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GEOLOGICAL SURVEY

WATER RESOURCES OF THE NISQUALLY INDIAN RESERVATION, WASHINGTON

By

D. A. Myers and J. E. Cummans

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WATER RESOURCES OF THE NISQUALLY INDIAN RESERVATION, WASHINGTON

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SUMMARY

The Nisqually Indian Reservation has an abundant supply of good-quality surface and ground water for increased housing and small-scale commercial development and for potential development of a fish hatchery or other aquaculture facilities. The average annual discharge of the Nisqually River is about 2,200 cfs (cubic feet per second), or 1 million gpm (gallons per minute), at the reservation, and discharges are rarely less than 220 cfs (100,000 gpm). Several large springs also have potential for use for a fish hatchery. Floods of the Nisqually River are reduced somewhat at La Grande and Alder Dams upstream. At the reservation, the river overflows its channel at discharges of about 21,000 cfs (9.5 million gpm), which has one chance in six of happening in any one year. A floodflow of about 35,800 cfs (16.1 million gpm) would cover the flood plain to a depth of about 2 feet. Such a flood has one chance in 100 of happening in any one year. The river water is of good chemical quality and is not as cloudy as many streams that originate at glaciers on Mount Rainier; most of the sediment settles out in the two upstream reservoirs.

The present ground-water use on the reservation is limited to domestic supplies from one well on the flood plain and five wells on the upland. However, the ground-water supply available is adequate to supply a considerable expansion of housing and modest commercial needs as well. Wells on the upland tap water in sand and gravel layers and the well on the flood plain taps finer materials. The underground water table beneath the reservation is near river level. Yields from wells range from 5 to 25 gpm but appreciably greater yields are possible. The ground water is of good chemical quality and suitable for drinking; no coliform bacteria were detected.

Septic-tank disposal could create a ground-water-quality problem on the flood plain along the river, but it probably would not be a problem affecting water quality of wells supplying upland homes.

INTRODUCTION

Description of Study Area

The Nisqually Indian Reservation is in Thurston County near Olympia, Wash. (fig. 1) and is bounded on the east by the Nisqually River. The reservation is reached from old Pacific Highway off Interstate Highway 5, State Highway 510, and Reservation Road. Graded roads provide access to interior parts of the reservation.

The reservation consists of 2.6 square miles of land and includes a prairielike upland above the river and the Nisqually River flood plain below; the two areas are separated by steep bluffs (fig. 2). At the present time (1973), residential development on the reservation is primarily on the more extensive upland area. Only a few homes are on the flood plain.

The study area has climate generally typical of the Puget Sound lowland, with mild, wet winters and relatively cool, dry summers. Generally, storms from the southwest carry moisture-laden air from the Pacific Ocean. More than three-fourths of the 40 inches of yearly precipitation, mostly rainfall but with some snow, occurs from early October through March. Torrential downpours are rare and most of the rainfall comes as a drizzle.

Purpose and Scope of the Study

The study of the Nisqually Indian Reservation was made at the request of the Nisqually Community Council to evaluate the water resources of the reservation and to provide a basis for protection and future management of the resources. The study included an assessment of the ground-water availability--its occurrence and quality, its present use and potential for further development, and its possible contamination. Surface-water resources were evaluated by a determination of the high,

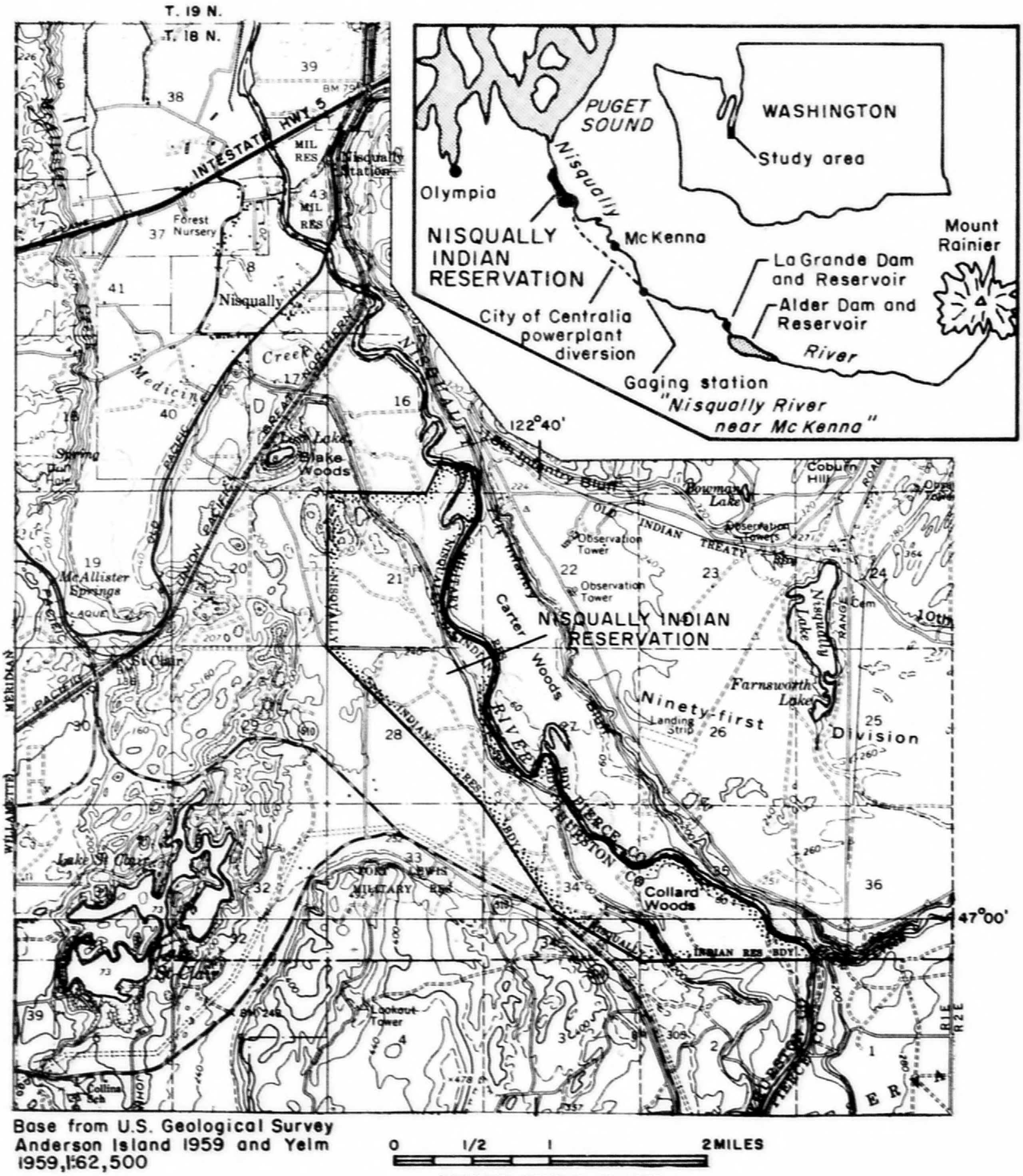

FIGURE 1.--Location of Nisqually Indian Reservation and Nisqually River.

