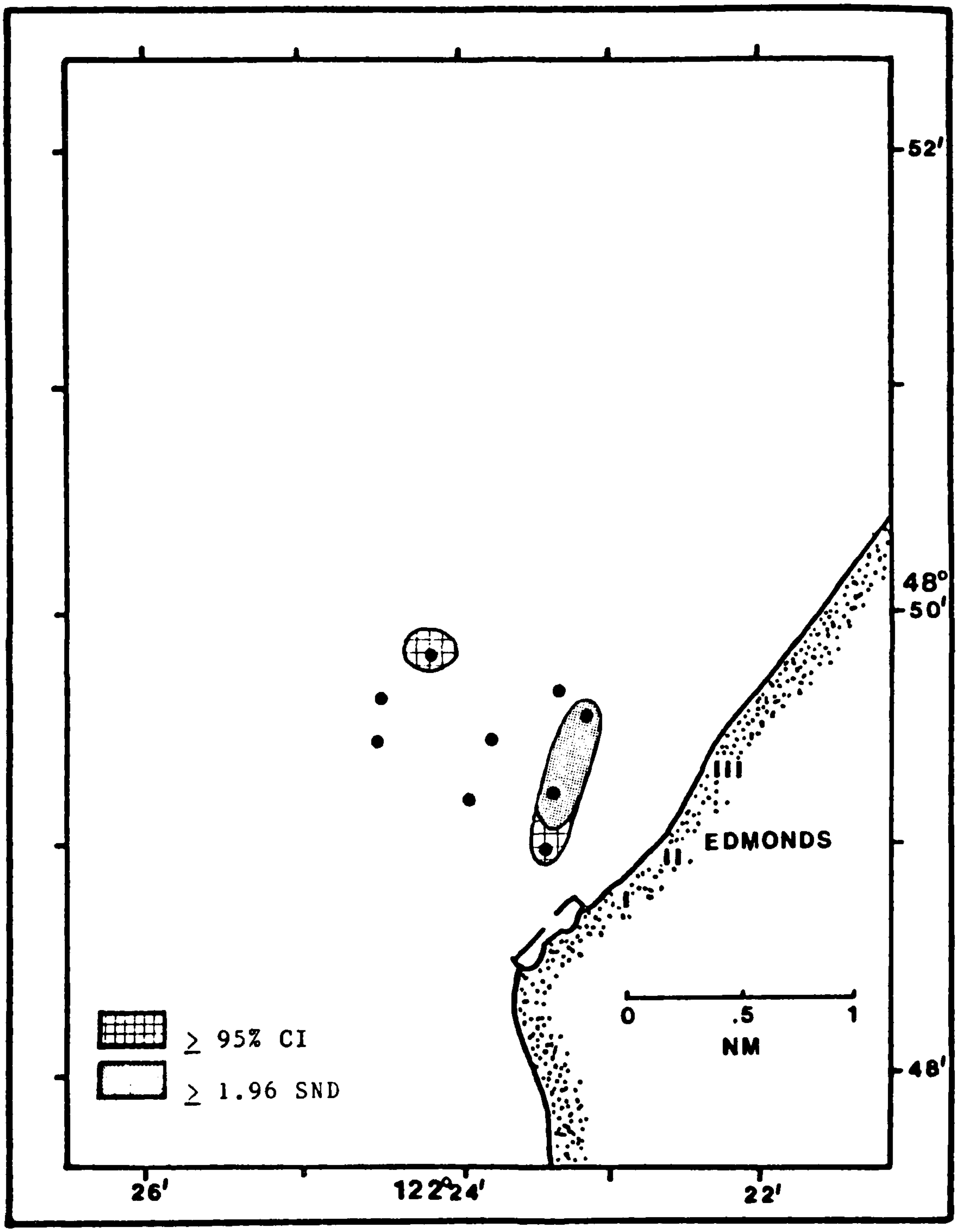


Figure 34. Areas where at least one parameter (percent volatile solids, biochemical oxygen demand, or percent water) exceeded the 95% confidence interval or the 1.96 standard normal deviate.

CONCLUSIONS

(Zones of Siting Feasibility)

By analyzing the organic enrichment and sediment grain sizes found in each of the five ZSF's selected for Phase I of the Puget Sound Dredge Disposal Analysis program, the depositional areas of lowest energy within those ZSF's were delineated. The major findings of this study were:

1) All five ZSF's contained areas of significantly elevated organics and small sediment grain sizes.

2) The preliminary sites within the ZSF's in Commencement Bay, inner Elliott Bay, Fourmile Rock, and Port Gardner contained high percentages of clay and organics elevated in excess of the 95% CI, indicating they were all areas of low current energy where fine sediments deposit naturally.

3) Nearly the entire ZSF in Saratoga Passage had levels of organics in excess of the 1.96 SND in addition to small grain size and high clay content. Therefore, the entire area is considered very depositional in nature.

4) The outer preliminary site within Commencement Bay appears to be slightly more depositional than the inner preliminary site.

5) Although nearly all of Port Gardner appears to be a low energy area, the preliminary site in central Port Gardner appears more depositional than the site near the southern shoreline.

6. A comparison of the five ZSF's to the results obtained for Edmonds indicates that organic content at Edmonds is much lower than that found in the ZSF's, but grain sizes and percent clay are similar. Therefore, current speeds at Edmonds are strong enough to keep organic materials from accumulating, but are too weak to keep fine sand and clay from settling.

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APPENDIX A. Station number, sampling date, time, and location, bottom depth, and type of samples collected for the sediment depositional analysis. G denotes grain size, V denotes volatile solids, B denotes five-day biochemical oxygen demand, PP denotes priority pollutants.

