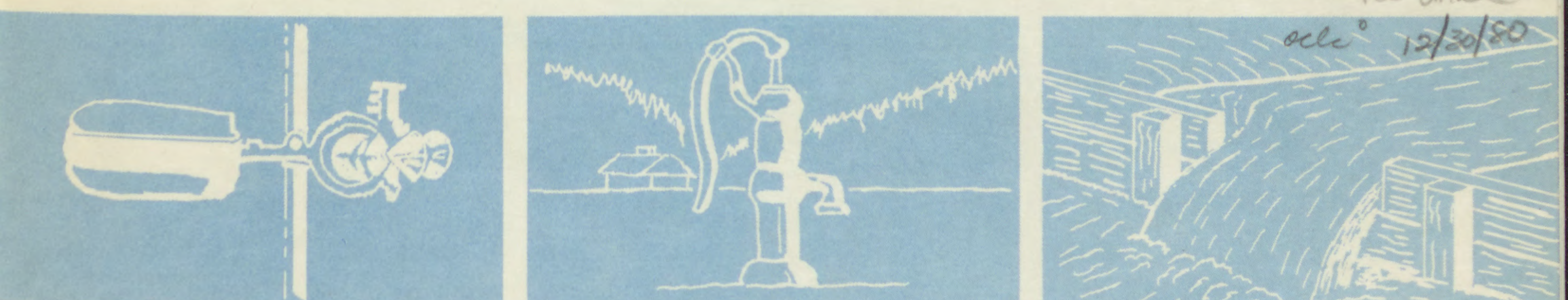
WATER RESOURCES OF THE PORT GAMBLE INDIAN RESERVATION, WASHINGTON



U.S. GEOLOGICAL SURVEY
Water-Resources Investigations
Open-File Report 79-66

Prepared in Cooperation With
Little Boston Tribe of the Klallam Indian Nation

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER RESOURCES OF THE PORT GAMBLE INDIAN RESERVATION, WASHINGTON

By W. E. Lum II

U.S. GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS

OPEN-FILE REPORT 79-66

Prepared in cooperation with the

Little Boston Tribe of the Klallam
Indian Nation

cat

Tacoma, Washington
1980

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, Secretary

GEOLOGICAL SURVEY

H. William Menard, Director

For additional information write to:

U.S. Geological Survey, WRD
1201 Pacific Avenue - Suite 600
Tacoma, Washington 98402

CONTENTS

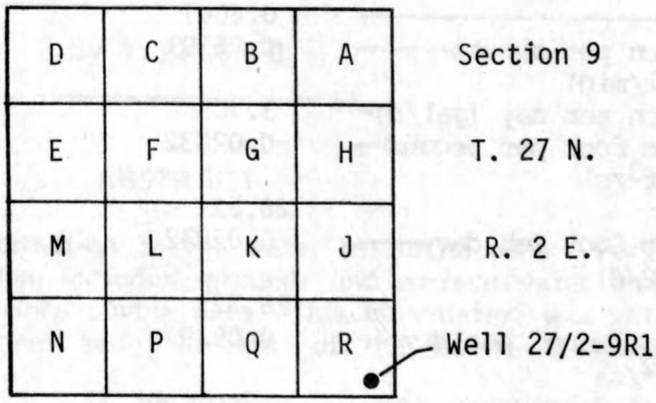
ILLUSTRATIONS

Page

TABLES

WELL-NUMBERING SYSTEM

In this report wells are designated by symbols that indicate their location according to the official rectangular public-land survey. For example, in the symbol 27/2-9R1, the part preceding the hyphen indicates successively the township and range (T.27 N., R.2 E.) north and east of the Willamette base line and meridian. The first number following the hyphen indicates the section (sec. 9), and the letter (R) indicates the 40-acre subdivision of the section, as shown in the accompanying diagram.



The last number is the number of the well assigned in sequence as the data are gathered in the particular 40-acre tract. Thus, well 27/2-9R1 is in the SE¼SE¼ sec.9, T.27 N., R.2 E., and is the first well in the tract to be listed. Of the 48 wells included in this report, 37 are located in T.27 N., R.2 E. To simplify their mention in the text, these wells are referred to only by their section, 40-acre subdivision, and serial number. For example, well 27/2-9R1 is referred to in the text as well 9R1. In figure 2 (map of the study area) the section number is dropped and the same well is marked R1.

In table 3 (computer printout of well information) the well numbers are given with slight modification; 27/2-9R1 becomes 27N/02E-09R01.

METRIC CONVERSIONS

The following factors are provided for conversion of inch-pound values to metric values:

Multiply	By	To obtain
inch	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile	1.609	kilometer (km)
acre	0.4047	hectare (ha)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
gallon per day (gal/d)	3.785	liter per day (L/d)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
	28.32	liter per second (L/s)
cubic foot per day (ft^3/d)	0.02832	cubic meter per day (m^3/d)
	28.32	liter per day (L/d)
feet squared per day (ft^2/d)	0.0929	meters squared per day (m^2/d)
degree Fahrenheit (°F)	Subtract 32, multiply remainder by 0.5556	degree Celsius (°C)

WATER RESOURCES OF THE PORT GAMBLE

INDIAN RESERVATION, WASHINGTON

By W. E. Lum II

ABSTRACT

This report provides information on the water resources of the Port Gamble Indian Reservation, Washington, including ground- and surface-water quality and quantity data and interpretations of the data. This information was gathered to provide a base for management and protection of the water resources of the reservation.

Ground water in the study area generally occurs in two aquifers. A shallow aquifer in weathered till (or fine sand and gravel) generally yields only enough water to wells to supply one or two households, and a lower artesian-aquifer system of sand and gravel layers near or below sea level produces higher yields--more than 65 gallons per minute to at least one well. Future supplies of ground water probably can be withdrawn from the lower artesian-aquifer system almost anywhere beneath the reservation. The estimated natural discharge of ground water from the lower artesian-aquifer system to Hood Canal and Port Gamble (bay) is about 42,000 cubic feet per day, or an average of about 220 gallons per minute. Of this amount, it is estimated that about 90 gallons per minute can be economically withdrawn, probably without greatly increasing chances of seawater intrusion. One well in the area taps a still deeper artesian aquifer that is otherwise unexplored. This aquifer, 75 to 80 feet or more below sea level, could possibly supply additional ground water for future use. Ground-water quality is good, but the water is moderately hard and has moderately high iron concentrations. Chloride analyses indicate that in 1977 there was no seawater intrusion into the lower aquifer tapped by wells in the community of Little Boston.

Analysis of streamflow characteristics at four sites indicates that average 7-day low flows estimated to occur an average of once every 20 years for Gamble Creek, Middle Creek, and Little Boston Creek are 0.6, 0.4, and 0.2 cubic foot per second, respectively. These are statistical estimates of average flow over a 7-day period and actual flow may be much lower, even zero, for some part of that period. Stream-water quality is good with all chemical characteristics analyzed being within acceptable limits for untreated drinking water.

Because the estimated low flows of Middle Creek and Little Boston Creek for 20-year recurrence intervals are greater than the estimated economical ground-water potential yield, the two streams can be considered, with treatment, as potential sources of domestic water.

At present, there is no evidence of pollution of the ground or surface waters from a solid-waste disposal site near the reservation.

INTRODUCTION

Purpose and Scope of the Study

The Port Gamble Indian Reservation is near the new Trident Nuclear Submarine Facility at Bangor, Wash. (fig. 1), and is within a broad area that is anticipated to have a population increase from about 100,000 people in 1975 to as many as 150,000 people within a few years (Hansen and Molenaar, 1976). This population increase will have a corresponding effect on water use in the area, increasing the demand for water for domestic and commercial purposes. For this reason, in 1975 officials of the Little Boston Tribe of the Klallam Indian Nation, who administer the reservation, recognized a need for an evaluation of the ground- and surface-water resources of the reservation. This background information would provide a water-resources data base and aid in assessing any future changes. Tribal officials also desired more specific information on:

(1) possible stream sites (on or near the reservation) for increasing the tribe's salmon enhancement programs;

(2) actual or potential contamination of the ground or surface water;

(3) any impact that increased water use in the surrounding area might have on the water resources of the reservation.

To evaluate the foregoing items and develop the desired information, the Little Boston Tribe requested the U.S. Geological Survey to make a study of the water resources of the reservation and aimed specifically at the following items:

(1) Ground water - Determine water levels and their seasonal fluctuation in the aquifer systems underlying the reservation; delineate possible areas for development of additional supplies of ground water; and evaluate the quality of the water and any actual or potential pollution problems (from septic tanks, seawater intrusion, or from the nearby solid-waste disposal site) that may occur owing to existing conditions or those that may come with a population increase.

(2) Surface water - Develop data on estimated streamflows and determine surface-water quality for specifically selected streams on and near the reservation.

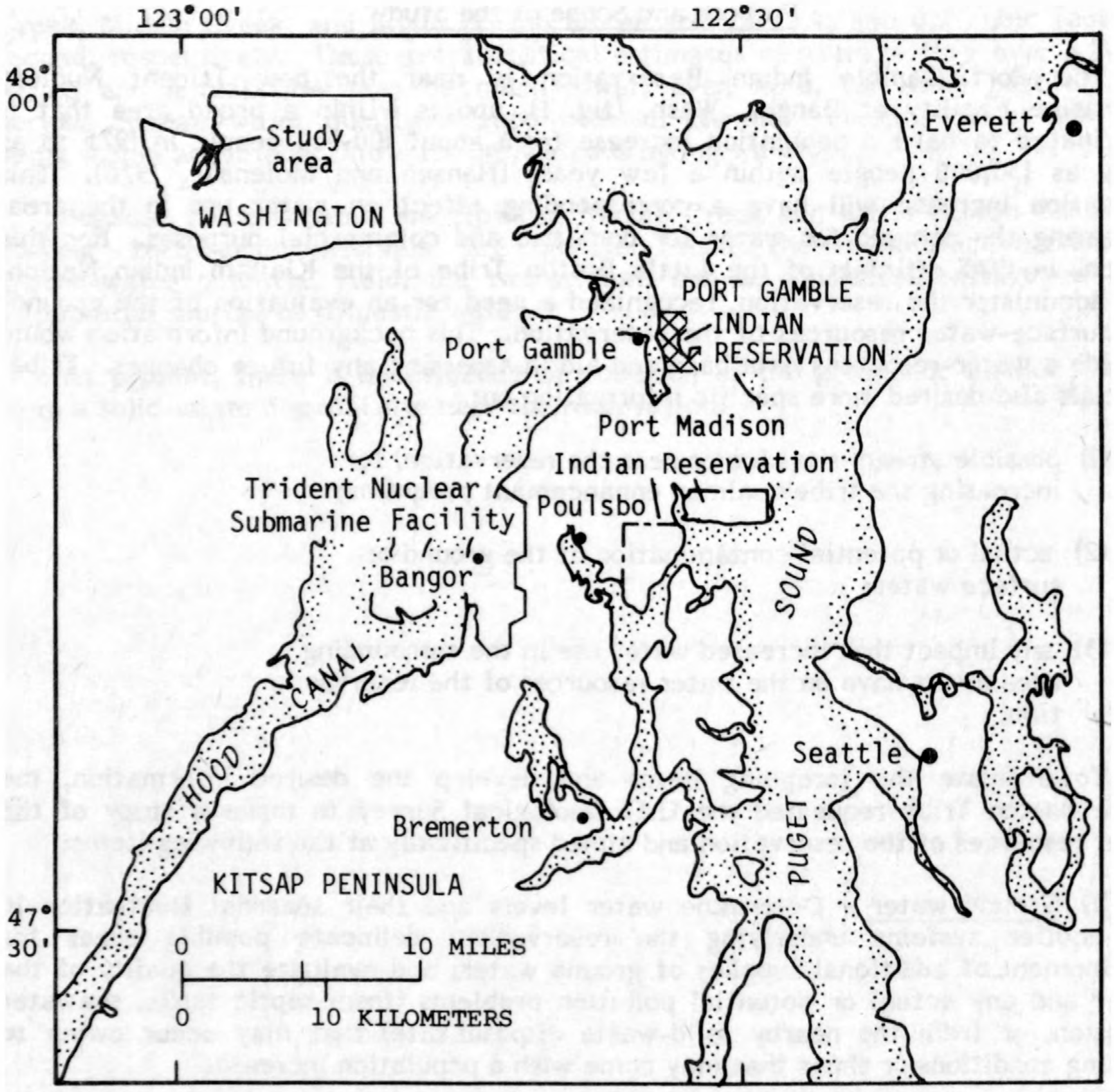


FIGURE 1.--Location of Port Gamble Indian Reservation.

Description of the Study Area

The Port Gamble Indian Reservation, which was established in 1936 under the Indian Reorganization Act of 1934, lies near the northern end of the Kitsap Peninsula in the Puget Sound Lowland of Washington (fig. 1). The reservation, about 20 miles north of Bremerton, Wash., covers about 1,300 acres (all tribally owned) and extends about 2 miles from north to south and about 1 mile from east to west (fig. 2). The land surface rises from sea level at Port Gamble (bay) on the west to about 400 feet above sea level near the eastern boundary of the reservation. The area is generally covered with second-growth cedar, fir, alder, and common types of underbrush.

Economic development of the reservation was limited in 1977 to tribally operated businesses including a store, gas station, and a mobile home park, all in the southeastern part of the reservation. There also is a small group of salmon-rearing tanks near the community of Little Boston.

Climate of the Study Area

The average annual precipitation in the area of the reservation is about 32 inches (U.S. Weather Bureau, 1965). A weather station at Everett, about 20 miles northeast of the reservation (fig. 1), provides long-term data on the monthly distribution of precipitation and average temperature that are representative of the study area (fig. 3). The average annual precipitation at the Everett station during 62 years of record (1915-76) was about 35 inches, and nearly 70 percent of this occurs during the period October-March. The average annual temperature is 50.5°F and monthly averages range from 38.2°F in January to 62.7°F in July. (All climatic data are from the U.S. National Oceanic and Atmospheric Administration, 1977a.)