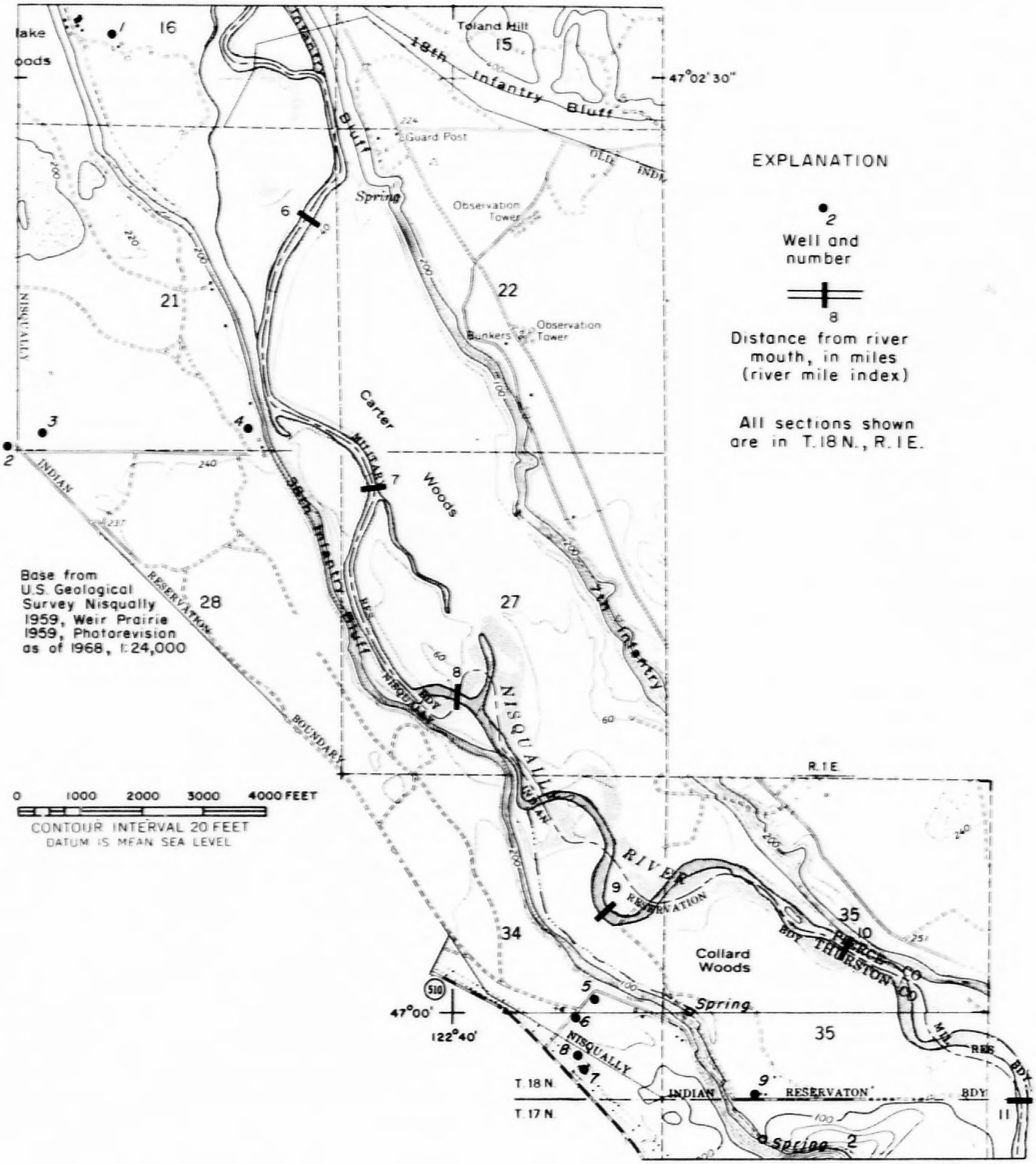

FIGURE 2.--Nisqually Indian Reservation, showing well locations and river-mile index.

average, and low flows of the Nisqually River, and by an analysis of the chemical quality and suspended-sediment content of the river water. Ground-water information collected during the study was provided by drillers' records and water-level measurements of wells on and immediately adjacent to the reservation, and chemical and sanitary analyses of well water.

Acknowledgments

Acknowledgment is made of the cooperation of residents of the reservation and adjoining lands for providing access to their wells for periodic measurements of water levels and collection of water samples for chemical analyses. The U.S. Public Health Service, Indian Health Unit, provided information on several wells drilled on the reservation. Technical reviews of the manuscript by F. T. Hidaka and Dee Molenaar of the Geological Survey improved the final report.

WATER RESOURCES

The Water Cycle

Precipitation as rain and snow is the source of virtually all fresh water. Generally, a part of the precipitation that reaches the land surface runs off the ground surface to streams, a part is evaporated directly back to the atmosphere, some rises through plant roots and stems and is "transpired" from foliage back to the atmosphere, and a part soaks downward to reach the "ground-water reservoir." The ground water drains slowly outward to spring zones, or to lakes and streams, or to the sea. Evaporation from these water bodies returns the water to the atmosphere, completing the water cycle, part of which is shown in figure 3.

The water cycle is controlled mainly by climate, slope and shape of the land surface, and types of rock materials that occur beneath the land. Discussed below are these various characteristics--as well as the activities of man--as they apply to the water resources of the Nisqually Indian Reservation.