STATION	REP	CODE	DATE	TIME (PST)	DEPTH (FT)	LAT (N)	LONG (W)
CBI-A100	1	GVB	8 APR 86	1530	107	47 17 00	122 28 36
CBI-B100	1	GVB	8 APR 86	1520	110	47 17 12	122 28 59
CBI-C100	1	GVB	8 APR 86	1500	110	47 17 40	122 29 30
CBI-D100	1	GVB	8 APR 86	1425	109	47 18 17	122 30 08
CBI-E100	1	GVB	8 APR 86	1414	104	47 18 37	122 31 06
CBII-A430	1	GVB	8 APR 86	1540	438	47 17 08	122 27 51
CBII-B480	1	GVB	8 APR 86	1600	486	47 17 22	122 28 44
CBII-C300	1	GVB	8 APR 86	1612	307	47 18 07	122 29 34
CBIII-A400	1	GVB	8 APR 86	2005	403	47 16 36	122 27 12
CBIII-B500	1	GVB	8 APR 86	1730	510	47 17 15	122 27 50
CBIII-C525	1	GVB	8 APR 86	1715	532	47 17 26	122 28 12
CBIII-D537	1	GVB	8 APR 86	1700	540	47 17 38	122 28 24
CBIII-E516	1	GVB	8 APR 86	1632	526	47 17 57	122 28 41
CBIII-F514	1	GVB	8 APR 86	1625	522	47 18 11	122 29 04
CBIII-G482	1	GVB	8 APR 86	1400	492	47 19 00	122 30 09
CBIII-H403	1	GVB	8 APR 86	1342	408	47 19 11	122 30 24
CBIV-A400	1	GVB	8 APR 86	1945	410	47 16 54	122 26 54
CBIV-B487	1	GVB	8 APR 86	1745	500	47 17 24	122 27 24
CBIV-C520	1	GVB	8 APR 86	1755	529	47 17 39	122 27 46
CBIV-D533	1	GVB	8 APR 86	1805	542	47 17 51	122 28 01
CBIV-E541	1	GVB	8 APR 86	1830	550	47 17 58	122 28 10
CBIV-F551	1	GVB	8 APR 86	1845	558	47 18 05	122 28 20
CBIV-G540	1	GVB	8 APR 86	1107	538	47 18 37	122 29 04
CBIV-H513	1	GVB	8 APR 86	1142	504	47 19 10	122 29 48
CBIV-I480	1	GVB	8 APR 86	1211	485	47 19 16	122 29 59
CBV-A420	1	GVB	8 APR 86	1935	411	47 17 07	122 26 34
CBV-B472	1	GVB	8 APR 86	1925	480	47 17 30	122 26 38
CBV-C539	1	GVB	8 APR 86	1900	553	47 18 02	122 27 46
CBV-D566	1	GVB	8 APR 86	955	558	47 18 24	122 28 12
CBV-E570	1	GVB	8 APR 86	1012	564	47 18 29	122 28 23
CBV-F538	2	GVB	8 APR 86	1040	545	47 18 52	122 28 55
CBVI-A430	1	GVB	8 APR 86	850	428	47 17 31	122 26 03
CBVI-B500	1	GVB	8 APR 86	900	506	47 17 49	122 26 44
CBVI-C543	1	GVB	8 APR 86	920	548	47 18 15	122 27 28
CBVI-D565	1	GVB	7 APR 86	1752	570	47 18 43	122 28 06
CBVI-E540	1	GVB	7 APR 86	1737	544	47 19 09	122 28 53
CBVII-A551	1	GVB	7 APR 86	1610	565	47 18 25	122 26 51
CBVII-B580	1	GVB	7 APR 86	1636	578	47 18 34	122 27 07
CBVII-C540	1	GVB	7 APR 86	1645	554	47 19 03	122 28 00
CBVII-D300	1	GVB	8 APR 86	933	303	47 19 18	122 28 38
CBVIII-A50	1	GVB	7 APR 86	1550	57	47 18 30	122 26 07
CBVIII-B75	2	GVB	7 APR 86	1540	82	47 18 34	122 26 08
CBVIII-C200	1	GVB	7 APR 86	1530	212	47 18 40	122 26 14
CBVIII-D300	1	GVB	7 APR 86	1520	310	47 18 42	122 26 19
CBVIII-E400	1	GVB	7 APR 86	1510	404	47 18 47	122 26 26
CBVIII-F570	1	GVB/PP	7 APR 86	1455	578	47 19 05	122 26 57
CBVIII-G576	1	GVB/PP	7 APR 86	1430	580	47 19 25	122 27 22
CBVIII-H540	1	GVB/PP	7 APR 86	1415	565	47 19 43	122 27 56
CBVIII-I200	1	GVB/PP	7 APR 86	1400	204	47 19 55	122 28 10
CBVIII-J162	1	GVB	7 APR 86	1350	170	47 20 19	122 28 41

CBVIII-K162	1	GVB	7	APR	86	1325	168	47	20	22	122	28	44
CBVIII-L100	1	GVB	7	APR	86	1310	104	47	20	38	122	28	58
CBVIII-M75	1	GVB	7	APR	86	1254	80	47	20	34	122	29	10
CBVIII-N50	1	GVB	7	APR	86	1246	55	47	20	37	122	29	16
CBIX-A50	2	GVB	7	APR	86	1014	54	47	19	15	122	25	40
CBIX-B75	2	GVB	7	APR	86	1026	80	47	19	16	122	25	38
CBIX-C200	1	GVB	7	APR	86	1036	205	47	19	20	122	25	40
CBIX-D300	1	GVB	7	APR	86	1048	305	47	19	25	122	25	40
CBIX-E588	2	GVB	7	APR	86	1125	579	47	19	47	122	26	39
CBIX-F75	2	GVB	7	APR	86	1210	82	47	20	45	122	27	02
CBIX-G50	1	GVB	7	APR	86	1153	58	47	20	48	122	26	59
EBI-A100	1	GVB	9	APR	86	1657	110	47	35	14	122	22	21
EBI-B300	1	GVB	9	APR	86	1630	298	47	35	48	122	22	19
EBI-C300	1	GVB	9	APR	86	1618	328	47	36	01	122	22	19
EBII-A100	1	GVB	9	APR	86	1649	110	47	35	16	122	21	49
EBII-B200	1	GVB	9	APR	86	1707	217	47	35	34	122	21	57
EBII-C220	1	GVB	9	APR	86	1738	223	47	36	02	122	21	56
EBII-D330	1	GVB	9	APR	86	1653	305	47	36	29	122	22	00
EBII.5-A220	1	GVB	9	APR	86	1724	216	47	35	49	122	21	39
EBIII-A100	1	GVB	9	APR	86	1853	107	47	35	25	122	21	20
EBIII-B200	1	GVB	9	APR	86	1838	210	47	35	36	122	21	15
EBIII-C250	1	GVB	9	APR	86	1826	257	47	35	51	122	21	18
EBIII-D280	1	GVB	9	APR	86	1813	289	47	36	04	122	21	23
EBIII-E300	1	GVB	9	APR	86	1802	310	47	36	12	122	21	20
EBIII-F300	1	GVB	9	APR	86	1753	312	47	36	18	122	21	20
EBIV-A100	1	GVB	9	APR	86	1906	106	47	35	24	122	21	04
EBIV-B200	1	GVB	9	APR	86	1913	213	47	35	41	122	21	04
EBIV-C250	1	GVB	9	APR	86	1922	260	47	36	04	122	21	04
EBV-A100	1	GVB	9	APR	86	1530	104	47	37	34	122	23	50
EBV-B300	1	GVB	9	APR	86	1520	306	47	37	21	122	24	08
EBV-C500	1	GVB	9	APR	86	1506	445	47	37	18	122	24	14
EBV-D600	1	GVB	9	APR	86	1451	602	47	36	56	122	24	41
EBV.5-A560	2	GVB	9	APR	86	1439	566	47	37	10	122	24	43
EBVI-A100	1	GVB	9	APR	86	1310	104	47	37	43	122	24	16
EBVI-B300	2	GVB	9	APR	86	1326	301	47	37	34	122	24	32
EBVI-C500	1	GVB	9	APR	86	1350	504	47	37	26	122	24	46
EBVI-D600	1	GVB	9	APR	86	1409	598	47	37	04	122	25	28
EBVII-A100	1	GVB	9	APR	86	1238	106	47	38	00	122	24	45
EBVII-B300	1	GVB	9	APR	86	1215	307	47	37	48	122	24	58
EBVII-C500	1	GVB	9	APR	86	1202	540	47	37	36	122	25	11
EBVII-D600	1	GVB	9	APR	86	1145	588	47	37	21	122	25	28
EBVIII-A100	1	GVB	9	APR	86	1030	106	47	38	11	122	25	07
EBVIII-B300	1	GVB	9	APR	86	1045	306	47	38	00	122	25	26
EBVIII-C500	1	GVB	9	APR	86	1110	503	47	37	52	122	25	40
EBVIII-D600	1	GVB	9	APR	86	1130	602	47	37	45	122	25	58
EI-A100	1	GVB	10	APR	86	900	105	47	48	50	122	23	24
EI-B300	1	GVB	10	APR	86	936	303	47	49	01	122	23	55
EI-C500	1	GVB	10	APR	86	1018	507	47	49	14	122	24	30
EII-A100	1	GVB	10	APR	86	915	104	47	49	08	122	23	23
EII-B300	1	GVB	10	APR	86	927	304	47	49	17	122	23	46
EII-C500	1	GVB	10	APR	86	1000	510	47	49	29	122	24	18
EIII-A100	1	GVB	10	APR	86	1100	102	47	49	23	122	23	11
EIII-B300	1	GVB	10	APR	86	1045	302	47	49	29	122	23	31
EIII-C500	1	GVB	10	APR	86	1033	505	47	49	39	122	23	58
PGI-A72	1	GVB	11	APR	86	848	82	47	58	13	122	14	01
PGI-B360	1	GVB/PP	11	APR	86	900	360	47	58	10	122	15	15

