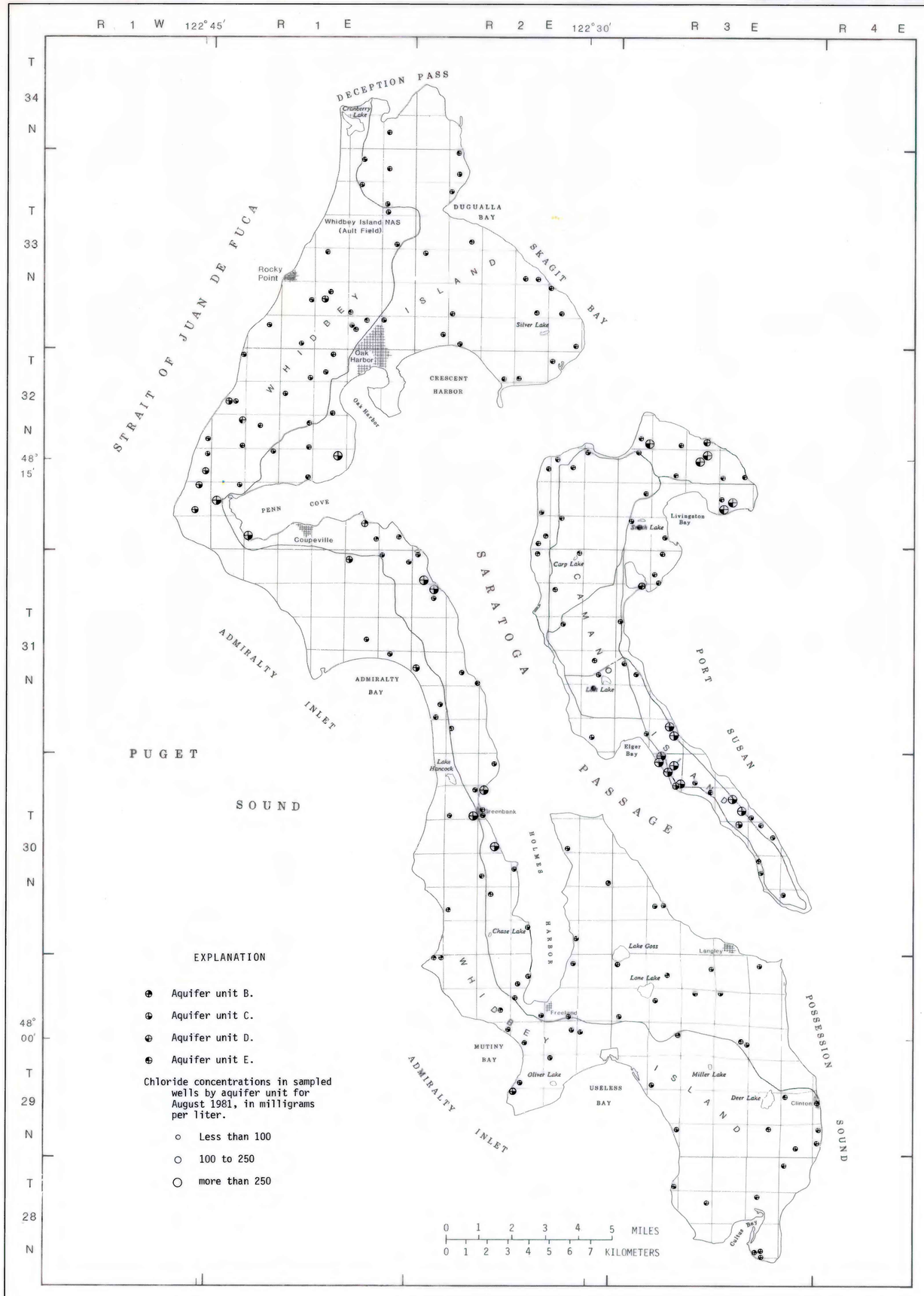

Comparisons of Chloride Concentrations

Seawater intrusion caused by overpumping of coastal aquifers can usually be detected by high chloride concentrations in well waters, or by increasing chloride concentrations over time. Excessive salts in drinking water produce unpalatable tastes, can be injurious to health, are corrosive to plumbing, and are difficult to remove once they have intruded an aquifer. The purpose of this part of the study was to assess the distribution of dissolved chloride in the ground water of Island County.