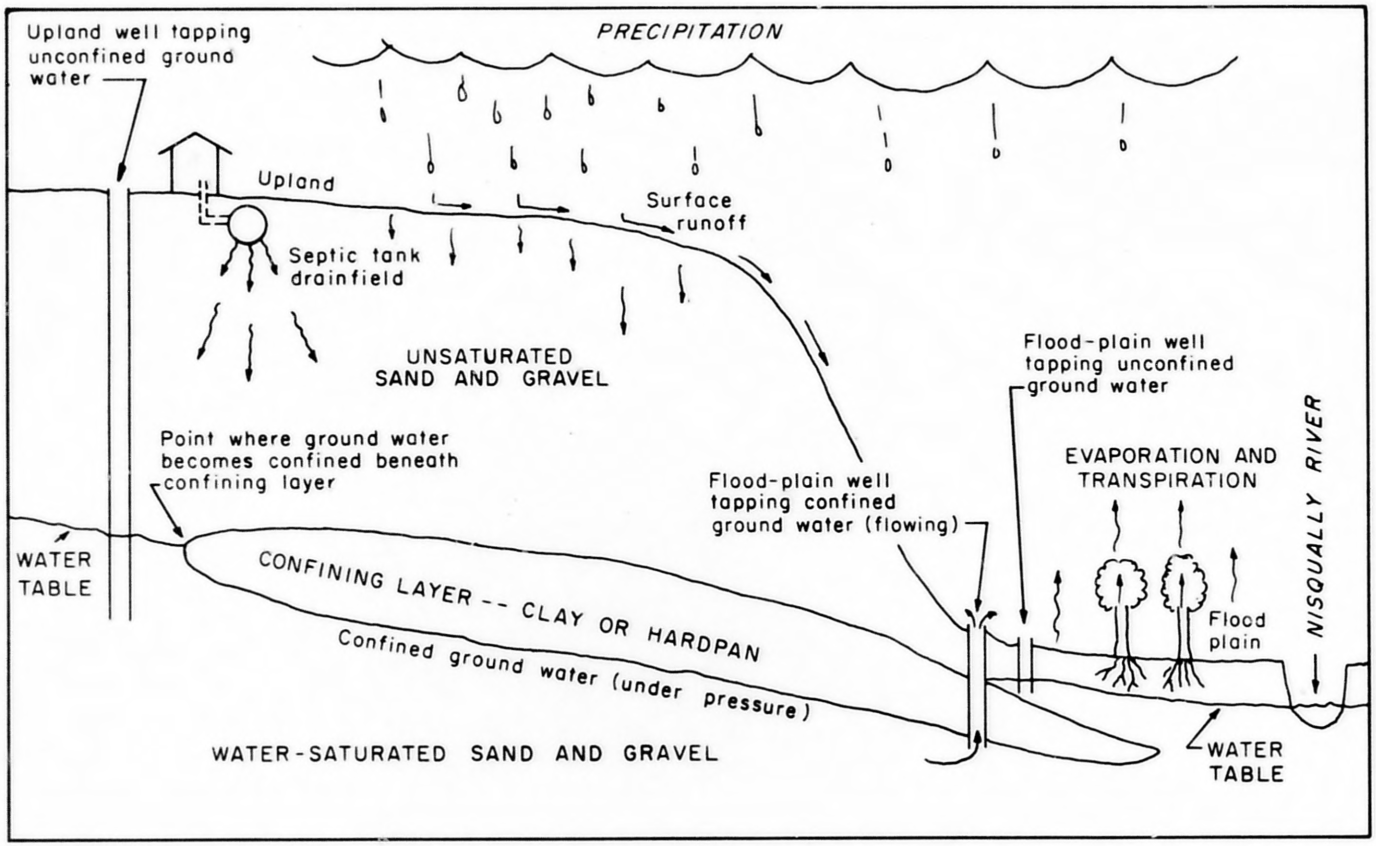

FIGURE 3.--Diagrammatic sketch showing water cycle and occurrence of ground water on Nisqually Indian Reservation.

Nisqually River

The only large source of surface water available to the Nisqually Indian Reservation is the Nisqually River which flows along the eastern boundary of the reservation for a distance of about 5.5 miles. The Nisqually River originates from glaciers on Mount Rainier and flows about 80 miles to Puget Sound (fig. 1) in a mountain valley and in a lowland valley cut by the river in glacial sand, gravel, and other sediments.

All of man's developments on the Nisqually River are upstream from the reservation. The city of Tacoma operates hydroelectric powerplants on the river at La Grande and Alder Dams, 20.5 and 22.2 miles, respectively, upstream from the reservation. The city of Centralia diverts water for power generation about 16 river miles downstream from La Grande Dam and returns the water to the river about 9 river miles downstream from McKenna (fig. 1). The U.S. Geological Survey stream-gaging station, Nisqually River near McKenna, records the flow of the river upstream from Centralia's diversion canal.

Streamflow Characteristics

Although natural flow of the Nisqually River is controlled at Alder and La Grande Dams, the yearly high and low flows of the river past the reservation occur during the months of highest and lowest rainfall. The flow is generally highest during the month of December and lowest during the month of August.

Estimates of the flow of the Nisqually River at the reservation are based on streamflow records obtained at the gaging station, Nisqually River near McKenna (table III in appendix), about 22 miles upstream from the reservation. The average yearly flow of the river past the reservation is probably a little more than 1 million gpm (gallons per minute), with the average flow in December (month of largest average flow) being about 1.5 million gpm. The average flow during August (month of smallest average flow) is about 400,000 gpm. Flows occasionally are much less for short periods of time but probably have not been less than 100,000 gpm since control of the flow by Alder Dam in 1945.

Floods

Floods in the Nisqually River basin are caused by heavy rainfall often accompanied by rapid snowmelt, and usually occur during the winter. Two or more floodflows often occur within a 2-week period. Large floods rarely occur during the May-June snowmelt period.

Since 1945 the control of the streamflow at Alder Reservoir has resulted in some reduction in floodflows in the reservation area. Although the dam was designed for hydroelectric power generation and not as a flood-control structure, the storage it provides reduces to some extent the size of most floods; however, it would probably not significantly reduce the size of extreme floods--floods of a size that, on the average, would occur only once in about 100 years.

The largest flood remembered by local residents occurred on December 22, 1933, prior to the construction of Alder Dam. The estimated flow during this flood was about 19 million gpm. A flood of about the same size occurred in 1917 or 1918 according to some residents. A flood of this size would cover an area slightly greater than that shown in figure 4.

The largest flood of the Nisqually River since completion of Alder Dam in 1945 occurred January 29, 1965, and, as measured at McKenna, had a flow of about 11.5 million gpm. The river was observed to overflow its banks and cover some of the land adjoining the river in the lower mile of the reservation; however, no information about flooding is known upstream through the remainder of the reservation. A flood of this size can be expected to occur, on the average, once in about 13 years.