PGI-C300	1	GVB/PP	11	APR	86	924	308	47	57	53	122	15	32
PGI-D198	1	GVB	11	APR	86	935	216	47	57	48	122	16	22
PGI-E198	1	GVB	11	APR	86	950	203	47	57	16	122	17	47
PGI-F618	1	GVB	10	APR	86	1551	642	47	56	54	122	19	23
PGI-G588	1	GVB	10	APR	86	1214	582	47	56	36	122	20	32
PGII-A48	1	GVB	11	APR	86	1205	50	47	58	47	122	13	28
PGII-B72	2	GVB	11	APR	86	1158	70	47	58	43	122	13	39
PGII-C198	1	GVB/PP	11	APR	86	1145	195	47	58	38	122	13	55
PGII-D300	1	GVB/PP	11	APR	86	1131	302	47	58	37	122	14	38
PGII-E336	2	GVB/PP	11	APR	86	1120	342	47	58	20	122	15	07
PGII-F402	2	GVB/PP	11	APR	86	1056	404	47	58	14	122	16	18
PGII-G450	1	GVB/PP	11	APR	86	1037	454	47	57	54	122	16	58
PGII-H498	1	GVB	11	APR	86	1535	512	47	57	46	122	17	26
PGII-I540	1	GVB	11	APR	86	1549	546	47	57	36	122	17	56
PGII-J600	1	GVB	10	APR	86	1600	605	47	57	27	122	18	43
PGII.5-A270	1	GVB	11	APR	86	1300	273	47	58	46	122	14	29
PGII.5-B300	1	GVB	10	APR	86	1310	303	47	58	41	122	14	57
PGIII-A48	1	GVB	11	APR	86	1322	52	47	59	04	122	14	25
PGIII-B72	1	GVB	11	APR	86	1333	76	47	59	05	122	14	32
PGIII-C198	1	GVB	11	APR	86	1343	199	47	58	58	122	14	40
PGIII-D300	1	GVB	11	APR	86	1356	306	47	58	51	122	15	16
PGIII-E402	1	GVB	11	APR	86	1413	414	47	58	42	122	16	13
PGIII-F450	1	GVB	11	APR	86	1448	455	47	58	16	122	17	19
PGIII-G498	1	GVB	11	APR	86	1522	503	47	58	08	122	17	46
PGIII-H540	1	GVB	10	APR	86	1621	546	47	57	55	122	18	21
PGIII-I600	1	GVB	10	APR	86	1525	630	47	57	27	122	19	47
PGIII-J102	1	GVB	10	APR	86	1224	100	47	57	07	122	20	50
PGIV-A300	1	GVB/PP	14	APR	86	1115	312	47	59	02	122	15	27
PGIV-B402	1	GVB/PP	14	APR	86	1056	427	47	58	59	122	15	57
PGIV-C402	1	GVB/PP	14	APR	86	1040	421	47	58	51	122	16	23
PGIV-D420	1	GVB/PP	14	APR	86	1020	434	47	58	35	122	16	54
PGIV-450	1	GVB/PP	14	APR	86	1010	459	47	58	25	122	17	24
PGIV-F100	1	GVB	10	APR	86	1234	98	47	57	22	122	20	45
PGV-B72	1	GVB	14	APR	86	1128	80	47	59	24	122	15	06
PGV-C198	1	GVB/PP	14	APR	86	1135	205	47	59	20	122	15	11
PGV-D300	1	GVB/PP	14	APR	86	1145	306	47	59	16	122	15	23
PGV-E402	1	GVB/PP	14	APR	86	1158	408	47	59	11	122	15	37
PGV-F450	1	GVB/PP	14	APR	86	1212	447	47	59	04	122	16	02
PGV-G402	1	GVB/PP	14	APR	86	1229	414	47	58	54	122	16	42
PGV-H450	1	GVB/PP	14	APR	86	955	468	47	58	40	122	17	40
PGV-I498	1	GVB	11	APR	86	1620	510	47	58	30	122	18	20
PGV-J540	1	GVB	10	APR	86	1633	546	47	58	10	122	19	07
PGV-K100	1	GVB	10	APR	86	1252	103	47	57	42	122	20	44
PGVI-A72	1	GVB/PP	14	APR	86	1430	70	47	59	43	122	15	26
PGVI-B198	1	GVB/PP	14	APR	86	1422	205	47	59	40	122	15	31
PGVI-C300	1	GVB/PP	14	APR	86	1412	311	47	59	36	122	15	42
PGVI-D402	1	GVB/PP	14	APR	86	1358	450	47	59	28	122	16	13
PGVI-E402	1	GVB/PP	14	APR	86	1347	444	47	59	25	122	16	29
PGVI-F450	1	GVB/PP	14	APR	86	940	468	47	58	55	122	17	56
PGVI-G498	1	GVB	10	APR	86	1648	506	47	58	47	122	18	41
PGVI-H198	1	GVB	10	APR	86	1316	200	47	58	16	122	20	25
PGVI-I102	1	GVB	10	APR	86	1307	104	47	58	07	122	20	40
PGVII-A48	1	GVB	14	APR	86	1441	47	48	00	05	122	15	40
PGVII-B372	1	GVB/PP	14	APR	86	1453	372	47	59	53	122	16	15
PGVII-C198	1	GVB/PP	14	APR	86	1523	202	47	59	46	122	16	25
PGVII-D102	1	GVB/PP	14	APR	86	1532	102	47	59	37	122	16	49

PGVII-E402	1	GVB/PP	14	APR	86	1543	418	47	59	41	122	17	18
PGVII-F450	1	GVB/PP	14	APR	86	928	466	47	59	21	122	18	06
PGVII-G498	2	GVB/PP	14	APR	86	915	500	47	59	09	122	18	45
PG1-318	1	GVB	14	APR	86	1640	284	48	01	00	122	17	24
PG2-318	1	GVB/PP	14	APR	86	1622	327	48	00	37	122	16	56
PG3-318	1	GVB/PP	14	APR	86	1608	340	48	00	16	122	16	20
PG4-48	1	GVB	14	APR	86	1555	52	47	59	52	122	17	13
PG5-498	1	GVB	10	APR	86	1354	506	47	59	51	122	20	49
PG6-552	1	GVB	10	APR	86	1415	574	47	59	16	122	19	16
PG7-582	1	GVB	10	APR	86	1338	582	47	59	08	122	20	23
PG8-540	1	GVB	10	APR	86	1445	560	47	58	07	122	20	06
PG9-660	1	GVB	10	APR	86	1500	657	47	57	48	122	19	51
PG10-528	1	GVB	10	APR	86	1433	524	47	58	44	122	19	46
PGCH-552	1	GVB	10	APR	86	1535	576	47	56	59	122	20	04
SPI-A75	1	GVB	24	APR	86	903	74	48	06	05	122	26	05
SPI-B100	2	GVB	24	APR	86	911	103	48	06	04	122	26	20
SPI-C200	1	GVB	24	APR	86	921	201	48	06	00	122	26	14
SPI-D300	1	GVB/PP	24	APR	86	935	302	48	05	41	122	26	25
SPI-E400	1	GVB/PP	24	APR	86	946	450	48	05	35	122	26	35
SPI-F342	1	GVB/PP	24	APR	86	957	344	48	05	00	122	26	44
SPI-G300	1	GVB/PP	24	APR	86	1011	306	48	04	40	122	27	22
SPI-AA50	1	GVB	24	APR	86	928	51	48	06	09	122	26	08
SPI.5-A336	1	GVB/PP	24	APR	86	1053	347	48	05	23	122	27	07
SPII-A50	1	GVB	24	APR	86	1142	51	48	06	20	122	26	45
SPII-B200	1	GVB	24	APR	86	1136	200	48	06	17	122	26	50
SPII-C300	1	GVB/PP	24	APR	86	1129	300	48	06	05	122	26	57
SPII-D402	1	GVB/PP	24	APR	86	1112	402	48	05	44	122	27	10
SPII-E348	1	GVB/PP	24	APR	86	1102	342	48	05	28	122	27	24
SPII-F336	1	GVB/PP	24	APR	86	1031	337	48	05	13	122	27	44
SPII-G300	1	GVB/PP	24	APR	86	1022	300	48	05	02	122	27	53
SPIII-A50	1	GVB	24	APR	86	1156	50	48	07	19	122	27	48
SPIII-B100	1	GVB	24	APR	86	1202	98	48	07	12	122	27	47
SPIII-C200	1	GVB	24	APR	86	1210	201	48	07	11	122	27	56
SPIII-D300	1	GVB	24	APR	86	1217	299	48	07	00	122	27	55
SPIII-E402	1	GVB/PP	24	APR	86	1241	402	48	06	30	122	28	19
SPIII-F402	1	GVB/PP	24	APR	86	1252	398	48	05	57	122	28	15
SPIII-G300	1	GVB	24	APR	86	1305	303	48	06	05	122	28	50