High chloride concentrations do not always indicate intrusion; high chloride concentrations can also result from contamination introduced by the disposal of manmade wastes, or from the presence of connate water—saline water that has been in the aquifer since its deposition. But in areas where high chloride concentrations occur near the coast in wells with water levels at or below sea level, present-day seawater intrusion appears to be the most probable cause.

METHODS OF DATA COLLECTION AND ANALYSIS

To determine the extent of seawater intrusion, wells in Island County were sampled each April and August from 1980 to 1983. These months were chosen for sampling because April generally represents the period of highest ground-water levels, following spring and winter recharge, and August generally represents the period of lowest water levels, following a period of low precipitation and high ground-water pumpage. In August 1980 a maximum of 319 wells were sampled and in April 1982 a minimum of 48 wells were sampled. Chloride samples were taken from aquifer wells tapping units B, C, D, and E throughout the county. The distribution of these sampling sites and the chloride concentrations for August 1981 is shown on the map

In order to determine the relative significance of the chloride concentrations found, frequency-distribution graphs were developed that show the percent cumulative frequency of the concentrations of water samples collected from wells in aquifer units B, C, D, and E (figs. 1-4). The percent cumulative frequency is the sum of the frequencies of each successive percent chloride value. For example, in figure 1 a chloride concentration of 20 mg/L or less occurred in approximately 44 percent of the samples and a concentration of 30 mg/L or less occurred in 74 percent of the samples.

In figures 1-4, the chloride concentrations and percent cumulative frequencies are plotted for water samples collected from both the wells finished above sea level (solid circles) and those finished at or below sea level (open circles). Wells finished above sea level are not susceptible to seawater intrusion, but water in wells completed above sea level may contain higher levels of chloride due to the disposal of manmade wastes and the presence of connate waters. The samples whose chloride concentrations were identified as being affected by the disposal of manmade waste were not used in this study. Therefore, chloride concentrations from samples analyzed in those wells finished above sea level can be considered representative of natural or "background" conditions for Island County.

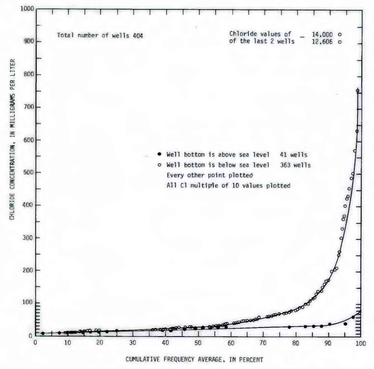

FIGURE 3.--Frequency distribution for chloride concentrations of samples collected from April 1980 to August 1983, for Aquifer unit C.

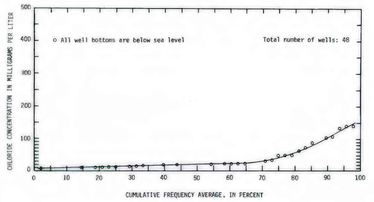

FIGURE 4.--Frequency distribution for chloride concentrations of samples collected from April 1980 to August 1983, for Aquifer unit B.

Figures 1 through 4 represent the cumulative frequency distributions of the chloride concentrations in samples collected from wells completed above and below sea level for aquifer units E through B. Figures 1 through 3 indicate that 100 percent of the observed chloride concentrations in those wells completed above sea level were less than or equal to 82 mg/L. Taken together (figs. 1-4), the preceding data indicate that chloride concentrations greater than, say, 100 mg/L can reasonably be assumed to be above background concentrations and probably represent the leading edge of the zone of mixing or diffusion between fresh and salt water. That is, wells with chloride concentrations above 100 mg/L have probably experienced some degree of seawater intrusion.

