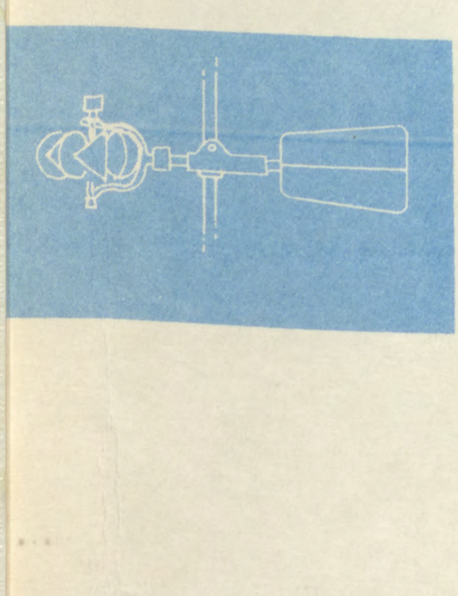
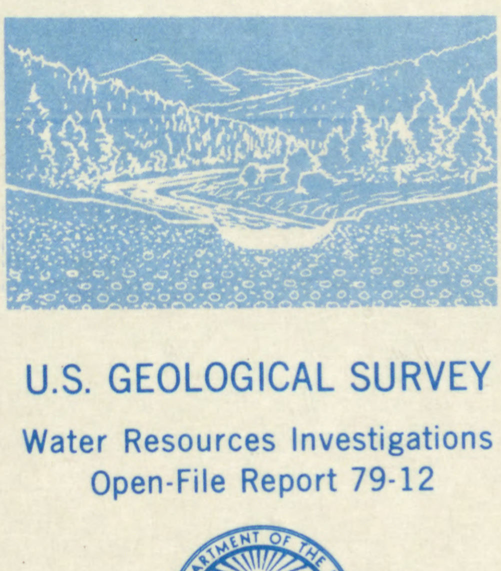
WATER RESOURCES OF THE SWINOMISH INDIAN RESERVATION, WASHINGTON





U.S. GEOLOGICAL SURVEY

Water Resources Investigations
Open-File Report 79-12

Prepared in Cooperation With
Swinomish Tribal Community

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER RESOURCES OF THE SWINOMISH INDIAN RESERVATION, WASHINGTON

By B. W. Drost

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WATER-RESOURCES INVESTIGATIONS

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Tacoma, Washington
1979

UNITED STATES DEPARTMENT OF THE INTERIOR
CECIL D. ANDRUS, Secretary

GEOLOGICAL SURVEY
H. William Menard, Director

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Frontispiece

Aerial view looking northwest over Swinomish Indian Reservation (outlined) and adjacent peninsulas and islands. San Juan Islands and Vancouver Island are in distance.

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ILLUSTRATIONS

(Plates 1-5 in pocket)

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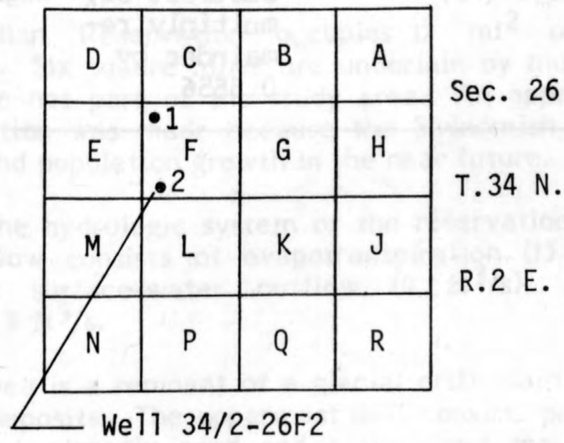
WELL- AND AREA-LOCATION NUMBERING SYSTEM

The well and area-location numbers used in this report give the location of wells and areas according to the official rectangular public-land survey. For example, in well number 34/2-26F2, the part preceding the hyphen indicates successively the township and range (T.34 N., R.2 E.) north and east of the Willamette base line and meridian, respectively. The first number following the hyphen indicates the section (sec. 26), and the letter (F) indicates the 40-acre subdivision of the section as shown in the sketch below. The last number is a sequence number used to distinguish wells in the same 40-acre tract. Thus, well 34/2-26F2 is in the SE¼ of the NW¼ of sec. 26, T.34 N., R.2 E. An s following the sequence number indicates that the site is a spring.



In computer-printout tables the same well is given the number 34N/02E-26F02. On plate 1, which shows numbered section, only the 40-acre subdivision, and sequence number are shown. Thus, well 34/2-26F2 is shown as F2.

METRIC CONVERSION FACTORS

Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
cubic foot per second (ft^3/s)	28.32	liter per second (L/s)
	.02832	cubic meter per second (m^3/s)
gallon per minute (gal/min)	.06309	liter per second (L/s)
degree Fahrenheit (°F)	Subtract 32, multiply remainder by 0.5556	degree Celsius (°C)

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ABSTRACT

The Swinomish Indian Reservation occupies 17 mi^2 on Fidalgo Island, northwestern Washington. Six square miles are underlain by mudflats or low-lying alluvial deposits, and are not part of the study area. An appraisal of the water resources of the reservation was made because the Swinomish Tribal Community expects rapid economic and population growth in the near future.

Average inflow to the hydrologic system of the reservation is 24 ft^3/s (cubic feet per second). Outflow consists of evapotranspiration (15 ft^3/s), subsurface outflow (5 ft^3/s), and surface-water outflow (4 ft^3/s). Recharge to the ground-water reservoir is 8 ft^3/s.

Most of the study area is a remnant of a glacial drift plain underlain by three types of unconsolidated deposits. The uppermost unit consists primarily of till, the intermediate unit is predominantly sand and gravel, and the lowermost unit is nearly all clay and silt. The total storage capacity is about 6.3 billion cubic feet of water.

During 1976 human interaction with the hydrologic system was negligible, with an average rate of water use of 0.19 ft^3/s. Seventy percent of this was pumped from the ground-water reservoir and the rest was imported.

Water levels in six wells extending below mean sea level were found to fluctuate as much as 2.8 feet in response to tidal fluctuations, representing maximum tidal efficiencies of 42 percent. Below sea level is a freshwater-saltwater zone of diffusion at least 150 feet thick.

Dissolved-solids concentrations are estimatd to be 10-20 mg/L (milligrams per liter) in precipitation, increase to 15-35 mg/L due to evapotranspiration, reach 45 mg/L in direct runoff, and increase to about 160 mg/L in shallow ground water and about 245 mg/L in deep ground water. In the zone of saltwater diffusion concentrations up to 1,570 mg/L were measured. Human interaction with the hydrologic system has had little apparent effect on water quality.

Ground-water quality is generally within the acceptable limits of the Federal Safe Drinking Water Act. The maximum contaminant levels for turbidity, arsenic, and coliform bacteria have been exceeded in a few samples.

Recommended limits have been exceeded for iron, manganese, chloride, dissolved solids, pH, and color. Most of the large concentrations of these constituents were in water from the zone of saltwater diffusion.

The ground-water reservoir can be developed to a greater degree. If 20 percent of the 8 ft^3/s of ground-water recharge can be intercepted, a net rate of ground-water withdrawal of 1.6 ft^3/s can be attained. Aquiculture development is possible on the two largest streams in the reservation in the form of incubation stations handling 600,000 eggs each.

INTRODUCTION

Purpose and Scope

The Swinomish Tribal Community initiated this water-resources study because existing (pre-1976) domestic water supplies frequently were inadequate in quantity and (or) quality, and because a dependable source of good-quality water would enhance economic growth on the reservation. In particular, anticipated population increases will result in the need for additional domestic water supplies. Also, the establishment of aquiculture facilities--as well as increases in recreational, commercial, and industrial activities--will depend on the availability of a sufficient supply of good-quality water.

The purpose of this study was to (1) describe and appraise the hydrologic system of the Swinomish Indian Reservation, (2) provide the water-resources information required for long-range water conservation planning, and (3) aid the Indian community in making optimum management decisions regarding future economic and population growth on the reservation.

The scope of this study was to (1) collect and collate all pertinent geohydrologic data, including well drillers' logs, water-quality analyses, water-level records and well records; (2) develop a conceptual model of the hydrologic system, including a water-budget analysis; (3) relate water quality to the flow system; and (4) prepare a report describing the results of the study and the potential for future water developments.

Description of the Area

The Swinomish Indian Reservation is part of Fidalgo Island in northwestern Washington, about 50 miles north of Seattle (fig. 1, pl. 1). The reservation boundaries are irregular (pl. 1), being originally defined in 1855 primarily by the position of extreme low tide. In 1873, a presidential executive order modified the northern boundary.

The total area of the reservation is about 17 mi^2. Of this, about 5 mi^2 is tideflats and about 1½ mi^2 in the northern part of the reservation is composed of recent flood-plain sediments lying only a few feet above mean sea level. The study area (pl. 1) covers 11 mi^2 and is the reservation minus the tideflats and area of recent flood-plain sediments, plus about 1/2 mi^2 of land adjacent to the northwestern part of the reservation. The study area is effectively an island, with only a small, low-lying connection to the remainder of Fidalgo Island, and as such is virtually an independent hydrologic system.

The study area is an elongate, north-south trending remnant of a glacial drift plain. The land surface consists almost entirely of till, and ranges in altitude from sea level to about 330 feet above mean sea level. Most of the study area has slopes of less than 15 percent, but in the northern half of the area slopes of 15 to 30 percent occur from the shoreline inland about 0.1 to 0.2 mile.

The study area has a maritime climate, with small diurnal temperature variations, cool dry summers, and mild, but cloudy, wet winters. The mountains of the Olympic Peninsula and Vancouver Island protect the area from the more intense winter storms which affect the Pacific Coast. The Cascade Range to the east protects the area in winter from cold arctic airmasses moving southwestward from Canada.

The airmasses affecting the study area have a prevailing flow from the Pacific, from the west and northwest, and cause a dry season that begins in May and extends through September. In an average summer, afternoon temperatures are in the 70's (°F) and nighttime temperatures are in the 50's (°F). Maximum temperatures reach 80° to 85°F on a few afternoons, and 90°F is considered exceptionally warm. Relative humidities in summer range from about 60 percent in the afternoon to 90 percent at night.

Prevailing southwesterly and westerly flowing airmasses result in a wet season during October-April that peaks in December or January. Almost all precipitation falls as rain, with only a few inches per year falling as snow or sleet. In an average winter, afternoon temperatures are in the 40's (°F) and nighttime temperatures are in the 30's (°F). Minimum daily temperatures drop below freezing during 40 to 50 nights in colder winters and less than 20 nights in warmer winters. Temperatures below 20°F are relatively rare.

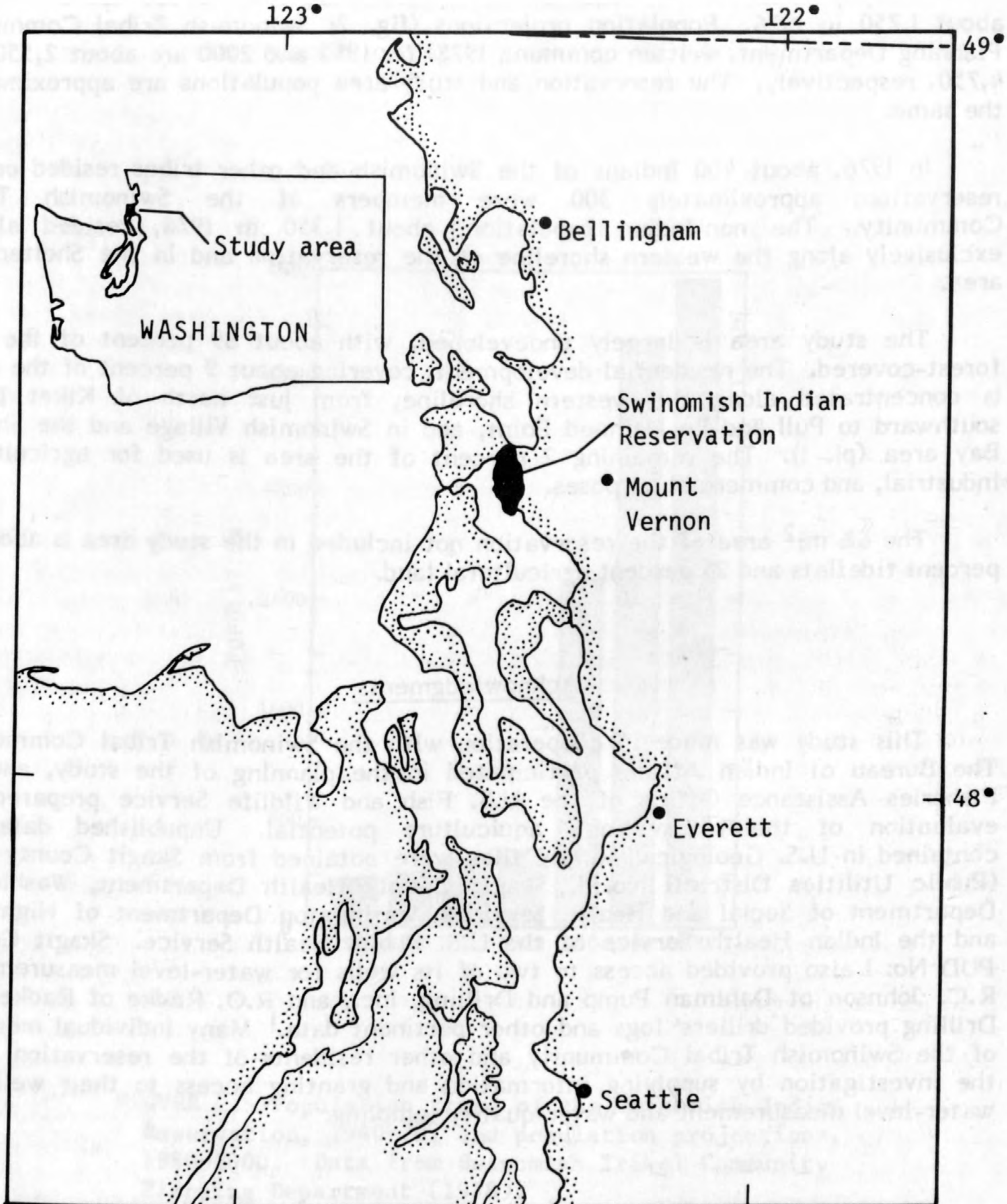


FIGURE 1.--Location of Swinomish Indian Reservation.

The population of the reservation has increased from about 380 in 1940 to about 1,750 in 1976. Population projections (fig. 2; Swinomish Tribal Community Planning Department, written commun., 1978) for 1980 and 2000 are about 2,550 and 4,750, respectively. The reservation and study-area populations are approximately the same.

In 1976, about 400 Indians of the Swinomish and other tribes resided on the reservation; approximately 300 were members of the Swinomish Tribal Community. The non-Indian population, about 1,350 in 1976, resided almost exclusively along the western shoreline of the reservation and in the Shelter Bay area.

The study area is largely undeveloped, with about 89 percent of the land forest-covered. The residential development, covering about 9 percent of the area, is concentrated along the western shoreline, from just north of Kiket Island southward to Pull and Be Damned Point, and in Swinomish Village and the Shelter Bay area (pl. 1). The remaining 2 percent of the area is used for agricultural, industrial, and commercial purposes.

The 6½ mi^2 area of the reservation not included in the study area is about 75 percent tideflats and 25 percent agricultural land.

Acknowledgments

This study was made in cooperation with the Swinomish Tribal Community. The Bureau of Indian Affairs participated in the planning of the study, and the Fisheries Assistance Office of the U.S. Fish and Wildlife Service prepared the evaluation of the reservation's aquiculture potential. Unpublished data not contained in U.S. Geological Survey files were obtained from Skagit County PUD (Public Utilities District) No. 1, Skagit County Health Department, Washington Department of Social and Health Services, Washington Department of Highways, and the Indian Health Service of the U.S. Public Health Service. Skagit County PUD No. 1 also provided access to two of its wells for water-level measurements. R.C. Johnson of Dahlman Pump and Drilling, Inc., and R.O. Radke of Radke Well Drilling provided drillers' logs and other pertinent data.[1] Many individual members of the Swinomish Tribal Community and other residents of the reservation aided the investigation by supplying information and granting access to their wells for water-level measurement and water-quality sampling.

[1]The mention of brand names and commercial operators in this report is for identification purposes only and does not imply endorsement by the U.S. Geological Survey.

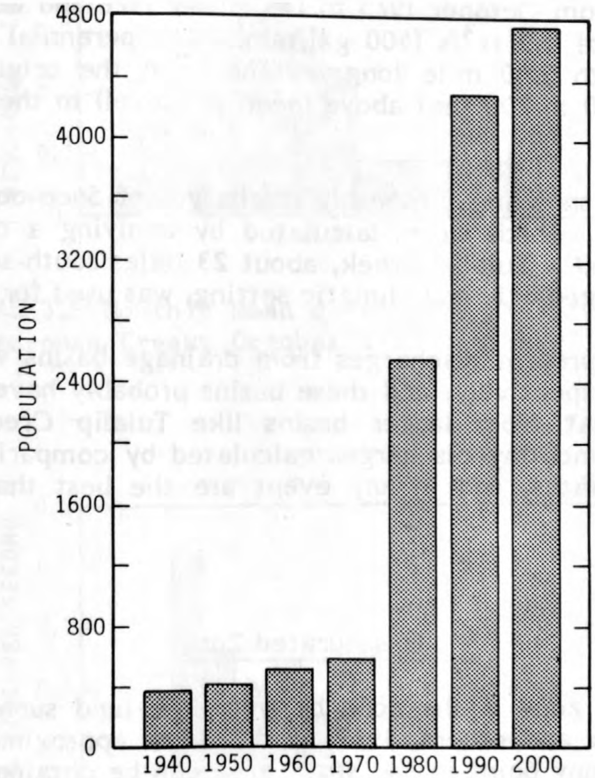


FIGURE 2.--Population trend of the Swinomish Indian Reservation, 1940-70, and population projections, 1980-2000. Data from Swinomish Tribal Community Planning Department (1978).

THE HYDROLOGIC SYSTEM

Surface-Water Bodies

Surface water is scarce in the study area. The only significant body of standing water is a marshy area on the upland (34/2-26), where a shallow pond usually survives year-round. Only three streams, Snee-oosh Creek, Munks Creek, and Unnamed Creek No. 1, are perennial, maintaining minimum flows of 0.05 ft^3/s (20 gal/min) or more. The discharges of Snee-oosh and Munks Creeks were measured monthly from October 1975 to December 1976 and were never observed to exceed a discharge of 0.9 ft^3/s (400 gal/min). The perennial reaches of the three streams, from 0.15 to 0.40 mile long, extend from the origin of spring flow (at altitudes of about 100 to 200 feet above mean sea level) to their points of discharge from the study area.

Figures 3 and 4 show mean monthly discharges of Snee-oosh and Munks Creeks (sites 1 and 2, pl. 1), which were calculated by applying a correlation procedure devised by Riggs (1969). Tulalip Creek, about 23 miles south-southeast of the study area and in a similar geologic and climatic setting, was used for the correlation.

Sites 1 and 2 represent discharges from drainage basins which are small, 0.62 mi^2 and 0.48 mi^2, respectively, and these basins probably have flow characteristics which vary somewhat from larger basins like Tulalip Creek basin (15.4 mi^2). However, the mean monthly discharges calculated by comparing these basins may be fairly good estimates, and in any event are the best that can be made with existing data.

Unsaturated Zone

The unsaturated zone is the zone between the land surface and the deepest water table (Lohman and others, 1972, p. 14). The approximate thickness of the unsaturated zone at any point in the study area can be obtained by subtracting the altitude of the water table (pl. 2) from the land-surface altitude. The total volume of material in the unsaturated zone in the study area is about 15 billion ft^3. Assuming a specific retention of 20 percent--the ratio of (1) the volume of water which the rock or soil, after being saturated, will retain against the pull of gravity to (2) the volume of rock or soil--there is 2.9 billion ft^3 of water stored in the unsaturated zone. This water cannot move into a well except where perched water bodies occur, and is therefore not available for direct use by man. However, this zone is important because (1) nearly all recharge to the ground-water reservoir must pass through this zone, (2) most recycled waste water is returned to this zone (septic-tank drain fields), and (3) many significant changes in water quality occur in this zone.

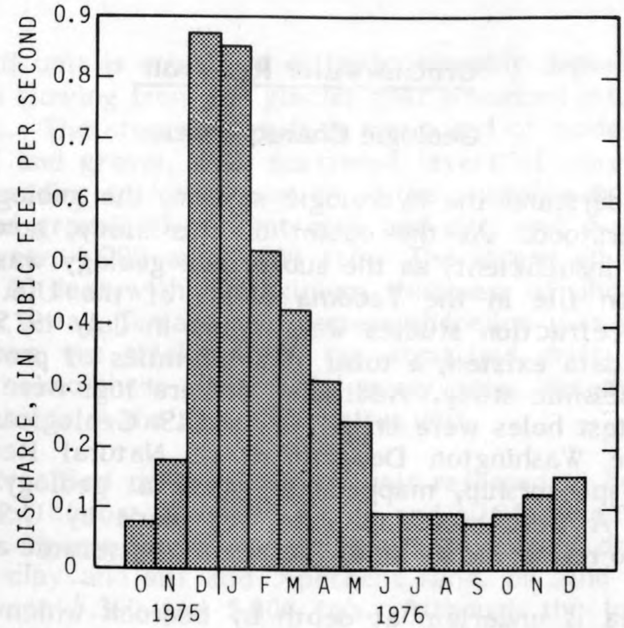


FIGURE 3.--Monthly mean discharges at site 1 on Snee-oosh Creek, October 1975-December 1976.

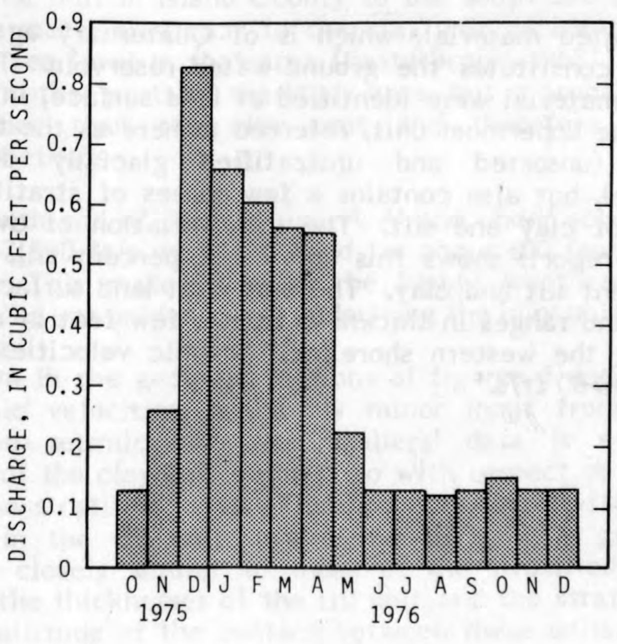


FIGURE 4.--Monthly mean discharges at site 2 on Munks Creek, October 1975-December 1976.