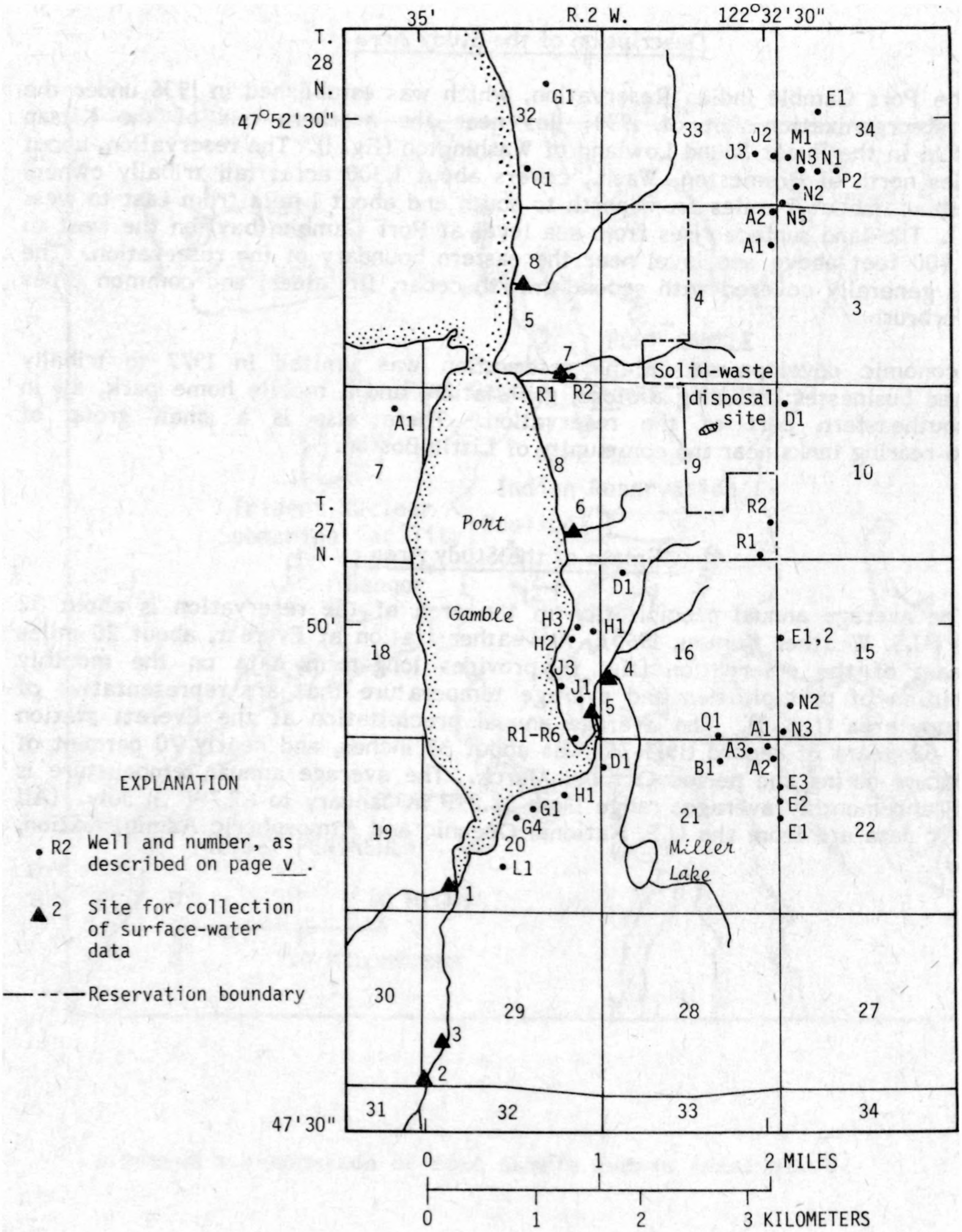


FIGURE 2.--Location of data-collection sites on and near the Port Gamble Indian Reservation.

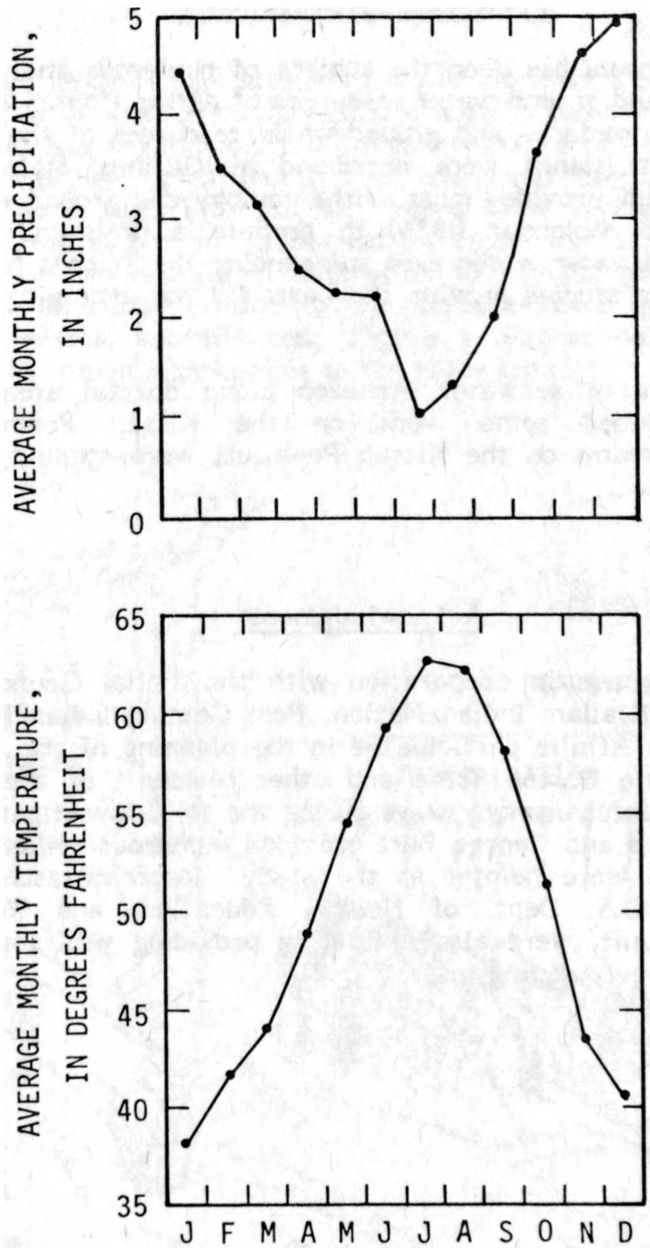


FIGURE 3.--Average monthly precipitation and temperature at Everett, Wash., during period 1915-76. Data from U.S. National Oceanic and Atmospheric Administration (1977a).

Previous Investigations

The Kitsap Peninsula has been the subject of numerous studies in the past 20 years. The geology and ground-water resources of Kitsap County were described by Sceva (1957), and the surface- and ground-water resources of the Kitsap Peninsula and certain adjacent islands were described by Garling, Molenaar, and others (1965). The latter study provided most of the geology and ground-water information used by Hansen and Molenaar (1976) to prepare a preliminary report on the availability of ground water in the area surrounding the Trident Nuclear Submarine Facility. All of these studies provide the basis for the geologic interpretations in this report.

A reconnaissance of seawater intrusion along coastal areas of Washington (Walters, 1971) included some work on the Kitsap Peninsula. Low-flow characteristics of streams on the Kitsap Peninsula were studied by Hidaka (1973) and Cummans (1977).

Acknowledgments

This study was made in cooperation with the Tribal Council of the Little Boston Tribe of the Klallam Indian Nation, Port Gamble Indian Reservation. The U.S. Bureau of Indian Affairs participated in the planning of the study. Individual members of the Little Boston Tribe and other residents of the reservation and nearby areas were helpful in many ways during the field investigations. Local well drillers Jerry Crabtree and George Burt provided numerous drillers' logs and other pertinent data which were helpful to the study. Representatives of the Indian Health Service (of U.S. Dept. of Health, Education, and Welfare), Western Washington Service Unit, were also helpful in providing well logs, water-quality data, and information on pumping tests.

THE HYDROLOGIC CYCLE

The hydrologic cycle is the pattern of water movement as it circulates through the natural system. Precipitation as rain and snow is the source of all freshwater. A part of the precipitation runs off rapidly to streams, a part is evaporated directly back to the atmosphere from the ground and from lakes, streams, and plant surfaces, and a part soaks into the soil where some is drawn up by plants and returns to the atmosphere by transpiration from the leaves. The remainder percolates downward to a zone of saturation to become ground water. In time, most of the ground water returns to the surface-water system by seepage to springs, lakes, streams, and the sea. Figure 4 diagrammatically illustrates the hydrologic cycle as it generally applies to the study area.

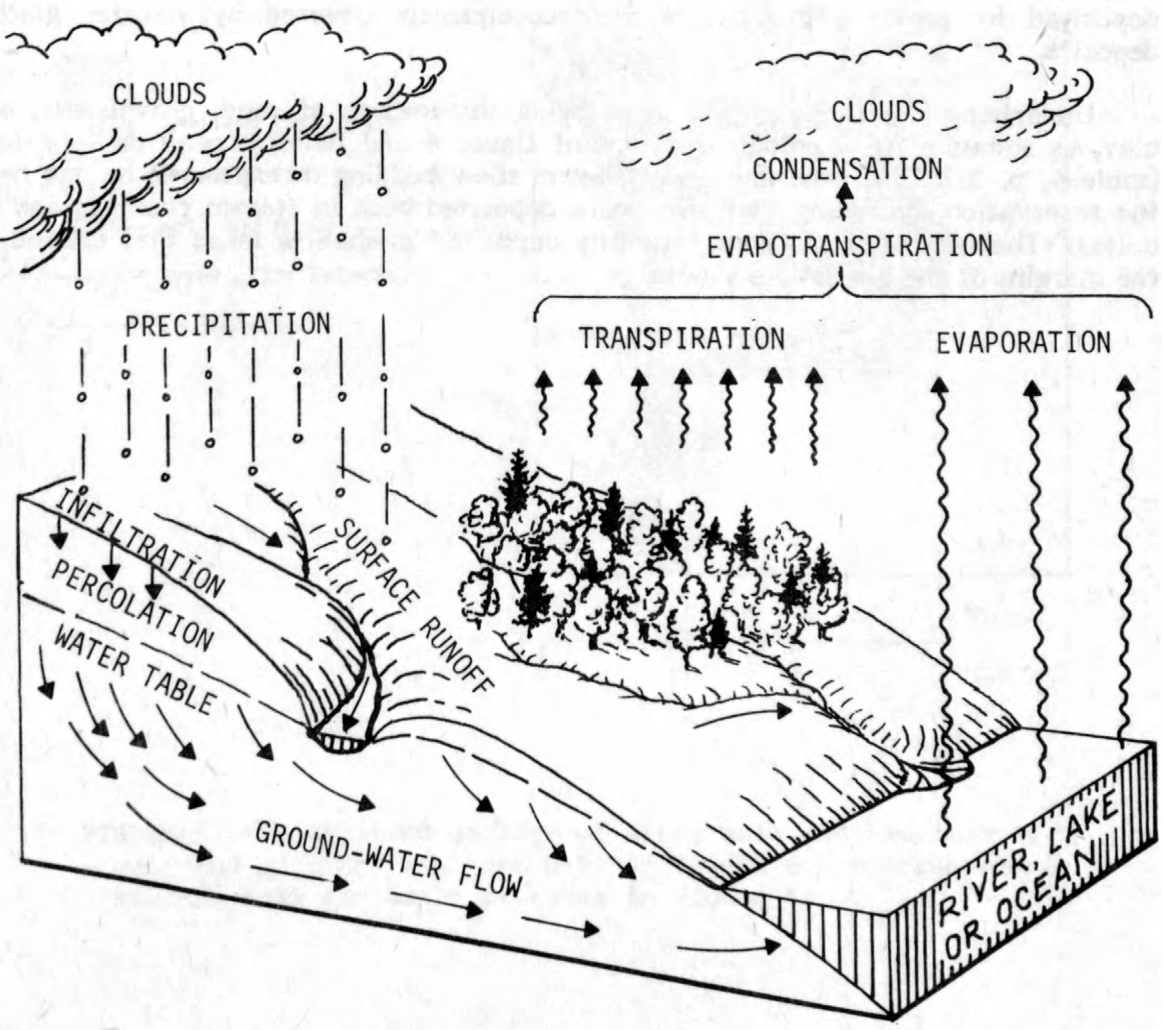


FIGURE 4.--Diagrammatic sketch of the hydrologic cycle.

Geology of the Study Area

The Port Gamble Indian Reservation is underlain by unconsolidated (loose) to poorly consolidated glacial deposits that are many hundreds of feet thick. For the reservation and adjacent areas, figure 5 shows a generalized surficial geologic map and figure 6 shows two geologic sections (as mapped by the author).

Most of the material at the surface is till (locally called "hardpan"), a compact, concretelike mixture of clay through boulder-sized sediments. The till, generally 20 to 50 ft thick, was deposited by glacial ice as it moved across the land surface during the Pleistocene "ice age," which ended about 12,000 years ago. The upper few feet of the till are normally weathered to a light brown, whereas the deeper, unweathered part of the till is a bluish gray. Other till units occur at depth, deposited by previous glaciations and subsequently covered by younger glacial deposits.

Underlying the surficial till are varying thicknesses of sand, gravel, silt, and clay, as shown in the geologic sections of figure 6 and listed in well drillers' logs (table 4, p. 37). The sand and gravel layers show bedding in exposures on and near the reservation indicating that they were deposited both in stream channels and on deltas. The clay and silt were generally deposited in shallow lakes that existed at the margins of the glacial ice sheets.