Homes located on some parts of the Nisqually River flood plain are subject to the threat of periodic flooding, and the entire flood-plain part of the reservation could be covered by water during a flood with a streamflow that occurs, on the average, once in 100 years.

Streamflows large enough to overtop the banks of the main channel (9.5 million gpm) occur, on the average, about once in 6 years. At intervals on an average slightly greater than every 6 years, a flood will cover some parts of the flood plain of the reservation. Streamflows of about 16.1 million gpm (smaller than the 1917 or 1918 and 1933 floods) are

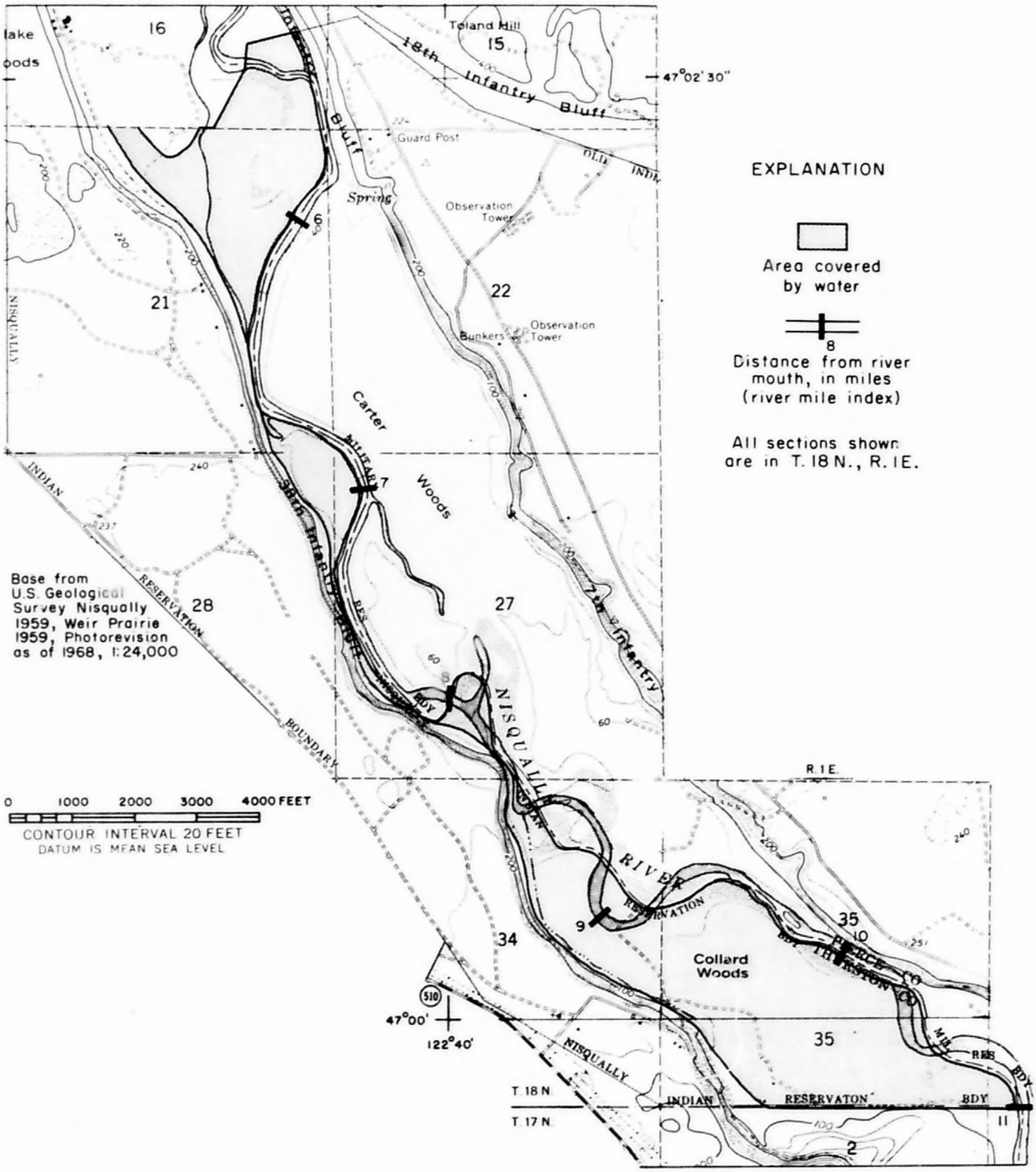

FIGURE 4.--Area of Nisqually Indian Reservation probably covered by water during a 100-year flood.

expected, on the average, about once in 100 years. The approximate area of the flood plain covered by water during a flood of this size is shown in figure 4. Some of the area will be covered by a floodflow of about 11 million gpm, which occur, on the average, once in 10 years.

Ground Water

Occurrence

Water-bearing materials underlying the upland part of the Nisqually Indian Reservation as mapped by Noble and Wallace (1966) include sand, gravel, clay, silt, and "hardpan" in layers of varying thickness and lateral extent. The lower part of the reservation--the Nisqually River flood plain--is underlain by river-deposited silt, sand, and gravel. Well drillers' records of wells on the upland on and near the reservation describe the materials as ranging in size from clay to boulders and generally poorly sorted. Layers of sand and gravel in the water-saturated zone will yield water to wells. Properly constructed wells can yield as much as 200 gpm; although the domestic-supply wells tapping these deposits generally have pumps yielding only 5 to 25 gpm.

Water levels in the wells on the reservation are usually only slightly above the elevation of the nearby Nisqually River. Therefore, wells on the flood plain are generally shallow, whereas wells at some places on the upland above the flood plain must be drilled to depths greater than 200 feet to reach water (fig. 3).

Spring zones in a few places along the bluff bordering the flood plain (fig. 2) indicate water-bearing materials beneath the upland. Most of the springs yield only 1 to 2 gpm, although in the southwest corner of sec. 35, T. 18 N., R. 1 E., a spring flowing from a wide zone was estimated to have a flow of about 800 gpm in December 1972. A field study by the Bureau of Sports Fisheries and Wildlife disclosed that additional springs in this area had a total flow greater than 6,500 gpm in February 1973.

The water-bearing material underlying the flood plain of the Nisqually River is mostly silt and sand, but does include layers of gravel. Properly developed wells tapping water in the gravel may yield as much as 200 gpm. The fine grain size of most of the material tends to slow down the downward and horizontal movement of ground water, and some clay and fine silt layers may trap the ground water under pressure. One well (well 5 in fig. 2, now owned by J. Simmons) drilled into these materials had an observed flow of about 4 gpm and a water level 2 feet above land surface.