Ground-Water Reservoir

Geologic Characteristics

In order to understand the hydrologic system, the geologic framework of an area must be understood. At the outset of this study, however, the available geologic data were insufficient, as the subsurface geology was known only from a few drillers' logs on file in the Tacoma office of the U.S. Geological Survey. Therefore, seismic-refraction studies were made in July 1975, primarily in areas where few drilling data existed; a total of 8 1/2 miles of profiles (cross sections) resulted from the seismic study. Additional drillers' logs were obtained from local drillers, and three test holes were drilled under U.S. Geological Survey supervision. E.A. Artim of the Washington Department of Natural Resources, under U.S. Geological Survey sponsorship, mapped the surficial geology of the reservation during the study. A field reconnaissance was made by U.S. Geological Survey personnel in order to relate the surficial geology to the seismic and drilling data.

The study area is underlain at depth by bedrock which is overlain in most places by a mass of unconsolidated material. However, the bedrock is exposed at several places and is composed predominantly of sedimentary and metamorphic rocks, mostly argillites, graywackes, green schists, and slates. Seismic velocities in the bedrock are from 13,000 to 17,000 ft/s. The approximate depth to bedrock, which is the same as the thickness of the overlying unconsolidated materials, is shown on plate 3.

The unconsolidated material, which is of Quaternary age and of glacial and interglacial origin, constitutes the ground-water reservoir. Three major units in the unconsolidated material were identified at land surface, in drillers' logs, and in seismic profiles. The uppermost unit, referred to here as the till unit, is composed primarily of till (unsorted and unstratified glacially derived material of clay-to-boulder size), but also contains a few lenses of stratified sand and gravel and a few layers of clay and silt. The interpretation of available drillers' logs (table 8 at end of report) shows this unit as 80-percent till, 10-percent sand and gravel, and 10-percent silt and clay. The unit is at land surface almost everywhere in the study area, and ranges in thickness from a few feet in some places to more than 150 feet along the western shoreline. Seismic velocities in the till unit are between 2,500 and 3,700 ft/s.

Beneath the till unit is stratified drift, presumably deposited as outwash from melt-water streams flowing from the glacier that advanced into the area during the Pleistocene ice age. The stratified drift is composed of moderately to well-sorted and stratified sand and gravel, with scattered layers of clay and silt and a few masses of till. According to interpretation of the available drillers' logs this unit is 80-percent sand and gravel, 15-percent clay and silt, and 5-percent till. Seismic velocities are between 4,200 and 5,000 ft/s. The stratified drift has an average thickness of about 60 feet with a maximum thickness of about 170 feet near the center of the study area. Toward the western shoreline it is very thin or does not exist. Plate 4 shows the thickness of the stratified drift as interpreted from seismic data. In the northern end of the study area, the available drillers' logs indicate great variability in the thickness of this unit.

Beneath the stratified drift is a thick unit referred to here as the clay unit. This unit is composed almost entirely of clay and silt but contains some fine sand and laminations of organic (peaty) material. The available drillers' logs show this unit as 95-percent clay and silt and 5-percent sand, or sand and gravel. Seismic velocities are between 5,300 and 5,800 ft/s. Although the total thickness of the clay unit is unknown, the deposits are as much as 100 feet thick where they crop out in the northern end of the study area, and wells 34/2-15R1 and 24F6 were drilled through 88 and 208 feet, respectively, of this material without encountering any underlying units. In one location where the clay unit is exposed at land surface (34/2-15D), E. A. Artim (written commun., 1976) tentatively identified an underlying unit situated just above mean sea level. It consists of till with poorly sorted sand and gravel. A similar unit in Island County to the south and southwest, underlying what appears to be material similar to the clay unit, is identified as probably the main aquifer below sea level in that area (Easterbrook, 1968). This underlying unit might exist beneath other parts of the study area, but it probably has a lower range of seismic velocities than the clay unit and therefore is undetectable by seismic-refraction methods.

Beneath the south end of seismic line A-A' and under seismic line C-C' (pl. 3), velocities of 7,600-7,800 ft/s were recorded for about 100 feet of material directly overlying bedrock. This material might be highly weathered bedrock or some unconsolidated unit, as yet unidentified, underlying the clay unit.

The units shown in the geologic sections of figures 5 and 6 were identified on the basis of seismic velocities, with only minor input from drillers' logs. The correlation between seismic data and drillers' data is excellent relative to identifying the top of the clay unit but less so with respect to the contact between the till unit and the stratified drift. This probably results from the variability of seismic velocities in the till unit; where the till unit is saturated, its seismic characteristics are closely similar to those of the stratified drift. The geologic sections show that the thicknesses of the till unit and the stratified drift are highly variable, as is the altitude of the contact between these units. The altitude of the contact between the stratified drift and the underlying clay unit is somewhat more consistent.

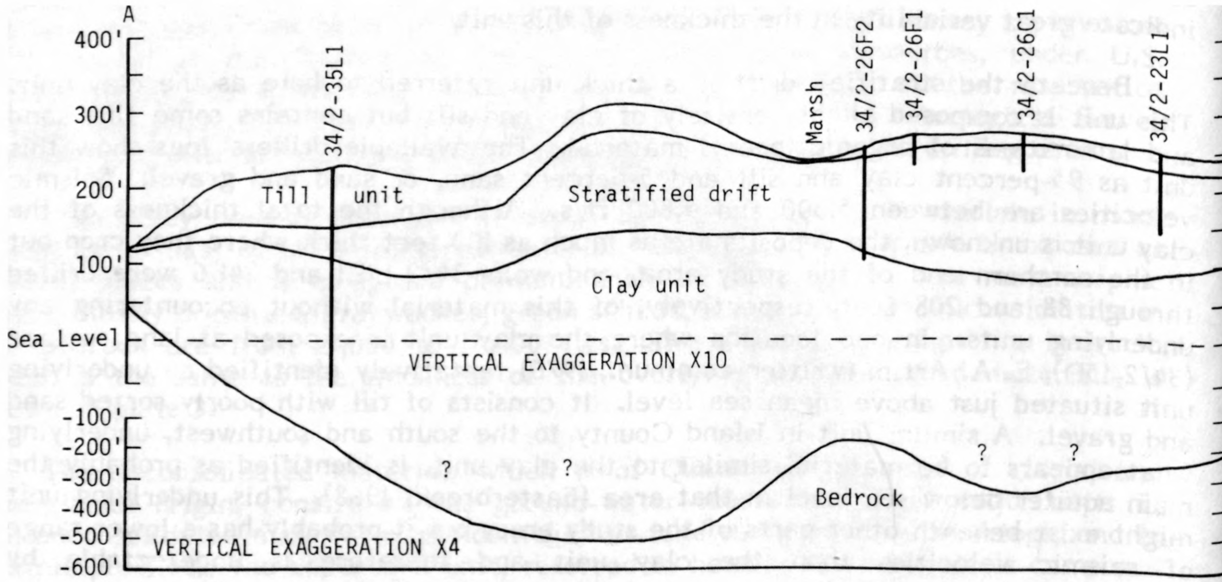


FIGURE 5.--Geologic section along line A-A' of plate 2.

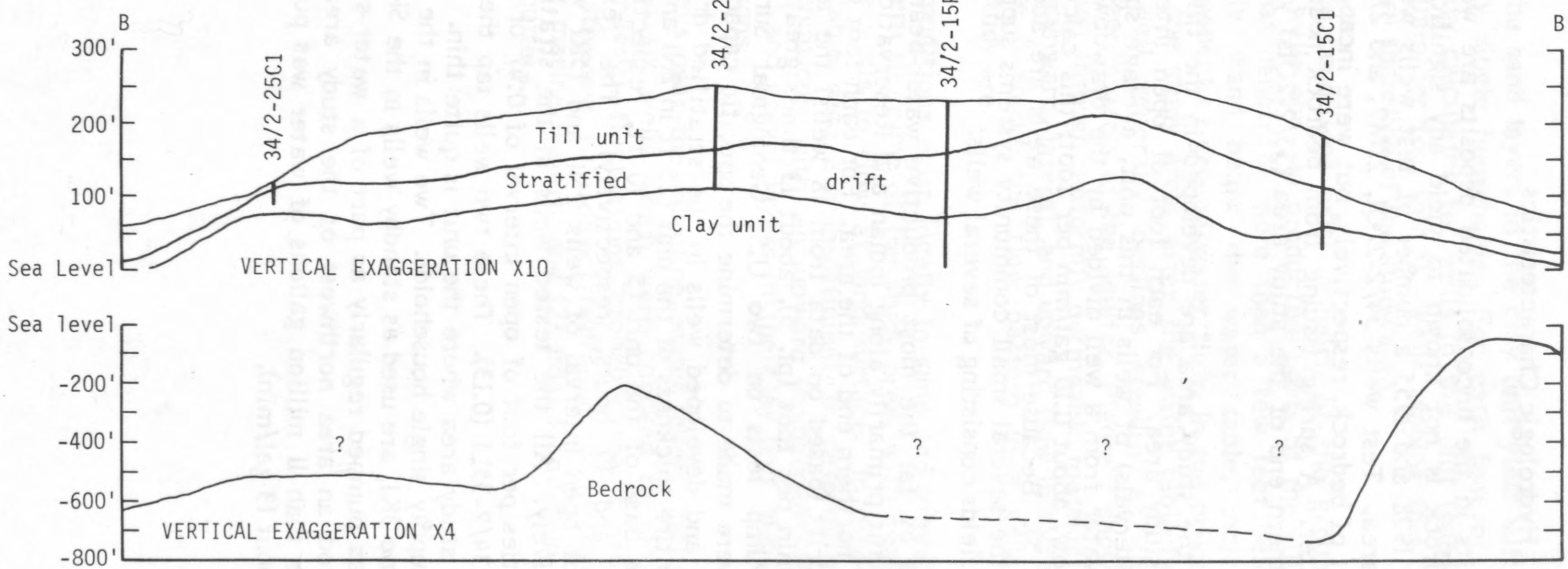


FIGURE 6.--Geologic section along line B-B' of plate 2.

Hydrologic Characteristics

All three principal units in the unconsolidated deposits are water-bearing to some degree, but the bedrock is not known to yield any significant amount of water. Between the years 1928 and 1955 a number of test wells were drilled into bedrock in the Snee-oosh area. Test wells 34/2-27Q1, 27M2, and 27P1 were drilled through 23, 90, and 412 feet of bedrock, respectively, but were incapable of yielding significant amounts of water. A spring issuing from bedrock near an abandoned strontium mine in the southern end of the study area (33/2-2Q1s) yields about 0.5 gal/min.

Many of the wells in the study area are developed in the till unit along the western shoreline of the study area. For each foot of open interval (screened, perforated, or noncased intervals) of wells in this unit, average specific capacity (the rate of discharge of water from a well divided by the drawdown of the water level in the well) is very low, about 0.10 gal/min per foot; this calculation is based on data from 20 wells (pl. 5). Because most of these wells are adequate only for single household supplies, the several small community systems supplied by the till unit generally require well fields consisting of several wells.

The stratified drift is by far the most productive water-bearing unit in the study area; wells tap this unit primarily along Indian and Reservation Roads on the upland and in the extreme northern end of the area. For each foot of open interval in wells in the stratified drift (based on data from 18 wells) the average specific capacity is about 1.3 gal/min per foot (pl. 5), about 13 times greater than that of wells in the till unit. Pump tests on two U.S. Geological Survey test wells (33/2-2N1 and 34/2-15R1) were made to determine the specific capacities obtainable from properly constructed and developed wells in the stratified drift. Both wells were drilled through the entire thickness of the unit (25 ft in 2N1 and 67 ft in 15R1); they were screened at the base of the unit (5 and 10 ft, respectively) and were developed by surging (14 and 10 hours, respectively). The resulting specific capacities for each foot of open interval of wells 2N1 and 15R1 were 1.8 and 1.1 gal/min per foot, respectively. All the tested wells in the stratified drift have calculated specific capacities per foot of open interval of 0.47 or greater, except wells 33/2-2D1 (0.23) and 34/2-35L1 (0.13). These two wells tap the stratified drift in the southern end of the study area where the unit is quite thin. Most wells that tap this unit are used to supply single households. Two wells in the northern end of the study area, 34/2-3G1 and 3K1, are used as standby wells in the Skagit PUD No. 1 system. Well 34/2-3G1 was pumped regularly as part of a water-supply system in the early 1960's and served an area northwest of the study area. During May 1962-December 1963, more than 11 million gallons of water was pumped from this well (an average rate of about 13 gal/min).

Some of the sand layers in the clay unit yield sufficient amounts of water to wells to supply single households. For each foot of open interval the average specific capacity calculated for wells in this unit (based on data from 14 wells) is about 0.04 gal/min per foot (pl. 5). Wells tapping this unit are concentrated along the southwestern shoreline of the study area.

Water-table conditions exist in much of the ground-water reservoir. This is seen in inland wells open to productive parts of the till unit or stratified drift. In inland wells that penetrate more than a few feet below the water table, water levels generally stand below the water table, indicating the existence of a downward component of ground-water flow. In the process of drilling a well in the inland part of the study area, after the water table has been reached, the water level in the well generally declines steadily as the well becomes open to progressively deeper parts of the aquifer. Figure 7 shows an idealized flow pattern in a cross section through uniformly permeable material. The flow lines show that there can be downward, lateral, and upward flow in different parts of a water-table aquifer. Figure 8 shows the flow pattern in a generalized east-to-west cross section in the study area.

Artesian conditions exist locally in sand and gravel layers within the till unit along the western shoreline of the study area, with enough hydraulic head in some layers to cause wells to flow at land surface. In other places along the western shoreline, available data are insufficient to determine if artesian conditions or water-table conditions with an upward component of flow are present. The productive sand and gravel layers in the clay unit also generally exhibit localized artesian conditions.

In some wells near the shoreline, water levels fluctuate with the tides. Table 1 gives data from six wells which were checked for possible tidal influence. The observed water-level fluctuations probably result from a combination of two different tidal stresses: (1) a direct hydraulic connection between the aquifers and the surrounding marine waters, and (2) tidal loading on top of the confining layers overlying the aquifers.

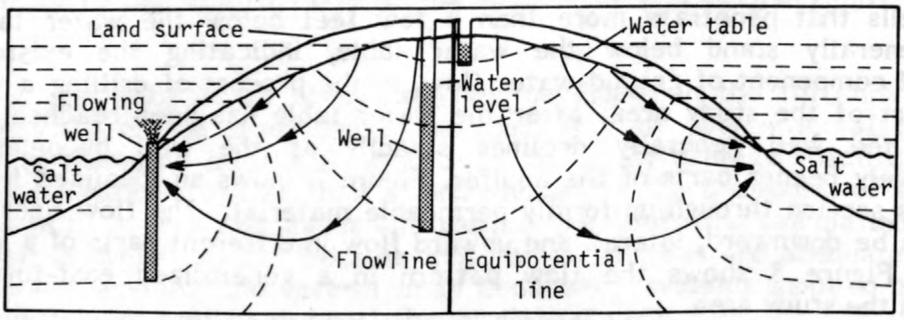


FIGURE 7.--Idealized flow pattern in uniformly permeable material. Adapted from Hubbert (1940).

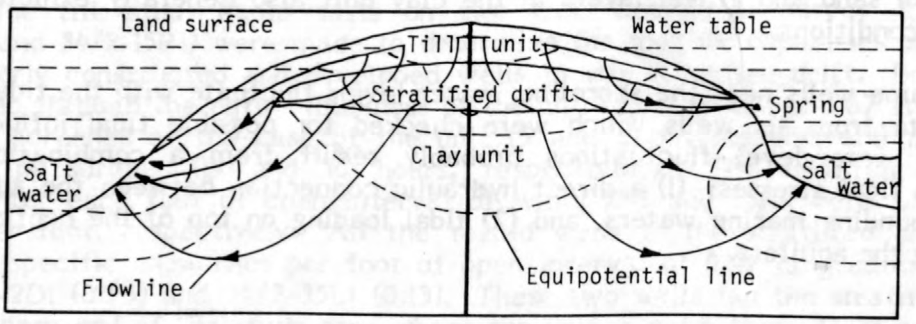


FIGURE 8.--Generalized flow pattern in an east-west cross section through the study area.

TABLE 1.--Fluctuations of water levels in selected wells in response to tidal fluctuations

Well number	Distance from shore-line (feet)	Depth of midpoint of open interval below mean sea level (feet)	Date measured	Altitude of water level above mean sea level (feet) and time of measurement		Apparent tidal effect (feet)	Tidal differ-ence[2] (feet)	Apparent tidal efficiency[3] (percent)
				High tide[1]	Low tide[1]			
34/2-34B1	50	97	9-24-76	23.9 5:33 p.m.	21.1 10:26 a.m.	2.8	6.7	42
			10-15-76	23.4 10:33 a.m.	22.3 4:58 p.m.	1.1	3.2	34
34/2-27M3	75	14	10-15-76	3.9 10:58 a.m.	3.4 4:40 p.m.	0.5	3.3	15
34/2-27D3	200	79	9-24-76	13.9 5:11 p.m.	13.3 11:18 a.m.	0.6	8.1	6
			10-15-76	13.6 11:22 a.m.	13.5 4:31 p.m.	0.1	3.0	3
33/2-3H2	300	54	9-24-76	13.6 5:43 p.m.	13.4 10:10 a.m.	0.2	6.1	3
34/2-3G1	300	1	10-15-76	13.6 11:54 a.m.	13.6 4:20 p.m.	0.0	2.6	0
34/2-35R1	700	9	10-15-76	34.3 9:16 a.m.	34.3 5:14 p.m.	0.0	1.6	0

[1]Tides: at Cornet Bay, Deception Pass (from [U.S.] National Oceanic and Atmospheric Administration, 1975).

9-24-76	High	10.5 ft	at 4:58p.m.	10-15-76	High	9.4 ft	at 10:43a.m.
	Low	1.9 ft	at 11:10a.m.		Low	5.9 ft	at 4:39p.m.
Difference		8.6 ft				3.5 ft	

[2]The difference between tidal elevations at times of measurements.

[3]Ratio of tidal effect to tidal difference, times 100 percent.

Boundaries

The boundaries of the fresh-ground-water reservoir are the water table at the top, the bedrock surface at the bottom, and the fresh water-salt water interface at the sides. The approximate position of the water table in July 1975, interpreted from seismic data, is shown on plate 2. Correlation of the seismic data with well drillers' data is possible in only a few cases because most wells penetrate far below the water table and, due to the steep hydraulic gradients, water levels in these wells are generally either below the water table (in inland wells) or above the water table (in shoreline wells). The water table is not a static boundary, its position changes continuously, reflecting changes in rates of recharge to and discharge from the ground-water reservoir or changes--near the shoreline--due to tidal fluctuations. The water table is a recharge boundary throughout most of the study area, and a discharge boundary along the shoreline.

The bedrock surface is the bottom of the ground-water reservoir. It is virtually impermeable relative to the unconsolidated material above it, and most water reaching the bedrock surface flows parallel to it and toward the margins of the ground-water reservoir. The top of the bedrock surface is probably far more irregular than indicated by the thickness of overlying deposits in plate 3, which doubtless results in rather complex patterns of flow at the base of the unconsolidated material.

The fresh ground-water reservoir is bounded laterally by salty ground water. The existence of this boundary is evident from the general pattern of increasing chloride concentrations in the ground water with increasing depth below sea level. However, the relationship is not a simple one: chloride concentrations are in excess of 50 mg/L in some wells extending only a few feet below sea level, but are as small as 20 mg/L in other wells extending more than 100 feet below sea level.

Chloride concentrations are related to fresh-water hydraulic head. The available data suggest a general relationship of increasing chloride concentrations with decreasing hydraulic head. The position of the freshwater-saltwater interface cannot be determined from the available data. However, a gross estimate of its position is possible. Using the sharp interface theory (position of the interface being governed by a dynamic equilibrium between freshwater flowing seaward and static saltwater, Hubbert, 1940), results in a general relationship between interface position (Z) and freshwater hydraulic head (h) in the study area of Z = 48 h from the equation

$$Z = \left(\frac{\rho_f}{\rho_s - \rho_f} \right) h ,$$

where,

ρ_f (density of freshwater) = 0.9992 g/mL (characteristic of ground water in the study area),

ρ_s (density of saltwater) = 1.0200 g/mL (characteristic of marine waters near the study area, Wagner and others, 1957)

This means that for each foot of hydraulic head of freshwater observed in a well, the theoretical freshwater-saltwater interface is 48 feet below sea level. Three wells in the study area with water levels of 1 to 2 feet above mean sea level were sampled and tested for chloride concentrations. The above relationship indicates that the location of the interface should be from 48 to 96 feet below mean sea level. However, these wells are open at depths up to 155 feet below sea level and chloride concentrations range from 25 to 425 mg/L, far less than that of saltwater (15,000 mg/L in the study area). The lack of correlation between the theoretical and observed values is probably due to two basic assumptions in the theory which apparently are not met in the study area--namely, that (1) a sharp interface exists, and (2) the saltwater is static.

This indicates the apparent existence of a zone of diffusion in which there is a gradation of chloride concentration from freshwater above mean sea level to saltwater at some depth below mean sea level. This zone is probably at least 155 feet thick beneath the study area (as seen in well 34/2-34R6) and may be much thicker.

The general shape of the zone may be similar to zones observed elsewhere. Figure 9 shows the probable configuration of the zone of diffusion modified from the general freshwater-saltwater relationships proposed by Kohout (1960). However, the relationship proposed by Kohout assumes vertical homogeneity in the aquifer. The vertical heterogeneity in the study area probably modifies the configuration in figure 9 by imposing a series of salty-water wedges with intervening freshwater zones, a similar system has been investigated on Long Island, New York (Franke and McClymonds, 1972).

Whatever the shape of the freshwater-saltwater boundary, it probably is not static, and it undergoes movements due primarily to changes in relative differences in the hydraulic heads of freshwater and saltwater. Although flow patterns in relation to this boundary are undoubtedly complex, fresh ground water probably moves primarily seaward.

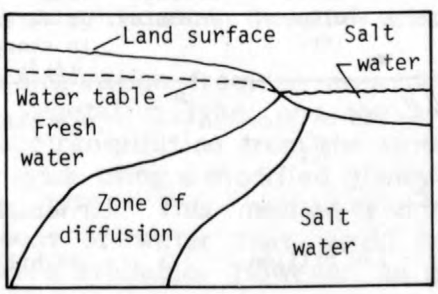


FIGURE 9.--Probable configuration of the zone of diffusion. Adapted from Kohout (1960).

Water in Storage

The approximate volume of the ground-water reservoir can be calculated from the information on plates 2 and 3. Neglecting the real freshwater-saltwater boundary by assuming a vertical boundary along the shorelines, the volume of the ground-water reservoir is calculated to be 130 billion ft^3. Assuming an average porosity (the ratio of the volume of interstices to the total volume) of 0.3, the volume of water in the ground-water reservoir equals 39 billion ft^3.

Of particular interest is the volume of water contained in the stratified drift, from which, unlike the till and clay units, wells produce at relatively high rates. This volume can be estimated from the information on plate 4. The total volume of the stratified drift is about 18 billion ft^3, and, assuming a porosity of 0.2, the volume of water in this unit is about 3.5 billion ft^3.