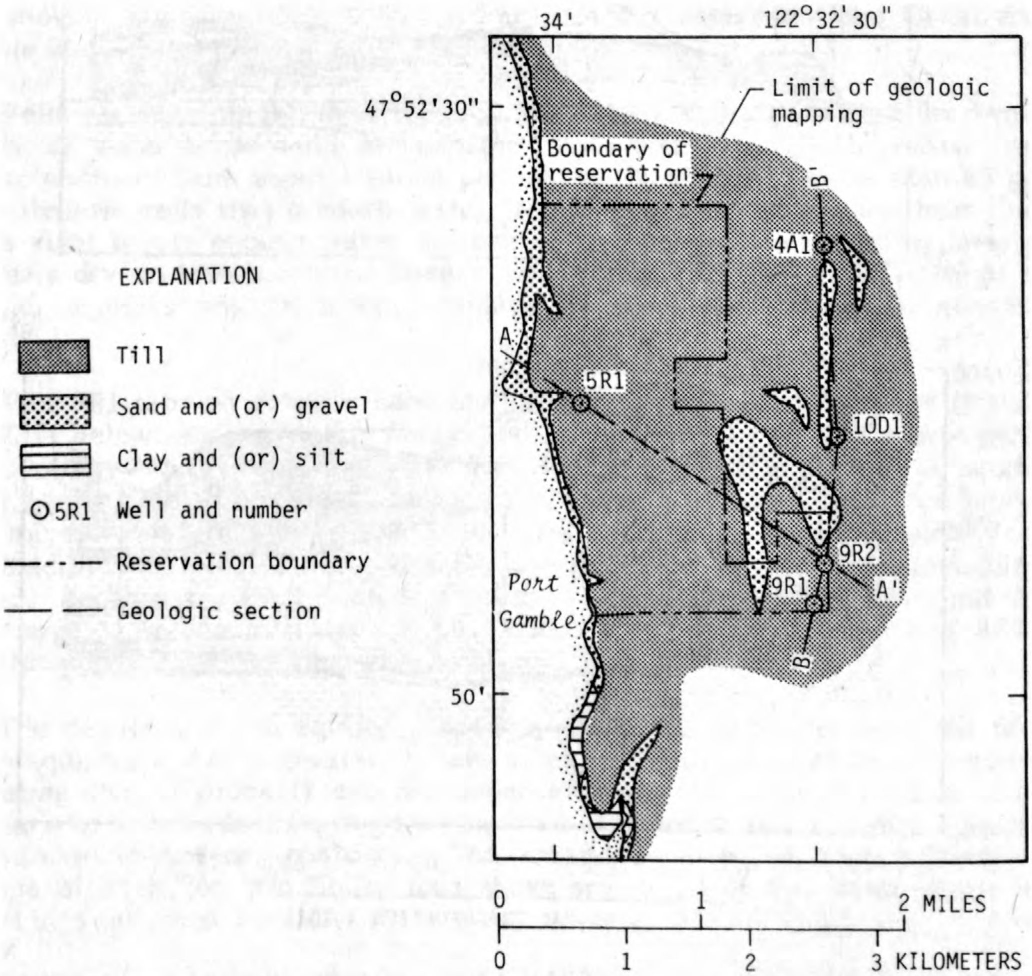


FIGURE 5.--Generalized geology of study area and location of geologic sections A-A' and B-B' of figure 6. Sections here are one-half the scale of those in figure 6.

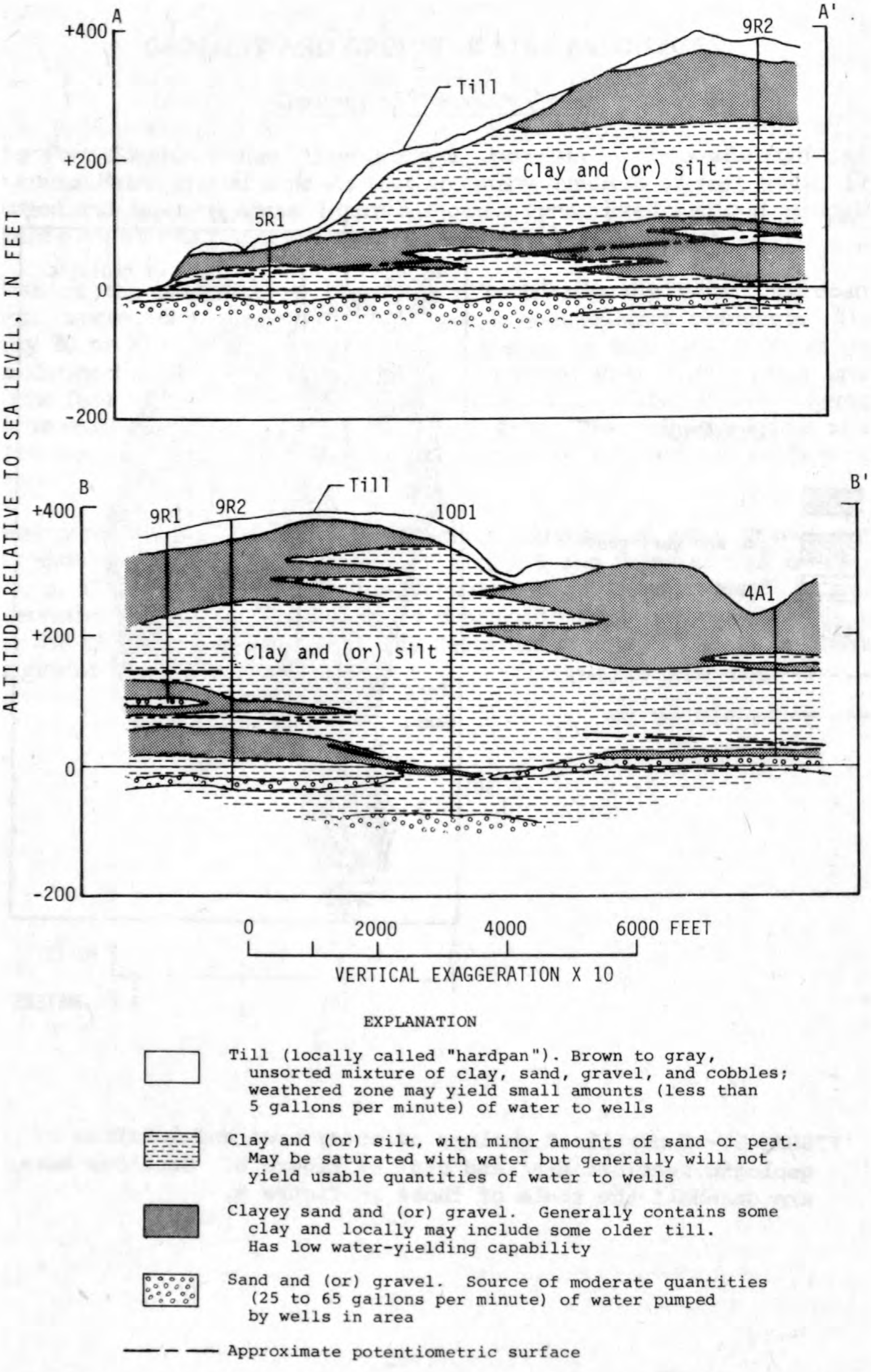


FIGURE 6.--Generalized geologic sections across the reservation: along lines shown in figure 5. Horizontal scale is twice that of figure 5.

Ground-Water Occurrence

Ground water beneath the Port Gamble Indian Reservation and surrounding area occurs in the unconsolidated materials described previously. At depth, most layers are saturated by ground water that is moving downward to lower layers and then moving laterally toward Puget Sound on the east and Hood Canal and Port Gamble (bay) on the west.

Wells recorded in the area range from 14 ft to 440 ft (table 3) in depth. The amount of water these wells are capable of yielding also ranges greatly from one well to another, from about 1 gallon per minute (gal/min) to more than 65 gal/min. Some shallow wells that produce water from the weathered till and from fine sand layers yield barely enough water for one or two households and sometimes go dry, or nearly dry, in late summer. Deeper wells (more than about 100 ft deep) tapping artesian aquifers are, in places, capable of producing substantial quantities of water.

Well 9R1 taps an artesian sand and gravel aquifer which is only 9 ft thick (261 to 270 ft below land surface). Above and below this aquifer are poorly permeable layers of clay with some sand and gravel. Where this intermediate aquifer was penetrated in well 9R2 (about 1,000 ft to the north) it contained large amounts of clay mixed with the sand and gravel. Well 9R2 had a very low yield from this intermediate zone and drilling was continued until a deeper artesian aquifer was tapped. Because the intermediate aquifer is of limited lateral extent and does not have large water-yielding capabilities where it is penetrated by well 9R2, it is thought to be unimportant as a source of additional ground water.

The deeper artesian aquifer tapped by well 9R2 (hereafter referred to as the lower aquifer) is much greater in lateral extent. It is tapped by numerous wells, indicating that it probably extends under most of the reservation and beyond its boundaries. The wells that tap the lower aquifer are shown in figure 7, along with potentiometric-surface contours. The contours show an approximate annual average altitude for 1975-77 (in feet above sea level) of the water levels in wells drilled into the lower aquifer.

Drillers' logs indicate that the lower aquifer is as much as 13 ft thick (as shown at well 9R2), and overlain nearly everywhere by layers of poorly permeable clay, silt and (or) peat, which in total reaches a thickness of as much as 140 ft in some places. The aquifer may thin or pinch out entirely at some localities. For example, well 10D1 did not encounter the lower aquifer at the altitude at which it occurs in nearby wells 4A1 and 9R2 (about 30 ft below sea level). However, it did encounter a still deeper aquifer. The extent and thickness of this deeper aquifer is unknown as its presence is indicated only at this location. The potentiometric head in this deeper aquifer is considerably lower than that of the lower aquifer, indicating that it may be more permeable or have a more direct connection to the seawater on one or both sides of the peninsula, or both.

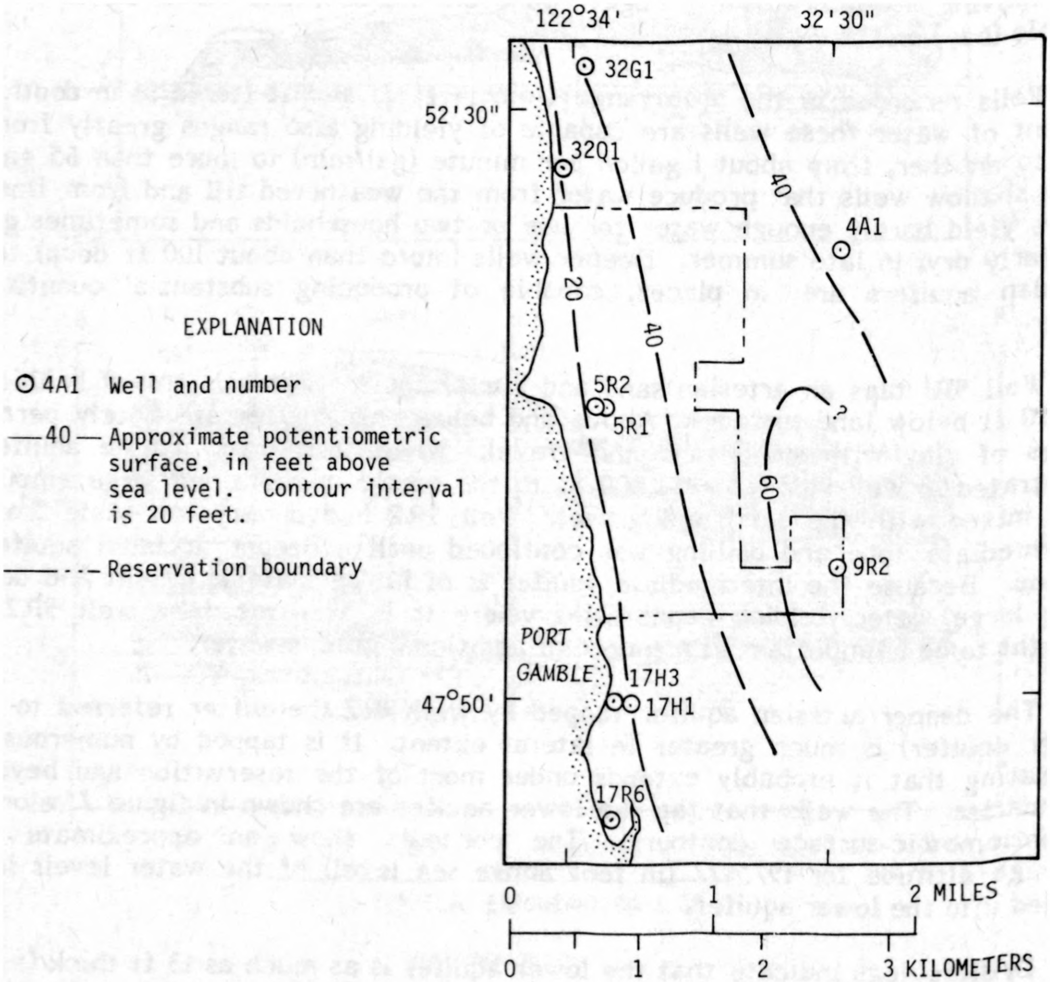


FIGURE 7.--Approximate average altitude of the potentiometric surface of the lower aquifer, as determined from 1975-77 water-level data.

Seasonal Fluctuations in Water Levels

Ground-water levels are subject to seasonal changes owing to the variations in rainfall (which recharges the aquifers under the study area). Generally, water levels in wells in the Puget Sound area are lowest in late fall and early winter (November-December), 3 to 4 months after the period of low rainfall and highest water use. The highest water levels occur during late spring and early summer (May-July), after the winter rains have slowly percolated down to these aquifers. These seasonal changes in water levels are most pronounced in shallow aquifers and tend to be less so in wells tapping deeper units.

Because water-level data were not sufficient to define the changes in shallower wells in the study area, a graph showing water-level fluctuations in three shallow wells in the nearby Port Madison Indian Reservation (which has closely similar geology and climate, and thus similar ground-water systems) is presented in figure 8. Figure 9 and table 1 show water-level fluctuations in two deeper tribally owned wells, 9R1 and 9R2 (268 ft and 412 ft deep, respectively).

Seasonal water-level fluctuations in the shallow wells shown in figure 8 were altered by the unusually dry winter of 1976-77. In June 1977 the water levels in these wells were still declining at a time when they would normally be rising and approaching their yearly maximums based on data collected in 1975-76 and from Garling, Molenaar, and others, 1965. Long-term effects of the dry winter of 1976-77 on the lower aquifer are not fully known, but may be small.

Normal annual water-level fluctuations in the three shallow wells on the Port Madison Indian Reservation appear to be about 3 feet. In the deeper Port Gamble wells 9R1 and 9R2 these fluctuations are about 1 to 2 feet. The smaller fluctuations in the deeper wells probably result from an averaging effect of the thicker overlying sediments, which smooth out the rate of recharge to the aquifer and thus maintain a more even water level.