Several small lakes are located on the upland immediately west of the reservation. The lakes are in closed basins without stream inlets or outlets, and the bottoms of St. Clair and Lost Lakes are below sea level. The lake surfaces indicate the elevation of the ground-water "table"--the top of the zone of water-saturated materials--beneath the upland part of the reservation. The levels of these lakes and water levels in wells are similar in their seasonal variations.

Water-Level Changes

Water levels in wells and in the closed-basin lakes are affected by seasonal changes in the addition and subtraction of water. The levels generally are higher in the winter and spring when precipitation is greater than pumpage, evaporation and transpiration, and the levels are lower in the summer and fall when pumpage, evaporation and transpiration generally are greater than precipitation. To determine the amount of such seasonal changes in water levels in the general area of the reservation, monthly measurements were made of the water levels in several wells in and near the reservation and of the level of Lost Lake. The measurements made on the reservation, shown graphically in figure 5, show the effects of seasonal precipitation patterns and pumping from wells.

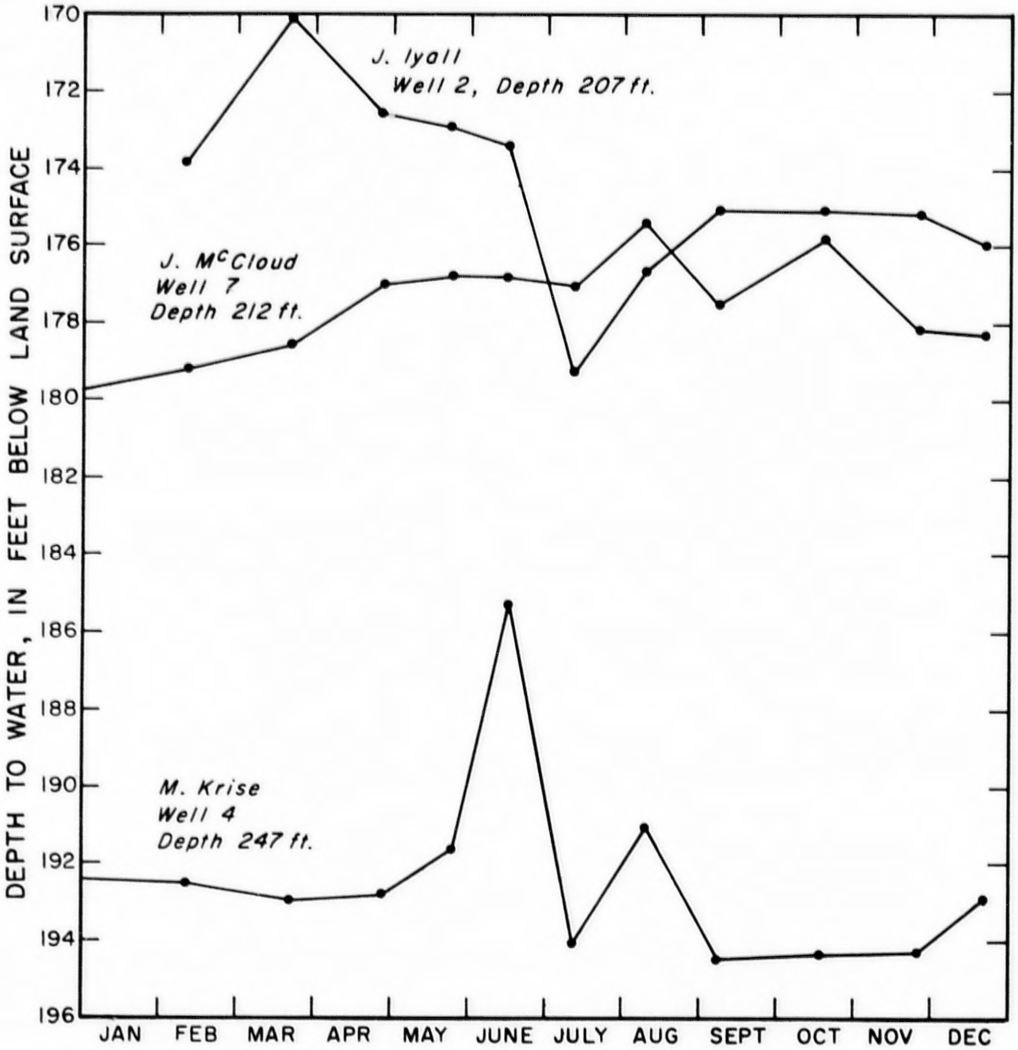

FIGURE 5.--Seasonal water-level changes in selected observation wells, 1972.

Potential for Future Use

At present (1973) ground-water use on the reservation is limited to one well on the flood plain and five wells on the upland above the river; about 16,000 gpd (gallons per day) are used. The study of ground-water conditions in the area indicates that the potential for future development would allow pumpage of several times this amount.

The analyses of seasonal water-level variations (fig. 5) and well records indicate that the water-bearing materials being tapped are capable of yielding much more water. Over the entire year, water-level variations are small and indicate that ground water moves easily through the materials. Spring flow from the base of the bluff (fig. 2) is fairly steady, also indicating that at present (1973) the water-bearing materials beneath the upland are not being used to their full capacity. Adequate supplies of water for additional housing development and (or) modest commercial activities are available.

QUALITY OF WATER

Precipitation that falls on the land surface changes in chemical character as it moves through the water cycle as surface or ground water. The concentrations of various chemicals and dissolved minerals in natural waters is partly dependent upon the length of time the water has been in contact with the ground. Ground water generally contains more dissolved matter than surface water. However, ground water tends to maintain a more stable temperature and chemical composition than surface water which is more likely to have temperature and chemical changes.

Fecal-coliform bacteria are considered to suggest water pollution. These bacteria come from both man and some animals. Surface water, by flowing over the ground, generally has a greater opportunity to pick up these organisms than does ground water. For this reason coliform bacteria in surface water generally can be expected to be more numerous than in ground water.

Nisqually River

Water in the Nisqually River is generally of excellent quality for most uses and would be suitable for drinking after filtration and chlorination. The water is generally quite clear except during the period of high streamflow, November through February. The reach of the river at the reservation is upstream from where there is effects of salt-water movement in the tidal reach of the river, so there are no problems of salt-water contamination.