These calculated volumes refer to the total amount of water held in the units discussed. Of greater interest is the storage capacity of the units (the total volume of water in a unit minus the volume of water that would be retained against the force of gravity if the unit were drained). This is equal to the specific yield (average porosity minus the specific retention) times the total volume of the unit. Specific yields in the ground-water reservoir probably range from a minimum of about 0.03 for clay layers to a maximum of about 0.25 for sand layers. Assuming an average specific yield of about 0.05 for the entire ground-water reservoir--because most of the ground-water reservoir is in the clay unit--its storage capacity is 6.3 billion ft^3. The storage capacity of the stratified drift, assuming an average specific yield of about 0.15, is 2.6 billion ft^3. Table 2 lists the values calculated for the various zones.

TABLE 2.--Total volume, average porosity, volume of water in storage, average specific yield, and storage capacity of the ground-water reservoir and the unsaturated zone

	Total volume (ft^3)	Average porosity	Total volume of water in storage (ft^3)	Average specific yield	Storage capacity (ft^3)
Unsaturated zone-----------	15 billion	--	2.9 billion	--	--
Ground-water reservoir:					
Stratified drift only----	18 billion	0.2	3.5 billion	0.15	2.6 billion
Total ground-water reservoir--------------	130 billion	.3	39 billion	.05	6.3 billion

Inflow to the Hydrologic System

Precipitation

Precipitation, the source of all naturally occurring freshwater in the study area, was determined from data collected at the weather station nearest the study area, 3 miles WNW of Mount Vernon (fig. 1). The station (Mount Vernon 3WNW) has been in operation since 1956, and during the period 1956-76 the average annual precipitation was about 32.5 inches, with a minimum of 24.1 inches in 1957 and a maximum of 42.4 inches in 1971 (fig. 10).

The probability that a particular amount of precipitation will occur in any single year can be estimated from figure 11. For example, the figure shows that only about 10 percent of the time will annual precipitation exceed 39 inches, and that about 90 percent of the time it will exceed 27 inches. These estimates of the probability of future precipitation shown in figure 11 are accurate only if the climatic factors in operation during the 21 years of record follow a similar pattern in the future.

Average monthly precipitation is shown in figure 17. The figure shows a distinct wet season during October-April and a dry season during May-September. The average monthly precipitation is about 2.7 inches, and monthly average precipitation ranges from 4.7 inches in January to 1.1 inches in July. The greatest monthly precipitation on record was 10.5 inches in January 1971, and the least was 0.00 inch in July 1958.

Disposition of Precipitation

Evapotranspiration.--Evapotranspiration refers to the transfer of water, in the form of vapor, from land areas and bodies of water to the atmosphere. In the study area evapotranspiration occurs primarily as evaporation from vegetation and land surfaces that have been wetted by precipitation and from surface-water bodies, and as transpiration from the unsaturated zone by vegetation. Evapotranspiration directly from the ground-water reservoir, where it intersects or nearly intersects the land surface, is relatively insignificant in the study area and is discussed later.

The amount of evapotranspiration from an area depends primarily on solar radiation, air temperature, vegetation type, and the availability of water. No direct measurements of evapotranspiration from the study area are available, but reasonable estimates can be made using a modified Blaney-Criddle calculation (U.S. Department of Agriculture, 1970). This method yields a value for potential evapotranspiration--the amount of water that would be evapotranspired if an unlimited source of water were available. However, an unlimited source of water does not exist in the study area.

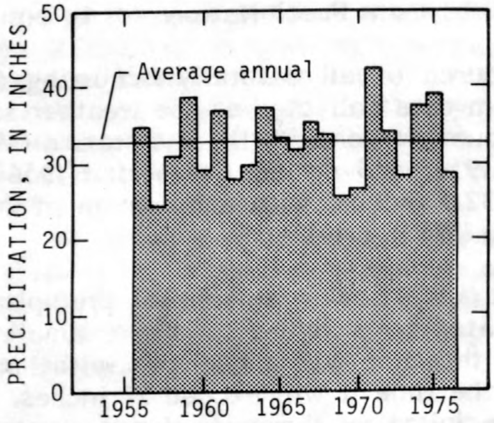


FIGURE 10.--Annual precipitation at the Mount Vernon weather station, 1956-76.

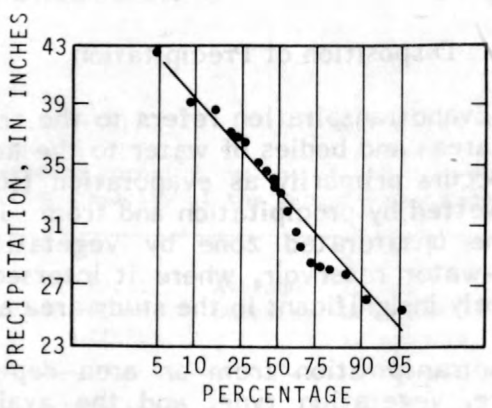


FIGURE 11.--Percentage of time various values of annual precipitation were equaled or exceeded, 1956-76.

In the study area, two different evapotranspiration regimes exist at different times: (1) wet periods, when precipitation is greater than potential evapotranspiration, during which the actual rate of evapotranspiration equals the potential rate, and (2) dry periods, during which potential evapotranspiration is greater than precipitation and the actual rate of evapotranspiration is generally less than the potential rate, being equal to precipitation plus available soil moisture accumulated during previous wet periods. Figure 12 shows the position of evapotranspiration within the hydrologic system: during wet periods (generally October-April), there is an excess of water which is either stored in the soil (soil-moisture recharge) to remain available for evapotranspiration, or is removed from the evapotranspiration environment as surface runoff or as recharge to the ground-water reservoir (water surplus). The soil in the study area has the ability to store about 2 1/3 inches of water, assuming an average soil thickness of 2 1/3 feet as determined by Ness and others (1960), and an assumed water-holding capacity of an inch of water per foot of soil.

During dry periods (generally May-September) there is a shortage of water and most of the stored soil moisture is rapidly evapotranspired (soil-moisture utilization), usually by early June. From this time until precipitation once again exceeds potential evapotranspiration, the actual rate of evapotranspiration is less than the potential rate (water deficit).

The average annual potential evapotranspiration in the study area is 31.0 inches, only slightly less than average annual precipitation (32.5 inches). However, average annual actual evapotranspiration is only about 18.8 inches, because, as seen in figure 12, the periods of greatest potential evapotranspiration coincide with the periods of least precipitation. During 1956-76 the calculated annual actual evapotranspiration ranged from a maximum of 22.2 inches in 1968 to a minimum of 14.6 inches in 1957 (fig. 13). Figure 14 shows the probability, based on the data in figure 13, that a particular amount of actual evapotranspiration will take place in any single year. Actual evapotranspiration will probably exceed 16 inches, in 9 of 10 years, but 21 inches in only 1 of 10 years.

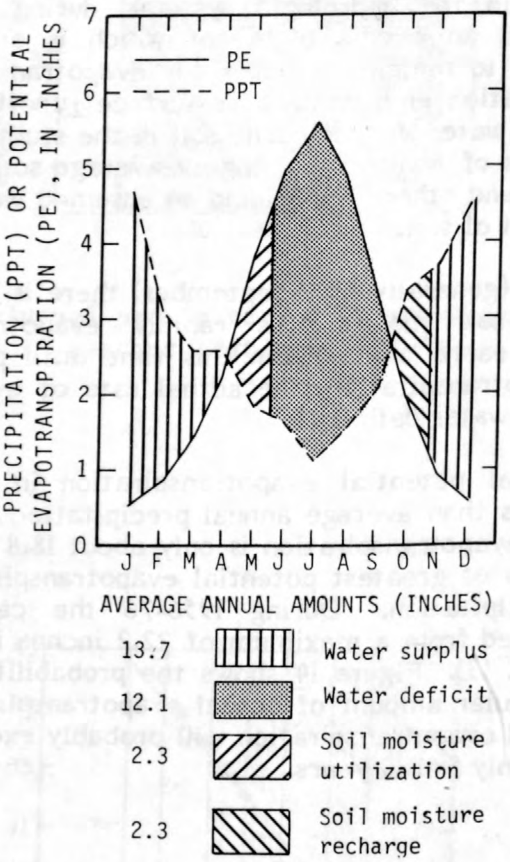


FIGURE 12.--Average annual water balance for the Mount Vernon weather station, 1956-76.

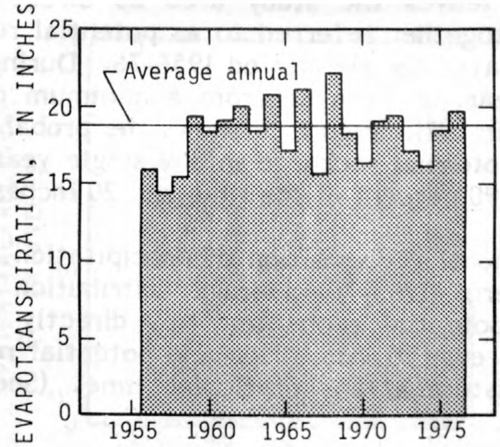


FIGURE 13.--Annual actual evapotranspiration in the study area, 1956-76.

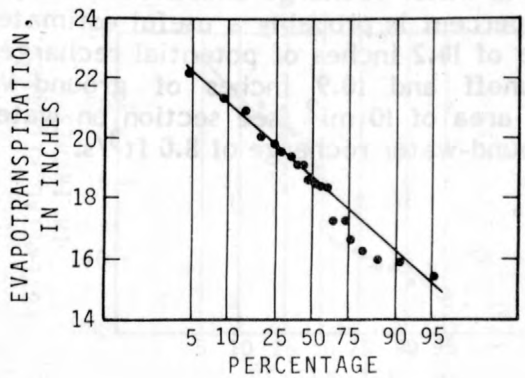


FIGURE 14.--Percentage of time various values of annual evapotranspiration were equaled or exceeded, 1956-76.

Potential recharge.--That part of precipitation not lost as evapotranspiration or stored as soil moisture leaves the study area as direct runoff or recharges the ground-water reservoir (together referred to as potential recharge). Figure 15 shows potential recharge calculated for the period 1956-76. During this period, it averaged about 14.2 inches per year, and ranged from a minimum of 7.1 inches in 1969 to a maximum of 23.2 inches in 1971. Figure 16 shows the probability of the occurrence of a particular amount of potential recharge in any single year. Potential recharge will probably exceed 9 inches 90 percent of the time and 20 inches 10 percent of the time.

A summary of the monthly disposition of precipitation is shown in figure 17. The figure shows the long-term (1965-76) average distribution of precipitation between evapotranspiration and potential recharge. Not directly shown in the figure, but affecting the amounts of evapotranspiration and potential recharge, is the amount of water stored as soil moisture at any particular time. (See fig. 12 for soil-moisture distribution.)

The available data do not allow for an accurate separation of the potential recharge into its components, ground-water recharge and direct runoff.

For the period November 1975 to April 1976 (the normal recharge period), potential recharge was about 17.8 inches. During this same period, it is estimated that the Munks and Snee-oosh Creek discharges were equal to 6.8 inches. Measurements above and below the main areas of ground-water discharge to the two creeks indicated that about 40 percent (2.7 inches) of the discharge was from ground-water discharge (springflow) and 60 percent (4.1 inches) was direct runoff. Therefore, 23 percent (4.1 of the 17.8 inches) of the potential recharge was direct runoff and the remaining 77 percent was ground-water recharge. The percentages of direct runoff versus ground-water recharge undoubtedly vary from year to year, but the 23 percent versus 77 percent is probably a useful estimate for most years. Based on the long-term average of 14.2 inches of potential recharge, long-term averages of 3.3 inches of direct runoff and 10.9 inches of ground-water recharge can be calculated. Assuming an area of 10 mi^2 (see section on water budget), yields direct runoff of 2.4 ft^3/s and ground-water recharge of 8.0 ft^3/s.

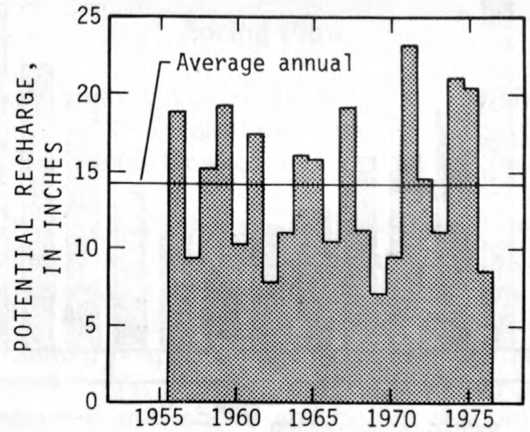


FIGURE 15.--Annual potential recharge, 1956-76.

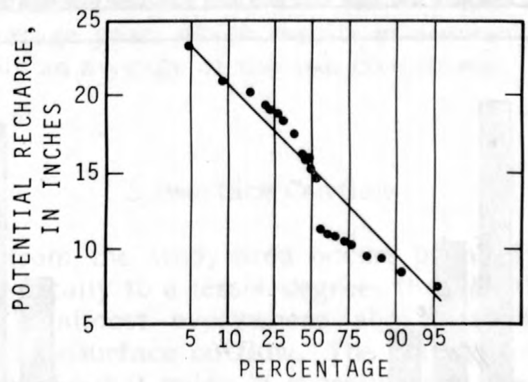


FIGURE 16.--Percentage of time various values of annual potential recharge were equaled or exceeded, 1956-76.

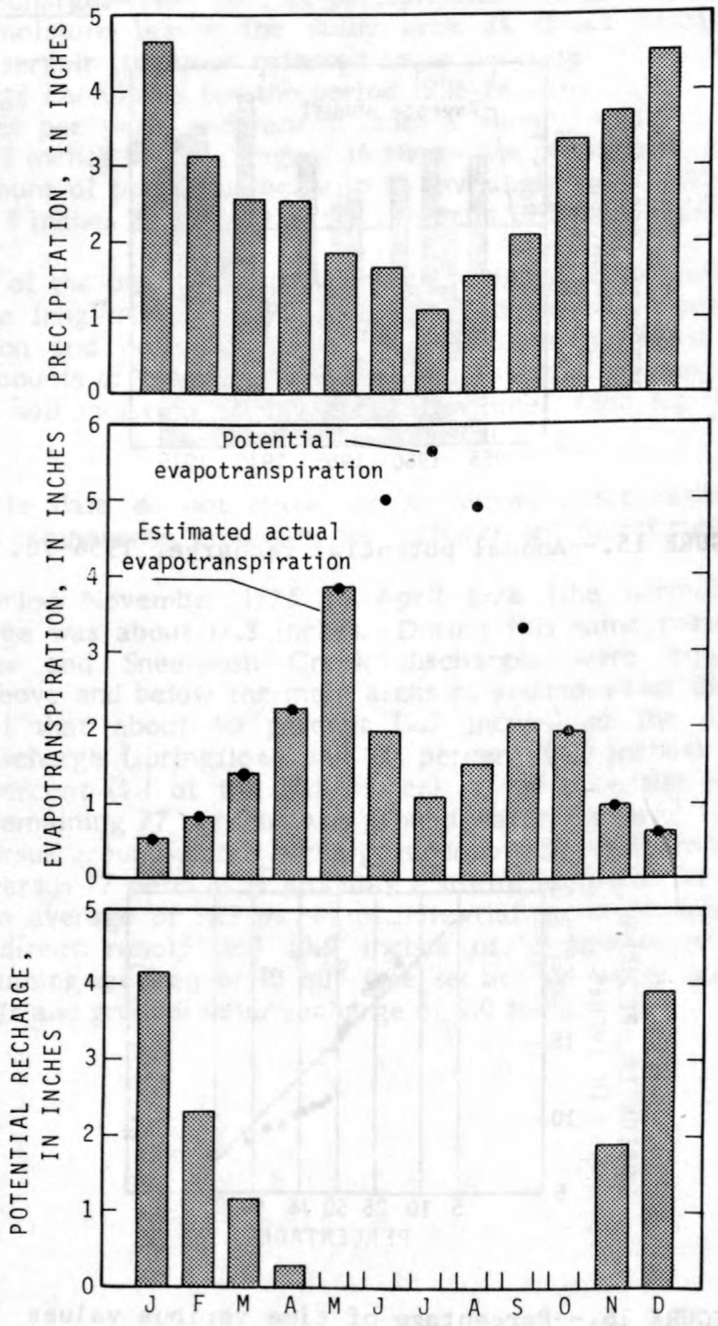


FIGURE 17.--Summary of mean monthly distribution of precipitation, evapotranspiration, and potential recharge.

Discharge from the Ground-Water Reservoir

Spring Flow

Springs and seeps occur along the margins of the study area, primarily at the contact between the stratified drift and the underlying clay unit. The larger springs discharge into Snee-oosh and Munks Creeks.

In 1976, the mean combined discharge of these two creeks during the dry season (May-October) was 0.22 ft^3/s, all of which originated as spring flow, primarily from the stratified drift. Estimating this as 40 percent of the total dry-season spring flow, yields a value of 0.55 ft^3/s for total dry-season spring flow in the study area. During the wet periods of 1976 (January-April and November-December), the mean discharge of the two creeks was 0.83 ft^3/s. Estimating that 40 percent of this originated as spring flow (based on measurements above and below the points of spring discharge), about 0.33 ft^3/s was wet-season spring flow. During wet periods spring flow occurs from both the stratified drift and the till unit. Therefore, assuming that this represents 25 percent of the total wet-season spring flow in the entire study area, the total spring flow discharge from the study area was 1.3 ft^3/s during the wet periods of 1976.

The mean dry-season spring flow is probably fairly constant from year to year, making the 0.55 ft^3/s flow in 1976 a reasonable long-term estimate. However, the mean spring flow during wet periods probably varies considerably on a long-term basis. In 1976, the total potential recharge was 8.6 inches, whereas the long-term average is 13.7 inches. Making the gross assumption that mean spring flow during wet periods is directly proportional to potential recharge, a long-term estimate of the mean flow can be calculated to be 2.1 ft^3/s. The dry and wet periods each occupy about 6 months of an average year, which results in a mean annual spring flow of 1.3 ft^3/s that is approximately an average of the two conditions.

Subsurface Outflow

Subsurface outflow from the study area occurs primarily below mean sea level, through the clay unit and locally to a lesser degree, through the till unit. The bottom of the stratified drift is almost everywhere above sea level, thus it does not contribute significantly to subsurface outflow. The clay unit has an average thickness of about 250 feet beneath about 11 miles of shoreline and the till unit averages about 75 feet in thickness beneath about 2 miles of shoreline.

Most of the outflow probably occurs through the sand or sand and gravel layers in the two units. About 5 percent of the clay unit and about 10 percent of the till unit are sand and (or) gravel layers, making effective thicknesses for outflow or about 12 feet and 8 feet, respectively.

The transmissivities (the rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient) of the two units can be roughly estimated from the specific-capacity data given on plate 5. Methods devised by Theis, 1963 and Brown, 1963, give transmissivities of about 130 ft^2/d for the clay unit and 210 ft^2/d for the till unit.

The hydraulic gradients in the two units have not been accurately defined. The slope of the water-table configuration shown on plate 2, about 250 ft/mi, is probably a reasonable estimate of the hydraulic gradients in both units.

Subsurface outflows can be calculated from the above estimates using Darcy's law, Q = TIL, where Q is the outflow in cubic feet per day, T is the transmissivity, I is the hydraulic gradient, and L is the width of the cross section through which the flow occurs. From this, the outflow through the clay unit is calculated to be 360,000 ft^3/d (4.1 ft^3/s) and the outflow through the till unit is 110,000 ft^3/d (1.3 ft^3/s), giving an estimated total subsurface outflow of 5.4 ft^3/s.

Ground-Water Evapotranspiration

In places where the water table is very shallow, roots of vegetation may reach it, resulting in evapotranspiration directly from the ground-water reservoir. The soil type in the study area generally limits the penetration of roots to about 3 feet below land surface (Ness and others, 1960). However, it can be seen on plate 2 that in most of the study area the depth to the water table is much more than 3 feet--the only areas where the water table might be as shallow as 3 feet are near the shoreline, near springs, and in the marshy area in 34/2-26. The amount of ground-water evapotranspiration in the study area cannot be directly calculated, but is probably a relatively small part of total ground-water outflow.

Ground-Water Withdrawal

As of 1976, the rate of withdrawal of water from the ground-water reservoir was small. Of the 1,750 residents, about 1,200 were obtaining water from wells in the study area. The remainder were obtaining water from the Anacortes Water System or the LaConner Water System (which purchases water from the Anacortes system). This imported water is obtained primarily from the Skagit River to the east.

About 40 percent of the population using water from the ground-water reservoir was supplied by six small public-supply systems: Snee-oosh (34/2-27K), Hope Island Water (34/2-34H), Shorewood (34/2-27Q), Goldenview Water Well Association (34/2-34J), Reef Point (34/2-27F), and Sunny Slopes (34/2-27R). The other 60 percent of the population was supplied primarily by individual household wells. The distribution of wells is shown on plate 1. The majority of wells, including all those serving the public-supply systems, are located near the southwestern shoreline of the study area. Well records and water levels are listed in tables 9 and 10 (p. 67 and 71).

Accurate water-use data are available only for the Snee-oosh system which supplies about 55 homes. In 1976 the average daily per-capita use from the system was about 68 gal/d, and ranged from a minimum of 58 gal/d in January to a maximum of 81 gal/d in July.

The per-capita use from the Snee-oosh system is probably representative of the average per-capita use by the entire population supplied from the ground-water reservoir. Assuming an average population served of about 1,200 and a per-capita use of 68 gal/d, the average rate of withdrawal was 82,000 gal/d, or 0.13 ft^3/s.

Assuming the same daily per-capita use for those consumers supplied by imported water, an additional 0.06 ft^3/s was used.