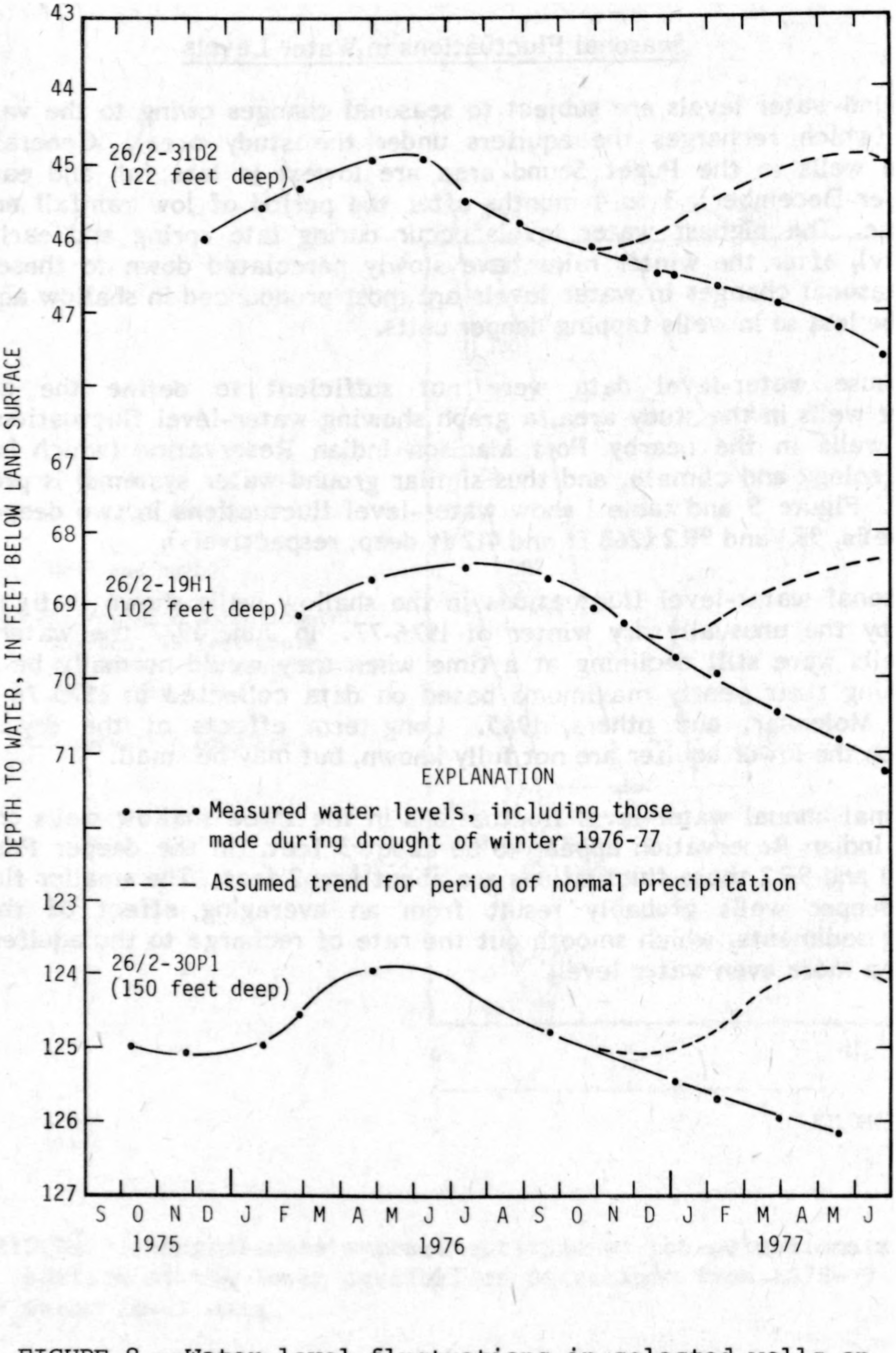


FIGURE 8.--Water-level fluctuations in selected wells on the nearby Port Madison Indian Reservation.

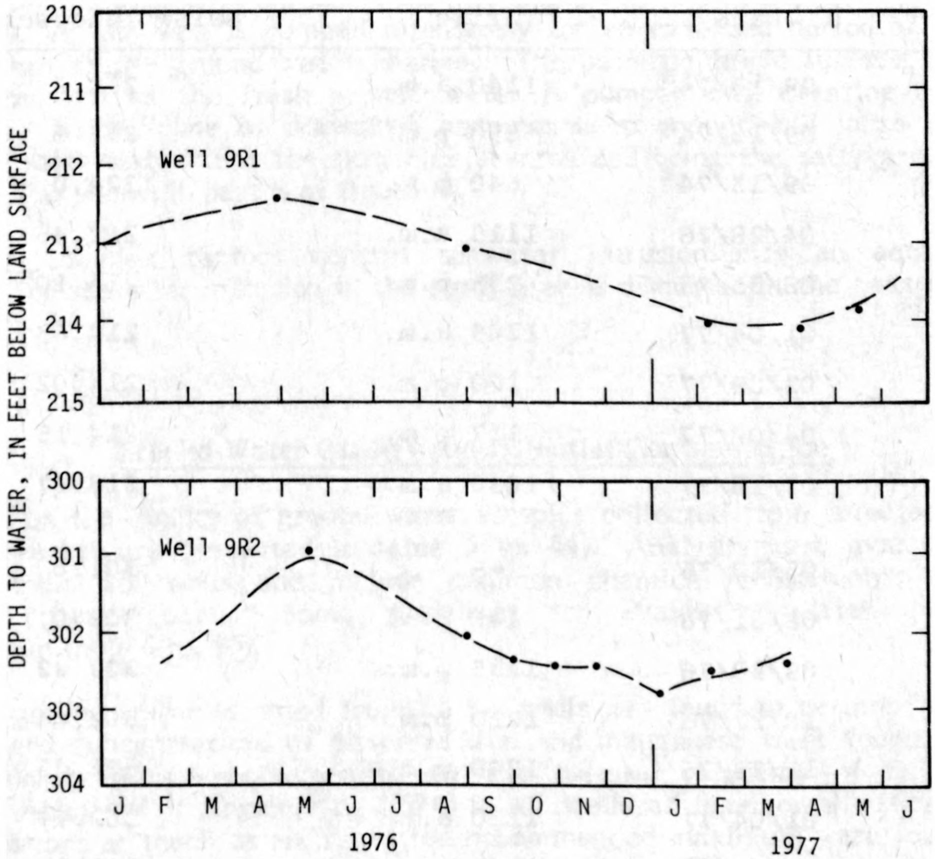


FIGURE 9.--Water-level fluctuations in wells 9R1 and 9R2 on the Port Gamble Indian Reservation.

TABLE 1.--Water-level measurements in selected wells on the Port Gamble Indian Reservation

Well no.	Date	Time	Depth to water (ft) below land surface
9R1	09/13/74[a]	1140 a.m.	212.2
	09/13/74[a]	550 p.m.	[b]235.8
	09/13/74[a]	640 p.m.	[c]224.0
	04/28/76	1115 a.m.	212.45
	08/31/76	235 p.m.	213.10
	01/04/77	1145 a.m.	214.63
	02/09/77	100 p.m.	214.02
	04/08/77	117 p.m.	214.15
	05/18/77	1030 a.m.	213.87
9R2	05/18/76	--	301.0
	08/31/76	140 p.m.	302.07
	09/28/76	1235 p.m.	302.42
	10/27/76	1210 p.m.	302.44
	11/23/76	1240 p.m.	302.45
	01/04/77	1130 a.m.	302.79
	02/09/77	1245 p.m.	302.50
	03/29/77	240 p.m.	302.42

[a]Indian Health Service data (written commun., 1976).

[b]Depth to water after pumping 20 gal/min for 6 hours.

[c]Depth to water 40 minutes after pumping stopped.

Seawater Intrusion

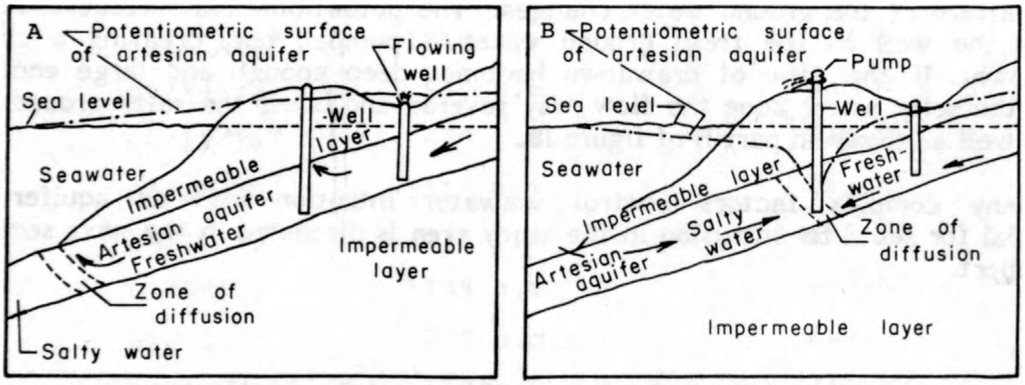
Along marine shorelines, wells tapping aquifers below sea level--and hydraulically connected to the sea--have a potential for causing seawater intrusion into the aquifer. The conditions before and after seawater intrusion in an artesian aquifer are shown by schematic diagrams in figure 10. When a well is first drilled into an artesian aquifer (water level in the well rises above the top of the aquifer, to the potentiometric surface) the ground-water flow through the aquifer is in equilibrium. The ground water flows past the well, mixes with the salty ground water in the zone of diffusion and then discharges into the overlying seawater (part A, fig. 10). As the well is pumped intensively for an extended period of time, the flow pattern of the ground water changes. The potentiometric surface is lowered around the well as the fresh ground water is pumped out, creating a cone of drawdown. If the cone of drawdown becomes deep enough and large enough to reach the salty water zone the flow may reverse and bring the salty ground water to the well as shown in part B of figure 10.

Many complex factors control seawater intrusion into an aquifer. The potential for seawater intrusion in the study area is discussed in the next section of this report.

Ground-Water Quality and Potential Contamination

Data on the quality of ground-water samples collected from selected wells on the reservation are presented in table 5 (p. 44). Analyses were available for 13 samples from six wells and include common chemical constituents and some physical characteristics. Some guidelines for evaluating water quality are presented in table 6 (p. 45).

The ground water sampled from all six wells was found to be moderately hard to hard, and concentrations of dissolved iron and manganese were found to exceed the maximum limits recommended by the Natural Academy of Sciences and National Academy of Engineering (1974) in all wells at least once. Dissolved-iron concentrations as much as six times the recommended maximum were found in well 5R2.



A **Simplified diagram of two wells tapping a confined (artesian) aquifer under conditions of equilibrium--no intrusion has occurred.**

B **Diagram of the same wells under conditions of intensive pumping--intrusion has reached the well nearest to the shoreline, flow in shallow well has ceased.**

FIGURE 10.--Schematic sections showing a nearshore confined aquifer before and after seawater intrusion. From Walters (1971). Arrows indicate directions of ground-water flow.

Potential contamination of the lower aquifer--which is currently supplying most of the water used on the reservation--could come from two sources: seawater intrusion into the aquifer and pollutants from the nearby solid-wastes disposal site (fig. 2). The potential for the solid-wastes disposal site polluting the lower aquifer is presently small. Any rainfall that percolates down through the disposal area and dissolves potential pollutants would also have to pass vertically downward through more than 300 ft of clay, silt, and fine sand and gravel deposits before reaching the lower aquifer. After reaching the aquifer the pollutants would have to travel laterally through the sand and gravel more than 3,000 ft before reaching the tribal community-supply wells 5R1 and 5R2. This large volume of glacial materials would act as a natural filter system that should effectively protect existing wells in the lower aquifer from bacteriological pollutants that could originate at the solid-wastes disposal site. However, there is a possibility that pollution could occur from this source by an unforeseen natural short-circuiting of the ground-water-flow system or future overloading of the natural filtering system. A program monitoring ground-water quality in all the wells, especially those used for public water supplies, probably would provide a warning of any contamination.

Although shallower aquifers could more easily become polluted from the solid-wastes disposal site, in 1977 there were no shallow wells near the disposal site to provide data for this study. Any future plans for drilling of wells in this area should include consideration that the lower aquifer is probably better protected from pollution that may come from this source.

An increasing chloride concentration may warn of impending seawater intrusion. At the time of the latest chemical analysis (1977) there was no evidence of seawater intrusion into the lower aquifer where it is tapped by community-supply wells 5R1 and 5R2. This is shown by a chloride concentration of 7.1 mg/L (milligrams per liter) of dissolved chloride in a sample taken from well 5R1 on February 9, 1977 and by previous analyses.

Copies of previous analyses completed by the Washington State Department of Social and Health Services were provided by the Indian Health Service, Seattle area office (written commun., 1976). These analyses of water from wells 5R1 and 5R2 during 1968 and 1971-74 showed chloride concentrations ranging from 2.8 mg/L on May 3, 1973 (in well 5R2) to 7.5 mg/L on October 12, 1971 (in well 5R1). Chloride concentrations less than 10 mg/L are considered natural background levels in this area (Walters, 1971), and chloride is not generally noticeable by taste below concentrations of 250 mg/L. The possibility of seawater intrusion would be small if the 1977 pumping rate from existing wells 5R1 and 5R2 is not greatly increased and if any new wells were drilled farther inland.

Potential Areas for Development of Future Ground-Water Supplies

It is not possible to select precisely the locations and depths of wells to provide future ground-water supplies because of the great variability in aquifer characteristics beneath the reservation. However, some general guidelines for site selection and estimated depth are presented below.

The general direction of ground-water flow in the lower aquifer is from the higher ground at the eastern edge of the reservation (recharge area) to the shoreline on Port Gamble (bay) and Hood Canal. Because of the location of a solid-waste disposal site just outside the eastern reservation boundary in part of the recharge area for the lower aquifer, future wells should be located as far as possible either north or south of the disposal site. Although there is only a minimal chance of contamination of the ground-water system (as described earlier) by this disposal site, the adjacent area and the area west of the site would be the first to be affected, should pollution occur.

The selected well site should also be located away from any septic tanks or sewage-treatment sites.

The lower aquifer, which is tapped by numerous wells in the area, probably is present nearly everywhere beneath the area and may provide a reliable source of additional ground water. A well tapping this zone probably can obtain water at depths of about 20 ft above to 50 ft below sea level. The average water level in such a well would be between 5 and 70 ft above sea level (as shown in fig. 7).