APPENDIX B. Grain Size Data for Phase I Depositional Analysis

STATION		% GRAVEL	% SAND	% SILT	% CLAY
COMMENCEMENT BAY					
CBI	A100	0.896	75.742	17.915	5.447
CBI	B100	0.551	75.198	17.744	6.507
CBI	C100	0.316	79.07	15.652	4.962
CBI	C100	0.32	76.761	17.533	5.385
CBI	D100	1.491	71.936	22.248	4.325
CBI	E100	2.969	63.108	27.998	5.924
CBII	A430	4.483	28.727	53.577	13.213
CBII	B480	0.017	20.691	63.206	16.086
CBII	C300	0.074	66.894	27.306	5.726
CBIII	A400	0.313	15.089	72.764	11.834
CBIII	B480	0	4.66	80.559	14.78
CBIII	C525	0.03	6.923	77.632	15.415
CBIII	D537	0	11.216	74.091	14.694
CBIII	E516	0.005	18.638	68.138	13.22
CBIII	F514	0.013	46.179	46.9	6.908
CBIII	G482	17.373	63.072	14.512	5.042
CBIII	G482	22.256	58.562	14.61	4.572
CBIII	G482	23.005	57.263	16.858	2.874
CBIII	H403	0.56	95.735	2.61	1.095
CBIV	A400	0.005	9.085	79.632	11.278
CBIV	B487	0.63	32.452	57.799	9.119
CBIV	C520	1.538	38.692	45.55	14.22
CBIV	D533	0.257	14.86	68.327	16.556
CBIV	E541	0.342	14.817	67.054	17.786
CBIV	F551	0.388	16.516	70.617	12.479
CBIV	G540	0.305	70.23	25.868	3.597
CBIV	G540	0.048	61.513	30.342	8.096
CBIV	H513	39.678	44.281	12.1	3.941
CBIV	H513	44.311	44.351	9.115	2.223
CBIV	I480	61.3	26.632	8.462	3.606
CBV	A420	0.024	9.977	64.271	25.729
CBV	B472	0	5.604	83.413	10.983
CBV	C539	1.032	25.506	59.842	13.621
CBV	D566	0.786	19.538	63.906	15.769
CBV	D566	0.107	10.675	78.142	11.076
CBV	E570	0.019	15.219	69.726	15.037
CBVI	F538	0.348	57.46	35.091	7.101
CBVI	A430	0	5.237	81.674	13.088
CBVI	B500	0.002	6.599	79.437	13.962
CBVI	C543	0.335	17.446	65.478	16.74
CBVI	D565	0.108	20.516	67.146	12.23
CBVI	E540	36.796	45.683	15.484	2.037
CBVII	A551	0.035	32.921	56.499	10.545
CBVII	B580	0.911	30.171	55.907	13.01
CBVII	C540	2.84	64.295	28.217	6.648
CBVII	D300	0.472	36.053	49.031	14.444
CBVIII	A50	13.197	61.832	19.232	5.738

STATION		% GRAVEL	% SAND	% SILT	% CLAY
COMMENCEMENT BAY					
CBVIII	B75	0.643	82.684	13.951	2.723
CBVIII	B75	0.479	82.047	13.932	3.542
CBVIII	C200	0.553	44.288	47.056	8.103
CBVIII	D300	0.572	12.454	71.893	15.081
CBVIII	E400	0.108	7.006	80.048	12.838
CBVIII	E400	0.052	4.992	77.227	17.729
CBVIII	F570	0.018	8.037	76.614	15.332
CBVIII	G576	0.006	19.964	66.835	13.195
CBVIII	H540	0.147	40.832	53.236	5.785
CBVIII	I200	0.366	85.928	10.366	3.34
CBVIII	I200	0.908	76.208	18.249	4.635
CBVIII	J162	0.007	80.725	14.91	4.358
CBVIII	K162	0.046	84.947	11.394	3.614
CBVIII	L100	0.157	81.191	13.987	4.665
CBVIII	M75	0.409	75.983	17.143	6.465
CBVIII	N50	0.203	79.909	14.811	5.077
CBVIII	N50	0.144	75.133	19.097	5.627
CBIX	A50	1.086	79.509	15.313	4.092
CBIX	B75	0.634	85.914	9.018	4.434
CBIX	B75	0.143	88.287	9.13	2.44
CBIX	C200	0.179	79.83	14.831	5.16
CBIX	D300	0.375	64.92	28.375	6.331
CBIX	E588	0.472	38.302	53.366	7.859
CBIX	E588	0.288	33.79	49.88	16.041
CBIX	F75	1.176	83.746	11.182	3.897
CBIX	G50	17.14	79.308	2.213	1.339
CBIX	G50	51.227	33.412	11.9	3.461
ELLIOTT BAY					
Inner Bay					
EBI	A100	0.603	45.504	43.167	10.726
EBI	B300	0.874	13.996	72.741	12.39
EBI	C300	0.197	9.343	74.77	15.69
EBII	A100	0.026	53.815	39.87	6.288
EBII	B200	0.498	33.995	53.695	11.812
EBII	C220	9.132	23.03	56.411	11.427
EBII	D330	0.006	6.937	79.363	13.693
EBII.5	A220	3.744	36.167	48.714	11.375
EBIII	A100	1.345	83.026	11.441	4.188
EBIII	B200	0.465	19.546	66.594	13.394
EBIII	C250	0.401	7.264	78.957	13.378
EBIII	D280	0.254	2.859	82.238	14.65
EBIII	E300	0.004	4.049	81.925	14.022
EBIII	F300	0.033	4.736	79.968	15.263
EBIV	A100	0.939	30.607	56.543	11.911
EBIV	B200	0.692	26.536	61.284	11.488
EBIV	C250	0.149	10.356	74.497	14.998
Four Mile Rock					
EBV	A100	0.543	71.39	22.257	5.811