Water Budget

Natural Conditions

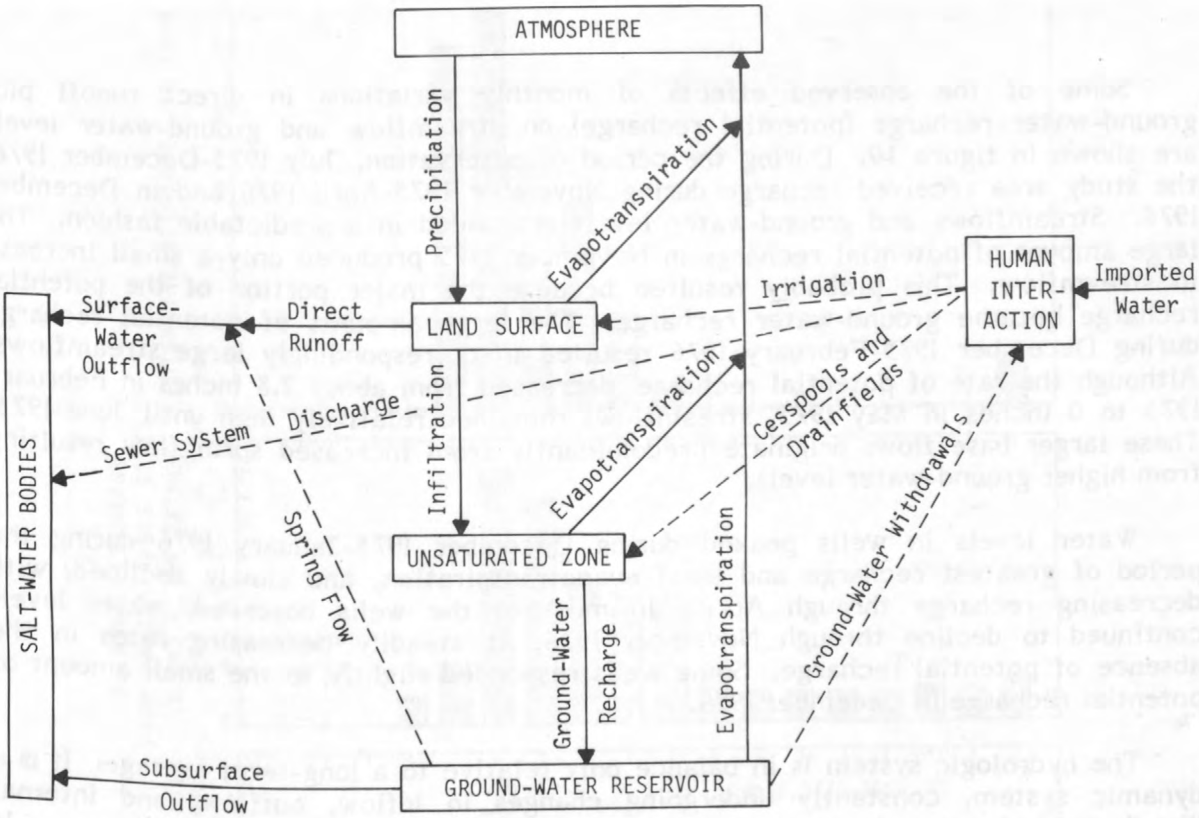
Under natural conditions the hydrologic system operating in the study area is presumably in a state of dynamic equilibrium. On a long-term basis, inflow to the system (precipitation) is equal to outflow (evapotranspiration, subsurface outflow, and surface-water outflow), and there is no change in the amount of water in storage at land surface, in the unsaturated zone, or in the ground-water reservoir.

Precipitation falling on the land surface follows three paths: (1) direct runoff to the surrounding saltwater bodies, (2) evapotranspiration at land surface, and (3) infiltration to the unsaturated zone. Water in the unsaturated zone percolates downward to recharge the ground-water reservoir or moves to the land surface by capillary action and is evapotranspired.

Water which reaches the ground-water reservoir flows slowly toward the margins of the study area. Some water flows deeply into the reservoir, moves beneath the margins of the study area, and eventually discharges (below sea level) to saltwater bodies. Where the water table is within reach of rooted plants, some water is evapotranspired, and where it intersects the land surface, springflow occurs. Together, springflow and direct runoff constitute the surface-water outflow from the hydrologic system.

The water budget in the study area under natural conditions is shown in figure 18. A land surface area of 10 mi^2 was used to calculate the water budget because about 1 mi^2 of the 11 mi^2 of study area has bedrock at the land surface, where virtually all precipitation is lost as direct runoff or as evapotranspiration.

Natural inflow to the hydrologic system is in the form of precipitation which averages 32.5 inches/yr, resulting in an average inflow of about 23.9 ft^3/s. Natural outflow occurs primarily as evapotranspiration from the land surface and unsaturated zone, at a rate of 18.8 inches/yr (13.8 ft^3/s), and as subsurface outflow (5.4 ft^3/s). Direct runoff accounts for about 2.4 ft^3/s, and springflow accounts for about 1.3 ft^3/s. These forms of outflow total 22.9 ft^3/s. Because the budget must be in balance (assuming the hydrologic system is in a state of equilibrium) there must be an additional 1.0 ft^3/s of outflow. To balance the budget this additional outflow is designated as ground-water evapotranspiration.



WATER BUDGET UNDER NATURAL CONDITIONS		
Inflow		ft³/s
Precipitation		23.9
Outflow		
Evapotranspiration		
From land surface and unsaturated zone	13.8	
From ground-water reservoir	1.0	
		14.8
Subsurface outflow		5.4
Surface-water outflow		
Direct runoff	2.4	
Spring flow	1.3	
		3.7
		23.9
Change in Storage		
Inflow-Outflow		0

HUMAN INTERACTION WITH THE HYDROLOGIC SYSTEM	
Water use	ft³/s
Ground-water withdrawals	0.13
Imported water	0.06
	0.19
Water disposal	
To unsaturated zone (Drainfields and cesspools)	0.12
To salt-water bodies (Sewer-system discharges)	0.05
To land surface (Irrigation; mostly lawns and gardens)	0.02
	0.19

FIGURE 18.--Flow diagram and water budget of the hydrologic system in the study area, showing natural conditions and those involving human interaction.

Some of the observed effects of monthly variations in direct runoff plus ground-water recharge (potential recharge) on streamflow and ground-water levels are shown in figure 19. During the period of observation, July 1975-December 1976, the study area received recharge during November 1975-April 1976 and in December 1976. Streamflows and ground-water levels responded in a predictable fashion. The large amount of potential recharge in November 1975 produced only a small increase in streamflow. This probably resulted because the major portion of the potential recharge became ground-water recharge. The large amounts of potential recharge during December 1975-February 1976 resulted in correspondingly large streamflows. Although the rate of potential recharge decreased from about 2.8 inches in February 1975 to 0 inches in May 1975, streamflows remained relatively high until June 1975. These larger base flows originate predominantly from increased springflow resulting from higher ground-water levels.

Water levels in wells peaked during December 1975-January 1976 during the period of greatest recharge and least evapotranspiration, and slowly declined, with decreasing recharge through April. In most of the wells observed, water levels continued to decline through November 1976, at steadily decreasing rates in the absence of potential recharge. Some wells responded slightly to the small amount of potential recharge in December 1976.

The hydrologic system is in balance only relative to a long-term average. It is a dynamic system, constantly undergoing changes in inflow, outflow, and internal distribution of water in response to fluctuations in climatic and other factors. It should be noted that short-term fluctuations have no significant effect on the amount of water stored in the system. At the average rate of 23.9 ft^3/s, total flow through the system in an entire year is about 750 million cubic feet, only about 12 percent of the storage capacity of the ground-water reservoir.

Human Interaction

As of 1976, human interaction with the hydrologic system had no apparent sigificant effect on the water budget. The rate of water use was about 0.19 ft^3/s, less than 0.8 percent of the natural rate of flow through the system (fig. 20). Ground-water withdrawals accounted for 0.13 ft^3/s of water use and the remaining 0.06 ft^3/s was imported.

Water was discharged to the unsaturated zone through drainfields and cesspools, to saltwater bodies through sewer-system discharges from Shelter Bay Development and Snee-oosh, and to the land surface by irrigation. Water discharged to the unsaturated zone (at an estimated rate of about 0.12 ft^3/s) and water applied to the land surface (about 0.02 ft^3/s) infiltrated to the ground-water reservoir or was evapotranspired, and thus was recycled through the land portion of the hydrologic system. Water discharged directly to saltwater bodies (about 0.05 ft^3/s) was not recycled.

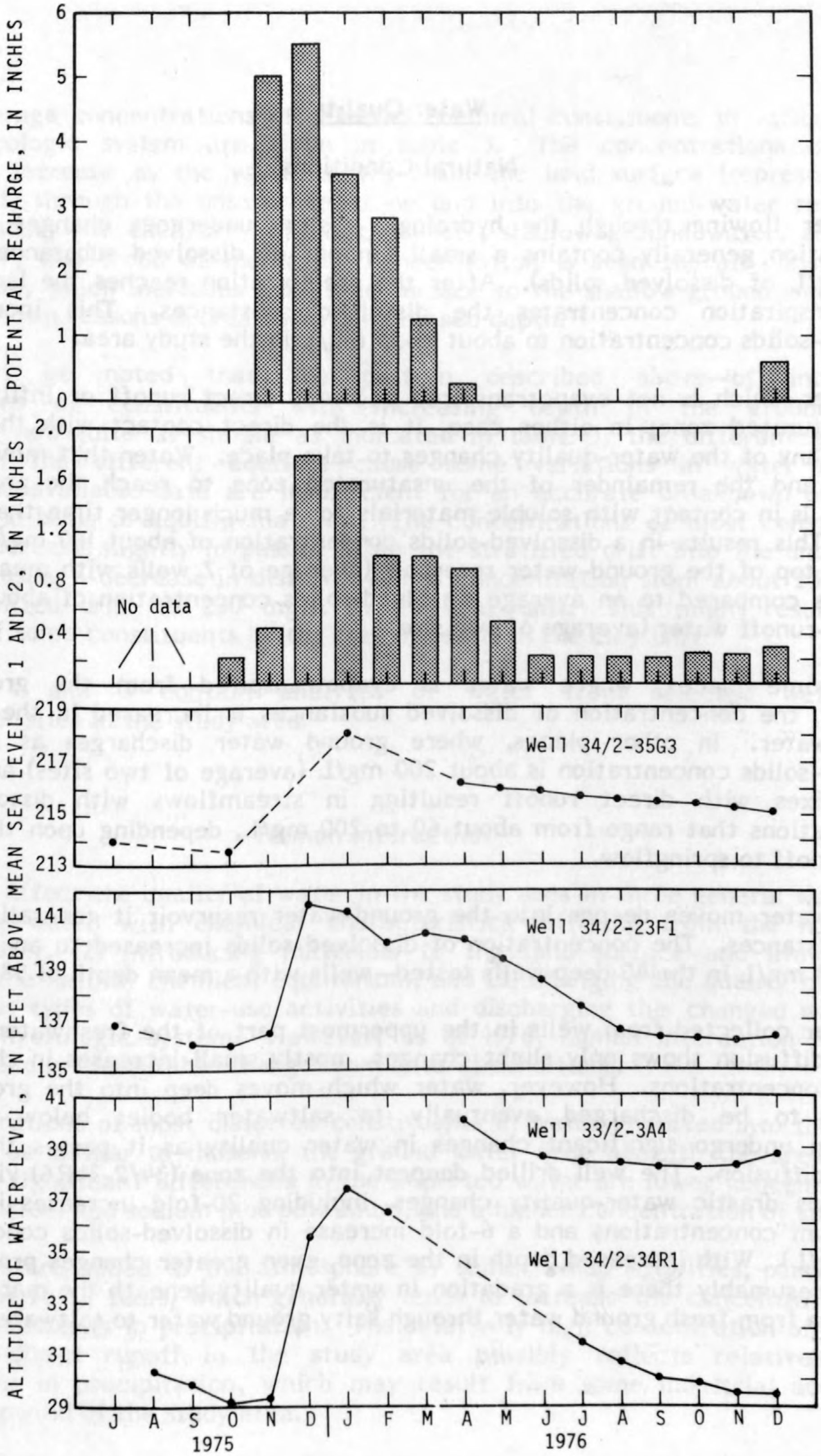


FIGURE 19.--Streamflow and ground-water level responses to varying rates of recharge, July 1975-December 1976.

Water Quality

Natural Conditions

Water flowing through the hydrologic system undergoes changes in quality. Precipitation generally contains a small amount of dissolved substances (possibly 10-20 mg/L of dissolved solids). After the precipitation reaches the land surface, evapotranspiration concentrates the dissolved substances. This increases the dissolved-solids concentration to about 15-35 mg/L in the study area.

Water which is not evapotranspired becomes direct runoff or infiltrates into the unsaturated zone; in either case, it is the direct contact with the soil that causes many of the water-quality changes to take place. Water that moves through the soil and the remainder of the unsaturated zone to reach the ground-water reservoir is in contact with soluble materials for a much longer time than is direct runoff. This results in a dissolved-solids concentration of about 160 mg/L in water near the top of the ground-water reservoir (average of 7 wells with mean depth of 32 ft), as compared to an average dissolved-solids concentration of about 45 mg/L in direct-runoff water (average of two sites).

In some places, where water is evapotranspired from the ground-water reservoir, the concentration of dissolved substances is increased in the remaining ground water. In other places, where ground water discharges as springflow, dissolved-solids concentration is about 200 mg/L (average of two sites) and in some cases mixes with direct runoff resulting in streamflows with dissolved-solids concentrations that range from about 60 to 200 mg/L, depending upon the ratio of direct runoff to springflow.

As water moves deeper into the ground-water reservoir it generally dissolves more substances. The concentration of dissolved solids increased to an average of about 245 mg/L in the 40 deep wells tested--wells with a mean depth of 98 ft.

Water collected from wells in the uppermost part of the freshwater-saltwater zone of diffusion shows only slight changes, mostly small increases in chloride and sodium concentrations. However, water which moves deep into the ground-water reservoir--to be discharged eventually to saltwater bodies below mean sea level--can undergo significant changes in water quality as it passes through the zone of diffusion. The well drilled deepest into the zone (34/2-34R6) yields water that shows drastic water-quality changes, including 20-fold increases in chloride and sodium concentrations and a 6-fold increase in dissolved-solids concentrations (1,570 mg/L). With increased depth in the zone, even greater changes probably take place. Presumably there is a gradation in water quality beneath the margins of the study area from fresh ground water through salty ground water to saltwater.

The average concentrations of selected chemical constituents in various parts of the hydrologic system are given in table 3. The concentrations of most constituents increase as the water moves from the land surface (represented as direct runoff) through the unsaturated zone and into the ground-water reservoir. When comparing the chemistry of direct runoff, shallow ground water, and deep ground water, this trend of increasing concentration is seen for all constituents except sulfate, which increases from land surface to the shallow ground water, but then for unknown reasons decreases with increased depth.

It must be noted that the pattern described above--of increasing concentrations of constituents with increasing depth in the ground-water reservoir--is not quite as simple as indicated in table 3; the different geologic materials in the different aquifers cause some variations in water quality. However, the available data are insufficient for an accurate breakdown of water quality on the basis of aquifer material. The concentrations of most constituents appear to decrease slightly in passing from the stratified drift into the underlying clay unit, causing a decrease in dissolved-solids concentration from about 255 mg/L in the stratified drift to 230 mg/L in the clay unit. This might result from adsorption of some constituents by the clay minerals in the clay unit.

Tables 4 and 5 contain analyses of water from selected wells and surface-water sites in the study area.

Human Interaction

Humans affect the quality of water in the study area in three general ways: by (1) importing water with chemical characteristics differing from the naturally occurring water, (2) introducing materials to the land surface and atmosphere which alter the natural chemical equilibrium, and (3) changing the quality of water during various types of water-use activities and discharging this changed water to the natural hydrologic system. However, as of 1976, human interaction had not caused any readily measurable change from natural conditions.

Concentrations of most dissolved constituents in water imported into the study area tend to be similar to those in the ground water deep beneath the area (table 3). The only significant differences in the imported water are lower concentrations of silica, chloride, and sodium plus potassium, and a higher concentration of sulfate.

Materials are added to the atmosphere by some human activities, particularly the burning of fossil fuels, which generally tends to increase the concentrations of chemical constituents in precipitation. The relatively high concentration of sulfate observed in direct runoff in the study area possibly reflects relatively high concentrations in precipitation, which may result from some industrial activities outside and upwind of the study area.

TABLE 3.--Average values of selected chemical constituents in various parts of the hydrologic system

Source of water	Milligrams per liter										Remarks
	Dissolved silica (SiO_2)	Dissolved iron plus manganese (Fe+Mn)	Dissolved calcium (Ca)	Dissolved magnesium (Mg)	Dissolved sodium plus potassium (Na+K)	Bicarbonate (HCO_3)	Dissolved sulfate (SO_4)	Dissolved chloride (Cl)	Dissolved fluoride (F)	Dissolved solids (residue at 180°C)	
Precipitation	No data available										All concentrations probably low. Dissolved solids probably <20 mg/L.
Surface water:											
Direct runoff	--	--	1.7	1.8	6.1	--	22	10	0.1	43	Average of two sites.
Streamflow (direct runoff plus spring flow)	--	--	10	7.6	11	48	18	12	.1	104	Average of two sites sampled on 3/2/76. Dissolved solids calculated.
Ground water:											
Shallow (average well depth 32 ft)	27	0.56	15	14	18	115	27	17	.1	162	Average of seven wells.
Springflow	--	--	23	17	16	150	14	17	.1	196	Average of two sites. Dissolved solids calculated.
Deep (average well depth 98 ft)	28	.59	27	23	23	218	19	23	.2	245	Average of 40 wells.
Freshwater-saltwater zone of diffusion	25	.70	11	15	564	716	150	420	.3	1570	Well 34/2-34R6.
Seawater	2.4	.01	320	1000	8600	110	2100	15,000	1.0	--	Calculated values based on Cl concentration of 15,000 mg/L (Wagner and others, 1957) and seawater constituent percentages (Mason, 1966).
Imported water (LaConner system)	13	.36	28	26	14	195	30	16	.1	224	Average of three samples.
Domestic sewage	--	--	38	28	86	--	45	56	--	438	Calculated average for domestic wastes. Used average increases in inorganic salts in domestic wastes (Miller and others, 1974), and applied increases to deep ground water and imported water on the basis of rate of use.

TABLE 4.--Concentrations of selected chemical constituents in water from selected wells

				Milligrams per liter									
Well number	Well depth (ft)	Date sampled	Data source[1]	Dissolved Iron (Fe)	Dissolved calcium (Ca)	Dissolved magnesium (Mg)	Dissolved sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Dissolved sulfate (SO_4)	Dissolved chloride (Cl)	Total Nitrate (N)	Remarks
34/2-2N1	90	08-12-76	G	0.82	17	14	52	203	12	16	--	
34/2-3G1	18	05-24-61	C	.23	10	17	--	112	14	30	0.25	In six earlier samples, Cl=15 or 16 mg/L.
34/2-3K1	200	11-29-62	C	--	13	17	18	121	22	12	.7	
34/2-15C1	150	02-13-73	S	.23	25	19	17	183	4.5	12	.45	Fe=0.95 mg/L on 3/11/76.
34/2-15R1	143	08-17-76	G	.53	43	23	18	237	19	14	--	
34/2-22E1	107	03-09-76	G	.03	21	61	--	--	--	45	--	
34/2-24F7	35	02-13-73	S	.16	36	22	20	217	31	15	.68	
34/2-26F1	40	02-13-73	S	1.0	12	26	11	131	8.3	16	.02	Fe=0.07 mg/L on 3/11/76.
34/2-27D6	177	10-22-75	G	.10	15	29	--	--	--	22	--	
34/2-27D11	141	03-09-76	G	.02	18	24	--	--	--	22	--	
34/2-27K3-5	48-54	01-27-75	S	.12	48	32	--	268	70	28	.5	Composite sample, K3, 4+5.
34/2-27L1	99	08-09-74	S	.01	36	11	--	128	14	32	.7	Na=26 mg/L.
34/2-27Q2+3	117	12-30-74	S	.00	26	27	--	216	22	28	.44	Composite sample, Q2+3.
34/2-34A2	99	10-22-75	G	.18	22	19	--	--	--	20	--	
34/2-34B1	112	01-26-76	G	--	27	20	21	189	9.9	22	--	Fe=0.06 mg/L on 10/22/75.
34/2-34H1	53	12-30-74	S	.00	29	16	--	146	24	13	.44	Na=14 mg/L.
34/2-34J1	160	03-09-76	G	.10	26	20	--	--	--	15	--	
34/2-34R6	200	01-26-76	G	.68	11	15	564	716	150	410	--	
34/2-34R7	75	10-22-75	G	.10	22	9.5	--	--	--	43	--	
34/2-34R9	80	11-16-76	G	.11	26	29	23	206	20	25	.00	
34/2-35E1	110	01-26-76	G	--	27	20	16	181	10	14	--	Fe=0.14 mg/L on 3/9/76.
34/2-35G1	138	10-31-72	S	.18	27	30	19	232	24	17	.76	Fe=1.8 mg/L on 3/9/76.
34/2-35G3	35	10-11-72	S	.46	22	7	16	112	57	7.5	<.01	
34/2-35G4	120	03-09-76	G	5.9	29	19	--	--	--	11	--	
34/2-35H2	84	03-09-76	G	.04	20	15	--	--	--	15	--	
34/2-35L1	130	03-09-76	G	1.6	27	20	--	--	--	14	--	

[1]G = U.S. Geological Survey, S = Washington State Department of Social and Health Services, C = Consulting firm of Robinson and Noble, Tacoma, Washington.

TABLE 5.--Water-quality characteristics at site 1 on Snee-oosh Creek and site 2 on Munks Creek

			Milligrams per liter							
Site number	Date sampled	Dis-charge (ft^3/s)	Dis-solved calcium (Ca)	Dis-solved magnesium (Mg)	Dis-solved sodium (Na)	Dis-solved potas-sium (K)	Bicar-bonate (HCO_3)	Dis-solved sulfate (SO_4)	Dis-solved chlo-ride (Cl)	Dis-solved fluo-ride (F)
1	03-02-76	0.51	9.8	7.9	10	2.1	46	18	14	0.1
	05-21-76	.17	17	14	13	2.6	103	11	18	.2
	08-26-76	.09	23	18	15	2.4	153	15	19	.1
	09-24-76	.07	21	19	16	2.5	150	15	19	.1
	12-16-76	.15	22	20	15	2.3	145	16	21	--
2	03-02-76	.59	11	7.4	9.0	1.2	49	19	11	.1
	05-21-76	.16	22	15	13	1.9	148	12	13	.1
	08-26-76	.12	24	15	13	2.0	148	13	14	.1
	09-24-76	.13	23	15	13	2.1	148	12	15	.1
	12-16-76	.13	23	17	13	2.0	144	14	15	--

	Milligrams per liter								
	Total nitrate (N)	Total nitrite (N)	Total ammonia (N)	Total phos-phorus (P)	Hard-ness (Ca,Mg)	pH (units)	Temper-ature (°C)	Turbidity (NTU)	Dis-solved oxygen (mg/L)
(site 1 continued)	0.91	0.01	0.40	0.07	57	7.2	3.4	2	12.2
	.62	.02	.15	.15	100	7.6	8.6	2	11.9
	.49	.01	.06	.18	130	--	11.4	0	10.4
	.41	.01	.06	.17	130	--	11.5	15	10.2
	.78	.01	.06	.14	140	--	8.8	1	10.8
(site 2 continued)	.59	.01	.06	.04	58	7.5	3.5	3	12.6
	.01	.01	.02	.07	120	8.5	9.0	1	11.8
	.11	.00	.03	.08	120	--	10.6	0	11.1
	.06	.00	.12	.07	120	--	10.8	1	10.5
	.31	.00	.02	.07	130	--	9.0	1	11.1

Other human activities introduce materials at or near the land surface which may react with water and change the natural concentrations of some chemical constituents. In the study area, these activities include the application of fertilizers, pesticides, and insecticides, and leakage from pipelines. The relative effects of these activities in the study area are unknown, but appear to be insignificant in terms of causing any substantial changes in the average concentration of the chemical constituents in water in any part of the hydrologic system.

The water used by humans often undergoes radical change in water quality before being disposed. The approximately 0.02 ft^3/s of water used for irrigation (mostly lawns and small gardens) modifies the natural water-quality cycle by applying to the land water--usually imported or from wells--that has greater concentrations of dissolved substances than the water naturally applied as precipitation.