The amount of water that can be safely withdrawn from the lower aquifer without causing seawater intrusion cannot be accurately determined from the existing data. However, an estimate of the natural discharge from the aquifer can be calculated from the data now available, and from this an estimate of a conservative withdrawal rate can be made. The average specific capacities (well yield divided by drawdown of the water level during pumping) of wells tapping the lower aquifer in the study area is about 1.6 gal/min per foot. Based on this average the transmissivity (measure of the capacity of the aquifer to transmit water) of the lower aquifer is about 430 feet squared per day (ft^2/d). The average thickness of the lower aquifer is assumed to be about 15 ft between well 9R2 and the shoreline at Port Gamble (bay), a distance of about 7,500 ft, and the change in potentiometric head in this distance is about 70 ft. The natural discharge from the part of the lower aquifer underlying the reservation takes place below sea level along 2 miles of Port Gamble (bay) and Hood Canal (fig. 1). From these approximations the continuous natural discharge of the lower aquifer is calculated to be about 42,000 ft^3/d, an average of about 220 gal/min.

The total quantity of ground water that can be economically withdrawn from properly constructed and located wells in the lower aquifer is probably about 40 percent of the total natural discharge from the aquifer, or about 90 gal/min on a continuous basis. The withdrawal of this amount of ground water from properly located wells tapping the lower aquifer would probably not greatly increase the chances for seawater intrusion. The 1977 rate of withdrawal was about 20 gal/min, continually, the additional 70 gal/min would supply an additional population of about 800 to 900 people on the basis of about 125 gal/d per person (Dion and Lum, 1977).

Locations of future wells that will withdraw water from the lower aquifer must be carefully considered as well as the anticipated quantity of water to be used. For example, the location of well 9R2 which supplies the mobile home park is considered good. The well, about 1 1/2 miles east of the shoreline, is near the area of highest potentiometric head in the lower aquifer and the future (not in use in 1977) estimated water use, about 20 gal/min continuously, will not substantially increase the chances of seawater intrusion into the lower aquifer. However, if this quantity were to be withdrawn from wells 5R1 and 5R2 which supply the community of Little Boston, more than doubling the 1977 rate of withdrawal, the effect probably would be a considerable lowering of the potentiometric head in the lower aquifer at that point. If the potentiometric head were lowered to below sea level the chance for seawater intrusion would be greatly increased.

Because fresh ground water is lighter than seawater it "floats" on seawater or salty ground water; when the potentiometric head is 1 foot above sea level the freshwater-salty ground-water interface is about 40 ft below sea level. Thus, if the potentiometric head in well 5R1--whose well screen (intake) is 20 to 27 ft below sea level—were to drop below 1 foot above sea level the freshwater-salty ground-water interface would be less than 40 ft below sea level and possibly would approach the well intake. This process of seawater intrusion does not ususally happen during a short time period: the water levels in a pumped well may be below sea level for a considerable time (sometimes months or years) in a near-shore location before seawater intrusion is detected at the well. The pumping water levels in any new or existing wells should be maintained above sea level and the pumping water levels in near-shore wells, such as 5R1 and 5R2, should be checked periodically and maintained at least 5 ft above sea level.

The aquifer tapped by well 10D1 (see tables 3 and 4, p. 34 and 37) is known to occur at only that location but, as indicated by its low potentiometric head, it may be more permeable than the previously described lower aquifer. Further exploration of this deeper aquifer could yield additional supplies of ground water for future use.

SURFACE-WATER RESOURCES

Several small streams on the reservation and in the surrounding area (fig. 2) appear to have potential for supplying water for any of a variety of salmon enhancement programs that may be undertaken. Two small streams on the reservation also have potential to supply domestic water for local use. Characteristics of streamflow and water quality at three sites on three streams on the reservation and at five sites on three streams outside the reservation are described below.

Streamflow Characteristics

Streamflow patterns on the reservation closely follow the seasonal trend of precipitation. The highest streamflows usually result from the higher precipitation during the period November-March. Most of the precipitation occurring as rain quickly flows over the ground surface to stream channels. Precipitation that falls as snow soon melts and contributes to streamflow. Some of the rain and melting snow seep into the soil and some of this slowly percolates down to become ground water. As precipitation diminishes in the summer, streamflow becomes dependent on flow from springs or ground-water seepage into the stream channel. During years of normal distribution of precipitation the lowest streamflows generally occur during the period July-September, and are most likely to occur in September (Cummans, 1977). Figure 11 illustrates this normal seasonal streamflow fluctuation, as represented by the 1947-71 average monthly flow of Dogfish Creek near Poulsbo (station 12070000) plotted for the period 1976-77. Unusually wet or dry periods, however, may cause this pattern to change.

During the 6-month period September 1976-February 1977, precipitation averaged almost 60 percent below normal. The total of 9.79 inches of precipitation at Everett, Wash. (U.S. National Oceanic and Atmospheric Administration, 1977a, 1977b) was considerably less than the 62-year average of 23.14 inches for the months, September-February. The relatively dry winter caused streamflow to drop significantly below what would normally be expected during late winter and spring.

Streamflow measurements made at site 3 (Gamble Creek) during March-July 1976 follow the downward trend of the average (for 1947-71) mean monthly flow of Dogfish Creek as shown in figure 11 and table 7. During October-February (in an average, nondrought year) when increasing precipitation should have caused increasing streamflow as shown by the increasing average monthly flow of Dogfish Creek (fig. 11), the flow of Gamble Creek showed only a small increase.

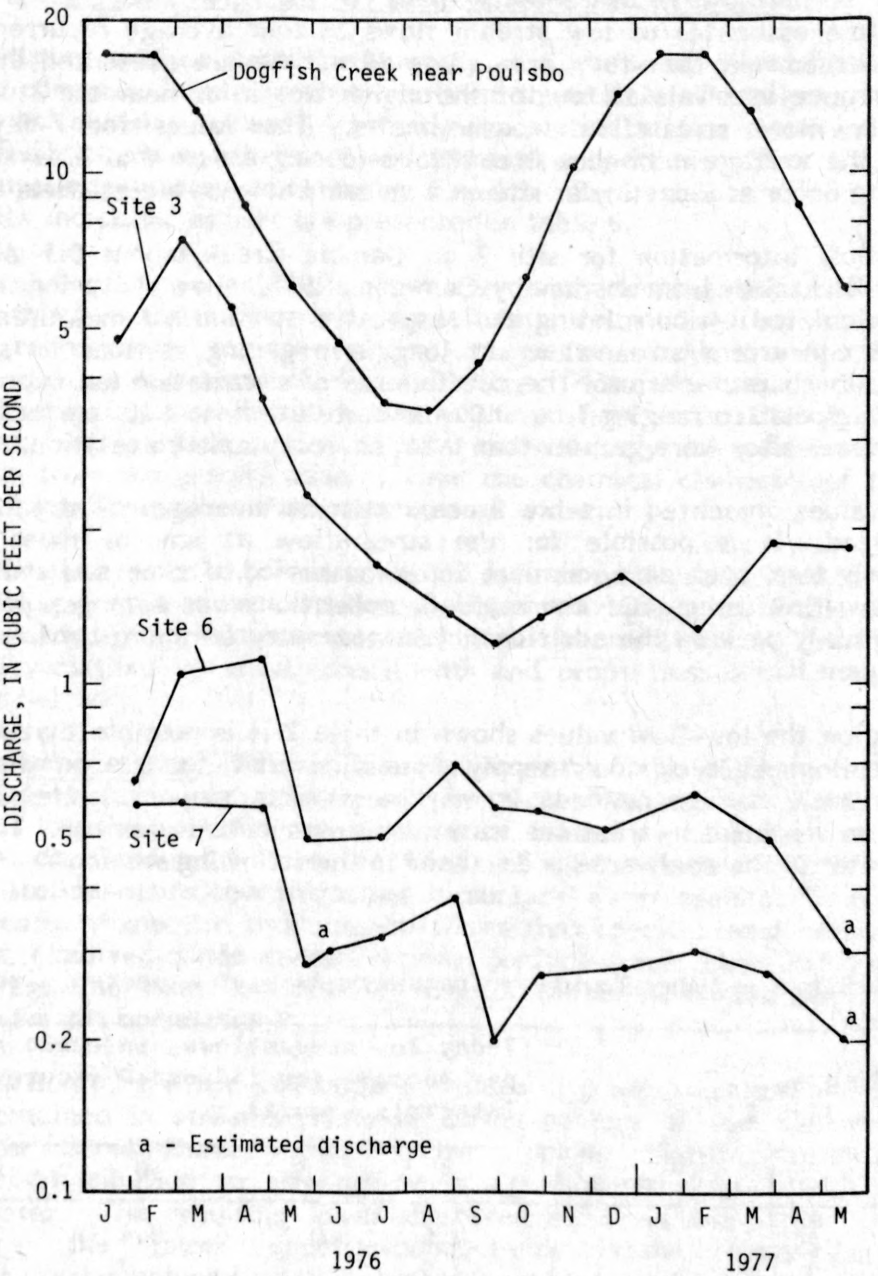


FIGURE 11.--Comparison of discharges at selected stream sites on and near Port Gamble Indian Reservation during period of January 1976-March 1977 with average monthly discharges of Dogfish Creek near Poulsbo during 1947-71.

From streamflow measurements made during this study, it is possible to present some estimates of low stream flows at four average recurrence intervals for some streams in the study area. Low-flow data are presented in table 2 for four recurrence intervals at four of the eight sites in or near the study area that had one or more streamflow measurements. The values for 7-day low flows represent the average minimum streamflows (during a period of 7 days) that can be expected to occur at a particular site on a stream based on a statistical analysis.

Low-flow information for site 2 on Gamble Creek (about 0.3 mile upstream from site 3) is taken from a study by Cummans (1977). Low flows for sites 3, 6, and 7 were calculated by correlating the respective streamflow measurements at the sites with concurrent streamflows at long-term gaging stations on streams with similar basin characteristics. The coefficients of correlation (an expression of the degree of association ranging from 0.00, no correlation, to 1.00, perfect correlation) for these three sites were greater than 0.84, an acceptable correlation.

The values presented in table 2 are statistical averages of streamflow over a 7-day period. It is possible for the streamflow at any of these sites to be significantly less, even zero, or more for some period of time and still satisfy this average low-flow value. Of course, data collection over a longer period of time would certainly provide the additional data necessary for more confident estimates of low stream flows.

Based on the low-flow values shown in table 2 it is possible that Middle Creek and Little Boston Creek could supply domestic water for use on the reservation with very little storage needed. It may be possible to pump water from a small reservoir on the stream, treat the water, and distribute it for use. The quality of surface water in the study area is discussed in the following sections.

TABLE 2.--7-day low-flow frequency data at selected sites

Site no. in fig. 2	7-day low streamflows, in cubic feet per second, for indicated recurrence intervals (years)			
	2	5	10	20
2[a]	0.6	0.5	0.4	0.4
3	.9	.7	.7	.6
6	.5	.4	.4	.4
7	.2	.2	.2	.2
8[b]	--	--	--	--

[a]From Cummans, 1977.

[b]Insufficient data for analysis; has been observed dry.

Surface-Water Quality and Potential Contamination

The quality of surface water in the study area was monitored with a total of 6 analyses for common chemical constituents at three sites, 10 analyses for nutrient constituents at four sites, 2 analyses for heavy metals at two sites, and numerous determinations of common chemical and physical properties at four sites. Results of these analyses are presented in tables 8 and 9. Water-quality criteria for public water supplies and fisheries uses are presented in table 6.

In general, surface water in the study area is chemically similar to the ground water beneath the area. The major constituents found dissolved in the surface water and ground water include calcium, magnesium (both contributing to the hardness of the water), bicarbonate, and silica. However, the concentration of these constituents is generally much less in the surface water than in the ground water. During the low-flow period of late summer-early fall when stream water comes largely from the ground-water system the chemical character of the stream water most nearly approaches that of the ground water.

The surface water on the reservation is soft to moderately hard, and of good chemical quality for most uses. However, dissolved organic material, causing the water to appear a light brown was observed in all streams studied. The significance and seasonal variations of some constituents and properties of the surface water are discussed below.

Specific conductance.--This is a measurement of the capacity of water to conduct an electrical current, expressed in micromhos per centimeter at 25°C. Measurements of the specific conductance of water can be used to estimate roughly the dissolved-solids concentration of the sample. Correlating the calculated dissolved-solids concentrations in surface-water samples from the study area with measured specific conductance shows that specific conductance is about 1.3 times the dissolved-solids concentration. Surface-water chemical-quality data given by Garling, Molenaar, and others (1965) for the entire Kitsap Peninsula give a similar value for the correlation.

A comparison of specific-conductance values of ground-water samples (table 5) with those obtained in streams (table 8) during periods of low streamflows and higher winter streamflows indicates that during higher streamflows the ground-water contribution to streamflow is significantly diluted with relatively pure rain water. The resulting lower dissolved solids in the stream water are indicated by the lower specific-conductance value measured. Higher specific-conductance values (and thus higher dissolved-solids concentrations) occur when streamflow is less (little or no dilution from rain water) and most of the streamflow is composed of ground-water outflow.

pH.--A measure of the acidity or alkalinity of water, expressed in units. A pH of 7.0 is "neutral," less than 7 is "acidic," and greater than 7 is "alkaline." Of the 27 pH measurements made of surface water all were between 6.0 and 8.0 units; 23 of the 27 were between 6.8 and 7.8; and the mean was 7.1. Data from Garling, Molenaar, and others (1965) for the entire Kitsap Peninsula showed pH ranging from 6.7 to 7.6, with a mean value between 7.0 and 7.1.

Turbidity.--A measure of the dispersion of light passing through a sample of water due to particles in suspension, reported in nephelometric turbidity units (NTU). The particles in suspension are probably organic material and sometimes, at higher streamflows, clay and silt particles. Turbidity values in study-area streams ranged from 0 (zero), virtually clear to 4 units, almost translucent (milky). Stream water tends to be more turbid (higher NTU values) at higher flows.

Total dissolved gases.--A measurement of percentage of saturation of all gases dissolved in the sample. Values ranged from 99 percent (slightly under saturation) to 101 percent (slightly over saturation). All values were less than the 110-percent limit suggested by the National Academy of Sciences and National Academy of Engineering (1974) for the safe propagation of salmonoid (trout and salmon) species.

Total coliform bacteria.--A count of all coliform bacteria colonies that occur in a specific volume (100 mL; milliliter) of water after incubation for 24 hours. All streams sampled had moderately high counts. Gamble Creek at site 3, had one very high count (28,100 col/100 mL on March 3, 1976) which probably was due to bacteria from nearby pastureland being transported overland to the stream following a heavy rainstorm. High coliform-bacteria concentrations may indicate pollution from manmade or natural sources, including septic tanks, domestic and wild animal waste, and possibly solid-wastes disposal sites.