STATION		% GRAVEL	% SAND	% SILT	% CLAY
ELLIOTT BAY					
EBV	A100	0.68	69.423	23.441	6.456
EBV	B300	4.257	62.17	27.201	6.373
EBV	C500	0.281	23.89	59.503	16.326
EBV	C500	0.313	21.297	63.903	14.487
EBV	D600	0.09	11.394	73.819	14.697
EBV.5	A560	0.486	17.202	69.16	13.153
EBVI	A100	0.962	74.353	19.757	4.927
EBVI	B300	0.634	67.104	25.949	6.312
EBVI	C500	0.991	49.933	39.474	9.602
EBVI	D600	0.002	5.254	78.517	16.227
EBVII	A100	2.842	61.133	30.808	5.217
EBVII	B300	0.45	76.371	18.702	4.477
EBVII	C500	0.112	90.157	6.967	2.764
EBVII	D600	0.491	15.062	70.085	14.362
EBVIII	A100	0.721	69.505	24.297	5.477
EBVIII	B300	3.002	60.586	30.913	5.498
EBVIII	C500	0.29	23.133	64.354	12.223
EBVIII	D600	0.056	6.018	78.823	15.103
EDMONDS					
EI	A100	0.196	79.228	16.728	3.848
EI	B300	0.277	55.401	37.071	7.251
EI	C500	2.734	24.804	63.32	9.141
EII	A100	4.068	69.41	22.022	4.499
EII	B300	0.848	58.941	32.392	7.82
EII	C500	3.112	21.873	59.88	15.135
EIII	A100	7.061	67.588	20.673	4.678
EIII	B300	2.343	52.898	36.111	8.649
EIII	C500	0	12.545	69.762	17.693
PORT GARDNER					
PGI	A72	0.034	71.446	22.165	6.354
PGI	A72	0.017	71.687	21.12	7.177
PGI	B360	0.592	27.037	59.713	12.658
PGI	C300	5.674	40.522	45.914	7.89
PGI	D198	2.479	59.197	30.038	8.286
PGI	E198	23.686	38.066	31.981	6.266
PGI	F618	0.128	7.98	74.497	17.395
PGI	G588	0.005	1.841	80.762	17.392
PGII	A48	9.553	39.425	42.07	8.951
PGII	B72	1.303	67.776	25.859	5.062
PGII	B72	1.051	69.812	23.308	5.829
PGII	C198	1.539	20.83	63.815	13.816
PGII	D300	0.104	27.319	59.818	12.759
PGII	E336	0.182	15.547	72.085	12.186
PGII	F402	0.021	14.758	68.761	16.46
PGII	G450	0.395	18.191	66.094	15.32
PGII	H498	0.034	5.731	76.928	17.307
PGII	I540	0.024	15.253	67.418	17.305

STATION		% GRAVEL	% SAND	% SILT	% CLAY
PORT GARDNER					
PGII	J600	0.008	5.573	84.925	9.494
PGII.5	A270	0.046	19.149	67.724	13.08
PGII.5	B300	0.51	17.626	67.244	14.619
PGIII	A48	0.046	20.72	63.991	15.243
PGIII	B72	0.03	27.36	59.381	13.228
PGIII	B72	0.19	32.165	61.511	6.134
PGIII	C198	0.321	17.281	65.783	16.615
PGIII	D300	0.93	28.838	57.477	12.755
PGIII	E402	0	7.062	75.328	17.61
PGIII	F450	0.285	4.97	77.625	17.12
PGIII	G498	0.169	4.632	78.093	17.107
PGIII	H540	0	2.24	77.095	20.665
PGIII	I600	0	2.27	79.299	18.431
PGIII	J102	0.025	82.539	12.892	4.544
PGIII	J102	0.01	80.743	13.93	5.316
PGIV	A300	0.205	21.574	64.294	13.927
PGIV	B402	0	10.7	80.615	8.679
PGIV	C402	0.066	6.767	74.127	19.04
PGIV	D420	0.011	3.74	79.924	16.324
PGIV	E450	0	3.976	77.541	18.482
PGIV	F100	0	84.306	12.454	3.24
PGV	B72	0.017	69.271	23.039	7.674
PGV	B72	0.004	70.613	21.919	7.464
PGV	B72	7.078	63.327	22.683	6.912
PGV	C198	0.057	26.804	61.734	11.405
PGV	D300	0.057	13.499	67.901	18.543
PGV	E402	0.026	12.184	74.284	13.506
PGV	F450	0.21	21.254	69.25	9.286
PGV	F450	0.025	7.841	76.903	15.231
PGV	G402	0.189	13.898	71.098	14.815
PGV	G402	0.07	3.951	83.532	12.477
PGV	H450	0.004	5.34	77.731	16.925
PGV	I498	0	1.796	80.43	17.775
PGV	I498	0.008	2.693	84.046	13.253
PGV	J540	0.006	2.086	80.303	17.605
PGV	K102	5.246	52.994	35.004	6.756
PGVI	A72	0.135	85.788	10.868	3.209
PGVI	A72	0.01	82.178	13.559	4.253
PGVI	B198	0.523	37.615	48.885	12.977
PGVI	C300	0.013	42.99	44.739	12.258
PGVI	D402	0.023	46.262	44.813	8.903
PGVI	D402	0.053	44.657	45.255	10.034
PGVI	E402	0.01	7.756	73.672	18.562
PGVI	F450	1.355	8.368	75.149	15.128
PGVI	G498	0.002	1.44	78.835	19.723
PGVI	H198	0.152	66.877	18.862	6.108
PGVI	I102	0.181	71.535	21.761	6.523
PGVII	A48	0.027	62.5	31.004	6.469
PGVII	B372	2.775	62.107	28.091	7.027
PGVII	C198	25.83	52.55	15.223	6.397
PGVII	C198	30.209	50.16	14.55	5.081

STATION		% GRAVEL	% SAND	% SILT	% CLAY
PORT GARDNER					
PGVII	D102	8.361	73.967	12.773	4.899
PGVII	D102	7.02	77.047	11.059	4.874
PGVII	E402	0.72	1.585	81.017	16.678
PGVII	F450	0	0.967	77.636	21.397
PGVII	G498	0	2.962	78.388	18.649
PG1	318	0	43.022	56.074	0.904
PG2	318	0.028	28.192	59.427	12.353
PG3	318	0.113	58.91	32.308	8.669
PG3	318	0.093	61.352	32.233	6.322
PG4	48	0.284	89.733	7.187	2.796
PG4	48	0.186	89.268	7.797	2.749
PG5	498	0.007	7.484	75.6	16.909
PG6	552	0.003	1.663	80.871	17.462
PG7	582	0	8.55	68.347	23.103
PG8	540	0.451	5.863	74.1	19.586
PG9	660	0	3.728	76.293	19.979
PG10	528	0.002	1.325	80.199	18.474
PGCH	552	0	1.864	78.019	20.117
SARATOGA PASSAGE					
SPI	AA50	0.031	91.071	6.756	2.142
SPI	AA50	0.011	89.948	7.121	2.92
SP1	A75	0.002	90.045	7.719	2.234
SP1	B100	0.02	83.913	11.133	4.934
SP1	C200	2.398	75.887	17.145	4.57
SP1	D300	4.747	65.574	23.898	5.781
SP1	E400	1.231	21.469	62.739	14.561
SP1	F342	0	2.046	78.554	19.4
SP1	F342	0.027	2.005	76.525	21.443
SP1	G300	0.641	70.467	23.555	5.337
SP1.5	A336	0	2.073	78.238	19.689
SPII	A50	0.03	89.166	6.38	4.424
SPII	A50	0.068	87.402	9.648	2.881
SPII	B200	0.048	74.898	19.12	5.934
SPII	C300	0.08	61.376	30.997	7.547
SPII	D402	0.053	9.509	71.936	18.502
SPII	E348	0.004	5.663	75.335	18.997
SPII	F336	0.092	3.881	76.707	19.321
SPII	G300	0.277	43.119	46.024	10.58
SPIII	A50	0.004	86.277	10.259	3.459
SPIII	B100	0	87.031	10.101	2.868
SPIII	C200	0.031	72.425	20.563	6.98
SPIII	D300	0.006	4.32	76.949	18.725
SPIII	E402	0.046	49.063	37.369	13.523
SPIII	E402	0.161	47.186	40.036	12.617
SPIII	F402	0	5.806	76.413	17.781
SPIII	G300	0.343	28.551	57.587	13.519