About 0.17 ft^3/s of the water used for domestic purposes becomes domestic sewage. Of this, 0.05 ft^3/s is collected in sewer systems, treated, and released to saltwater bodies, thus creating no significant changes in the natural water quality. However, the remaining 0.12 ft^3/s of domestic sewage is discharged to septic tanks and cesspools. The quality of this sewage is markedly different than that of the water before use, including greater concentrations of sodium plus potassium, sulfate, chloride, and dissolved solids (table 3). As of 1976, this domestic sewage probably had little effect on the average water quality in the hydrologic system. An estimate of the general magnitude of the effect can be made by calculating the change in concentration of dissolved solids caused by the sewage. Assuming a straight mixing of sewage and natural ground water--0.12 ft^3/s of sewage with a dissolved-solids concentration of 438 mg/L, and 8.0 ft^3/s of natural ground water (average rate of ground water recharge) with a dissolved-solids concentration of 162 mg/L--the mixture would have a concentration only 4.0 mg/L greater than that of the natural ground water. However, this calculation assumes total mixing within the system. At any point where sewage is released, the ground water would have a dissolved-solids concentration between that of the sewage and a total mixture.

Comparison to Drinking-Water Standards

On the basis of the available water-quality data, most of the water in the study area is chemically suitable for drinking without treatment. Table 6 lists the chemical standards for drinking water which went into effect in June 1977, in accordance with the Federal Safe Drinking Water Act (Public Law 93-523); also given are the number of sites and samples in the study area which have exceeded these standards in the past.

The maximum contaminant levels listed are of primary importance because they refer to concentrations of constituents which, if exceeded, may affect the health of consumers. The secondary recommended limits do not refer to health hazards but to concentrations of constituents which may affect the esthetic quality of the water.

The maximum contaminant level determined for turbidity has been exceeded in the study area. Water with high turbidity values is hazardous primarily because it may affect chlorination processes. However, most high turbidity values in ground water in the study area are probably related to oxidation of dissolved iron after pumping, and therefore do not indicate any significant health hazard.

One high arsenic concentration, 11 times the maximum contaminant level, was observed in water from a spring issuing from bedrock near an abandoned strontium mine. The water also contained a very high concentration of strontium (1.1 mg/L) and, based on analyses of the mined rock material, possibly also had relatively high concentrations of mercury and nickel.

The presence of coliform bacteria is the major water-quality problem in the study area. The problem is restricted primarily to shallow wells and surface water (table 7). Six of the eight shallow wells (46 ft deep or less) tested and all five of the surface-water sites tested showed the presence of coliform bacteria in at least one sample.

The secondary recommended limits of iron, manganese, chloride, dissolved solids, pH, and color have been exceeded in the study area. At the sites tested, iron and manganese were the most common problems, exceeding their recommended limits in 27 and 50 percent, respectively, of the samples tested. Large concentrations of either of these two constituents often create a bad taste, stain plumbing fixtures and laundry, and cause clogging of pumps and pipes.

The recommended limits of chloride, dissolved solids, and pH were exceeded only in water from well 34/2-34R6. The bottom of this well is in the freshwater-saltwater zone of diffusion, where these conditions are expected. Large concentrations of chloride and dissolved solids may also exist in other parts of the study area. When well 34/2-35L1 was being drilled in 1972, layers of "brackish water-bearing sand" were reportedly encountered in the clay unit between 272 and 289 feet below land surface (37 to 54 ft below mean sea level). However, the well is located more than one-half mile inland and probably does not tap water within the zone of diffusion. The sand layers may have been deposited in a marine environment and may retain chemical characteristics between those of their original environment and the fresh ground water presently moving through the hydrologic system. It was not possible to test water from the sand because the well was backfilled and developed at a shallower depth after the brackish water was encountered.

High values of color (platinum-cobalt units) have presented no significant problems in the study area although water from three sites has exceeded the recommended limit. Values above the recommended limit can be esthetically undesirable for domestic use, and can be economically undesirable for some industrial uses.

TABLE 6.--Comparison of water quality in the study area with standards established by the Federal Safe Drinking Water Act

Constituent	Number of sites sampled	Number of samples tested	Water-quality standards: Maximum contaminant level[1]	Water-quality standards: Proposed secondary recommended limit[2]	Number of sites exceeding chemical standard	Number of samples exceeding chemical standard	Maximum value observed	Sites which have exceeded chemical standards
Iron	37	59	--	0.3 mg/L	10	12	5.9 mg/L	34/2-2N1,15C1,15R1,26F1,27K1, 34R6,35G1,35G3,35G4,35L1
Manganese	22	32	--	.05 mg/L	11	13	0.62 mg/L	34/2-3G1,15C1,27D11,34J1,34R9, 35E1,35G1,35G3,35G4,35H2,35L1
Sulfate	20	32	--	250 mg/L	0	0	150 mg/L	
Chloride	47	88	--	250 mg/L	1	3	440 mg/L	34/2-34R6
Fluoride[3]	30	45	1.4 to 2.4 mg/L	--	0	0	0.3 mg/L	
Nitrate	20	32	10 mg/L		0	0	1.0 mg/L	
Dissolved solids	15	20	--	500 mg/L	1	1	1,570 mg/L	34/2-34R6
pH	27	41	--	<6.5 or >8.5	1	1	range 6.7-8.6	34/2-34R6
Color	17	22	--	15 platinum-cobalt units	3	3	140 units	34/2-34R6,35G1,35G3
Turbidity[4]	16	28	1 JTU	--	6	9	16 JTU	34/2-15C1,26F1,35G1,35G3 Sites 1 and 2
Coliform bacteria[5]	13	24	1 col/100 mL	--	10	18	9,600 col/ 100 mL	33/2-3A4 Sites 1,2,3,5 and 6 34/2-23P1,24F1,24F7,35G3
Arsenic	1	1	0.05 mg/L	--	1	1	0.55 mg/L	33/2-2Q1s

[1] U.S. Environmental Protection Agency, 1975, National interim primary drinking water regulations are those which deal with constituents that may affect the health of consumers.

[2] U.S. Environmental Protection Agency, 1977, National secondary drinking water regulations. Secondary regulations are those which deal with the esthetic quality of drinking water, and are guidelines only.

[3] The maximum contaminant level for fluoride is dependent upon the annual average of the maximum daily air temperature at the location in which the water-supply system is situated; the mean air temperature at the Mount Vernon weather station (1956-76) was 50.1°F, and the average maximum daily air temperature was about 60°F. At temperatures of 58.4° to 63.8°F, the maximum contaminant level is 2.0 mg/L.

[4] Although the maximum contaminant level for turbidity applies only to surface water, the relatively high turbidities in ground-water samples on the reservation warrant inclusion in this summary.

[5] The maximum contaminant level depends upon the number of samples taken and the method of determination. The 1 col/100 mL level in the table is a convenient value for evaluating the small public and private systems in the study area.

TABLE 7.--Total coliform-bacteria in water from surface-water sites and selected wells

Water source		Total coliform bacteria (colonies/100 mL) 10-23-75	1-21-76	3-2-76	4-21-76	5-21-76	Remarks
Surface-water site							
1		360	--	88	--	4,400	Supplies one home.
2		420	--	64	--	2,600	Not used.
3		620	--	--	--	--	Supplies one home.
5		1,100	--	--	--	--	
6		--	--	--	--	9,600	----------DO----------
Well	depth (ft)						
33/2-3A4	28	1,200	13	--	< 1	--	Sanitary conditions of well were improved after sampling on 1/21/76.
34/2-10D1	--	1	< 1	--	--	--	
34/2-23P1	46	80	< 1	--	< 1	--	
34/2-24F1	22	> 2,000	--	--	--	--	
34/2-24F7	35	--	--	--	35	--	
34/2-26F1	40	--	--	--	< 1	--	
34/2-27K1	89	--	--	--	< 1	--	
34/2-35G3	35	265	40	--	60	--	Test for fecal coliform by Public Health Service on 12/3/75 was positive.

POTENTIAL FOR FURTHER DEVELOPMENT OF THE HYDROLOGIC SYSTEM

Of primary concern to those responsible for water management in the study area is the potential for increased ground-water withdrawals and the associated consequences, and the potential for aquiculture development.

Because the hydrologic system in the study area has never been significantly stressed, its reaction to potential future stresses imposed by man can be estimated only qualitatively. Any stress will produce a response by the system which is consistent with the hydrologic equation,

Inflow = outflow ± change in storage.

A change in any item in the equation will cause one or both of the other items to change. Although the equation is simple, the types and magnitudes of responses may be complex.

Development of the Ground-Water Reservoir

Below are discussed the potential for withdrawal of water from the ground-water reservoir and the resulting changes in the amount and paths of flow, and in quality of water in the hydrologic system.

Future changes in withdrawals of ground water in the study area must result in changes of inflow to, outflow from, or storage in the ground-water reservoir, in accordance with the hydrologic equation (shown above). The only significant inflow to the ground-water reservoir is recharge through the unsaturated zone. Under the existing near-natural conditions this annual recharge to the study area averages about 8.0 ft^3/s--equal to precipitation minus direct runoff and evapotranspiration from the land surface and unsaturated zone. This is the present maximum average rate of withdrawal possible without reducing the volume in storage. However, sustained large rates of withdrawal in areas where the water table is very near the land surface may result in an increased rate of recharge by allowing infiltration of water which under natural conditions would be rejected to become direct runoff.

A maximum average rate of withdrawal equal to total recharge is obviously unattainable; not all recharge can be captured by any practical development of the ground-water system. A system of properly spaced wells might be able to intercept about 20 percent of the recharge, or about 1.6 ft^3/s.

Withdrawals of ground water must be accompanied by decreases in the natural forms of outflow from the ground-water reservoir (subsurface outflow, spring flow, and ground-water evapotranspiration). Because such decreases in outflow might adversely affect other parts of the hydrologic system, it is important to consider the maximum average rate of withdrawal that can be attained without producing undesirable results. Perhaps the most important undesirable result would be decreases in springflow, which is a significant part of the total flow in Snee-oosh and Munks Creeks. Decreases in flows of these streams would adversely affect their potential for development of aquiculture activities.

The above discussion of ground-water withdrawal is based on the assumption that all water pumped from the ground-water reservoir is completely removed from the hydrologic system, such as water discharged to saltwater bodies through sewer systems. However, if the withdrawn water follows the other available paths shown in figure 20 and is applied at the land surface or discharged to the unsaturated zone, some of the water becomes ground-water recharge, thus making the net withdrawal from the ground-water reservoir less than the actual amount pumped.

When the withdrawn water is recycled in this manner, the factor of water quality must be considered. Each time the water is pumped from the ground-water reservoir, used, and returned, its quality probably will deteriorate. The types of water use, methods of treatment (if any), and methods of disposal will be the key factors in the types and magnitudes of water-quality changes produced.

Listed below are some general recommendations regarding development of the ground-water reservoir. These recommendations and listed related considerations, both favorable and unfavorable, are based primarily on hydrologic factors and do not take into account any associated economic and legal factors.

1. Development of well fields should be in the recharge areas in the central inland part of the study area--probably in secs. 15,22,23, and 26 of T.34 N., R.2 E. These wells should be developed in the stratified drift aquifer.

   a. This part of the study area is apparently underlain by the thickest part of the stratified drift where the greatest yields should be attainable with the fewest wells.
   b. This might increase the rate of recharge over that of natural conditions.
   c. By developing in the inland areas, with well bottoms far above mean sea level, induced saltwater encroachment can be avoided.
   d. Development in this area may result in significant decreases in springflow.

2. Most of the water withdrawn from the ground-water reservoir should be discharged to the unsaturated zone (via septic tanks and drain fields) or to the land surface.

   a. This should increase recharge, significantly reducing the net withdrawal.
   b. This might result in deterioration of water quality.

3. Water discharged to the land surface, unsaturated zone, or ground-water reservoir may require treatment before being discharged.

   a. This will help maintain good water quality.
   b. Water discharged near the recharge areas will require the most treatment (possibly being recycled several times), and water discharged near areas of outflow from the hydrologic system will require the least treatment, or possibly no treatment.

Any form of major development in the study area should be studied in terms of its possible effects on the ground-water reservoir before implementation.

Activities which affect the land surface may alter the rates of direct runoff, ground-water recharge, and evapotranspiration. For example, paving large areas might increase direct runoff and decrease ground-water recharge, whereas removal of large areas of natural vegetation might decrease evapotranspiration and increase ground-water recharge.

The use of substances and facilities in the study area may endanger water quality. For example, (1) pesticides, insecticides, and fertilizers may infiltrate to and contaminate the ground-water reservoir, and (2) pipelines carrying petroleum products, sewage, and other undesirable substances may leak, resulting in infiltration and contamination of the underlying ground water.

Therefore, any major development of the ground-water reservoir should be accompanied by:

1. Development of a steady-state model to evaluate the interactions of natural and manmade stresses in this complex hydrologic system.

2. Planned programs of data collection to monitor the effects of the development.

   a. In conjunction with large rates of withdrawal, water levels should be periodically measured in pumped wells and unpumped observation wells to determine any changes in the water-table configuration and the distribution of freshwater hydraulic head.
   b. In conjunction with major discharges of used water to the land surface, unsaturated zone, or ground-water reservoir, water samples should be collected and analyzed to determine any water-quality changes.

Aquiculture Potential

A report evaluating the aquiculture potential of the two largest streams in the study area was completed in April 1977 by the U.S. Fish and Wildlife Service, using data collected by their personnel and by U.S. Geological Survey personnel during this study. Below is a summary of the report by Michael Camp (written commun., 1977).

Although a greater volume of water would be more desirable, both Snee-oosh and Munks Creeks have potential for Netart salmon propagation. Snee-oosh Creek is near the Swinomish fishtraps, which would ease egg-taking and harvesting of returning adults. The Swinomish Channel, into which Munks Creek flows, is a saltwater remnant of a reach of the Skagit River which once supported a large run of salmon. The U.S. Army Corps of Engineers built a jetty on this channel in 1937, changing the flow pattern and diverting the salmon run away from the channel.

Streamflow records indicate that during December-March sufficient flow is available in both creeks to support incubation stations, each handling up to 600,000 eggs and rearing facilities with 400-pound capacities. The incubation capacity is based on requirements of 0.06 ft^3/s of flow and one complete water change per hour. Dissolved-oxygen concentrations (table 5) and water temperatures (fig. 20) also appear suitable for such use.

The small creek channels would seem to limit salmonid production to pink, chum, or fall chinook, which do not require extended freshwater rearing. Average expected return rates of adult salmon are generally 0.1 to 0.5 percent for unfed pink and chum salmon and 0.05 to 0.25 percent for fall chinook. Using the average of these figures, and a 20-percent egg-to-fry mortality rate, probable adult returns to each creek from maximum production of unfed fry would be 720 fall chinook or 1,440 pink or chum salmon. Adult returns could perhaps be doubled if the fry are fed and if successive releases are made to allow the fish to attain 2 inches in length before the final release.

During the winter of 1976-77, the Swinomish Tribe successfully incubated 120,000 chum eggs in Munks Creek in a 4-foot by 16-foot by 2-foot Netart box. Sediment proved to be the major difficulty encountered but settling basins, filters, or other mechanical devices probably could alleviate the problem.

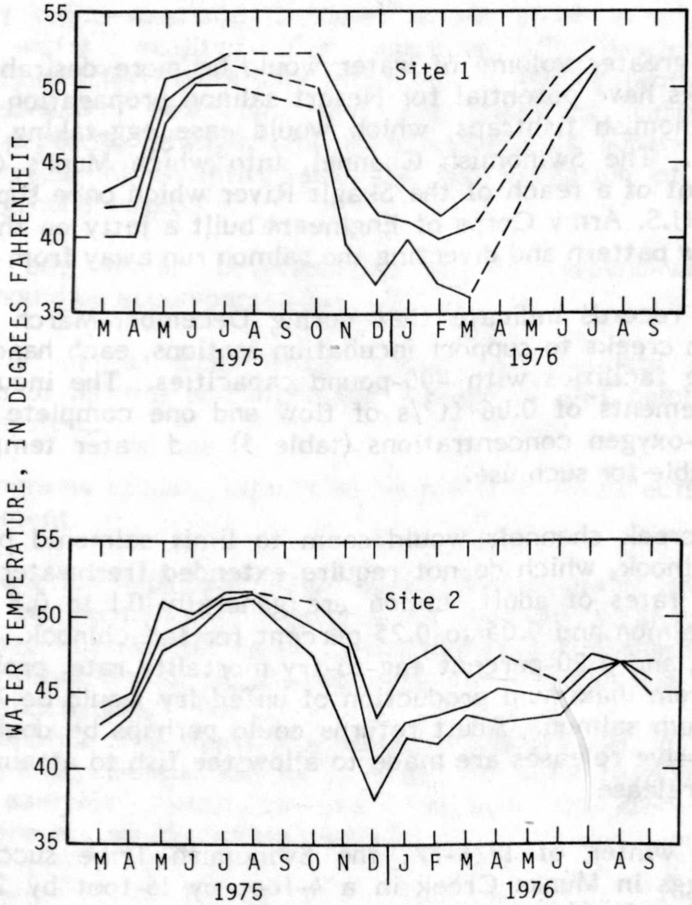


FIGURE 20.--Maximum, mean, and minimum monthly water temperatures at site 1 on Snee-oosh Creek and site 2 on Munks Creek.

The cost of a Netart hatchery facility varies according to the method of incubation, type of materials, cost of manpower, and amount of production, but generally ranges from \$10,000 to \$25,000 for each million eggs incubated. Variations in return rates and adult fish prices make estimation of a benefit-to-cost ratio difficult, but it has been found to range between 2 to 1 and 4 to 1 for hatcheries of suitable size for Snee-oosh and Munks Creeks.

The type of aquiculture development suggested above by the U.S. Fish and Wildlife Service would impose no significant stress on the hydrologic system of the study area. The natural streamflow would be used very near the points of natural discharge from the system. Some changes in water quality would probably result from the presence of the fish at the mouths of the creeks involved, but these changes would have a minimal effect on the system.

REFERENCES CITED

Brown, R. H., 1963, Estimating the transmissibility of an artesian aquifer from the specific capacity of a well, in Bentall, R., Compiler, Methods of determining permeability, transmissibility, and drawdown: U.S. Geological Survey Water-Supply Paper 1536-I, p.336-338.

Easterbrook, D. J., 1968, Pleistocene stratigraphy of Island County: Washington Dept. Water Resources Water Supply Bulletin 25, pt. 1, 34 p.

Franke, O. L., and McClymonds, N. E., 1972, Summary of the hydrologic situation on Long Island, New York, as a guide to water-management alternatives: U.S. Geological Survey Professional Paper 627-F, 59 p.

Hubbert, M. K., 1940, The theory of ground-water motion: Journal of Geology v. 48, p. 785-944.

Kohout, F. A., 1960, Cyclic flow of salt water in the Biscayne aquifer of southeastern Florida: Journal of Geophysical Research, v. 65, no. 7, p. 2133-2141.

Lohman, S. W., and others, 1972, Definitions of selected ground-water terms—revisions and conceptual refinements: U.S. Geological Survey Water-Supply Paper 1988, 21 p.

Mason, Brian, 1966, Principles of geochemistry 3d ed. : New York, John Wiley and Sons, Inc., 329 p.

Miller, D. W., DeLuca, F. A., and Tessier, T. L., 1974, Ground-water contamination in the northeast States: Environmental Protection Agency Technology Series, EPA-660/2-74-056, 325 p.

Ness, A. O., Buchanan, D. E., and Richins, C. G., 1960, Soil survey of Skagit County, Washington: U.S. Soil Conservation Service, Soil Survey Series 1951, no. 6, 91 p.

Riggs, H. C., 1969, Mean streamflow from discharge measurements: Bulletin of the International Association of Scientific Hydrology, v. XIV, no. 4, p. 95-110.

Theis, C. V., 1963, Estimating the transmissibility of a water-table aquifer from the specific capacity of a well, in Bentall, R., Compiler, Methods of determining permeability, transmissibility, and drawdown: U.S. Geological Survey Water-Supply Paper 1536-I, p. 332-336.

U.S. Department of Agriculture, 1970, Irrigation water requirements: U.S. Soil Conservation Service, Engineering Division, Technical Release no. 21, 79 p.

U.S. Environmental Protection Agency, 1975, National interim primary drinking water regulations: Federal Register, v. 40, no. 248, p. 59566-59588.

-----1977, National secondary drinking water regulations: Proposed regulations: Federal Register, v. 42, no. 62, p. 17143-17146.

U.S. National Oceanic and Atmospheric Administration, 1975, Tide tables 1976, high and low water predictions: 222 p.

Wagner, R. A., Ziebell, C. D., and Livingston, Alfred, III, 1957, An investigation of pollution in northern Puget Sound: Washington Pollution Control Commission Technical Bulletin 22, 27 p.

TABLE 8.--Drillers' logs of selected wells in and adjacent to the Swinomish Indian Reservation

33/2-2D2. Barbara Silverman. Drilled by Radke Well Drilling, July 1977. Altitude 90 ft.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Gravel	6	8
Gravel, cemented	35	43
Sand and gravel	51	94
Sand, water-bearing	5	99

Cased 6 inches to 94 ft. Screen 94-99 ft. Slot size 0.020 inches.

33/2-3A4. Daisy Damen. Drilled by Hilton Hayes, December 1963. Altitude 45 ft.

Material	Thickness (feet)	Depth (feet)
Topsoil	3	3
Sand and silt, brown, dry	7	10
Sand, brown, some water	5	15
Sand and coarse gravel, brown, water-bearing	13	28
Clay, gray	5	33

Cased 6 inches to 23 ft. Screen 23-28 ft. Slot size 0.020 inches.

33/2-3H1. Max Balich. Drilled by Radke Well Drilling, July 1975. Altitude 41 ft.

Material	Thickness (feet)	Depth (feet)
Topsoil	1	1
Clay and sand	14	15
Clay, blue	80	95
Clay, with thin, water-bearing, sand layers	12	107
"Hardpan"	1	108
Clay, with thin, water-bearing, sand layers	5	113
"Bedrock"	at	113

Cased 6 inches to 113 ft. Perforated 106-113 ft.

33/2-3H2. Ben Cribb. Drilled by Radke Well Drilling, 1973. Altitude 38 ft.

Material	Thickness (feet)	Depth (feet)
Topsoil	1	1
"Hardpan"	14	15
"Hardpan" and boulders	3	18
"Hardpan"	2	20
"Hardpan" and boulders	19	39
Clay, blue	29	68
"Hardpan"	22	90
Sand and gravel, water-bearing	2	92

33/2-3J3. R. Vanderstoep. Drilled by Hilton Hayes, June 1949. Altitude 37 ft.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Clay, sand, and gravel	13	15
Clay, soft, sand, and gravel	7	22
Sand and gravel, dry	2	24
Clay and boulders	9	33
Till, sandy	2	35
Clay, blue	7	42
Till and sand	2	44
Clay, sand and gravel, water-bearing	2	46
Till, sand and gravel	12	58
Slate, soft, blue	4	62
Slate, hard, blue	3	65
Shale, very hard, white	12	77

34/2-2N1. Test hole 1. Drilled by Dahlman Pump and Drilling, Inc., July 1976. Altitude 86 ft.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Clay, tan to brown, sand, and fine to medium gravel	12	14
Clay, gray, with some fine gravel	1	15
Clay, compact, brown, dry	3	18
Clay, blue-gray, and fine gravel	14	32
Clay, gray, with some sand and fine gravel	10	42
Clay, dark gray-brown, with some fine sand	10	52
Clay, brown, sand and fine gravel, partly cemented, dry	12	64
Sand and coarse gravel, with some brown clay	3	67
Sand and clay, brown	3	70
Sand and gravel, brown, some water	4	74
Sand and very coarse gravel, brown	6	80
Sand and gravel, gray	4	84
Sand and gravel, coarse, water-bearing	5	89
Clay, gray, very hard	11	100

Cased 6 inches to 84 ft 9½ inches. Screen 84 ft 9½ inches to 89 ft 10 inches. Slot size 0.040 inches.