During the period of higher flow, much clay, silt and fine sand is eroded from the riverbanks and carried in the water. The water appears quite muddy during periods of high streamflow but these periods usually last only a few days and occur only a few times each winter. The water tends to clear up between these short periods of high streamflow. Samples of river water collected at McKenna in 1965 and 1966 indicate that, on the average, about 250,000 to 300,000 tons of fine sand, silt, and clay particles are carried by the river each year. Most of this material is moved between November-February during three or four short periods of floodflows. About 100,000 tons of the fine materials are estimated to be carried in a single day when the average daily flow is about 5.2 million gpm.

The temperature range of the Nisqually River water makes it suitable for fish propagation and rearing. Highest, lowest, and average water temperatures for each month, as observed at McKenna during 1945-68, are given in the following table:

Value	Degrees Fahrenheit											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Highest	43	43	47	48	49	57	64	63	64	58	51	45
Average	40	40	42	45	49	53	55	56	57	54	47	41
Lowest	35	35	39	41	42	48	51	52	52	47	41	37

Ground Water

Samples of ground water were collected from several wells and analyzed for dissolved minerals and fecal-coliform bacteria. The water sampled showed no contamination from bacteria. Chemical analyses of the water show it to be of good quality and suitable for drinking. The only exception to this generally good quality was found in well 5 (fig. 2); the water was observed to contain a noticeable quantity of iron. Although dissolved iron in excessive concentration has not been found dangerous to man, the water has an unpleasant taste and color when exposed to the air and can stain laundry and plumbing fixtures.

CONCLUSIONS

Housing Locations

Sites for additional housing units on the reservation would be most favorable on the upland area. Supplies of good-quality ground water appear to be available from wells drilled to depths of 200 to 250 feet. Disposal of household wastes by means of septic tanks and drainfields probably would not adversely affect the quality of the ground water beneath the upland because of the thick (150-200 ft) layers of silt and clay material overlying the water-saturated materials. The silt and clay should act as a filter system that largely protects the ground water from contamination from above.

Land developed for housing construction on the Nisqually River flood plain would be subject to flooding; water could be as much as 2 feet deep across the entire valley bottom. In addition to this infrequent, but very real hazard, the ground water at shallow depths near the river would be subject to contamination from septic tanks, possibly rendering it unsafe for drinking. If housing units must be situated on the flood plain, the houses should be raised several feet above flood levels, and wells should be drilled to depths considerably below river level (30-50 ft).

Fish-Hatchery Location

The Nisqually River is a noted producer of steelhead and salmon. These resources could be enhanced by a hatchery on the reservation. The quality of the Nisqually River water is excellent for this purpose, especially from a temperature standpoint. A ground-water supply could be easily developed along the river to provide water when the floodflows were too turbid for hatchery use--or perhaps to provide warmer water during the winter for greater growth rate. The potential exists here for an aquaculture project similar to that operated by the Lummi Indians.

A hatchery or similar facilities would have to be protected from flooding from the river. The land level would have to be raised several feet or the area protected with a dike. Suitable fill material is available locally and this need should not increase the cost of a hatchery appreciably.

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APPENDIX

I. Previous Investigations

The Nisqually Indian Reservation was included in the area covered by a general investigation of the geology and ground-water resources of Thurston County by Wallace and Molenaar (1961) and Noble and Wallace (1966). The countywide study included a canvass of some of the wells on the reservation and a geologic reconnaissance of the area.

The soils of the area were examined in a countywide study by Ness and others (1958).

A general evaluation of the hydrologic characteristics of the Nisqually River basin is included in a study by the Puget Sound Task Force, Hydrologic Studies Technical Committee (1970), and the low-flow and temperature characteristics of the Nisqually River were included in studies by Hidaka (1972, 1973). Measurements of water temperature in the Nisqually River were made as part of a statewide study of stream temperatures by Collings (1973) and Collings and Higgins (1973).

II. Data Collection

Surface Water

Although streamflow values throughout the report are given in gallons per minute, in the appendix tabulations they are given in cubic feet per second, the unit commonly used by hydrologists in this country. (A cubic foot per second equals about 449 gallons per minute.)

The records of discharge (streamflow) of the Nisqually River at the gaging station, Nisqually River near McKenna (fig. 1), were analyzed to present data on monthly discharges (table III-A), the maximum, minimum, and annual average discharges and average daily discharges (table III-B), low-flow frequencies (table III-C), and floodflow frequencies (table III-D).

Sampling of the Nisqually River water for chemical and sanitary analyses was made on a regular basis from 1959 through 1969. Data on suspended-sediment concentration in the river water and related riverflows were obtained almost monthly during the period February 1972 to present (1973), at the bridge on Interstate Highway 5 downstream from the reservation.

Ground Water

The evaluation of ground-water conditions on the reservation was based on data obtained during a field canvass and inventory of wells (table V-A) and from drillers' pump tests and records of materials penetrated (table V-B). Measurements of water levels in several wells (fig. 5) were made on a monthly basis. The chemical and sanitary quality of ground water on the reservation was determined from collection of water samples from two wells (table V-C). The water-quality samples were collected beyond the pressure tanks, and after the tanks had been emptied, to assure sampling for coliform bacteria from the aquifer rather than from the pumps and tank systems.

III. Streamflow Data for Nisqually River near McKenna

A. Maximum, minimum, and average monthly discharge, 1942-71:

	Discharge (cfs)		
	Maximum	Average	Minimum
January	4,193	2,822	1,681
February	4,446	2,779	1,751
March	3,346	2,205	931
April	2,620	2,074	1,248
May	2,864	1,967	920
June	2,267	1,539	625
July	1,780	1,003	480
August	1,142	810	479
September	1,422	946	681
October	2,286	1,498	841
November	4,586	2,286	578
December	5,370	2,883	1,038

B. Maximum, minimum, and average annual discharge, and maximum and minimum average daily discharges, 1942-62, 1970-71:

	Discharge (cfs)	Date
Annual:		
Maximum	2,540	1956
Average	1,803	
Minimum	1,372	1962
Average daily:		
Maximum	17,000	December 12, 1955
Minimum	197	November 9, 1952