Nutrients.--Defined as those chemicals necessary for the growth and reproduction of plants (National Academy of Sciences and National Academy of Engineering, 1974). Analyses were made for the major nutrients--total ammonia, nitrite, nitrate, total Kjeldahl nitrogen, total phosphorus, and dissolved orthophosphorus. Specific limits have not been established for these nutrients, but these and other constituents may contribute to nuisance aquatic growths which interfere with certain uses of the water.

High concentrations of nutrients in surface waters are often considered both the cause and indicators of pollution in a stream's drainage basin. Concentrations of nutrients in all samples collected during this study indicate only natural concentrations--levels not affected by man's activities.

Heavy metals.--Include chromium, copper, lead, manganese, mercury, and zinc, the presence of heavy metals may indicate pollution. Streams at sites 6 and 7 were sampled to determine concentrations of these heavy metals. The analyses indicate that lead is the only heavy metal present in detectable quantities; however, it was far below the recommended maximum given in table 6.

Major potential sources of pollution to the stream waters on the reservation include (1) improper disposal of sewage material--such as an inadequate drainfield for a septic tank that allows untreated sewage to flow overland to a stream, or a drainfield placed so close to the stream that sewage leaks directly into the streambed--and (2) pollution from the solid-wastes disposal site near the reservation (fig. 2).

The results of the analyses for nutrients and heavy metals (along with other constituents) indicate that in 1977 there was no pollution of the surface waters studied on and near the reservation. The quality of the surface water on the reservation is within the limits established by the U.S. Environmental Protection Agency (1968) and the National Academy of Sciences and National Academy of Engineering (1974) for untreated drinking water. However, a program of regularly scheduled chemical analyses might give warning of any deterioration in chemical quality. Steps could then be taken to prevent any further changes that might be detrimental to fish or the public depending on the use of the water.

SUMMARY AND CONCLUSIONS

The unconsolidated materials that underlie the Port Gamble Indian Reservation are, in general, saturated with water percolating downward from precipitation on the land surface. This ground water is recoverable by pumping from shallow wells tapping the near-surface materials (weathered till and fine sand and gravel), or from deeper wells tapping the lower artesian aquifer near or below sea level and consisting of coarse sand and (or) gravel. The near-surface materials generally yield only small quantities of water, adequate for one or two families, whereas the lower artesian aquifer is capable of yielding more than 65 gal/min to a single well. The lower artesian aquifer appears to underlie most of the reservation and adjacent areas, but it may be thin or absent in some places. Because of the large lateral extent of the lower aquifer it can be a source of substantial quantities of ground water for the future. About 90 gal/min probably can be withdrawn continuously from the lower artesian aquifer without greatly increasing chances for seawater intrusion. This amount of water could supply as many as 800 to 900 additional people using an average of about 125 gal/d per person. The deeper aquifer below the lower artesian aquifer is not fully explored but may have the potential to supply additional ground water in this area.

The ground water was found to be of good quality and moderately hard, but concentrations of iron and manganese were found to exceed Environmental Protection Agency limits in some cases. No evidence was found during this study to indicate either seawater intrusion into the lower aquifer or contamination of the aquifer by the nearby solid-wastes disposal site.

Surface water on and near the reservation was found to be of good chemical quality, being soft to moderately hard and having considerably less dissolved solids than the ground water of the area. Biological contamination as evidenced by moderately high coliform-bacteria counts, was noted in Gamble Creek; this probably was due to runoff from nearby pastureland. Late summer low flows were statistically estimated for four stream sites on and near the reservation. The 7-day low flows with an average 20-year recurrence interval were estimated to be 0.6 ft^3/s for site 3 on Gamble Creek, 0.4 ft^3/s for site 6 on Middle Creek, and 0.2 ft^3/s for site 7 on Little Boston Creek. Longer-term data collection would increase the accuracy of the estimated values. Surface water on the reservation represents a potential source of domestic water supplies equal to or greater than the lower artesian aquifer.

In 1977 there was no detectable contamination of the surface waters of the reservation from the nearby solid-wastes disposal site. However, because of a possibility that the disposal site could detrimentally affect the surface water and (or) ground water in the area, a water-quality monitoring program operated on a continuing basis might help warn of ongoing pollution. Such a program might include, on at least a quarterly basis, complete chemical and biological analyses of all ground water and surface water used for public supply or for salmon-related uses. Analysis for heavy metals (including lead, copper, chromium, mercury, and zinc) should also be considered--possibly on a semiannual basis--as additional indicators of pollution problems. Analysis of well water for dissolved chloride would be especially helpful in warning of ongoing seawater intrusion into the lower aquifer. Such analyses are inexpensive and water samples should be collected at least quarterly, and possibly monthly, from the community supply wells (5R1 and 5R2) and from any other wells put into operation near the shoreline.

SELECTED REFERENCES

Cummans, J. E., 1977, Low-flow characteristics of streams on the Kitsap Peninsula and selected adjacent islands, Washington: U.S. Geological Survey Open-File Report 76-704, 19 p.

Dion, N. P., and Lum, W. E. II, 1977, Municipal, industrial, and irrigation water use in Washington, 1975: U.S. Geological Survey Open-File Report 77-308, 34 p.

Drost, B. W., 1977, Preliminary assessment of the water resources of the Tulalip Indian Reservation, Washington: U.S. Geological Survey Open-File Report 76-493, 89 p.

Garling, M. E., Molenaar, Dee, and others, 1965, Water resources and geology of the Kitsap Peninsula and certain adjacent islands Washington: Washington Division Water Resources Water Supply Bulletin 18, 309 p.

Hansen, A. J., Jr., and Molenaar, Dee, 1976, Availability of ground water in the area surrounding the Trident Submarine Construction Facility, Kitsap County, Washington: U.S. Geological Survey Open-File Report 76-351, 30 p.

Hidaka, F. T., 1973, Low-flow characteristics of streams in the Puget Sound region, Washington: U.S. Geological Survey open-file report, 55 p.

National Academy of Sciences and National Academy of Engineering, 1974, Water quality criteria, 1972: U.S. Government Printing Office, Washington, D.C., 594 p.

Sceva, J. E., 1957, Geology and ground-water resources of Kitsap County, Washington: U.S. Geological Survey Water-Supply Paper 1413, 178 p.

U.S. Environmental Protection Agency, 1968, Report of the committee on water quality criteria: Federal Water Pollution Control Administration, Washington, D.C., 234 p.

U.S. Geological Survey, 1947, 1958, 1959, Surface water supply of the United States, Part 12, Pacific Slope Basins in Washington and Upper Columbia River basin: U.S. Geological Survey Water-Supply Papers 1092, 1555, 1636.

U.S. National Oceanic and Atmospheric Administration (formerly U.S. Weather Bureau), 1977a, Climatological data, Washington, annual summary 1976: v. 80, no. 13.

-----1977b, Climatological data, Washington (monthly summaries): National Oceanic and Atmospheric Administration, Environmental Data Service, National Climatic Center, Asheville, N.C.

U.S. Weather Bureau, 1965, Mean annual precipitation, 1930-57, State of Washington: Portland, Oregon, U.S. Soil Conservation Service, map M-4430.

Walters, K. L., 1971, Reconnaissance of sea-water intrusion along coastal Washington, 1966-68: Washington Department Water Resources Water Supply Bulletin 32, 208 p.

TABLE 3.--Records of selected wells on and adjacent to the Port Gamble Indian Reservation

EXPLANATION

Local number: Numbered by township, range, section, and 40-acre subdivision, as described on page V.

Owner: Name of owner or tenant at the time of inventory.

Altitude of land surface: Altitude of land surface adjacent to the well, in feet above mean sea level.

Depth of well: Depth of completed well, in feet below land surface, as measured by U.S. Geological Survey personnel or by other agencies or as reported by well owner or driller.

Casing diameter: As measured by U.S. Geological Survey personnel or as reported by well owner or driller, in inches.

Finish: Method used to finish well in aquifer tapped: O, open-end casing; S, screen; C, porous concrete casing; X, open hole in aquifer below casing.

Depth to first opening: Depth, in feet, to top of screen or perforations, or to bottom of solid casing.

Water level and date: As measured by Survey personnel or as reported by well owner or driller, in feet below land surface; F, well is reported to flow or was observed flowing by Survey personnel, on date shown.

Discharge: Measured or reported pumped discharge of well during pumping test or actual use; in gallons per minute; not necessarily the maximum available from the well.

Drawdown: Distance, in feet, that water level was lowered (below static water level), by pumping at stated discharge rate. Length of pumping period ranged from less than 1 hour to more than 24 hours.

TABLE 3.--Records of selected wells on and adjacent to the Port Gamble Indian Reservation--Continued

LOCAL NUMBER	OWNER	ALTITUDE OF LAND SURFACE (FEET)	DEPTH OF WELL (FEET)	CASING DIAM-ETER (INCHES)	FINISH	DEPTH TO FIRST OPENING (FEET)	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED	DISCHARGE (GALLONS PER MINUTE)	DRAW-DOWN (FEET)
27N/02E-03M01	MEKALSON, W	220	30	36	O	--	24.00	01/29/1976	--	--
27N/02E-04A01	WATER, ERICKSON	240	231	6	S	226	206.00	09/21/1967	10	1
27N/02E-04A02	TESTER, J E	260	284	6	S	--	--	--	--	--
27N/02E-05R01	GAMBLE IR, PORT	80	107	6	S	102	51.00	04/18/1968	15	18
27N/02E-05R02	GAMBLE IR, PORT	80	108	6	S	98	63.20	06/18/1973	30	36
27N/02E-07A01	POPE/TALBO	60	169	10	P	159	56.00	12/19/1957	100	10
27N/02E-09R01	GAMBLE IR, PORT	360	268	6	S	263	214.20	09/13/1974	20	24
27N/02E-09R02	GAMBLE IR, PORT	380	412	8	S	401	301.00	05/18/1976	65	65
27N/02E-10D01	HARTSOUGH, M	360	440	6	S	435	355.00	11/19/1976	10	45
27N/02E-15E01	CALIP, R	290	16	60	O	--	6.00	01/26/1976	--	--
27N/02E-15E02	CALIP, R	290	210	6	S	206	143.00	02/15/1977	10	47
27N/02E-15N02	URBAN, W	265	211	6	--	--	--	--	--	--
27N/02E-15N03	RYAN, J T	270	100	6	--	--	--	--	--	--
27N/02E-16D01	SILVERWOOD	160	45	6	S	--	--	--	--	--
27N/02E-16Q01	FARNSWORTH, KEITH	180	47	6	S	44	21.00	09/20/1974	11	16
27N/02E-17H01	WARREN, C	90	140	6	S	--	70.00	01/ /1976	--	--
27N/02E-17H02	KNUTH, V	60	95	6	S	90	37.00	04/24/1973	10	38
27N/02E-17H03	BASS/RICH	60	136	6	O	130	45.00	01/31/1969	20	15
27N/02E-17J02	GILLS, E D	55	40	6	S	38	8.00	04/ /1973	18	15
27N/02E-17J03	MAY, C H	20	131	6	S	--	30.00	01/ /1976	--	--
27N/02E-17R01	LEGAZ, L	15	20	42	C	--	3.00	01/ /1976	--	--
27N/02E-17R02	NELSEN, J A	10	26	42	C	--	3.00	01/ /1976	--	--
27N/02E-17R03	FLY	10	25	42	C	--	3.00	01/ /1976	--	--
27N/02E-17R04	FORD, W P	15	200	4	O	--	F	01/ /1976	--	--
27N/02E-17R05	FORD, W P	20	50	6	--	--	--	--	--	--
27N/02E-17R06	GAYTE, P	20	89	6	S	84	18.00	08/04/1976	7	55
27N/02E-20G01	GEOSSO, J	40	80	6	S	75	3.00	06/ /1974	6	63
27N/02E-20G04	CHIN, Q	30	244	6	S	239	F	07/10/1976	18	--
27N/02E-20H01	HANSEN, A B	40	71	6	S	66	11.00	07/ /1969	16	32
27N/02E-20L01	GAMBLEWOOD	80	129	8	S	110	8.00	10/ /1967	70	30
27N/02E-21A01	KING, W H	260	56	48	--	--	52.00	--	--	--
27N/02E-21A02	HALSTEAD, J W	240	50	48	--	--	47.00	--	--	--
27N/02E-21A03	JONES, D W	220	72	6	S	68	46.00	06/01/1975	--	--
27N/02E-21B01	TURNBULL, P	170	20	60	C	--	8.00	01/ /1976	--	--
27N/02E-21D01	HELLAND, E	40	53	6	S	48	5.00	08/ /1968	16	23
27N/02E-22E01	DAHMER, M H	200	109	6	S	105	84.00	11/ /1973	7	12
27N/02E-22E02	UTILITIES, DAPARWOOD	220	100	6	S	95	62.00	01/ /1970	33	19
27N/02E-22E03	ALLDREDGE, O W	225	17	36	C	--	8.00	09/ /1950	--	--
28N/02E-32G01	CLIFF DEV CO	135	120	8	S	115	92.00	06/ /1960	50	10
28N/02E-32Q01	SORG, L	90	103	6	S	98	65.00	07/21/1975	15	18

TABLE 3.--Records of selected wells on and adjacent to the Port Gamble Indian Reservation--Continued

LOCAL NUMBER	OWNER	ALTITUDE OF LAND SURFACE (FEET)	DEPTH OF WELL (FEET)	CASING DIAM-ETER (INCHES)	FINISH	DEPTH TO FIRST OPENING (FEET)	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED	DISCHARGE (GALLONS PER MINUTE)	DRAW-DOWN (FEET)
28N/02E-33J02	EYER, J M	240	28	48	X	--	1.00	01/ /1976	--	--
28N/02E-33J03	EYER, J M	265	14	48	C	--	7.00	01/ /1976	--	--
28N/02E-34E01	THORNTON, D E	270	35	60	X	--	9.00	01/28/1976	--	--
28N/02E-34M01	BIRKELAND, D I	240	42	36	C	--	2.00	01/ /1976	--	--
28N/02E-34N01	CROSS-SOUND INC	230	26	36	--	--	--	--	1	--
28N/02E-34N03	SVARTHUNLE	235	20	72	C	--	1.00	01/28/1976	--	--
28N/02E-34N04	MCCLOUGH, G W	230	73	50	O	--	30.00	01/ /1976	--	--
28N/02E-34N05	DAVIS, J	240	30	36	O	--	--	--	--	--
28N/02E-34P02	BIRKELAND, L	228	22	48	X	9	6.00	01/ /1976	--	--