34/2-2P1. Washington State Highway Department test hole. Drilled June 1968. Altitude 2 ft.

Material	Thickness (feet)	Depth (feet)
Silt, gray, and sand, fine, silty, alternating layers	3	3
Sand, fine, silty, gray, with lenses of organic matter and wood fragments	18	21
Sand, fine to very fine, silty, gray, with lenses of silt and organic matter and wood	89	110
Sand and silt, gray, with 2- to 6-inch layers of gray silt and clay, and layers of silty fine sand, organic matter, and wood fragments	47	157

TABLE 8.--Drillers' logs of selected wells in and adjacent to the Swinomish Indian Reservation--Continued

Material	Thick-ness (feet)	Depth (feet)
34/2-2Q1. Washington State Highway Department test hole. Drilled June 1968. Altitude 10 ft.		
Sand, fine, silty, gray	10	10
Sand, fine, silty	6	16
Sand, fine, silty, gray, with lenses of organic matter and wood fragments	13	29
Sand, fine to very fine, silty, gray, with lenses of silt and organic matter and wood	81	110
Casing pulled.		
34/2-3G1. Skagit County PUD No. 1. Drilled by A. G. Kounkel, February 1961. Altitude 15 ft.		
Sand	4	4
"Hardpan"	2	6
Gravel, coarse, and sand	12½	18½
Clay	½	19
Cased 8 inches to 13½ ft. Screen 13½-18½ ft. Slot size 0.040 inches.		
34/2-3K1. Skagit County PUD No. 1. Drilled by L. R. Gaudio, November 1955. Altitude 144 ft.		
Sand and gravel	5	5
"Hardpan," clay, and gravel	12	17
Sand and some gravel	16	33
Clay	6	39
Silt, sandy	5	44
Sand	21	65
Sand, compact	17	82
Clay	6	88
Sand, compact, and some gravel	18	106
Clay, sandy, blue, with layers of sticky clay	30	136
Gravel and coarse sand, water-bearing	11	147
"Hardpan," blue, with thin, water-bearing; streaks of sand and gravel	23	170
"Hardpan," blue	20	190
Clay, blue	10	200
Cased 8 inches to 200 ft. Perforated 140-170 ft.		
34/2-3K2. Sanderson - Skagit County PUD No. 1, test hole. Drilled by A. G. Kounkel(?), February 1961. Altitude 135 ft.		
Topsoil	4	4
"Hardpan," (till)	11	15
Sand, brown, dry	10	25
Gravel and sand	9	34
Clay, silty, blue	26	60
Clay, blue	22	82
Clay, silty, brown	13	95
Sand, brown, dry	11	106
Clay, blue	32	138
Sand and gravel, some water	2	140
Clay, blue and gray	30	170
Casing pulled(?).		
34/2-3P1. J. MacQueen. Dug by owner, 1963. Altitude 55 ft.		
"Hardpan"	5	5
Sand	10	15
34/2-3Q1. Skagit County PUD No. 1 test hole. Drilled by A. G. Kounkel(?), 1961 Altitude 149 ft.		
Clay	12	12
Sand, brown	14	26
Sand and gravel, "tight," brown	4	30
Sand and gravel, dark gray, some water	5	35
Clay, blue	50	85
"Hardpan"	1	86
Sand and gravel, "dirty," gray, dry	28	114
Sand and gravel,"dirty"	12	126
"Hardpan," gray	4	130
Clay, gray-blue	40	170
Casing pulled(?).		
34/2-11A1. Washington State Highway Department test hole. Drilled June 1968. Altitude 3 ft.		
Clay and silt, brown	2	2
Sand, fine to very fine, silty, gray, with lenses of silt, organic matter, and wood	152	154
Casing pulled.		

TABLE 8.--Drillers' logs of selected wells in and adjacent to the Swinomish Indian Reservation--Continued

Material	Thick-ness (feet)	Depth (feet)
34/2-11A2. Washington State Highway Department test hole. Drilled June 1968. Altitude 4 ft.		
Clay and silt, brown	2	2
Sand, fine, and silt, gray	5	7
Sand, fine to very fine, silty, gray, with lenses of silt, organic matter, and wood	109	116
Casing pulled.		
34/2-11A3. Washington State Highway Department test hole. Drilled June 1968. Altitude 0 ft; drilled in bottom of Swinomish Channel.		
Water, Swinomish Channel	18	18
Sand, fine to very fine, silty, gray, with lenses of silt, organic matter, and wood	126	144
Casing pulled.		
34/2-11B1. Washington State Highway Department test hole. Drilled June 1968. Altitude 0 ft; drilled in bottom of Swinomish Channel.		
Water, Swinomish Channel	19	19
Sand, fine, silty, gray, with traces of shells, fine gravel, and lenses of organic matter	35	54
Sand, fine to very fine, silty, gray, with lenses of silt, organic matter, and wood	100	154
Casing pulled.		
34/2-15C1. Larry Campbell. Drilled by Dahlman Pump and Drilling, Inc., August 1972. Altitude 193 ft.		
Topsoil	9	9
Clay, hard, brown, and gravel	31	40
Clay, blue	9	49
Clay, brown, and some coarse gravel	6	55
"Hardpan," blue	12	67
Clay, brown, sand and gravel	10	77
Gravel, water-bearing	37	114
Clay and gravel	11	125
Sand and wood	2	127
Clay, blue	18	145
Sand, water-bearing	3	148
Clay, blue	17	165
Cased 6 inches to 143 ft. Screen 143-148 ft.		
34/2-15L1. Charles Johnson. Drilled by Dahlman Pump and Drilling, Inc., June 1974. Altitude 240 ft.		
Topsoil	6	6
Clay, blue, and gravel	24	30
Clay, gray, and gravel	125	155
Gravel	14	169
Clay, brown, and gravel	20	189
Gravel	12	201
Clay	at	201
Cased 6 inches to 195 ft. Screen 195-200 ft. Slot size 0.040 inches.		
34/2-15R1. Test hole 2. Drilled by Dahlman Pump and Drilling, Inc., August 1976. Altitude 234 ft.		
Clay, sand and gravel, gray-brown, dry	10	10
Clay, gray	2	12
Clay, sand and gravel, very hard from 20 to 25 ft	63	75
Sand and clay, brown	6	81
Sand, brown, with some silt and clay, dry	3	84
Sand and gravel, some clay, dry	32	116
Sand and gravel, brown, water-bearing	17	133
Sand and gravel, gray, water-bearing	9	142
Clay, blue-gray, with some sand and gravel	20	162
Clay, gray-tan-brown, gray sand, and fine gravel, with scattered organic material	7	169
Clay and sand, gray, some fine gravel, and wood chips	6	175
Clay and silt, gray	3	178
Clay and silt, gray, with organic material, dry	4	182
Clay and silt, gray, with some brown clay	6	188
Clay and sand, gray	35	223
Clay and sand, gray, harder than above	7	230
Cased 6 inches to 133 ft. Screen 133-143 ft. Slot size 0.030 inches.		
34/2-21H10. Ken Evans. Drilled by Dahlman Pump and Drilling, Inc., December 1977. Altitude 45 ft.		
Clay and gravel	51	51
Clay, sand, and rock	9	60
Clay and gravel	6	66
Gravel	7	73
Sand	3	76
Cased 6 inches to 71 ft. Screen 71-76 ft. Slot size 0.015 inches.		

TABLE 8.--Drillers' logs of selected wells in and adjacent to the Swinomish Indian Reservation--Continued

Material	Thickness (feet)	Depth (feet)
34/2-21J9. Glenn Skomerza. Drilled by Radke Well Drilling, August 1977. Altitude 25 ft.		
Topsoil	1	1
"Hardpan"	20	21
Gravel	4	25
"Hardpan"	40	65
Clay and gravel	20	85
Sand, water-bearing	8	93
Cased 6 inches to 88 ft. Screen 88-93 ft. Slot size 0.018 inches.		
34/2-22E1. Ray Charles. Drilled by Hilton Hayes, December 1963. Altitude 98 ft.		
Clay, yellow	6	6
Till, gravelly, yellow	9	15
Till, gravelly, gray	10	25
Clay, sand and gravel	9	34
Clay, sand and gravel, light gray, some water	40	74
Clay, soft, light gray, sand and gravel	19	93
Clay, sand and gravel	8	101
Sand and gravel, gray, water-bearing	6	107
Clay	at	107
34/2-22E3. Henry Smith. Drilled by Dahlman Pump and Drilling, Inc., September 1977. Altitude 120 ft.		
Clay and gravel	125	125
Gravel and sand	8	133
Cased 6 inches to 127 ft. Screen 127-132 ft. Slot size 0.020 inches.		
34/2-22N1. Robert Misner. Drilled by Hilton Hayes, January 1948. Altitude 34 ft.		
Clay and till	28	28
Sand, coarse, "heaving"	3	31
Till, sand and gravel	19	50
Sand and gravel, water-bearing	2	52
34/2-22N2. H. Kristofferson. Drilled by Hilton Hayes, January 1948. Altitude 36 ft.		
Topsoil and gravel	2	2
Till, gravel and clay, hard	13	15
Till, hard, and gray sand	10	25
Sand and clay	5	30

(continued)

Material	Thickness (feet)	Depth (feet)
34/2-22N2--Continued		
Gravel, sand and clay	4	34
Sand and clay	18	52
Sand, hard, and clayey till	10	62
Sand and gravel, water-bearing	2	64
Clay	at	64
34/2-22N3. Pat Hulbert. Drilled by Hilton Hayes, February 1948. Altitude 32 ft.		
Topsoil, sandy	2	2
Clay, yellow	8	10
Till, gray, sand and gravel	12	22
Till, hard, sand and gravel	8	30
Sand, hard	4	34
Sand, gravel and clay	5	39
Sand and gravel, water-bearing	3	42
34/2-22N6. Mrs. Robert J. Hulbert. Drilled by Dahlman Pump and Drilling, Inc., September 1977. Altitude 40 ft.		
Topsoil	2	2
Sand and gravel, dirty	8	10
Clay, blue, and gravel	65	75
Sand	3	78
Cased 6 inches to 72 ft. Screen 72-77 ft. Slot size 0.015 inches.		
34/2-23F1. Roger Cayou. Drilled by Hilton Hayes, December 1963. Altitude 245 ft.		
Topsoil	3	3
Clay, brown	7	10
Till, brown	4	14
Sand and clay, brown	8	22
Clay and gravel, tan	12	34
Gravel and sand, dry	26	60
Till, gravelly, gray	20	80
Gravel, dry	6	86
Till, gravelly, gray	9	95
Gravel, dry	5	100
Gravel, water-bearing	4	104
Clay, gray, and wood	6	110
Clay, light tan	6	116
Clay, dark tan	8	124
Till, sandy, tan, and wood	8	132
Gravel and sand, firm, water-bearing	3	135
Clay	at	135

TABLE 8.--Drillers' logs of selected wells in and adjacent to the Swinomish Indian Reservation--Continued

Material	Thickness (feet)	Depth (feet)
34/2-23L1. Albert Irvine. Drilled by Hilton Hayes, November 1963. Altitude 254 feet.		
Topsoil, sandy, dark brown	6	6
Silt and clay, light tan	4	10
Clay, sandy, yellow	6	16
Till and coarse gravel, tan	4	20
Sand, gravel and clay	9	29
Till, gravelly, soft, gray-tan	12	41
Clay, dark tan	8	49
Clay and gravel, dark tan	15	64
Gravel and sand, some silt and clay, tan, some water(?)	3	67
Clay, sand, and gravel, dry	7	74
Clay and sand, yellow	18	92
Gravel and sand, water-bearing	1	93
Clay, yellow	7	100

Cased 6 inches to 92 ft. Open end.

Material	Thickness (feet)	Depth (feet)
34/2-24F6. Lorraine Grossglass. Drilled by Dahlman Pump and Drilling, Inc., September 1972. Altitude 70 ft(?).		
Clay, brown, with some sand	35	35
Clay, blue	89	124
Sand and clay	20	144
Sand, coarser than above and clay	2	146
Sand and clay	52	198
Sand, coarser than above	5	203
Clay, blue	5	208

Casing pulled.

Material	Thickness (feet)	Depth (feet)
34/2-24M1. Test hole 3. Drilled by Dahlman Pump and Drilling, Inc., August 1976. Altitude 175 ft.		
Sand, gravel and clay, brown-gray	10	10
Sand and clay, gray-brown	8	18
Sand, gravel and clay, sticky, gray-brown, dry	10	28
Sand and clay, light brown	8	36
Sand, gravel and clay, light brown	13	49
Sand, silty, light brown	5	54
Sand, gravel and clay, light brown	20	74
Sand and clay, light brown	1	75
Sand, gravel and clay, light brown	1	76
Sand, gravel and clay, dark brown	4	80
Sand, gravel and clay, light brown	17	97
Sand and gravel, some blue-gray clay, some water	2	99
Clay, blue-gray, with lenses of sand and gravel	16	115
Clay, sticky, blue-gray, dry	35	150

Cased 6 inches to 99 ft. Open end.

Material	Thickness (feet)	Depth (feet)
34/2-25C1. Norval Charles. Drilled by Hilton Hayes, December 1963. Altitude 125 ft.		
Topsoil	1	1
Sand and gravel, brown	2	3
Sand, clay, and gravel, soft, brown	17	20
Gravel and sand, some silt and clay, brown, water-bearing	1	21
Sand, coarse, and fine gravel, gray, water-bearing	10	31

Cased 6 inches to 26 ft. Screen 26-31 ft. Slot size 0.030 inches.

Material	Thickness (feet)	Depth (feet)
34/2-26C1. Gasper Dan. Drilled by Hilton Hayes, November 1963. Altitude 273 ft.		
Silt and sand, brown	4	4
Till, gravelly, brown	6	10
Silt and sand, hard, gray	8	18
Sand, silt, and clay, soft, gray	16	34
Silt and sand, brown	5	39
Gravel, medium to coarse, water-bearing	7	46
Sand and gravel	at	46

Material	Thickness (feet)	Depth (feet)
34/2-26F1. Alfred Edwards. Drilled by Hilton Hayes, November 1963 (to 36 ft). Deepened by Dahlman Pump and Drilling, Inc., August 1972. Altitude 281 ft.		
(Hayes log)		
Sand and gravel, tan	4	4
Till and "rocks," brown	3	7
Till and "rocks," light tan	8	15
Clay, sand, and gravel, light tan	9	24
Sand, soft, brown, water-bearing	8	32
Gravel, water-bearing	4	36
Sand and clay, brown, dry	at	36
(Dahlman log)		
Gravel and sand	4½(?)	38
Unknown	½	38½
Gravel, dry	4½	43

Cased 6 inches to 33½ ft. Screen 33½-38½ ft. Slot size 0.015 inches.

Material	Thick-ness (feet)	Depth (feet)
34/2-26F2. Carmen Scoleri. Drilled by Radke Well Drilling, March 1977. Altitude 265 ft.		
Topsoil	2	2
"Hardpan" and gravel	13	15
"Hardpan"	5	20
Clay, sandy	20	40
"Hardpan"	13	53
Sand	5	58
Clay, brown	12	70
Gravel, dry	75	145
Sand, water-bearing	16	161
Cased 6 inches to 156 ft. Screen 156-161 ft. Slot size 0.015 inches.		
34/2-27D2. C. Johnson. Drilled by Hilton Hayes, December 1947 (to 56 ft). Deepened by Hayes, June 1949. Altitude 16 ft.		
Clay, gray	10	10
Till and boulders, water-bearing streak at 28 ft	44	54
Sand, water-bearing	2	56
Till, sand, and gravel, dry	5	61
Sand and gravel, dry	7	68
Sand and gravel, water-bearing	2	70
Gravel and sand, water-bearing	2	72
34/2-27D6. L. Hughes. Drilled by Dahlman Pump and Drilling, Inc., March 1975. Altitude 68 ft.		
Sand and gravel, "dirty"	57	57
Sand and gravel	5	62
Sand and gravel, "dirty"	72	134
Clay, sand, and gravel	38	172
Sand and gravel, water-bearing	5	177
Clay and sand	6	183
Cased 6 inches to 172 ft. Screen 172-177 ft. Slot size 0.015 inches.		
34/2-27D10. W. F. Grobschmit. Drilled by Hilton Hayes, April 1949. Altitude 29 ft.		
Topsoil, gravelly	1	1
Gravel, "cemented," and boulders	30	31
Gravel and sand	2	33
Clay, gravel and sand, hard	12	45
Sand, "cemented"	5	50
Clay, gravel and sand, softer than above	5	55
Clay and sand, softer than above	4	59
Boulder	1	60
Sand and clay	3	63
Sand and gravel	4	67

(continued)

Material	Thick-ness (feet)	Depth (feet)
34/2-27D10.--continued		
Clay, sandy	3	70
Sand, "cemented"	5	75
Sand and gravel, soft, water-bearing	3	78
Cased 6 inches to 75 ft. Open end.		
34/2-27D11. David Bedingfield. Drilled by Dahlman Pump and Drilling, Inc., September 1975. Altitude 26 ft.		
Clay, brown, and gravel	54	54
Gravel	2	56
Clay, blue, and gravel	61	117
Boulder	1	118
Clay, sandy	22	140
Sand, water-bearing	1	141
Cased 6 inches to 141 ft. Open end.		
34/2-27F2. Reef Point Community. Drilled by Hilton Hayes, April 1964. Altitude 42 ft.		
Topsoil	2	2
Sand, gravel and clay, brown	6	8
Clay and coarse gravel	6	14
"Hardpan," gravelly, gray	10	24
Gravel and sand, some water	2	26
"Hardpan," sandy, gray	8	34
Gravel, some water	1	35
Clay, sand and gravel, gray	45	80
Gravel and sand, water-bearing	2	82
"Hardpan," gravelly	10	92
Gravel and sand, water-bearing	2	94
Clay, "shaley"	4	98
"Shale"	5	103
Cased 6 inches to 98 ft. Perforated 24-26 ft, 34-35 ft, 80-81 ft, and 92-94 ft.		
34/2-27K1. Snee-Oosh Land Co. Drilled by N. C. Jannsen, November 1928(?). Altitude 48 ft.		
Clay, boulders and gravel	12	12
Gravel	8	20
Gravel and clay	15	35
Gravel, loose	5	40
Gravel and sand	33	73
"Bedrock," black	16	89
Cased 6 inches to 73 ft(?). Perforated(?) and open end.		

TABLE 8.--Drillers' logs of selected wells in and adjacent to the Swinomish Indian Reservation--Continued

34/2-27K4. Snee-Oosh Land Co. Drilled by Hilton Hayes, November 1957. Altitude 44 ft.

Material	Thickness (feet)	Depth (feet)
Clay, yellow, and "hardpan"	4	4
Clay, yellow	4	8
Clay, gray	5	13
Sand and gravel, gray, and "hardpan"	13	26
Sand and gravel, soft, with silt and clay streaks	24	50
Gravel and coarse sand, water-bearing	1½	51½
Sand, fine, water-bearing	½	52
Gravel, coarse, water-bearing	2½	54½

Cased 6 inches to 54 ft. Open end.

34/2-27L1. Reef Point Community. Drilled by Hilton Hayes, February 1964. Altitude 40 ft.

Material	Thickness (feet)	Depth (feet)
"Hardpan," gravelly, gray	8	8
"Hardpan," light gray, and gravel	3	11
Clay, gray, sand and gravel	18	29
Gravel, coarse, some water	7	36
Silt and sand	11	47
Silt and gravel	7	54
"Hardpan," gravelly	2	56
Sand, fine, and gravel with streaks of dry sand, clay and gravel	15	71
Gravel, coarse, dry	2	73
Clay and gravel, sandy	3	76
Gravel, coarse, some water	4	80
Gravel and coarse sand, some water	12	92
Clay, sand and gravel, dry	2	94
Sand and fine gravel, "heaving"	2	96
"Hardpan"	2	98
Gravel, medium, and sand, water-bearing	1	99
"Hardpan"	at	99

Cased 6 inches to 98 ft. Perforated 29-34 ft. Open end.

34/2-27L2. Paul Wagner. Drilled by Dahlman Pump and Drilling, Inc., June 1977. Altitude 50 ft.

Material	Thickness (feet)	Depth (feet)
Clay and gravel	101	101
Sand and gravel	12	113

Cased 6 inches to 107 ft. Screen 107-112 ft. Slot size 0.040 inches.

34/2-27M1. Snee-Oosh Land Co. Drilled by Floyd Holmes, May 1953. Altitude 35 ft.

Material	Thickness (feet)	Depth (feet)
"Hardpan"	10	10
Clay, "plastic," gray	8	18
Gravel, fine, some water	1	19
"Bedrock"	at	19

Casing pulled(?).

34/2-27M2. MacMillan Brothers. Drilled by N. C. Jannsen, May 1955. Altitude 20 ft.

Material	Thickness (feet)	Depth (feet)
Gravel and clay	15	15
Boulder and clay	10	25
Boulders and sand	5	30
Boulders and gravel	5	35
Boulders, hard	5	40
"Bedrock"	90	130

Casing pulled(?)

34/2-27P1. Snee-Oosh Land Co. Drilled by N. C. Jannsen, October 1928. Altitude 20 ft.

Material	Thickness (feet)	Depth (feet)
Clay	30	30
Boulder	3	33
Clay with gravel streak	5	38
"Bedrock," black (metargillite?)	80	118
"Granite"	10	128
"Bedrock," black	322	450

Casing pulled(?).

34/2-27P2. MacMillan Brothers. Drilled by N. C. Jannsen, February 1929. Altitude 35 ft.

Material	Thickness (feet)	Depth (feet)
Gravel and clay	15	15
"Bedrock," black (metargillite?)	5	20

Casing pulled(?).

TABLE 8.--Drillers' logs of selected wells in and adjacent in the Swinomish Indian Reservation--Continued

Material	Thick-ness (feet)	Depth (feet)
34/2-27Q1. MacMillan Brothers. Drilled by N. C. Jannsen, February 1929. Altitude 46 ft.		
Clay and gravel	20	20
Gravel, some water	5	25
Gravel and boulders	5	30
Boulders and sand	7	37
"Bedrock," (metargillite?)	23	60
Casing pulled(?).		
34/2-27R1. F. L. Lombard. Drilled by Dahlman Pump and Drilling, Inc., 1972. Altitude 100 ft.		
Topsoil	10	10
Clay, blue	52	62
Clay and gravel	3	65
Gravel, water-bearing	8	73
Cased 6 inches to 69 ft. Screen 69-73 ft.		
34/2-27R2. Robert B. Clifton. Drilled by Dahlman Pump and Drilling, Inc., April 1965. Altitude 113 ft.		
Topsoil	2	2
Sand and clay	6	8
Gravel, dry	70	78
"Hardpan"	2	80
Sand and gravel, water-bearing	5	85
Cased 6 inches to 82 ft. Screen 82-85 ft. Slot size 0.025 inches.		
34/2-27R3. Robert B. Clifton. Drilled by Dahlman Pump and Drilling, Inc., November 1974. Altitude 111 ft.		
Sand and gravel	46	46
Gravel	1	47
Clay	20	67
Gravel, sandy, water-bearing	5	72
Sand, fine	at	72
Cased 6 inches to 67 ft. Screen 67-72 ft. Slot size 0.030 inches.		