APPENDIX C. CONVENTIONAL CHEMISTRY DATA

REGION	VS	BOD	H2O	DRY/WETWT
SEAHURST STUDY				
TRANS A				
A-200E	1.31			
A-400E	4.79			
	3.51			
A-600E	10.1			
	9.78			
A-700E	8.1			
A.5	10.01			
TRANS B				
B-50E	0.77			
B-200E	2.05			
	1.13			
B-400E	3.54			
B-600E	8.92			
B-700E	8.67			
B.5	9.83			
TRANS C				
C-50E	1.19			
C-100E	1.25			
	0.92			
C-200E	6.96			
	1.12			
C-400E	4.51			
	2.98			
C-600E	10.9			
	9.18			
C-700E	9.96			
	9.34			
OT-1	8.34			
	9.27			
OT-2	9.11			
	9.15			
TRANS D				
D-50E	1.34			
D-100E	1.02			
D-200E	1.36			
D-400E	2.99			
D-700E	8			
TRANS E				
E-50E	1.05			
E-100E	0.86			
E-200E	1.58			
E-600E	4.04			
E-700E	7.76			
TRANS F				

REGION	VS	BOD	H2O	DRY/WETWT
F-200E	1.12			
	1.2			
F-600E	3.02			
	1.7			
F-700E	4.38			
TRANS G				
G-50E	1.55			
	0.73			
G-100E	1.05			
	0.64			
G-200E	2.92			
	1.5			
G-400E	2.69			
	2.41			
G-600E	6			
	3.27			
G-700E	9.75			
	9.2			
TRANS H				
H-50E	1.44			
	0.66			
H-100E	1.2			
	0.7			
H-400E	4.71			
	5.65			
H-600E	10			
	9.99			
H-700E	9.82			
	10.4			
TRANS I				
I-200E	2.99			
	1.55			
I-400E	2.49			
	1.93			
I-600E	5.45			
	5.04			
I-700E	9.73			
	8.52			
DP-4	7.54			
PB-1	1.11			
	0.98			
PB-2	1.34			
	0.98			
TRANS J				
J-50E	2.07			
	1.2			
J-100E	1.34			
	0.99			
J-400E	4.51			
	1.58			
J-600E	11			
	10.2			

REGION	VS	BOD	H2O	DRY/WETWT
J-700E	7.86			
	7.85			
DP-3	5.49			
TRANS J.5				
J.5-50E	1.27			
	1.25			
J.5-100E	1.1			
	0.75			
J.5-200E	1.26			
	1.28			
J.5-400E	5.36			
	4.08			
J.5-600E	7.97			
	9.15			
PB-3	1.26			
	1.01			
PB-4	1.14			
	0.85			
TRANS K				
K-50E	0.86			
	0.63			
K-100E	0.83			
	0.65			
K-200E	1.41			
	0.88			
K-400E	6.58			
	4.41			
K-600E	8.23			
	7.89			
TRANS K.5				
K.5-50E	1.31			
K.5-100E	1.18			
K.5-200E	1.43			
K.5-400E	4.23			
K.5-600E	10.27			
TRANS L				
L-50E	2.2			
	1.37			
L-100E	1.22			
	1.2			
L-200E	4.06			
	4.53			
L-400E	7.34			
L-600E	6.91			
DP-1	7.98			
TRANS L.5				
L.5-200E	2.97			
	3.33			
L.5-400E	3.02			
	2.84			
L.5-600E	5.76			
	5.3			

REGION	VS	BOD	H2O	DRY/WETWT
QM-1	7.34			
QM-1	7.34			
	9.25			
QM-2	5.42			
	6.88			
QM-3	1.34			
M-200	0.92			
	0.78			
TRANS N				
N-50E	0.99			
N-100E	0.84			
N-200E	1.65			
O-200	2.02			
SS-1	4.47			
SS-2	4.39			
SS-3	4.05			
SS-4	9.04			
SS-5	9.68			
SS-6	7.7			
SS-7	2.49			
SS-8	3.18			
SS-9	1.76			
SS-10	2.38			
SS-11	1.72			
SS-12	3.58			
B-II	0.44			
	1.79			
	1.25			
	4.32			
	5.79			
B-III	2.22			
	8.67			
	8.75			
B-IIIC	8.42			
	7.41			
B-IIIN	6.99			
B-III.5	1.42			
	1.49			
B-IV	0.94			
	1.84			
	2.97			
	9.12			
B-IVC	8.98			
	6.89			
B-IVN	8.57			
B-V	0.88			
	1.15			
	5.8			
	8.39			
B-VC	8.41			
B-VN	8.22			
	7.76			

REGION		VS	BOD	H2O	DRY/WETWT
B-VI		0.77			
		1.44			
		7.76			
		6.78			
		8.67			
B-VIN		7			
B-VII		1.27			
		1.24			
		7.36			
		8.47			
B-VIIN		8.6			
B-VIII		0.93			
		1.36			
		2.19			
		6.25			
		6.09			
B-VIIIN		7.3			
B-IX		4.02			
		2.9			
		5.75			
		6.97			
B-X		11.12			
		12.83			
		3.51			
		5.75			
B-XI		3.17			
		7.41			
		6.5			
B-XII		3.75			
		9.7			
# 25					
#25C		7.25			
# 37		8.39			
		10.79			
# 35		8.82			
# 32		7.13			
		6.68			
TRANS A		5.13			
SS-11		2.58			
		2.5			
XI-300		4.27			
VIII-750		6.6			
		6.24			
COMMENCEMENT BAY					
CBI	A100	1.81	659	26.2	0.7573
		1.84	881	24.3	
		1.75		24.1	
				24.4	
CBI	B100	2.76	780	30.8	0.6892
		2.45	938	31.3	

REGION		VS	BOD	H2O	DRY/WETWT
CBI	C100	1.03	452	22.5	0.7836
		1.1	300	21.4	
		1.35		21.5	
				21.7	
CBI	D100	1.48	360	25.4	0.7474
		1.45	400	24.1	
		1.47		25.1	
				25.4	
CBI	E100	2.63	603	29.9	0.7132
		2.34	418	29.9	
		2.32			
CBII	A430	2.9	280	38	0.6169
		3.21	360	38	
CBII	B480	5.66	740	53.9	0.4561
		5.51	795	54.3	
		5.49			
CBII	C300	2.64	430	38.5	0.6423
		2.5	425	36.6	
		2.7			
CBIII	A400	4.47	500	46.9	0.529
		4.38	700	47.2	
		4.41			
CBIII	B480	4.97	800	52.1	0.4705
		5	670	53.8	
CBIII	C525	5.32	770	54.2	0.4538
		5.34	690	55.1	
CBIII	D537	5.69	1253	55.7	0.447
		5.72	1039	54.8	
CBIII	E516	5.17	645	53.5	0.4652
		5.14	425	53.5	
CBIII	F514	4.3	408	39.7	0.6264
		2.78	410	39	
		2.67			
CBIII	G482	1.36	260	21.5	0.7701
		1.55	300	24.1	
		1.63			
CBIII	H403	1.21	240	17.3	0.8173
		1.33	175	16	
		1.2		17.6	
				18.9	
CBIV	A400	4.21	1563	50.3	0.5107
		4.22	1606	49.6	
		4.14			
CBIV	B487	2.91	726	40.6	0.9029
		2.58	492	41.2	
		2.71			
CBIV	C520	3.1	750	40.1	0.5978
		3.21	770	40	
CBIV	D533	5.29	940	53.3	0.4727
		4.97	740	53.4	
		5.27			
CBIV	E541	5.69	626	56.2	0.4327
		5.77	868	57.3	