The Environmental Protection Agency's secondary drinking-water standards suggest that chloride concentrations not exceed 250 mg/L; this is the approximate level of chloride at which the taste of salt would first be apparent to most people. Table 1, which summarizes the results of the chloride concentrations in samples collected in April and August, 1980 through 1983, indicates that concentrations were highest in August 1981 and August 1983, when 8 percent of the water samples collected had concentrations greater than 250 mg/L. Because the number of wells sampled during 1982 was small compared to the remaining years, data comparisons were not made using the 1982 data for tables 1 and 2.

The median chloride concentrations observed in water samples collected from wells in April and August, 1980 through 1983, are listed in table 2. These data tend to suggest that chloride concentrations increased slightly over the period of study.

A direct comparison of water samples collected from the intruded wells in April and August of 1980, 1981, and 1983 indicates a seasonal increase in chloride concentrations for each of these years. On the basis of the data presented, however, it is difficult to discern if a year-to-year increase is taking place. The significance of the apparent increase in chloride concentration in the non-intruded wells from April 1980 to April 1981 is difficult to evaluate because the increase is so small (5 mg/L) that it falls within the margin of error expected in the analytical process.

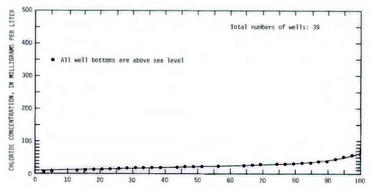

FIGURE 1.--Frequency distribution for chloride concentrations of samples collected from April 1980 to August 1983, for Aquifer unit E.

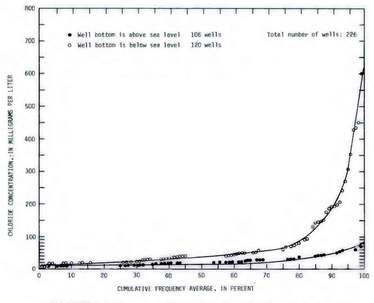

FIGURE 2.--Frequency distribution for chloride concentrations of samples collected from April 1980 to August 1983, for Aquifer unit D.

In order to put the data presented in tables 1 and 2 into perspective, it is important to note that in all six sampling periods over 80 percent of the wells were not influenced by seawater intrusion, and of that 80 percent, over half of the chloride concentrations were 30 mg/L or less.

Chloride concentrations are influenced in large part by water levels, which in turn are determined by recharge, discharge, tidal effects, and pumpage. The seasonal changes in chloride concentration observed in this short-term study are undoubtedly a reflection of seasonal changes in those factors, and should not be interpreted as long-term or permanent changes in chloride concentration or of intrusion conditions; such long-term changes cannot be determined from available data. In order to determine long-term trends in water levels and chloride concentrations, and to separate the manmade changes from natural changes, additional data would need to be collected on a long-term basis.

TABLE 1.--Percentage of water samples collected in April and August, 1980-83, that exceeded indicated chloride concentrations

Chloride concentrations, in milligrams per liter	Percentage of samples							
	Apr. 1980	Aug. 1980	Apr. 1981	Aug. 1981	Apr. 1982	Aug. 1982	Apr. 1983	Aug. 1983
Less than 100	92	84	87	83	52	40	85	81
100 to 250	6	11	7	9	25	32	10	11
More than 250	2	5	6	8	23	28	5	8
Number of samples	230	319	180	193	48	50	181	181

TABLE 2.--Median chloride concentrations in samples from intruded and non-intruded wells, 1980-83

[Non-intruded wells had water with chloride concentrations less than 100 milligrams per liter (mg/L); intruded wells had water with chloride concentrations of 100 mg/L or more]

Well type	Median chloride concentration, in milligrams per liter							
	Apr. 1980	Aug. 1980	Apr. 1981	Aug. 1981	Apr. 1982	Aug. 1982	Apr. 1983	Aug. 1983
Non-intruded (number of samples)	20 (212)	30 (267)	25 (157)	25 (159)	31 (25)	21 (20)	23 (153)	23 (147)
Intruded (number of samples)	160 (18)	195 (52)	210 (23)	250 (34)	250 (23)	250 (30)	190 (28)	240 (34)

OCCURRENCE OF GROUND WATER AND POTENTIAL FOR SEAWATER INTRUSION, ISLAND COUNTY, WASHINGTON

By M. A. Jones

1985

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BASE SHEET. T
for PLATES 1, 2