TABLE 4.--Drillers' logs of selected wells on and adjacent to the Port Gamble Indian Reservation

Material	Thickness (ft)	Depth (ft)
27/2-4A1. Erickson Water Co. Altitude 240 ft. Drilled by Burt Well Drilling Co., September 1967. Casing 6-inch to 226 ft, screen or openings 0.014 inch slot size, 226-231 ft.		
Sand, brown to gray	72	72
Sand, black, and fine silt	3	75
Clay, blue	10	85
Sand and fine silt; some water	4	89
Clay, blue	129	218
Till, blue	8	226
Sand, medium, water-bearing	5	231
27/2-5R1. Little Boston Tribe (Little Boston Community well). Altitude 80 ft. Drilled by Burt Well Drilling Co., April 1968. Casing 6-inch to 102 ft. Screen or openings 0.014-inch slot size, 102-107 ft.		
Soil	3	3
Till, brown	10	13
Till, blue	5	18
Sand, brown, dry	7	25
Sand, blue-gray, dry	22	47
Silt and clay, blue	53	100
Sand, water-bearing	7	107
27/2-5R2. Little Boston Tribe (Little Boston Community well). Altitude 80 ft. Drilled by Burt Well Drilling, May 1973. Casing 6-inch to 98 ft. Screen or openings 98-108 ft, 0.014 inch slot size.		
Soil	3	3
Clay, sandy	12	15
Clay, gray, sandy and gravel	25	40
Sand	2	42
Clay, brown, sandy	3	45
Clay and silt, blue	59	104
Sand and gravel, water-bearing	4	108

TABLE 4.--Drillers' logs of selected wells on and adjacent to the Port Gamble Indian Reservation--continued

Material	Thickness (ft)	Depth (ft)
27/2-9R1. Little Boston Tribe (store well). Altitude 360 ft. Drilled by Tacoma Pump and Drilling, September 1974. Casing 6-inch to 263 ft. Screen or openings 263-268 ft., 0.018-inch slot size.		
Till	28	28
Sand, brown, fine	72	100
Sand, gray, fine, and clay layers	6	106
Sand, silty, and clay layers	28	134
Clay, blue	35	169
Clay, blue, sticky	40	209
Clay, brown	19	228
Clay, blue, and sand and gravel layers	14	242
Sand, blue-gray, dirty	1	243
Clay, and sand and gravel layers	18	261
Sand and gravel, water-bearing	9	270
Sand, gravel, and clay	1	271
27/2-9R2. Little Boston Tribe (Mobile home park well). Altitude 380 ft. Drilled by Crabtree Well Drilling, May 1976. Casing 10-inch to 34 ft., 8-inch to 401 ft. Screen or openings 401-411 ft., 0.018-inch slot size.		
Soil	3	3
Till, brown	32	35
Sand and brown pea-size gravel	95	130
Sand and gravel, brown	4	134
Clay, blue	11	145
Clay, blue with gray silt layers	20	165
Silt, gray	10	175
Clay, blue	108	283
Clay, gray with gravel layers	8	291
Clay, green with sand and gravel layers	10	301
Clay, purple with gravel	7	308
Clay, blue	10	318
Sand and gravel, gray, cemented	14	332
Clay, blue with sand and gravel layers	43	375
Clay, brown	2	377
Peat	10	387
Clay, brown	3	390
Sand, brown with clay	7	397
Till, brown	2	399
Sand and gravel, water-bearing	13	412
Clay, blue	--	--

TABLE 4.--Drillers' logs of selected wells on and adjacent to the Port Gamble Indian Reservation--continued

Material	Thickness (ft)	Depth (ft)
27/2-10D1. M. Hartsough. Altitude 360 ft. Drilled by Crabtree Well Drilling, November 1976. Casing 6-inch to 435 ft. Screen or openings 435-440 ft, 0.012-inch slot size.		
Till and "boulders"	17	17
Clay, brown, sandy	108	125
Silt, blue, hard	13	138
Clay, blue	222	360
Peat (?), brown	23	383
Sand and gravel, small	1	384
Peat, brown with gray clay layers	52	436
Sand and gravel	4	440
27/2-15E2. R. Calip. Altitude 290 ft. Drilled by Crabtree Well Drilling, February 1977. Casing 6-inch to 206 ft. Screen or openings 206-210 ft., 0.014 inch slot size.		
Soil	3	3
Till, brown	17	20
Till, blue-gray	11	31
Sand, brown	4	35
Clay, brown	5	40
Clay, blue	108	148
Till, brown	13	161
Sand and silt, brown	1	162
Clay and gravel, brown	3	165
Clay, blue	5	170
Clay, silt and sand, brown	20	190
Clay, blue	5	195
Till, blue	5	200
Till, brown	6	206
Sand and gravel, brown	4	210

TABLE 4.--Drillers' logs of selected wells on and adjacent to the Port Gamble Indian Reservation--continued

Material	Thickness (ft)	Depth (ft)
27/2-16Q1. K. Farnsworth. Altitude 180 ft. Drilled by Crabtree Well Drilling, September 1974. Casing 6-inch to 44 ft. Screen or openings 44-47 ft., 0.014 inch slot size.		
Sand, brown	3	3
Till, brown	16	19
Till, gray	12	31
Sand, brown	9	40
Clay, blue	3	43
Sand and gravel, blue-gray, water-bearing	4	47
27/2-17H2. V. Knuth. Altitude 60 ft. Drilled by Crabtree Well Drilling, April 1973. Casing 6-inch to 90 ft. Screen or openings 90-95 ft., 0.018-inch slot size.		
Soil	2	2
Till	4	6
Clay, brown, sandy	3	9
Clay, gray	18	27
Till, gray	1	28
Peat, brown and clay, gray	11	39
Sand, hard	13	52
Till, gray	8	60
Sand, hard	11	71
Clay, gray, silty	14	85
Till, gray	3	88
Sand and gravel	7	95
Till, gray	--	--

TABLE 4.--Drillers' logs of selected wells on and adjacent to the Port Gamble Indian Reservation--continued

Material	Thickness (ft)	Depth (ft)
27/2-17H3. R.H. Bass and R. Rich. Altitude 60 ft. Drilled by Crabtree Well Drilling, January 1969. Casing 6-inch to 130 ft. Screen or openings 130-135 ft., slot size unknown.		
Soil	8	8
Till	15	23
Clay, blue	30	53
Sand and clay	5	58
Clay and peat	23	81
Sand and clay	6	87
Peat	3	90
Clay, blue and sand	4	94
Clay and peat (layers)	16	110
Peat, sand and clay	10	120
Clay, blue-green	7	127
Clay	1	128
Gravel	1	129
Sand	7	136
27/2-17R6. P. Gayte. Altitude 20 ft. Drilled by Crabtree Well Drilling, August 1976. Casing 6-inch to 84 ft. Screen or openings 84-89 ft., 0.014-inch slot size.		
Soil	6	6
Till, brown	24	30
Sand and gravel, brown	2	32
Till, brown	3	35
Till, gray	3	38
Sand, gray with clay	8	46
Till	20	66
Clay, blue with some sand	10	76
Till	4	80
Sand and gravel, dirty	6	86
Sand, water-bearing	3	89

TABLE 4.--Drillers' logs of selected wells on and adjacent to the Port Gamble Indian Reservation--continued

Material	Thickness (ft)	Depth (ft)
27/2-20G1. Q. Chin. Altitude 30 ft. Drilled by Crabtree Well Drilling, July 1976. Casing 6-inch to 239 ft. Screen or openings 239-244 ft., 0.012-inch slot size.		
Soil	2	2
Sand, brown	8	10
Clay, blue with silt layers	130	140
Silt, blue	55	195
Clay, blue, silty	17	212
Sand with clay	1	213
Sand	9	224
Clay, blue	15	239
Sand, water-bearing	5	244
27/2-21A3. D. Jones. Altitude 220 ft. Drilled by Crabtree Well Drilling, June 1975. Casing 6-inch to 68 ft. Screen or openings 68-72 ft., 0.014-inch slot size.		
Till with cobbles	12	12
Till	24	35
Clay, blue	32	67
Sand and gravel, water-bearing	5	72
27/2-22E1. Daparwood Water Co. Altitude 220 ft. Drilled by Crabtree Well Drilling, January 1970. Casing 6-inch to 95 ft. Screen or openings 95-100 ft., 0.015-inch slot size.		
Soil	4	4
Till	66	70
Sand and gravel	1	71
Sand, muddy	1	72
Sand and gravel, muddy	12	84
Gravel	1	85
Till	10	95
Sand and gravel, water-bearing	5	100

TABLE 4.--Drillers' logs of selected wells on and adjacent to the Port Gamble Indian Reservation--continued

Material	Thickness (ft)	Depth (ft)
28/2-32G1. Cliffside Dev. Co. Altitude 135 ft. Drilled by (owner ?) June 1960. Casing 6-inch to 115 ft. Screen or openings 115-120 ft, slot size unknown.		
Fill material	16	16
Till, gray	19	35
Sand and gravel	1	36
Till with sand layers	27	63
Clay, blue	10	73
Sand and some gravel	21	94
Sand	10	104
Clay, blue, some sand	11	115
Sand, coarse to fine	5	120
28/2-32Q1. L. Sorg. Altitude 90 ft. Drilled by Crabtree Well Drilling, July 1975. Casing 6-inch to 98 ft. Screen or openings 98-103 ft., 0.015-inch slot size.		
Till, brown	6	6
Till, gray	17	23
Gravel, dry	4	27
Till	33	60
Sand and gravel, brown	10	70
Till, blue-gray	26	96
Sand	7	103
28/2-34N1. Cross-Sound Realty Inc. Altitude 230 ft. Drilled by E. T. Miller, April 1971. Casing unknown.		
Soil	3	3
Till, with sand layers at bottom	23	26
28/2-34N2. G.W. McClough. Altitude 230 ft. Drilled by (owner), 1962. Casing 50-inch to 73 ft. Screen or openings (open end).		
Till	67	67
Sand and gravel	6	73

TABLE 5.--Chemical analysis of water from selected wells

Well no.	Date of sample	Time	Pump or flow period prior to sampling (min)	Instantaneous flow rate (gal/min)	Specific conductance (μmho/cm)	pH (units)	Temperature (°C)	Color (platinum-cobalt units)	Hardness (Ca,Mg) (mg/L)	Noncarbonate hardness (mg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)
27/2-5R1	4-19-68	1230 p.m.	1440	15	111	7.7	14.0	15	132	--	30	14	5	5
	10-12-71	100 p.m.	--	--	268	7.4	--	25	144	18	33	15	44	3
	1-4-72	1040 a.m.	--	--	340	7.4	--	20	144	8	27	18	10	3
	2-13-73	130 p.m.	--	--	233	7.5	--	20	132	0	19	21	36	3
27/2-5R2	5-3-73	130 p.m.	--	--	280	7.6	--	25	280	140	16	10	10	2
	9-8-74	1130 a.m.	--	--	276	7.3	--	20	--	15	34	19	6	--
	10-10-74	1100 a.m.	--	--	--	--	--	--	144	--	--	--	--	--
	2-9-77[a]	130 p.m.	20	20	282	--	--	--	--	--	--	--	--	--
27/2-7A1	4-8-76[a]	1010 a.m.	--	--	326	--	--	--	--	--	--	--	--	--
27/2-9R1	9-13-74	200 p.m.	380	20	225	8.3	--	9	--	4	17	14	7	--
	9-22-75	300 p.m.	--	--	--	--	--	--	100	--	--	--	--	--
27/2-9R2	5-18-76[a]	1210 p.m.	180	65	--	--	11.6	14	100	0	21	12	22	3.8
27/2-20L1	5-17-76[a]	1140 a.m.	--	--	128	--	12.0	--	--	--	--	--	--	--

Well no.	Date of sample	Time	Bicarbonate (HCO_3) (mg/L)	Alkalinity as $CaCO_3$ (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Dissolved silica (SiO_2) (mg/L)	Dissolved solids (residue at 180°C) (mg/L)	Dissolved solids (sum of constituents) (mg/L)	Total nitrite plus nitrate (N) (mg/L)	Dissolved iron (Fe) (μg/L)	Dissolved manganese (Mn) (μg/L)
27/2-5R1	4-19-68	1230 p.m.	166	136	3	4.5	0.4	49	--	--	0.5	460	100
	10-12-71	100 p.m.	154	126	7.2	7.5	.3	7.5	--	--	.1	220	--
	1-4-72	1040 a.m.	166	136	6	5.0	.2	--	--	--	1.1	540	12
	2-13-73	130 p.m.	170	139	2	4.4	0	135	--	--	.1	80	--
27/2-5R2	5-3-73	130 p.m.	171	140	11	2.8	.2	40	--	--	2.3	220	270
	9-8-74	1130 a.m.	182	149	2	4.5	.2	31	--	--	.3	1,860	150
	10-10-74	1100 a.m.	--	--	--	--	--	--	--	--	--	1,610	160
	2-9-77[a]	130 p.m.	--	--	--	7.1	--	--	--	--	--	--	--
27/2-7A1	4-8-76[a]	1010 a.m.	--	--	--	3.4	--	--	--	--	--	--	--
27/2-9R1	9-13-74	200 p.m.	117	96	6	4.0	.3	22	--	--	.4	590	120
	9-22-75	300 p.m.	--	--	--	--	--	--	--	--	--	60	60
27/2-9R2	5-18-76[a]	1210 p.m.	194	159	1.9	2.8	.2	55	229	216	.02	1,500	190
27/2-20L1	5-17-76[a]	1140 a.m.	--	--	--	4.6	--	--	--	--	--	--	--

[a]Analysis by U.S. Geological Survey laboratory, other analyses by Indian Health Service (written commun., 1976).