REGION		VS	BOD	H2O	DRY/WETWT
CBIV	F551	6.26	697	56.8	0.4315
		6.24	700	56.9	
		6.44			
CBIV	G540	1.83	463	29.4	0.7116
		2.15	420	27.8	
				28.2	
				29.9	
CBIV	H513	1.47	321	21.7	0.7798
		1.28	363	22.4	
CBIV	I480	1.2	323	14.6	0.8673
		1.34	333	11.9	
CBV	A420	4.08	927	54.4	0.5017
		4.17	1077	51.9	
		3.91		50.5	
				49.2	
CBV	B472	4.98	762	55.8	0.4464
		4.67	850	55.9	
		4.47			
CBV	C539	3.6	988	48.1	0.5322
		3.73	1064	45.9	
		3.84		46.2	
				47.3	
CBV	D566	6.34	490	55	0.4516
		6.44	500	54.7	
CBV	E570	5.81	987	56.4	0.53
		5.68	1151	54.3	
		5.54		54.5	
		5.67		53.7	
CBV	F538	1.88	574	29.7	0.7109
		1.89	340	30.4	
		1.84			
CBVI	A430	4.77	920	58.7	0.4185
		4.52	1100	56.8	
		4.98		57	
				59.3	
CBVI	B500	4.54	770	56.5	0.4592
		4.44	1200	55.2	
		4.67		53	
				55.2	
CBVI	C543	5.25	908	54	0.4567
		5.3	875	54.6	
CBVI	D565	6.89	520	53.7	0.4645
		6.45	330	53.4	
CBVI	E540	1.45	418	23.1	0.7633
		1.72	438	24.3	
		1.62		23.1	
		1.64			
CBVII	A551	4.96	1196	54.3	0.4565
		4.87	1031	54.4	
CBVII	B580	9.98	595	51.9	0.4864
		8.13	580	50.8	
CBVII	C540	2.15	300	31.9	0.68
		2.4	340	32.1	

REGION		VS	BOD	H2O	DRY/WETWT
CBVII	D300	3.85	510	44.7	0.5741
		3.67	620	43.9	
		3.7			
CBVIII	A50	1.6	515	21	0.7903
		1.44	440	20.9	
		1.5		20.4	
		1.36			
CBVIII	B75	1.09	500	21.6	0.7914
		0.94	350	20	
CBVIII	C200	2.85	1055	33.4	0.6651
		3.38	826	33.4	
CBVIII	D300	4.67	1120	47.9	0.5204
		4.16	950	48	
CBVIII	E400	5.69	975	56.2	0.4386
		5.12	1030	56	
CBVIII	F570	7.45	1460	61.8	0.3902
		12.04	1215	62.1	
		7.45		59.3	
		7.76		62.7	
		7.16			
		7.61			
CBVIII	G576	4.7	573	52.9	0.4701
		4.6	610	53.1	
CBVIII	H540	3.74	1570	51.1	0.4831
		4.41	1088	52.2	
CBVIII	I200	1.25	210	25.8	0.7421
		1.33	250	25.7	
CBVIII	J162	1.05	200	26.1	0.7401
		1.13	206	25.9	
CBVIII	K162	0.95		25.7	0.7453
		0.74		25.2	
CBVIII	L100	1.29		26.3	0.7408
		1.36		25.7	
CBVIII	M75	1.92		31.5	0.6906
		1.86		30.4	
CBVIII	N50	1.62		28.1	0.7159
CBVIII	N50	1.65		28.7	
CBIX	A50	1.81		28.6	0.715
		1.8		28.4	
CBIX	B75	0.95		24.4	0.7506
CBIX	B75	0.79		24.4	
CBIX	C200	1.58		28.5	0.7128
		1.59		29	
CBIX	D300	1.97		32.5	0.6732
		1.77		32.2	
		2.21			
		1.92			
CBIX	E588	8.67		54	0.4588
CBIX	E588	9.91		54.3	
CBIX	F75	1.32		24.3	0.7547
		0.99		24.8	
CBIX	G50	0.79		15.6	0.8475
CBIX	G50	0.86		14.9	

REGION		VS	BOD	H2O	DRY/WETWT
ELLIOTT BAY Inner Bay					
EBI	A100	3.46		36.5	0.6388
		3.52		36.1	
EBI	B300	6.12		57.3	0.4226
		7.42		58.1	
		6.66			
		6.52			
EBI	C300	6.11		56.9	0.429
		6.57		57	
		6.29		57.3	
		6.69		57.4	
EBII	A100	2.95		36.8	0.631
		3.11		37	
EBII	B200	3.73		42.8	0.5736
		4.23		42.4	
EBII	C220	4.81		48.7	0.5159
		5.84		48.1	
		5.45			
		5.31			
EBII	D330	6.96		63.7	0.366
		7.2		63.9	
		6.89		63.3	
		6.98		63.5	
EBII.5	A220	3.77		40.7	0.5939
		3.52		40.5	
EBIII	A100	1.01		19.4	0.8055
		1.03		19.5	
EBIII	B200	7.45		48.7	0.5144
		5.72		48.4	
		5.9			
		5.45			
EBIII	C250	7		61	0.39
		6.84		61.1	
EBIII	D280	7.28		63.3	0.3713
		7.07		62.4	
		6.86		63.3	
		7.41		62.7	
EBIII	E300	7.5		65.1	0.3487
		7.01		65.2	
EBIII	F300	7.07		63.2	0.3715
		6.95		62.6	
EBIV	A100	4.44		42.9	0.5709
		4.21		42.9	
EBIV	B200	3.45		32.6	0.668
		3.47		32.9	
EBIV	C250	7.3		57.9	0.38
		7.27		62.6	
		7.22		62.5	
		6.13		61.7	
		7.24			

REGION		VS	BOD	H2O	DRY/WETWT
Four Mile Rock					
EBV	A100	1.51		23.2	0.7668
EBV	A100	1.39		23.4	
EBV	B300	2.68		23.2	0.7712
		2.07		22.5	
		2.13			
		1.94			
EBV	C500	5.21		51.9	0.484
EBV	C500	5.03		51.6	
		5.52		51.4	
		5.03		51.4	
EBV	D600	7.51		65.3	0.3489
		7.29		65	
EBV.5	A560	6.32		59.1	0.4089
		6.3		59.1	
EBVI	A100	3.13		31.5	0.6796
		3.54		32.6	
EBVI	B300	3.99		39.8	0.6069
		3.93		38.8	
EBVI	C500	2.44		34.8	0.6526
		2.18		34.7	
EBVI	D600	7.43		65.7	0.3428
		7.99		65.8	
EBVII	A100	2.93		32.1	0.6826
		3.05		31.4	
EBVII	B300	1.63		27.1	0.7294
		1.63		27	
EBVII	C500	1.23		24.3	0.7519
		1.47		25.4	
		1.93		24.9	
		1.65		24.6	
EBVII	D600	7.04		61.1	0.3897
		7.04		61	
EBVIII	A100	1.55		27.9	0.728
		1.73		27.1	
		1.37		26.5	
		2		26.7	
EBVIII	B300	2.72		36.5	0.6458
		2.54		36.6	
		2.65		33.7	
				34.8	
EBVIII	C500	4.86		52.8	0.4674
		5.16		53.7	
EBVIII	D600	7.39		64.3	0.3572
		7.63		64.3	
EDMONDS					
EI	A100	1.3		22.3	0.7708
		1.48		23.5	

REGION		VS	BOD	H20	DRY/WETWT
EI	B300	2.34		29.8	0.7034
		2.29		29.6	
EI	C500	4.6		49.2	0.5018
		4.59		50	
EII	A100	3.18		29.2	0.7065
		2.89		29.5	
EII	B300	1.82		25.7	0.7445
		1.99		25.4	
EII	C500	4.23		47.4	0.529
		4.28		46.7	
EIII	A100	1.64		22.6	0.7763
		1.77		22.2	
EIII	B300	2.17		33	0.6688
		1.98		33.2	
EIII	C500	5.94		60.5	0.3942
		5.32		60.6	
PORT GARDNER					
PGI	A72	1.83		28	0.716
PGI	A72	1.87		28.8	
PGI	B360	5.16		50	0.4989
		5.44		50.2	
PGI	C300	3.68		39.7	0.6044
		3.38		39.4	
PGI	D198	1.94		28	0.718
		2.06		28.4	
		1.83		28.3	
		2.2		28.6	
PGI	E198	3.21		33	0.6676
		3.28		33.5	
PGI	F618	6.75		62.1	0.3791
		7.12		62.1	
PGI	G588	8.27		67.2	0.3278
		8.26		67.2	
PGII	A48	6.76		43.4	0.5676
		6.84		43.1	
PGII	B72	2.6		24.1	0.7515
PGII	B72	3.2		25.5	
		3.19		24.7	
		2.84		25.4	
PGII	C198	7.49		46.8	0.5291
		7.68		47.3	
PGII	D300	5.71		46	0.5359
		5.84		46.8	
PGII	E336	5.08		46.8	0.5355
		5.44		46.6	
		5.08		46.3	
		5.14		46.3	
PGII	F402	5.42		53	0.4676
		5.15		53.5	