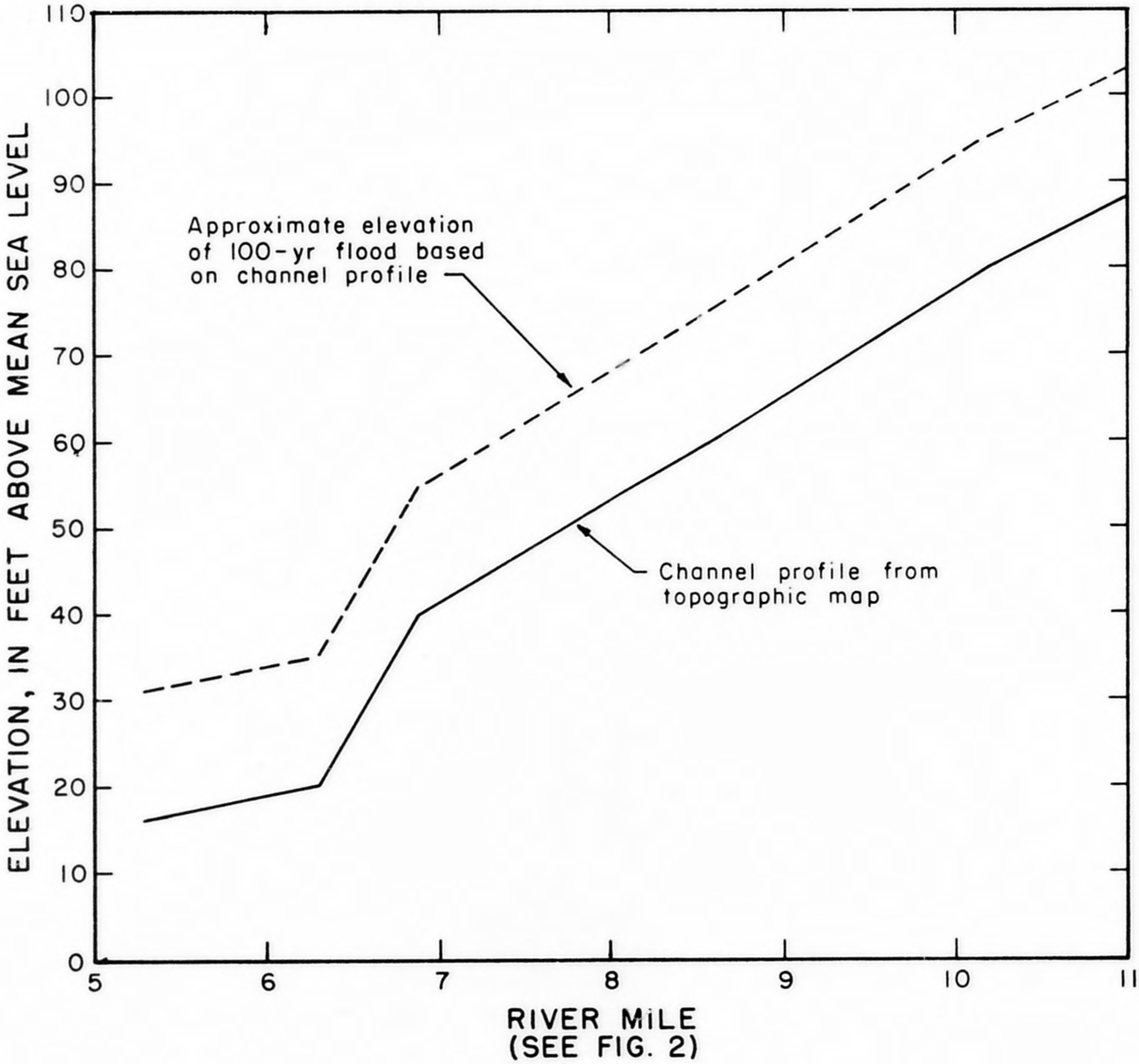
C. Average discharge and recurrence intervals of low flows of selected durations, 1941-63 (Hidaka, 1973, p. 39):

Number of consecutive days of given low flow	Average streamflow (cfs) for indicated recurrence interval (yrs)				
	2.0	5	10	20	30
7	540	445	405	375	360
30	690	560	500	455	430
90	830	660	590	540	510
183	1,190	990	900	840	800

D. Flood discharges and frequencies, for periods 1942-63, 1970-72:

Peak discharge (cfs)	Recurrence interval (yrs)
19,900	5
21,200	6
24,100	10
26,500	15
29,100	25
32,600	50
35,800	100

Data obtained from a number of crest-stage gages were used to estimate the approximate 100-year flood profile shown in the accompanying figure.



ELEVATION, IN FEET ABOVE MEAN SEA LEVEL
110
100
90
80
70
60
50
40
30
20
10
0
5
6
7
8
9
10
11
RIVER MILE
(SEE FIG. 2)
Approximate elevation of 100-yr flood based on channel profile
Channel profile from topographic map