Material	Thick-ness (feet)	Depth (feet)
34/2-34A1. Louis Thorp. Drilled by Dahlman Pump and Drilling, Inc., April 1974. Altitude 36 ft.		
Silt and clay(?), brown	15	15
Clay, blue	33	48
Sand	½	48½
Clay, blue	36½	85
Sand and gravel, water-bearing	7	92
Sand, fine	at	92
Cased 6 inches to 84 ft. Screen 84-89 ft. Slot size 0.030 inches.		
34/2-34A2. Leroy Anderson. Drilled by Dahlman Pump and Drilling, Inc., April 1974. Altitude 38 ft.		
Clay, brown	15	15
Clay, blue	75	90
Sand and gravel, water-bearing	9	99
Cased 6 inches to 94 ft. Screen 94-99 ft. Slot size 0.015 inches.		
34/2-34A4. Joe Nelles. Drilled by Dahlman Pump and Drilling, Inc., April 1977. Altitude 37 ft.		
Clay and gravel	59	59
Sand, fine, and clay	8	67
Clay, blue	10	77
Sand, fine	1	78
Clay	11	89
Sand, water-bearing	6	95
Clay	at	95
Cased 6 inches to 90 ft. Screen 90-95 ft. Slot size 0.020 inches.		
34/2-34A5. Arberta Lammers. Drilled by Dahlman Pump and Drilling, Inc., October 1976. Altitude 50 ft.		
Topsoil	1	1
Gravel	29	30
Clay and gravel	15	45
Sand and gravel, wet	8	53
Clay, blue, and gravel	7	60
Clay, blue	43	103
Clay, blue, and gravel	24	127
Clay, blue	33	160
Cased 6 inches to 128 ft. Open end.		

TABLE 8.--Drillers' logs of selected wells in and adjacent in the Swinomish Indian Reservation--Continued

Material	Thick-ness (feet)	Depth (feet)
34/2-34R1. G. L. Everitt. Drilled by Hilton Hayes, July 1973. Altitude 32 ft.		
Clay, light gray, some water at 12 ft	14	14
Clay, gray, some gravel, some water at 21 ft	7	21
Sand, gravel and clay, brown, some water	6	27
Gravel, medium, gray, water-bearing	3	30
Clay, sand and gravel, tan	1½	31½
Sand, tan, and fine gravel, water-bearing	3½	35
Cased 6 inches to 32 ft. Screen 32-35 ft. Slot size 0.020 inches.		
34/2-34R2. C. P. Smith. Drilled by Radke Well Drilling, 1970. Altitude 43 ft.		
"Hardpan"	4	4
Clay, sandy	7	11
Sand, brown	3	14
Sand and gravel	16	30
Clay, sandy	18	48
Sand and gravel, some water	2	50
Clay, blue	44	94
Sand and gravel, some water	1	95
Open end. Perforated 48-50 ft.		
34/2-34R10. Greg Snelson. Drilled by Dahlman Pump and Drilling, Inc., January 1977. Altitude 65 ft.		
Sand, "dirty," and gravel	50	50
Sand, brown, and gravel	5	55
Clay, blue	63	118
Sand and gravel, water-bearing	7	125
Sand and gravel	5	130
Cased 6 inches to 125 ft. Open end.		
34/2-35H1. Chester J. Norkowski. Dug by owner, 1953. Altitude 178 ft.		
"Hardpan"	6	6
Sand, fine, brown	13	19
Sand and gravel, water-bearing	4	23
34/2-35H4. Maude Efeir. Drilled by Dahlman Pump and Drilling, Inc., September 1977. Altitude 170 ft.		
Topsoil	3	3
Clay, blue	102	105
Sand and gravel	5	110
Cased 6 inches to 105 ft. Screen 105-110 ft. Slot size 0.040 inches.		
34/2-35L1. James Sword. Drilled by Dahlman Pump and Drilling, Inc., September 1972. Altitude 235 ft.		
Clay, brown	29	29
Clay and gravel	24	53
Clay and sand	47	100
Clay, blue	2	102
Sand, coarse, dry	3	105
Gravel, fine, and coarse sand	16	121
Sand, coarse, and fine gravel, some water	8	129
Clay, soft, gray	143	272
Clay, hard, gray, with thin layers of brackish-water-bearing sand	17	289
Rock	at	289
Cased 6 inches to 123 ft(?). Screen 123-128 ft. Slot size 0.014 inches.		
34/2-35R1. Shelter Bay Development. Drilled by Hilton Hayes, December 1963. Altitude 80 ft.		
Gravel and silt, brown	3	3
Till, gravelly, brown	32	35
Boulders	2	37
Till, gravelly, brown	5	42
Till, sandy, gray	18	60
Till, gravelly, very hard, gray	10	70
Clay, wet(?)	1	71
Till, sandy, very hard, gray	14	85
Sand, fine, gray, and gravel, water-bearing	6	91
Sand	at	91
Cased 6 inches to 86 ft. Screen 86-91 ft. Slot size 0.020 inches.		
34/2-36E1. M. Sandstron. Dug by owner, 1923. Altitude 142 ft.		
"Hardpan"	35	35
Sand, water-bearing	12	47

TABLE 9.--*Records of selected wells in and adjacent to the Swinomish Indian Reservation*

[Use of water: C, commercial; F, fire protection; H, domestic; P, public supply; U, unused.
Water level: below land surface unless accompanied by a + which indicates above land surface; F, flowing; P, pumping, R, recently pumped; Z, affected by gas pressure.]

LOCAL NUMBER	OWNER	USE OF WATER	ALTITUDE OF LAND SURFACE (FEET)	DEPTH TO FIRST OPENING (FEET)	DEPTH OF WELL (FEET)	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED	SPECIFIC CAPACITY (GPM/FT)
33N/02E-02D01	--	H	85	--	3	2.00	11/19/1975	--
33N/02E-02D02	SILVERMAN, BARBARA	H	90	94	99	79.00	07/29/1977	1.1
33N/02E-02K01	DUNLAP, GENE	H	169	--	19	12.40 Z	04/20/1976	--
33N/02E-02Q01S	DUNLAP, GENE	U	10	--	--	--	--	--
33N/02E-03A01	PURTILL, R	H	28	--	25	8.00	07/29/1975	--
33N/02E-03A04	DAMEN, DAISY	H	45	23	28	5.00	12/12/1963	3.2
33N/02E-03H01	BALICH, MAX	H	41	106	113	27.50	07/25/1975	0.04
33N/02E-03H02	CRIBB, BEN H	H	38	--	92	25.15	08/25/1975	0.2
33N/02E-03H03	CORRIGAN, JOE	H	32	--	15	4.70	07/29/1975	--
33N/02E-03H04	LEE &, LOY	H	36	--	80	--	--	--
33N/02E-03H05	SATHER	H	30	--	--	--	--	--
33N/02E-03H06	GOSSETT, R	H	25	--	12	.00	07/29/1975	--
33N/02E-03H07	DYKERS	H	30	--	12	9.00	07/29/1975	--
33N/02E-03J01	BUCKINGER, C	U	35	--	43	22.60	07/29/1975	--
33N/02E-03J02	HOLLOMAN, W	U	45	--	--	--	--	--
33N/02E-03J03	VANDERSTOEP, R	H	37	--	77	35.27	07/29/1975	--
33N/02E-03J04	BESSNER, B	H	46	--	67	43.19	08/25/1975	--
34N/02E-02N01	SWIN-TRIBE	U	86	85	90	69.00	07/26/1976	4.5
34N/02E-02P01	HGWY DEPT	U	2	--	--	2.00	06/20/1968	--
34N/02E-02Q01	HGWY DEPT	U	10	--	--	10.00	06/13/1968	--
34N/02E-03G01	SKAGIT-PUD	P	15.0	14	19	0.72	02/27/1961	8.9
34N/02E-03G02	SDGL CO	--	117	--	106	100.00	1953	--
34N/02E-03G03	SDGL CO	--	16	--	11	5.50	11/15/1963	--
34N/02E-03K01	SKAGIT-PUD	P	144	140	200	132.00	11/15/1955	20.3
34N/02E-03K02	SKAGIT-PUD	U	135	--	170	--	--	--
34N/02E-03K03	BROWN, NATHAN	--	140	--	132	--	--	--
34N/02E-03L01	LARSON, J	H	90	--	108	73.68	07/23/1975	12.5
34N/02E-03L02	LARSON, J	H	32	--	44	--	--	--
34N/02E-03L03	LARSON, J	H	46	--	24	13.13	07/23/1975	--
34N/02E-03P01	MACQUEEN, J	H	55	--	15	1.00	07/23/1975	--
34N/02E-03Q01	SKAGIT-PUD	U	149	--	--	25.00	01/ /1961	--
34N/02E-03R01	DMNMILLER	H	76	--	72	57.00	07/23/1975	--
34N/02E-10D01	ASMUS, J	H	35	--	--	--	--	--
34N/02E-10D02	GLENN	H	18	--	6	5.00	07/23/1975	--
34N/02E-11A01	HGWY DEPT	U	3	--	--	3.00	06/07/1968	--
34N/02E-11A02	HGWY DEPT	U	4	--	--	4.00	06/12/1968	--
34N/02E-11A03	HGWY DEPT	U	0	--	--	--	--	--
34N/02E-11B01	HGWY DEPT	U	0	--	--	--	--	--
34N/02E-15C01	CAMPBELL, LARRY	H	193	143	150	108.50	03/11/1976	0.6
34N/02E-15D01	ANDRICH, NED	U	80	--	--	1.00	08/26/1975	--

TABLE 9.--Records of selected wells in and adjacent to the Swinomish Indian Reservation--Continued

LOCAL NUMBER	OWNER	USE OF WATER	ALTITUDE OF LAND SURFACE (FEET)	DEPTH TO FIRST OPENING (FEET)	DEPTH OF WELL (FEET)	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED	SPECIFIC CAPACITY (GPM/FT)
34N/02E-15L01	JOHNSON, CHARLES	H	240	195	200	184.00	06/12/1974	12.0
34N/02E-15R01	SWIN-TRIBE	U	234	133	143	113.00	08/04/1976	10.1
34N/02E-21H01	SKAGIT-PUD	H	32	60	65	--	--	--
34N/02E-21H02	THOMPSON, PAUL	H	58	--	125	--	--	--
34N/02E-21H03	EVANS	H	26	--	--	23.06	08/26/1975	--
34N/02E-21H04	CARR	H	23	--	30	6.00	07/23/1975	--
34N/02E-21H07	FINSEN, DON	H	33	--	40	28.52 R	08/27/1975	--
34N/02E-21H08	--	H	41	--	80	36.50	08/27/1975	--
34N/02E-21H09	CLARK, V	H	62	--	125	--	--	--
34N/02E-21H10	EVANS, KEN	H	45	71	76	34.00	12/12/1977	0.2
34N/02E-21J01	SULLIVAN, E J	H	25	--	60	22.12	07/23/1975	--
34N/02E-21J02	HAVLAND, JOHN	H	30	--	--	--	--	--
34N/02E-21J03	MOILANEN, JOHN	H	21	--	48	--	--	--
34N/02E-21J06	EVANS, MARY	H	38	--	--	--	--	--
34N/02E-21J08	PRETTEGIAN, MARY J	H	28	--	40	25.00	07/23/1975	--
34N/02E-21J09	SKOMERZA, GLENN	H	25	88	93	17.00	08/08/1977	0.4
34N/02E-21M01	SKAGIT-PUD	H	41	--	10	0.00	07/24/1975	--
34N/02E-22E01	CHARLES, RAY	H	98	--	107	83.16	11/20/1975	1.0
34N/02E-22E02	WILBUR, CLAUDE,JR	H	89	--	108	74.35 R	09/22/1975	--
34N/02E-22E03	SMITH, HENRY	H	120	127	132	107.00	09/16/1977	0.3
34N/02E-22N01	MISNER, ROBERT	H	34	--	52	8.69	05/12/1953	0.4
34N/02E-22N02	ERICKSON, DR.	--	36	--	64	12.00	01/ /1948	0.8
34N/02E-22N03	HULBERT, PAT	H	32	--	42	8.00	02/ /1948	0.3
34N/02E-22N05	ASHLAND, SIGNE	H	34	--	47	9.00	02/ /1948	0.3
34N/02E-22N06	HULBERT, MRS. ROBT J	H	40	72	77	20.00	09/23/1977	0.2
34N/02E-23C01	SAMPSON	H	239	--	105	89.78	07/21/1975	--
34N/02E-23F01	CAYOU, ROGER	U	245	--	135	108.19	07/21/1975	3.0
34N/02E-23L01	IRVINE, ALBERT	H	254	--	93	68.00	11/18/1963	2.0
34N/02E-23L02	MCLEOD, HECTOR	H	250	--	49	37.00	10/28/1977	2.1
34N/02E-23P01	MCCLOUD, VERN	H	262	--	46	38.70	07/22/1975	10.0
34N/02E-24F01	DEWEY, H	H	25	--	22	11.11	10/23/1975	--
34N/02E-24F02	WEED, HAROLD	H	35	--	25	15.00	07/22/1975	--
34N/02E-24F04	WILBUR, LAURA	H	20	--	32	--	--	--
34N/02E-24F06	GROSSGLASS, LORRAINE	U	70	--	--	--	--	--
34N/02E-24F07	GROSSGLASS, LORRAINE	H	70	30	35	19.50	09/29/1972	--
34N/02E-24M01	SWIN-TRIBE	U	175	--	99	84.90	08/26/1976	--
34N/02E-24N01	ROBINSON, E	H	182	--	25	10.00	07/21/1975	--
34N/02E-25C01	CHARLES, NORVAL	U	125	25	30	14.20	07/21/1975	5.0
34N/02E-26C01	DAN, GASPER	U	273	--	46	32.50	04/21/1976	10.0
34N/02E-26F01	EDWARDS, REGGIE	H	281	34	40	25.00	08/31/1972	10.0

TABLE 9.--Records of selected wells in and adjacent to the Swinomish Indian Reservation--Continued

LOCAL NUMBER	OWNER	USE OF WATER	ALTITUDE OF LAND SURFACE (FEET)	DEPTH TO FIRST OPENING (FEET)	DEPTH OF WELL (FEET)	WATER LEVEL (FEET)		DATE WATER LEVEL MEASURED	SPECIFIC CAPACITY (GPM/FT)
34N/02E-26F02	SCOLERI, CARMAN	H	265	156	161	135.00		03/29/1977	5.0
34N/02E-27D01	WAGNER, PAUL F	H	21	88	108	4.00		03/ /1967	0.6
34N/02E-27D02	JOHNSON, C M	H	16	--	72	8.71	R	05/03/1967	--
34N/02E-27D03	HOVRUD, OLA	H	25	97	112	11.50		07/31/1975	0.3
34N/02E-27D05	VAN-PELT, S	H	66	--	--	--		--	--
34N/02E-27D06	HUGHES, L H	H	68	172	177	31.08		07/31/1975	0.1
34N/02E-27D07	THRONSEN, P	H	20	--	50	10.33		07/31/1975	--
34N/02E-27D10	GROBSCHMIT, W F	H	29	--	75		F	04/ /1949	1.5
34N/02E-27D11	BEDINGFELD, DAVID	H	26	--	141	6.71		03/09/1976	0.5
34N/02E-27E01	MACKENZIE, W	H	23	--	56	13.40		07/31/1975	--
34N/02E-27F01	LENNARTZ, G	C	80	--	42	35.79		05/03/1967	--
34N/02E-27F02	REEF-POINT	P	42	24	98	18.00		04/20/1964	0.1
34N/02E-27K01	SNEE-OOSH	U	48	--	89	6.00		1928	0.7
34N/02E-27K02	SNEE-OOSH	U	50	--	70	6.00		10/19/1949	--
34N/02E-27K03	SNEE-OOSH	P	46	--	48	15.00		11/05/1957	0.5
34N/02E-27K04	SNEE-OOSH	P	44	--	54	21.00		11/05/1957	0.8
34N/02E-27K05	SNEE-OOSH	P	51	--	48	29.51	P	05/02/1967	--
34N/02E-27L01	REEF PT.	P	40	29	99	6.00		04/20/1964	0.1
34N/02E-27L02	WAGNER, PAUL	H	50	107	112	12.00		07/06/1977	0.2
34N/02E-27M01	SNEE-OOSH	U	35	--	--	--		--	--
34N/02E-27M02	MACMILLAN, BROS.	U	20	--	--	--		--	--
34N/02E-27M03	WEAVER, BARBARA	H	14	--	28	12.40		09/05/1975	--
34N/02E-27P01	SNEE-OOSH	U	20	--	--	--		--	--
34N/02E-27P02	MACMILLAN, BROS.	U	35	--	--	--		--	--
34N/02E-27Q01	MACMILLAN, BROS.	U	40	--	--	--		--	--
34N/02E-27Q02	SHOREWOOD	P	46	--	117	0.13+		07/30/1975	0.1
34N/02E-27Q03	SHOREWOOD	P	47	--	--	--		--	--
34N/02E-27R01	LOMBARD, F L	P	100	69	73	21.00		10/ /1972	0.1
34N/02E-27R02	CLIFTON, ROBERT B	P	113	82	85	33.00		04/12/1965	0.3
34N/02E-27R03	CLIFTON, ROBERT B	U	111	67	72	39.00		11/25/1974	0.2
34N/02E-34A01	THORP, LOUIS	H	36	84	89	30.00		07/30/1975	0.1
34N/02E-34A02	ANDERSON, LEROY	H	38	94	99	29.50		07/30/1975	0.0
34N/02E-34A03	SPENCER, E	H	23	--	100	--		--	--
34N/02E-34A04	NELLES, JOE	H	37	90	95	30.00		04/01/1977	0.1
34N/02E-34A05	LAMMERS, ARBERTA	H	50	--	128	38.00		10/29/1976	0.0
34N/02E-34B01	DAN, MORRIS	U	13	107	112	2.65+		09/22/1975	0.1
34N/02E-34H01	HOPE-IS-WT	P	35	33	53	--		--	2.8
34N/02E-34J01	GOLDENVIEW	P	105	--	160	55.80		07/30/1975	--
34N/02E-34R01	EVERITT, G L	H	32	32	35	1.70		08/25/1975	1.4
34N/02E-34R02	SMITH, C. P	H	43	48	95	38.00		1970	0.1

TABLE 9.--Records of selected wells in and adjacent to the Swinomish Indian Reservation--Continued

LOCAL NUMBER	OWNER	USE OF WATER	ALTITUDE OF LAND SURFACE (FEET)	DEPTH TO FIRST OPENING (FEET)	DEPTH OF WELL (FEET)	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED	SPECIFIC CAPACITY (GPM/FT)
34N/02E-34R03	ESTELLE	H	50	--	87	--	--	--
34N/02E-34R04	MCDONALD	U	33	0	16	15.00	07/30/1975	--
34N/02E-34R05	BARR, R A	H	33	--	25	5.00	07/30/1975	--
34N/02E-34R06	MANSFIELD, G	H	45	--	200	44.00	04/20/1976	--
34N/02E-34R07	GARDINER, J	H	50	--	75	48.60	07/30/1975	--
34N/02E-34R08	SCHRODER, GLENN	H	36	--	--	1.70	08/25/1975	--
34N/02E-34R09	JORGENSON	H	50	--	80	48.86	09/22/1975	1.7
34N/02E-34R10	SNELSON, GREG	H	65	--	125	60.00	01/03/1977	0.4
34N/02E-35E01	BAILEY, GEORGE	H	206	--	108	88.09 R	07/22/1975	4.8
34N/02E-35F01	HOGGE, M	H	256	--	20	5.00	07/22/1975	--
34N/02E-35F02	MILLER, C	H	232	--	124	108.28	07/22/1975	--
34N/02E-35G01	CHARLES, MELVIN	H	240	--	138	110.44	07/23/1975	--
34N/02E-35G02	KLINE, SHEILA	H	226	--	120	--	--	--
34N/02E-35G03	CHARLES, NELLIE	H	231	--	35	16.99	07/23/1975	--
34N/02E-35G04	PENT-CHRCH	H	193	--	89	73.44	07/22/1975	--
34N/02E-35H01	NORKOWSKI, CHESTER J	C	178	--	21	14.08	05/13/1953	--
34N/02E-35H02	NORKOWSKI, CHESTER J	C	180	--	84	--	--	--
34N/02E-35H03	SWANSON, JACK	H	153	--	180	138.39	05/02/1967	--
34N/02E-35H04	EFEIR, MAUDE	H	170	105	110	64.00	09/09/1977	0.1
34N/02E-35L01	SWORD, JAMES	H	235	123	130	108.71	03/09/1976	0.7
34N/02E-35R01	SHLTER-BAY	U	80	86	91	46.00	08/26/1975	0.4
34N/02E-36B01	CEDAR MILL	F	8	--	20	--	--	--
34N/02E-36E01	SANDSTRON, M	U	142	--	47	43.00	05/13/1953	--

TABLE 10.--Water levels in selected wells in and adjacent to the Swinomish Indian Reservation

[F, well flowing; O, well obstructed - no measurement; P, well being pumped; R, well recently pumped; S, nearby well being pumped; Z, gas pressure buildup]

WELL 33N/02E-03A04 SITE NUMBER 482257122315201

HIGHEST WATER LEVEL 5.00 FEET BELOW LAND SURFACE DATUM APR 21,1976.

LOWEST WATER LEVEL 6.80 FEET BELOW LAND SURFACE DATUM SEP 24,1976.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
APR 21,1976	5.00	JUL 22,1976	6.60	OCT 15,1976	6.80		
MAY 20	6.00	AUG 26	6.60	NOV 16	6.70 R		
JUN 14	6.40 R	SEP 24	6.80	DEC 16	6.30		

WELL 33N/02E-03H02 SITE NUMBER 482238122315101

HIGHEST WATER LEVEL 24.00 FEET BELOW LAND SURFACE DATUM DEC 16,1976.

LOWEST WATER LEVEL 25.40 FEET BELOW LAND SURFACE DATUM AUG 25,1975.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
AUG 25,1975	25.40	OCT 22,1975	24.61	SEP 24,1976	24.60	DEC 16,1976	24.00
SEP 04	25.15	NOV 19	24.58	OCT 15	24.70		
22	24.86	AUG 26,1976	25.30	NOV 16	24.30		

WELL 34N/02E-02N01 SITE NUMBER 482727122313201

HIGHEST WATER LEVEL 68.20 FEET BELOW LAND SURFACE DATUM JUL 28,1976.

LOWEST WATER LEVEL 68.80 FEET BELOW LAND SURFACE DATUM NOV 30,1976.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
JUL 23,1976	68.40	AUG 02,1976	68.20	SEP 24,1976	68.60	NOV 30,1976	68.80
26	68.30	05	68.20	OCT 15	68.60	DEC 16	68.50
28	68.20	26	68.70	NOV 16	68.70		

WELL 34N/02E-03G01 SITE NUMBER 482755122315701

HIGHEST WATER LEVEL 0.20 FEET BELOW LAND SURFACE DATUM APR 20,1976.