REGION		VS	BOD	H2O	DRY/WETWT
PGII	G450	6.25		56.9	0.4294
		6.2		57.2	
PGII	H498	7.3		61.7	0.383
		7.32		61.7	
PGII	I540	6.33		61.5	0.3856
		6.53		61.4	
PGII	J600	7.63		65.6	0.3439
		7.78		65.6	
PGII.5	A270	5.59		47.9	0.5205
		5.8		48	
PGII.5	B300	6.18		52.5	0.474
		6.37		52.7	
PGIII	A48	4.94		43.5	0.5652
		4.94		44.8	
PGIII	B72	5.87		44.6	0.5591
PGIII	B72	5.61		44	
		5.75		43.9	
		5.54		43.8	
PGIII	C198	5.55		43.5	0.5666
		5.48		43.2	
PGIII	D300	5.84		48.9	0.5124
		5.79		48.6	
PGIII	E402	6.52		60	0.3994
		6.28		60.1	
PGIII	F450	7.34		62.2	0.369
		7.41		63	
		7.46		64	
		7.03		64	
PGIII	G498	7.34		68	0.3225
		7.73		67.5	
PGIII	H540	7.97		63.7	0.3642
		7.77		63.5	
PGIII	I600	8.36		67	0.3283
		7.88		67.3	
PGIII	J102	0.9		21.6	0.788
PGIII	J102	0.98		20.8	
PGIV	A300	5.33		48.3	0.5152
		5.45		48.6	
PGIV	B402	6.85		57.3	0.4244
		6.56		57.8	
PGIV	C402	7.17		61	0.3881
		7.19		61.4	
PGIV	D420	6.99		62.9	0.3712
		6.66		62.8	
PGIV	E450	7.1		64.1	0.3585
		7.39		64.2	
PGIV	F100	1.08		21.6	0.7826
		0.8		21.9	
PGV	B72	1.93		29.7	0.6984
PGV	B72	1.92		30.6	
PGV	B72				
PGV	C198	4.33		43.4	0.5654
		4.61		43.5	

REGION		VS	BOD	H2O	DRY/WETWT
PGV	D300	5.8		50	0.5
		5.86		49.9	
PGV	E402	6.81		57.4	0.4225
		6.26		58	
PGV	F450	7.21		59.2	0.4066
PGV	F450	6.7		59.1	
		7.28		59.5	
		7.4		59.7	
PGV	G402	7.54		62	0.3819
PGV	G402	7.5		61.7	
PGV	H450	7.97		66.3	0.338
		7.91		66.1	
PGV	I498	8.39		68.6	0.3115
PGV	I498	8.52		69	
PGV	J540	7.75		65.3	0.3471
		8.03		65.3	
		8.29			
		7.67			
PGV	K102	3.4		28.6	0.7095
		3.25		29.5	
		3.42			
		5.19			
PGVI	A72	1.64		29.8	0.7004
PGVI	A72	1.65		30	
PGVI	B198	5.5		39.3	0.6048
		5.74		39.7	
PGVI	C300	3.56		43.1	0.5682
		3.14		43.3	
PGVI	D402	3.14		41.6	0.5875
PGVI	D402	3.38		41.5	
		3.3		40.5	
		3.37		41.4	
PGVI	E402	7.66		61.6	0.36
		7.8		63.8	
		7.81		63.2	
		7.89		64.4	
PGVI	F450	7.65		65.2	0.3462
		8.19		65.6	
		8.07			
		8.2			
PGVI	G498	8.07		68.1	0.3194
		8.32		68	
PGVI	H198	1.83		21.9	0.7874
		1.81		20.6	
PGVI	I102	1.48		22.7	0.7711
		1.52		23.1	
PGVII	A48	3.31		35.5	0.6419
		3.74		36.1	
PGVII	B372	2.3		30.1	0.7014
		2.42		29.6	
PGVII	C198	1.71		20.9	0.7912
PGVII	C198	1.69		20.9	
PGVII	D102	1.28		22.8	0.778

REGION		VS	BOD	H2O	DRY/WETWT
PGVII	D102	1.3		21.7	
PGVII	E402	8.42		68.5	0.3136
		8.06		68.6	
PGVII	F450	8.38		69.2	0.305
		7.79		68.6	
		8.2		70.9	
		7.4		70.4	
PGVII	G498	8.55		68.6	0.3131
PGVII	G498	8.55		68.6	0.3131
		8.31		68.7	
PG1	318	3.83		43.9	0.5607
		3.52		43.9	
PG2	318	4.44		48	0.515
		4.56		48	
		4.33		48.7	
				49.4	
PG3	318	2.73		33.3	0.6643
PG3	318	2.87		33.8	
PG4	48	0.99		20.7	0.7943
PG4	48	0.87		20.4	
		0.97		20.5	
		1.21		20.8	
		0.9		20.8	
PG5	498	6.92		64.7	0.3525
		7.03		64.8	
PG6	552	8.2		66.2	0.335
		8.1		66.8	
		8.16		66.4	
		7.96		66.5	
PG7	582	6.72		62.1	0.3789
		6.74		62.1	
PG8	540	7.88		66.6	0.3347
		7.3		66.5	
PG9	660	7.97		66.2	0.3377
		7.82		66.3	
PG10	528	8.37		69.3	0.3081
		8.27		69.1	
PGCH	552	7.74		67	0.3312
		8.37		66.8	
SARATOGA PASSAGE					
SPI	AA50	0.89		21.8	0.7819
SPI	AA50	0.86		21.8	
SP1	A75	1.11		21.4	0.7851
		1.06		21.6	
SP1	B100	0.89		23.4	0.7696
		1.02		22.7	
SP1	C200	1.31		19.6	0.8051
		1.94		19.4	

REGION		VS	BOD	H2O	DRY/WETWT
SP1	D300	1.52		29.1	0.7122
		1.38		28.4	
SP1	E400	4.93		58.1	0.419
		4.8		58.1	
SP1	F342	8.29		71.7	0.2805
SP1	F342	7.87		72	
SP1	G300	1.5		28.9	0.7101
		1.21		29.1	
SP1.5	A336	8.38		72.7	0.2744
		8.16		72.5	
SPII	A50	2.39		24.3	0.759
SPII	A50	1.35		23.9	
SPII	B200	1.34		25.6	0.7417
		1.33		26.1	
SPII	C300	1.92		32.3	0.6761
		1.81		32.5	
SPII	D402	6.82		65.7	0.342
		6.83		65.9	
SPII	E348	8.44		72.5	0.2764
		8.24		72.2	
SPII	F336	7.84		71.1	0.288
		7.65		71.3	
SPII	G300	2.49		44.3	0.5579
		2.88		44.1	
SPIII	A50	1.2		24.5	0.7528
		1.23		24.8	
SPIII	B100	1.21		21.4	0.7846
		1.12		21.7	
SPIII	C200	1.36		28.1	0.7219
		1.43		27.6	
SPIII	D300	7.3		68.8	0.3119
		7.01		68.8	
SPIII	E402	3.13		44.5	0.5536
SPIII	E402	2.88		44.5	
SPIII	F402	8		70.2	0.2959
		7.61		70.6	
SPIII	G300	4.17		51.6	0.4834
		3.78		51.7	

END

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