TABLE 6.--Water-quality criteria (modified from Drost, 1977)

Constituent or characteristic	Recommended maximum[a]	Desirable criteria[b]	Detrimental effects of exceeding recommended limits, and other remarks
Physical:			
Color---------	75 platinum-cobalt units	[c]<10 platinum-cobalt units	Esthetically undesirable to consumer; economically undesirable to some industries.
Temperature---	No recommendation	--	High temperatures may stimulate growth of taste- and odor-producing organisms.
Turbidity-----	do.	--	Can reduce the effectiveness of chlorination by physically protecting microorganisms from direct contact with the disinfectant.
Microbiological:			
Coliform (total)[d]	1 col/100 mL	<100 col/100 mL	Coliform content is an indication of the sanitary quality of the water (high content = unsanitary).
Coliform (total)[e]	20,000 col/100 mL	<100 col/100 mL	Do.
Inorganic chemicals:			
Alkalinity------	No recommendation	--	High concentrations cause unpleasant taste; low concentrations may indicate highly acidic water.
Ammonia---------	0.5 mg/L	<0.01 mg/L	May indicate pollution; may interfere with chlorination; is sometimes corrosive to copper and copper alloys.
Chloride--------	250 mg/L	<25 mg/L	Salty taste; may indicate seawater intrusion. The recommended maximum is based on taste preferences, not on toxic considerations.
Fluoride-------	2.0 mg/L	--	May cause dental fluorosis. The recommended maximum is dependent upon air temperature. The value of 2.0 mg/L is for an annual average maximum daily air temperature of 59°F to 64°F.
Hardness-------	No recommendation	--	High levels (usually in excess of 200 mg/L) may cause undesirable taste and result in increased soap and detergent use; low levels indicate corrosiveness.
Iron (dissolved)	300 mg/L	Virtually absent	Bad taste; stains fixtures and laundry; accumulates in pipes.
Manganese------	50 mg/L	--	Do.
Nitrate (as N)-	10 mg/L	Virtually absent	Highly toxic to some infants.
Nitrite (as N)-	1 mg/L	--	Highly toxic (more so than nitrate).
pH (range)-----	5.0-9.0	--	Water may be corrosive where pH is less than 5.0.
Sodium---------	No recommendation	--	High concentrations may indicate presence of sewage or industrial effluents; concentrations exceeding 20 mg/L may adversely affect individuals on restricted sodium intakes.
Sulfate-------	250 mg/L	<50 mg/L	Possible bad taste; possible laxative effect.
Dissolved solids	500 mg/L[b]	<200 mg/L	Possible bad taste; possible laxative effect; possibly corrosive.
Chromium------	50 µg/L	Absent	May cause serious, adverse health problems.
Copper--------	1,000 µg/L[f]	Virtually absent	Do.
Lead----------	50 µg/L (30 µg/L)[g]	Absent	Do.
Mercury-------	3 µg/L	--	Do.
Zinc----------	5,000 µg/L[f]	Absent	Possibly bad taste.

[a]National Academy of Sciences, National Academy of Engineering (1974).

[b]U.S. Environmental Protection Agency (1968).

[c]Symbol "<" means less than.

[d]These values are for water after treatment or for water which will not be treated before use.

[e]These values are for raw water (before treatment).

[f]Less than this value for fisheries uses, National Academy of Sciences, National Academy of Engineering (1974).

[g]Fisheries uses, National Academy of Sciences, National Academy of Engineering (1974).

TABLE 7.--Streamflow measurements and estimates at selected sites (some data from U.S. Geological Survey 1947, 1958, and 1959)

Site no. in fig. 2	Drainage area (mi^2)	Date	Streamflow (ft^3/s)
1	0.86	08/25/47	0.17
		08/26/58	.10
		08/27/59	.02
2	4.87	07/08/47	.56
		07/24/47	.92
		08/05/47	.73
		08/25/47	.45
		09/17/47	.86
		09/29/47	.87
		08/26/58	.69
		08/27/59	.72
3	5.86	01/21/76	4.65
		03/03/76	7.38
		04/06/76	5.36
		04/27/76	3.51
		05/25/76	2.33
		07/12/76	1.68
		09/01/76	1.34
		09/28/76	1.19
		10/27/76	1.35
		12/21/76	1.61
		02/09/77	1.27
		03/29/77	1.89
		05/18/77	1.82
4	(not calculated)	04/27/76	1.05
5	2.79	08/09/61	.10
6	.45	08/09/61	.30
		02/02/76	.64
		03/03/76	1.03
		04/28/76	1.11
		05/25/76	.49
		07/13/76	.50
		08/31/76	.7 (e)
		09/01/76	.69

TABLE 7.--Streamflow measurements and estimates at selected sites (some data from U.S. Geological Survey 1947, 1958, and 1959)--continued

Site no. in fig. 2	Drainage area (mi^2)	Date	Streamflow (ft^3/s)
6	0.45	09/28/76	0.57
		10/27/76	.56
		12/21/76	.52
		02/09/77	.61
		03/29/77	.49
		05/18/77	.3 (e)
7	.69	08/09/61	.15
		02/02/76	.58
		03/03/76	.58
		04/27/76	.57
		05/25/76	.28
		06/09/76	.3 (e)
		07/13/76	.32
		08/31/76	.4 (e)
		09/01/76	.38
		09/28/76	.20
		10/27/76	.27
		12/21/76	.28
		02/09/77	.30
		03/29/77	.27
		05/18/77	.2 (e)
8	1.86	08/09/61	Dry

(e) Streamflow estimated.

TABLE 8.--Selected physical and chemical characteristics of water at selected stream sites

Site no., date and time of sample collection	Stream-flow (ft^3/s)	Specific conductance (µmho/cm)	pH (units)	Water tempera-ture (°C)	Tur-bid-ity (NTU)	Dis-solved oxygen (mg/L)	Total dissolved gases (percent)	Total coliform bacteria (col/100 mL)
Site 3 Gamble Crk.								
01/21/76[a] 205 p.m.	4.65	89	6.9	4.7	1	12.1	100	540
03/03/76 1135 a.m.	7.38	78	6.0	2.2	2	12.8	100	28,000
04/06/76 140 p.m.	5.36	80	6.9	9.8	1	10.6	100	400
04/27/76[a] 1115 a.m.	3.51	86	6.9	8.8	2	10.6	101	[b]730
05/25/76 1110 a.m.	2.33	107	7.4	10.2	2	10.8	101	1,300
07/12/76 110 p.m.	1.68	112	7.7	12.4	2	9.9	100	3,100
09/01/76[a] 1120 a.m.	1.34	108	7.1	12.2	1	9.8	99	--
09/28/76 1115 a.m.	1.19	114	6.8	12.6	1	9.3	99	1,500
10/27/76 920 a.m.	1.35	112	7.5	8.0	1	10.3	99	420
12/21/76 105 p.m.	1.61	112	7.3	5.8	1	11.2	99	1,200
02/09/77 220 p.m.	1.27	--	--	8.0	--	--	--	--
03/29/77 1205 p.m.	1.89	--	--	7.2	--	--	--	--
05/18/77 1230 p.m.	1.82	--	--	10.6	--	--	--	--
Site 4								
04/27/76[a] 100 p.m.	1.05	53	--	12.0	1	9.7	100	--
Site 6 Middle Crk.								
02/02/76[a] 1055 a.m.	.64	119	7.2	5.8	1	12.2	100	500
03/03/76 1145 a.m.	1.03	--	--	3.6	--	--	--	--
04/28/76[a] 1245 p.m.	1.11	126	7.0	9.4	2	11.3	100	1,900
05/25/76 1250 p.m.	.49	122	6.9	9.4	1	11.3	100	140
07/13/76[a] 1110 a.m.	.50	122	8.0	11.2	1	8.0	100	500
08/31/76 155 p.m.	[c].7	130	7.5	11.6	2	10.6	100	200
09/01/76 105 p.m.	.69	--	--	11.2	--	--	--	--

TABLE 8.--Selected physical and chemical characteristics of water at selected stream sites--continued

Site no, date and time of sample collection	Streamflow (ft^3/s)	Specific conductance (umho/cm)	pH (units)	Water temperature (°C)	Turbidity (NTU)	Dissolved oxygen (mg/L)	Total dissolved gases (percent)	Total coliform bacteria (col/100 mL)
Site 6 (cont)								
09/28/76 110 p.m.	.57	134	6.9	11.8	1	10.2	100	490
10/27/76 1025 a.m.	.56	121	7.8	9.0	1	11.2	100	210
12/21/76 1125 a.m.	.52	118	7.5	7.2	1	11.5	100	200
02/09/77 120 p.m.	.63	--	--	8.0	--	--	--	--
03/29/77 1245 p.m.	.49	--	--	7.4	--	--	--	--
05/18/77 1110 a.m.	[c]0.3	--	--	9.0	--	--	--	--
Site 7 Little Boston Creek								
02/02/76[a] 105 p.m.	.58	138	6.8	5.5	1	10.9	100	610
03/03/76 1255 p.m.	.58	133	6.4	3.1	1	12.9	100	120
04/27/76[a] 205 p.m.	.57	110	6.6	9.2	3	10.8	100	36
05/25/76 135 p.m.	.28	150	7.4	9.4	2	10.9	100	170
07/13/76[a] 955 a.m.	.32	153	7.8	11.4	1	10.4	100	400
08/31/76 205 p.m.	[c].4	155	7.5	12.4	4	10.5	100	1,100
09/01/76 1240 p.m.	.38	--	--	11.8	--	--	--	--
09/28/76 130 p.m.	.20	167	7.1	12.2	3	9.7	99	700
10/27/76 1045 a.m.	.27	124	7.8	8.8	1	10.7	100	200
12/21/76 1135 a.m.	.28	156	7.6	6.4	1	11.3	99	300
02/09/77 130 p.m.	.30	--	--	7.0	--	--	--	--
03/29/77 100 p.m.	.27	--	--	6.4	--	--	--	--
05/18/77 1055 a.m.	[c].2	--	--	9.0	--	--	--	--

[a]Additional quality of water data collected this date, see table 9.

[b]Fecal coliform sample taken at same time, 76 col/100 mL.

[c]Streamflow was estimated.

TABLE 9.--Chemical analyses of water at selected stream sites

Date	Time	Color (platinum-cobalt units)	Hardness (Ca,Mg) (mg/L)	Noncarbonate hardness (mg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Carbonate (CO_3) (mg/L)	Alkalinity as $CaCO_3$ (mg/L)
Site 3 (12069651) - "Gamble Creek"											
Jan, 1976											
21......	205 p.m.	70	36	5	9.0	3.4	3.7	1.4	38	--	31
Apr											
27......	1115 a.m.	--	--	--	--	--	--	--	--	--	--
Sep											
01......	1120 a.m.	--	52	7	10	6.5	5.1	1.4	55	0	45
Site 4 (no station number) Unnamed tributary to Port Gamble (bay)											
Apr, 1976											
27......	100 p.m.	--	--	--	--	--	--	--	--	--	--
Site 6 (12069660) "Middle Creek"											
Feb, 1976											
02......	1055 a.m.	50	57	14	10	7.7	5.0	1.4	52	0	43
Apr											
28......	1245 p.m.	--	--	--	--	--	--	--	--	--	--
Jul											
13......	1110 a.m.	--	55	4	7.6	8.8	5.2	1.3	62	0	51
Site 7 (12069663) "Little Boston Creek"											
Feb, 1976											
02......	105 p.m.	65	64	13	9.6	9.7	5.5	1.7	62	0	51
Apr											
27......	205 p.m.	--	--	--	--	--	--	--	--	--	--
Jul											
13......	955 a.m.	--	70	9	10	11	5.8	1.5	75	0	62

TABLE 9.--Chemical analyses of water at selected stream sites--continued

Date	Dis-solved sulfate (SO_4) (mg/L)	Dis-solved chlo-ride (Cl) (mg/L)	Dis-solved fluo-ride (F) (mg/L)	Dis-solved silica (SiO_2) (mg/L)	Dis-solved solids (resi-due at 180° C) (mg/L)	Dis-solved solids (sum of consti-tuents) (mg/L)	Dis-solved solids (tons per ac-ft)	Dis-solved solids (tons per day)	Total nitrate (N) (mg/L)	Total nitrite (N) (mg/L)	Total ammonia nitro-gen (N) (mg/L)
Site 3--continued											
Jan, 1976											
21.......	7.4	4.1	0.1	18	79	70	.11	1.00	0.75	0.01	0.12
Apr											
27.......	--	--	--	--	--	--	--	--	.46	.01	.14
Sep											
01.......	7.6	3.3	--	--	--	--	--	--	.38	.01	.12
Site 4--continued											
Apr, 1976											
27.......	--	--	--	--	--	--	--	--	.16	.01	.21
Site 6--continued											
Feb, 1976											
02......	10	4.7	.1	27	99	98	.13	.17	1.2	.00	.05
Apr											
28......	--	--	--	--	--	--	--	--	.68	.00	.07
Jul											
13......	8.7	4.8	--	--	--	--	--	--	.24	.01	.06
Site 7--continued											
Feb, 1976											
02......	11	5.5	.1	27	124	109	.17	.19	1.5	.01	.08
Apr											
27......	--	--	--	--	--	--	--	--	1.2	.01	.11
Jul											
13......	9.9	5.4	--	--	--	--	--	--	.65	.01	.09

TABLE 9.--Chemical analyses of water at selected stream sites--continued

Date	Total kjel-dahl nitro-gen (N) (mg/L)	Total phos-phorus (P) (mg/L)	Dis-solved ortho-phos-phorus (P) (mg/L)	Dis-solved chro-mium (Cr) (µg/L)	Dis-solved copper (Cu) (µg/L)	Dis-solved iron (Fe) (µg/L)	Dis-solved lead (Pb) (µg/L)	Dis-solved man-ganese (Mn) (µg/L)	Total mercury (Hg) (µg/L)	Dis-solved zinc (Zn) (µg/L)
Site 3--continued										
Jan, 1976										
21......	0.41	0.04	0.02	--	--	240	--	30	--	--
Apr										
27......	.53	.04	.02	--	--	--	--	--	--	--
Sep										
01......	.50	.05	.02	--	--	--	--	--	--	--
Site 4--continued										
Apr. 1976										
27......	.83	.04	.02	--	--	--	--	--	--	--
Site 6--continued										
Feb, 1976										
02......	.38	.05	.04	--	--	120	--	10	--	--
Apr										
28......	.40	.06	.05	--	--	--	--	--	--	--
Jul										
13......	.38	.08	.07	0	0	--	4	--	0.0	0
Site 7--continued										
Feb, 1976										
02......	.47	.05	.04	--	--	140	--	10	--	--
Apr										
27......	.68	.05	.04	--	--	--	--	--	--	--
Jul										
13......	.54	.10	.07	0	0	--	4	--	.0	0