LOWEST WATER LEVEL 7.92 FEET BELOW LAND SURFACE DATUM AUG 12,1963.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
FEB 27,1961	0.72	JUL 26,1962	12.19 P	AUG 29,1962	11.52 P	NOV 14,1962	9.96 P
MAY 17,1962	2.35	27	11.83 P	31	11.58 P	19	10.37 P
MAY 25	6.08 P	30	7.50	SEP 04	11.50 P	DEC 05	3.58
JUN 05	7.13 P	AUG 01	11.83 P	06	12.71 P	JAN 07,1963	8.35 R
11	7.83 P	02	7.42	07	13.58 P	JAN 15	8.83 P
22	9.02 P	03	11.67 P	10	11.75 P	22	4.92
26	9.50 P	06	10.98 P	11	11.48 P	28	3.67
27	10.42 P	08	5.87	14	7.63	FEB 04	5.92
29	10.13 P	09	11.33 P	17	5.92	08	9.83 P
JUL 01	10.08 P	10	11.13 P	20	10.92 P	18	6.25
03	10.33 P	13	5.00	24	5.58	MAR 26	11.04 P
05	10.98 P	14	10.31 P	26	10.00 P	MAY 17	9.08 P
09	4.29	15	11.25 P	28	10.83 P	21	9.48 P
11	11.21 P	16	11.25 P	OCT 01	5.54	24	9.92 P
13	11.42 P	17	11.06 P	02	5.33	27	9.00 P
16	11.75 P	20	11.67 P	22	4.00	29	9.58 P
18	5.25	21	11.79 P	24	9.04 P	JUN 03	7.00
19	11.08 P	22	11.83 P	31	9.29 P	05	10.42 P
23	12.21 P	23	11.58 P	NOV 06	9.42 P	07	10.37 P
24	12.29 P	24	12.15 P	09	9.71 P	10	8.79 P
25	12.25 P	27	9.79 P	12	5.19	13	10.42 P

TABLE 10.--Water levels in selected wells in and adjacent to the Swinomish Indian Reservation--Continued

WELL 34N/02E-03G01 SITE NUMBER 482755122315701 -- CONTINUED

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
JUN 17,1963	10.79 P	NOV 27,1963	8.83 P	JUL 15,1964	9.79 P	AUG 18,1965	8.65 P
19	10.87 P	29	9.00 P	17	8.83 P	SEP 03	8.13 P
21	11.08 P	DEC 02	9.46 P	20	8.67 P	27	7.40 P
24	10.37 P	04	9.58 P	24	8.87 P	OCT 04	8.00 P
28	11.33 P	06	9.50 P	27	9.90 P	NOV 09	8.04 P
JUL 01	6.25	09	6.17 R	29	10.29 P	19	8.92 P
02	9.17 P	11	9.25 P	31	10.29 P	JUN 10,1966	7.96 P
05	9.98 P	13	8.58 P	AUG 03	9.37 P	JUN 20	8.00 P
08	10.17 P	18	4.42	07	9.58 P	22	8.75 P
15	10.13 P	20	3.83	12	9.37 P	AUG 09	8.54 P
19	10.48 P	26	3.52	14	9.67 P	10	8.83 P
22	10.71 P	30	3.63	17	9.31 P	24	9.25 P
26	10.77 P	JAN 10,1964	3.13	19	9.75 P	SEP 18,1967	6.00 P
29	7.79	JAN 27	2.46	21	6.44	SEP 03,1969	5.79 P
AUG 05	10.33 P	FEB 03	2.46	24	10.17 P	SEP 04	5.50 P
09	11.23 P	10	2.46	26	6.83	05	6.46 P
12	7.92	26	2.69	SEP 02	8.33 P	08	6.25 P
14	7.79	MAR 18	6.33 P	04	9.25 P	09	6.37 P
16	7.25 P	20	6.42 P	30	3.83	JUL 16,1970	6.42 P
SEP 20	6.85	APR 17	2.21	NOV 02	4.04	JUL 17	5.92 P
26	6.13	22	2.06	13	7.75 P	AUG 31	6.58 P
30	6.08	MAY 18	6.31 P	DEC 14	7.35 P	SEP 08	6.92 P
OCT 02	5.77	20	7.08 P	FEB 12,1965	4.31 P	APR 22,1971	4.67 P
04	5.73	22	6.33 P	MAR 03	4.42 P	MAR 11,1976	0.60
18	9.08 P	25	6.06 P	05	5.50 P	MAR 18	0.63
21	9.87 P	28	6.13 P	APR 21	6.33 P	APR 20	0.20
23	6.48	JUN 01	3.35	MAY 06	7.29 P	MAY 20	0.95
25	6.25	03	6.85 P	07	7.50 P	JUN 14	1.05
28	5.75	05	7.06 P	10	7.87 P	JUL 19	1.35
29	5.50	09	8.17 P	JUN 09	9.00 P	28	1.35
31	5.25	11	9.44 P	16	8.98 P	AUG 26	1.15
NOV 04	5.08	15	7.92 P	30	10.79 P	SEP 24	1.25
08	4.96	29	7.90 P	JUL 02	11.75 P	OCT 15	1.45
15	4.50	JUL 01	8.06 P	08	7.79 P	NOV 16	1.19
18	4.46	03	8.21 P	12	7.67 P	30	1.35
20	4.17	06	7.75 P	16	8.92 P	DEC 16	1.12
22	4.04	08	9.15 P	23	9.08 P		
25	5.79 R	13	8.29 P	28	9.37 P		

WELL 34N/02E-03G02 SITE NUMBER 482745122315601

HIGHEST WATER LEVEL 100.00 FEET BELOW LAND SURFACE DATUM JAN 01,1953.

LOWEST WATER LEVEL WELL DRY NOV 15,1963; NOV 18,1963; NOV 22,1963; NOV 25,1963; NOV 27,1963; NOV 29,1963; DEC 02,1963.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
1953	100.00	NOV 18,1963	DRY	NOV 25,1963	DRY	NOV 29,1963	DRY
NOV 15,1963	DRY	22	DRY	27	DRY	DEC 02	DRY

WELL 34N/02E-03G03 SITE NUMBER 482753122320101

HIGHEST WATER LEVEL 4.85 FEET BELOW LAND SURFACE DATUM NOV 22,1963.

LOWEST WATER LEVEL 5.60 FEET BELOW LAND SURFACE DATUM NOV 18,1963.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
NOV 15,1963	5.50	NOV 22,1963	4.85	NOV 27,1963	4.95 T	DEC 02,1963	5.20 S
18	5.60	25	4.90 S	29	5.00 S		

WELL 34N/02E-03K01 SITE NUMBER 482735122321201

HIGHEST WATER LEVEL 128.51 FEET BELOW LAND SURFACE DATUM MAR 18,1976.

LOWEST WATER LEVEL 136.50 FEET BELOW LAND SURFACE DATUM OCT 19,1960.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
NOV 14,1955	133.00	MAR 11,1976	129.61	JUN 14,1976	128.90		
JAN 06,1956	130.70	MAR 18	128.51	JUL 19	129.40		
OCT 19,1960	136.50	MAY 20	128.80	28	128.60		

TABLE 10.--Water levels in selected wells in and adjacent to the Swinomish Indian Reservation--Continued

WELL 34N/02E-03L01 SITE NUMBER 482740122321401

HIGHEST WATER LEVEL 73.68 FEET BELOW LAND SURFACE DATUM JUL 23,1975.

LOWEST WATER LEVEL 86.30 FEET BELOW LAND SURFACE DATUM NOV 14,1955.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
OCT 20,1955	86.10	JAN 06,1956	84.50	SEP 22,1975	74.15		
NOV 14	86.30	JUL 23,1975	73.68				

WELL 34N/02E-15C01 SITE NUMBER 482630122323801

HIGHEST WATER LEVEL 103.60 FEET BELOW LAND SURFACE DATUM DEC 16,1976.

LOWEST WATER LEVEL 108.50 FEET BELOW LAND SURFACE DATUM MAR 11,1976.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 11,1976	108.50	JUN 14,1976	104.00	OCT 15,1976	103.80		
APR 21	104.00	JUL 21	103.80	NOV 30	103.80		
MAY 20	104.30	SEP 24	104.20	DEC 16	103.60		

WELL 34N/02E-15L01 SITE NUMBER 482602122323601

HIGHEST WATER LEVEL 171.60 FEET BELOW LAND SURFACE DATUM APR 20,1976.

LOWEST WATER LEVEL 181.40 FEET BELOW LAND SURFACE DATUM NOV 30,1976.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
APR 20,1976	171.60	JUL 19,1976	181.20	SEP 24,1976	181.30	NOV 30,1976	181.40
MAY 20	0	28	180.90	OCT 15	181.30	DEC 16	181.30

WELL 34N/02E-15H01 SITE NUMBER 482545122314801

HIGHEST WATER LEVEL 109.90 FEET BELOW LAND SURFACE DATUM DEC 16,1976.

LOWEST WATER LEVEL 110.40 FEET BELOW LAND SURFACE DATUM AUG 04,1976.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
AUG 04,1976	110.40	SEP 24,1976	110.30	NOV 16,1976	110.40	DEC 16,1976	109.90
05	110.30	OCT 15	110.20	30	110.40		

WELL 34N/02E-22E02 SITE NUMBER 482518122330401

HIGHEST WATER LEVEL 72.94 FEET BELOW LAND SURFACE DATUM MAR 18,1976.

LOWEST WATER LEVEL 74.35 FEET BELOW LAND SURFACE DATUM SEP 22,1975.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
SEP 22,1975	74.35	JAN 20,1976	74.00	APR 20,1976	73.60	SEP 24,1976	74.10 R
OCT 22	74.10	FEB 19	73.84	MAY 20	73.80	OCT 15	74.00 R
NOV 20	74.08	MAR 11	73.90	JUN 14	76.20 R	NOV 16	73.90
DEC 17	74.30	18	72.94	JUL 21	74.10	DEC 16	74.10 R

WELL 34N/02E-23F01 SITE NUMBER 482527122311401

HIGHEST WATER LEVEL 103.50 FEET BELOW LAND SURFACE DATUM DEC 17,1975.

LOWEST WATER LEVEL 109.02 FEET BELOW LAND SURFACE DATUM OCT 22,1975.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
JUL 21,1975	108.19	JAN 20,1976	103.80	JUN 14,1976	106.40	OCT 15,1976	108.70
SEP 22	108.90	FEB 19	105.10	JUL 19	107.50	NOV 16	108.80
OCT 22	109.02	MAR 18	104.70	28	107.50	30	108.80
NOV 20	108.50	APR 20	104.90	AUG 26	108.40	DEC 16	108.70
DEC 17	103.50	MAY 20	105.70	SEP 24	108.70		

TABLE 10.--Water levels in selected wells in and adjacent to the Swinomish Indian Reservation continued

WELL 34N/02E-23P01 SITE NUMBER 482457122311801

HIGHEST WATER LEVEL 37.50 FEET BELOW LAND SURFACE DATUM APR 21,1976.

LOWEST WATER LEVEL 38.70 FEET BELOW LAND SURFACE DATUM JUL 22,1975.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
JUL 22,1975	38.70	JAN 21,1976	38.30	APR 21,1976	37.50		

WELL 34N/02E-24M01 SITE NUMBER 482509122300901

HIGHEST WATER LEVEL 83.40 FEET BELOW LAND SURFACE DATUM OCT 15,1976.

LOWEST WATER LEVEL 84.90 FEET BELOW LAND SURFACE DATUM AUG 26,1976.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
AUG 26,1976	84.90	OCT 15,1976	83.40	DEC 16,1976	83.40		
SEP 24	83.60	NOV 16	83.40				

WELL 34N/02E-26C01 SITE NUMBER 482448122311301

HIGHEST WATER LEVEL 32.40 FEET BELOW LAND SURFACE DATUM MAY 20,1976.

LOWEST WATER LEVEL 33.60 FEET BELOW LAND SURFACE DATUM DEC 16,1976.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
APR 21,1976	32.50	JUL 19,1976	32.50	SEP 24,1976	32.90	DEC 16,1976	33.60
MAY 20	32.40	28	32.50	OCT 15	33.00		
JUN 14	32.40	29	32.40	NOV 16	33.40		

TABLE 10.--Water levels in selected wells in and adjacent to the Swinomish Indian Reservation--Continued

WELL 34N/02E-27D03 SITE NUMBER 482438122330001

HIGHEST WATER LEVEL 9.48 FEET BELOW LAND SURFACE DATUM FEB 19,1976.

LOWEST WATER LEVEL 12.38 FEET BELOW LAND SURFACE DATUM SEP 22,1975.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
JUL 31,1975	11.50	DEC 17,1975	9.90	APR 20,1976	9.60	OCT 15,1976	11.40
SEP 22	12.38	JAN 20,1976	10.20	MAY 20	10.10	NOV 16	11.00
OCT 22	11.84	FEB 19	9.48	JUL 21	11.10	DEC 16	10.40
NOV 20	10.52	MAR 18	9.82	SEP 24	11.70		

WELL 34N/02E-27D06 SITE NUMBER 482438122325201

HIGHEST WATER LEVEL 31.02 FEET BELOW LAND SURFACE DATUM SEP 04,1975.

LOWEST WATER LEVEL 33.97 FEET BELOW LAND SURFACE DATUM NOV 20,1975.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
JUL 31,1975	31.10	OCT 22,1975	37.93 R	DEC 17,1975	31.30		
SEP 04	31.02	NOV 20	33.97				

WELL 34N/02E-27K01 SITE NUMBER 482410122322901

HIGHEST WATER LEVEL 16.10 FEET BELOW LAND SURFACE DATUM MAY 20,1976.

LOWEST WATER LEVEL 25.00 FEET BELOW LAND SURFACE DATUM NOV 05,1957.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAY 12,1953	16.85	APR 21,1976	31.40 P	JUL 21,1976	29.10 R	OCT 15,1976	27.00 R
NOV 05,1957	25.00	20	16.10	AUG 26	33.60 R		
SEP 04,1975	22.00	JUN 14	24.10 R	SEP 24	26.80 R		

TABLE 10.--Water levels in selected wells in and adjacent to the Swinomish Indian Reservation--Continued

WELL 34N/02E-27M03 SITE NUMBER 482417122325501

HIGHEST WATER LEVEL 8.80 FEET BELOW LAND SURFACE DATUM NOV 16,1976.

LOWEST WATER LEVEL 12.40 FEET BELOW LAND SURFACE DATUM SEP 05,1975.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
SEP 05,1975	12.40	DEC 17,1975	9.40	APR 20,1976	11.40	OCT 15,1976	10.10
22	11.58	JAN 20,1976	10.70	MAY 20	10.70	NOV 16	8.80
OCT 22	10.99	FEB 19	10.30	JUL 21	10.30	DEC 16	9.40
NOV 19	10.14 R	MAR 18	10.77	SEP 24	11.50		

WELL 34N/02E-27Q02 SITE NUMBER 482400122322101

HIGHEST WATER LEVEL 1.00 FEET ABOVE LAND SURFACE DATUM OCT 22,1975.

LOWEST WATER LEVEL 0.48 FEET BELOW LAND SURFACE DATUM SEP 04,1975.

WATER LEVELS IN FEET ABOVE OR BELOW(-) LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
JUL 30,1975	0.12	SEP 22,1975	-0.22	NOV 19,1975	F		
SEP 04	-0.48	OCT 22	1.00				

WELL 34N/02E-34A02 SITE NUMBER 482345122321001

HIGHEST WATER LEVEL 33.83 FEET BELOW LAND SURFACE DATUM NOV 19,1975.

LOWEST WATER LEVEL 44.10 FEET BELOW LAND SURFACE DATUM JUL 30,1975.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
JUL 30,1975	44.10	OCT 22,1975	42.08	DEC 17,1975	37.80 R		
SEP 22	35.16	NOV 19	33.83				

TABLE 10.--Water levels in selected wells in and adjacent to the Swinomish Indian Reservation--Continued

WELL 34N/02E-34B01 SITE NUMBER 482354122322301

HIGHEST WATER LEVEL 11.60 FEET ABOVE LAND SURFACE DATUM NOV 16,1976.

LOWEST WATER LEVEL 2.65 FEET ABOVE LAND SURFACE DATUM SEP 22,1975.

WATER LEVELS IN FEET ABOVE LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAY 02,1967	F	NOV 19,1975	5.80	MAY 20,1976	4.60 R	OCT 15,1976	10.40
JUL 30,1975	F	DEC 17	9.70	JUN 14	6.70	NOV 16	11.60
SEP 04	F	JAN 20,1976	9.50	JUL 21	7.40	DEC 16	9.90
22	2.65	JAN 26	11.10	AUG 26	9.90		
OCT 22	2.86	MAR 18	8.10	SEP 24	8.10		

WELL 34N/02E-34J01 SITE NUMBER 482327122320101

HIGHEST WATER LEVEL 54.60 FEET BELOW LAND SURFACE DATUM NOV 19,1975.

LOWEST WATER LEVEL 66.90 FEET BELOW LAND SURFACE DATUM JUN 09,1978.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
JUL 30,1975	55.80	NOV 19,1975	54.60 R	JUN 09,1978	66.9		
SEP 04	58.50 R	MAR 09,1976	54.80				

WELL 34N/02E-34R01 SITE NUMBER 482307122315301

HIGHEST WATER LEVEL 5.50 FEET ABOVE LAND SURFACE DATUM JAN 20,1976.

LOWEST WATER LEVEL 2.77 FEET BELOW LAND SURFACE DATUM OCT 22,1975.

WATER LEVELS IN FEET ABOVE OR BELOW(-) LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
AUG 25,1975	-1.70	NOV 19,1975	-2.70	JUL 23,1976	-0.60	NOV 16,1976	-2.50
SEP 04	-2.04	DEC 17	3.50 R	AUG 26	-1.30	DEC 16	-2.50
22	-2.46	JAN 20,1976	5.50 R	SEP 24	-1.90		
OCT 22	-2.77	FEB 19	4.50 R	OCT 15	-2.10		

TABLE 10.--Water levels in selected wells in and adjacent to the Swinomish Indian Reservation--Continued

WELL 34N/02E-34R06 SITE NUMBER 482310122315301

HIGHEST WATER LEVEL 44.00 FEET BELOW LAND SURFACE DATUM APR 20,1976.

LOWEST WATER LEVEL 44.00 FEET BELOW LAND SURFACE DATUM APR 20,1976.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
NOV 19,1975	55.29 Z	JAN 26,1976	50.10 Z	APR 20,1976	44.00	JUL 23,1976	50.70 R

WELL 34N/02E-34R07 SITE NUMBER 482309122315401

HIGHEST WATER LEVEL 47.40 FEET BELOW LAND SURFACE DATUM NOV 16,1976.

LOWEST WATER LEVEL 49.30 FEET BELOW LAND SURFACE DATUM JUN 14,1976.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
JUL 30,1975	48.60	NOV 19,1975	48.83	MAR 18,1976	48.52	JUL 23,1976	48.80
SEP 04	48.00	DEC 17	48.30	APR 20	49.00	AUG 26	48.60
22	48.33	JAN 20,1976	48.90	MAY 20	48.30	NOV 16	47.40
OCT 22	48.05	FEB 19	48.20	JUN 14	49.30		

WELL 34N/02E-35E01 SITE NUMBER 482333122314301

HIGHEST WATER LEVEL 82.20 FEET BELOW LAND SURFACE DATUM MAR 18,1976.

LOWEST WATER LEVEL 87.30 FEET BELOW LAND SURFACE DATUM SEP 04,1975.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
JUL 23,1975	88.09 R	FEB 19,1976	82.70	MAY 20,1976	83.40 R	SEP 24,1976	82.50
SEP 04	87.30	MAR 09	82.94	JUN 14	83.10	OCT 15	82.40
NOV 09	82.96	18	82.20	JUL 22	82.50	NOV 16	82.60
JAN 26,1976	83.10 R	APR 20	82.70	AUG 26	82.70	DEC 16	82.30 R

TABLE 10.--Water levels in selected wells in and adjacent to the Swinomish Indian Reservation--Continued

WELL 34N/02E-35F02 SITE NUMBER 482332122312801

HIGHEST WATER LEVEL 102.20 FEET BELOW LAND SURFACE DATUM MAR 18,1976.

LOWEST WATER LEVEL 108.28 FEET BELOW LAND SURFACE DATUM JUL 22,1975.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
JUL 22,1975	108.28	DEC 17,1975	103.40	MAY 20,1976	103.00	SEP 24,1976	102.80
SEP 04	107.10	JAN 20,1976	103.20	JUN 14	104.10	OCT 15	102.70
22	106.66	FEB 19	103.00 R	JUL 22	102.70	NOV 16	102.80
OCT 22	105.71	MAR 18	102.20	29	102.40	DEC 16	102.40
NOV 19	103.39	APR 20	103.00	AUG 26	103.00		

WELL 34N/02E-35G03 SITE NUMBER 482336122311101

HIGHEST WATER LEVEL 12.90 FEET BELOW LAND SURFACE DATUM JAN 21,1976.

LOWEST WATER LEVEL 17.47 FEET BELOW LAND SURFACE DATUM OCT 23,1975.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
JUL 23,1975	16.99	APR 21,1976	14.80	JUL 22,1976	15.30	OCT 15,1976	15.60
OCT 23	17.47	MAY 20	15.00	AUG 26	15.40	NOV 16	15.70
JAN 21,1976	12.90	JUN 14	15.10	SEP 24	15.50	DEC 16	15.80

TABLE 10.--Water levels in selected wells in and adjacent to the Swinomish Indian Reservation--Continued

WELL 34N/02E-35G04 SITE NUMBER 482334122305501

HIGHEST WATER LEVEL 71.80 FEET BELOW LAND SURFACE DATUM OCT 15,1976.

LOWEST WATER LEVEL 73.44 FEET BELOW LAND SURFACE DATUM JUL 22,1975.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
JUL 22,1975	73.44	SEP 22,1975	72.64	DEC 17,1975	72.90	SEP 24,1976	72.00 R
AUG 25	72.90	OCT 22	72.63 R	JAN 20,1976	72.60	OCT 15	71.80
SEP 04	72.50	NOV 19	72.65 R	JUL 22	71.90	NOV 16	72.00 R

WELL 34N/02E-35R01 SITE NUMBER 482310122303901

HIGHEST WATER LEVEL 45.31 FEET BELOW LAND SURFACE DATUM MAR 18,1976.

LOWEST WATER LEVEL 46.64 FEET BELOW LAND SURFACE DATUM SEP 22,1975.

WATER LEVELS IN FEET BELOW LAND SURFACE DATUM.

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
AUG 26,1975	46.20	DEC 17,1975	46.40	MAY 20,1976	45.90	OCT 15,1976	45.70
SEP 04	46.40	JAN 20,1976	45.90	JUN 14	46.00	NOV 16	45.90
22	46.64	FEB 19	45.70	JUL 22	45.80		
OCT 22	46.59	MAR 18	45.31	AUG 26	45.90		
NOV 19	46.62	APR 20	45.80	SEP 24	45.80		