IV. Water-Quality Characteristics, Nisqually River near McKenna

Year	Number of samples	Value	Milligrams per liter												pH (units)	Temperature (°F)	Turbidity (Jackson turbidity units)	Dissolved oxygen (DO), in mg/l	Coliform (colonies per 100 ml)
			Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrogen (N)	Total dissolved solids					
1959	6	Maximum	15.0	4.40	6.0	1.6	3.0	1.3	30	3.1	2.0	0.3	0.15	53	7.4	59.0	--	12.1	930
		Minimum	13.0	.10	3.5	.9	2.3	.5	18	1.8	.0	.0	.00	44	6.2	41.9	--	10.4	0
		Average	14.0	1.44	.52	1.2	2.8	.8	24	2.6	1.3	.1	.06	46	6.9	51.4	--	11.0	259
1960	8	Maximum	18.0	.61	7.0	1.6	3.8	.7	35	5.2	2.2	.2	.10	54	7.4	61.3	--	12.4	430
		Minimum	14.0	.11	5.0	.9	2.7	.4	24	1.8	1.0	.0	.00	42	6.9	40.6	--	9.9	0
		Average	15.1	.30	5.8	1.2	3.0	.6	27	2.7	1.6	.1	.06	48	7.2	48.7	--	11.2	53
1961	4	Maximum	15.0	.53	6.0	1.7	3.2	.5	28	3.8	2.2	.1	.10	51	7.2	53.6	--	12.3	430
		Minimum	14.0	.10	5.0	1.2	2.6	.3	25	1.8	1.2	.0	.02	45	6.9	41.9	--	10.0	36
		Average	14.3	.27	5.5	1.4	2.9	.4	27	2.8	1.6	.1	.56	48	7.1	46.9	*25	11.5	144
1962	4	Maximum	22.0	.43	7.5	2.4	4.2	.9	41	3.4	2.0	.1	1.5	61	7.4	60.6	15	11.5	210
		Minimum	15.0	.09	5.5	.8	2.8	.6	25	2.4	1.2	.0	.50	46	7.0	41.2	0	8.6	0
		Average	17.8	.28	6.3	1.3	3.4	.8	30	2.9	1.7	.1	.90	51	7.2	49.7	10	10.6	83
1963	4	Maximum	16.0	.36	6.0	1.7	3.8	.8	32	3.4	2.2	.1	.16	55	7.3	55.9	20	12.0	2,400
		Minimum	15.0	.24	5.5	1.1	3.0	.5	26	2.4	1.5	.1	.05	48	7.0	41.0	5	10.3	0
		Average	15.3	.30	5.8	1.5	3.3	.7	29	3.0	1.9	.1	.10	50	7.1	48.0	11	11.3	667
1964	4	Maximum	15.0	.75	5.5	1.8	3.3	.7	29	2.6	2.2	.1	.18	48	7.3	53.2	20	11.7	430
		Minimum	12.0	.19	5.0	1.1	3.1	.4	24	1.4	1.5	.0	.05	37	6.8	41.4	5	11.2	36
		Average	13.8	.40	5.1	1.4	3.2	.6	26	2.2	1.9	.1	.11	43	7.1	47.3	14	11.5	183
1965	4	Maximum	17.0	.36	7.2	2.1	3.9	.7	37	2.8	2.8	.1	.20	54	7.3	68	15	12.8	230
		Minimum	13.0	.14	5.2	1.1	3.2	.4	23	1.6	2.0	.0	.06	37	6.9	41	0	9.8	0
		Average	15.0	.22	6.1	1.7	3.4	.6	30	2.4	2.0	.1	.09	47	7.2	50.2	7	11.5	107
1966	4	Maximum	15.0	--	6.0	1.7	3.6	.9	32	2.8	1.8	.1	.15	50	7.4	59.7	--	12.3	1,500
		Minimum	12.0	--	5.0	1.4	3.2	.5	26	1.8	1.0	.0	.04	39	6.9	43.2	--	10.9	0
		Average	13.0	--	5.4	1.6	3.4	.6	28	2.2	1.4	.1	.09	44	7.2	51.6	--	11.4	530
1967	10	Maximum	15.0	--	5.5	1.9	3.6	1.3	31	2.8	2.0	.2	.20	51	7.5	51	--	13.7	930
		Minimum	13.0	--	5.0	1.1	2.9	.4	23	1.4	1.0	.1	.02	42	7.1	42	--	10.3	0
		Average	14.2	--	5.2	1.5	3.1	.7	27	2.1	1.7	.1	.06	46	7.3	46	--	11.8	180
1968	12	Maximum	16	--	6.2	1.7	3.6	.6	31	2.2	1.7	.1	.11	52	7.6	55.4	--	13.9	400
		Minimum	12	--	4.6	1.2	2.7	.5	23	1.2	1.0	.0	.02	39	6.9	39.2	--	9.9	45
		Average	13	--	5.1	1.4	3.1	.6	26	1.8	1.4	.1	.07	44	7.3	47.4	--	10.6	186
1969	12	Maximum	15	--	5.9	1.7	3.6	.7	30	3.4	1.8	.2	.29	58	7.6	77.0	--	13.0	1,000
		Minimum	11	--	4.9	1.4	2.6	.5	25	1.4	.9	.0	.02	38	7.0	37.4	--	10.3	110
		Average	13	--	5.4	1.5	3.2	.6	27	2.3	1.4	.1	.09	48	7.2	50.0	--	11.5	428

*One sample only.

V. Ground-Water Data

A. Records of wells

EXPLANATION

Altitude (feet): altitude above mean sea level of land surface at well interpolated from topographic maps.
Type of well: dr, drilled.
Water level: measurements expressed in feet and decimals of feet were made by the Geological Survey; those in whole feet were reported by owner, tenant, or driller.

Type of pump: S, submersible; C, centrifugal.
Use of water: H, domestic; I, irrigation; U, unused.
Remarks: dd, drawdown of water level during pumping, in feet; C, chemical analysis; gpm, gallons per minute; L, log in table V-B; Obs, water-level-observation well; 470140N12241511, U.S. Geological Survey reference number.

Well no. on fig. 2	Owner or tenant	Well				Water-bearing zone(s)		Water level		Pump		Use of water	Remarks
		Altitude (ft)	Type	Diameter (in.)	Depth (ft)	Material	Depth interval (ft)	Below top of casing (ft)	Date	Type	Horsepower		
1	S. W. Staatz	39	Dr	8	48	Gravel	41-48	7.46	12-22-71	C	20	I	Pumped 150 gpm for 4 hrs with 12 ft dd; L, Obs.; 470237N12241221.
2	J. A. Iyall	221	Dr	6	207	Gravel and sand Gravel and coarse sand	183-200 200-205	173.9	2-14-72	S	1	H	L, Obs.; 470140N12241501.
3	Carolina Sandoval	230	Dr	8	352	Sand Gravel and sand	341-345 345-350	184	1-19-71	S	7½	H	L; 470132N12241281.
4	M. Krise	236	Dr	6	247	Sand and gravel	225-245	194.29	12-21-71	S	1	H	L, Obs.; 470134N12240491.
5	J. Simmons	263	Dr	6	231	Gravel, sandy	189-231	198.75	12-21-71	S	1	H	Has probable leak in pump column L, Obs.; 470002N12239261.
6	C. Smith	273	Dr	6	239	Sand and gravel	221-239	193	7- 7-71	S	1	H	C, L; 465959N12239301.
7	J. McCloud	280	Dr	6	212	Sand and gravel	180-183 190-212	181.16	12-21-71	S	1	H	L, Obs.; 465949N12239271.
8	G. McCloud	280	Dr	6	222	Sand and gravel	203-222	183.48	12-21-71	S	1	H	L; 465952N12239301.
9	F. Mounts	96	Dr	6	123	Sand and gravel	116-123	+2.0	1-10-72	--	--	U	Possible iron problem; C, L; 465949N12239541.

B. Drillers' logs of wells

Material	Thickness (feet)	Depth (feet)
Well 1 (470237N12241221). S. W. Staatz. Drilled by R. E. Charlion, 1953.		
Sand and clay	40	40
Gravel	8	48
Casing, 8-inch to 48 ft; perforated, 41-48 ft; SWL, 6 ft. Pumped 4 hrs at 150 gpm, dd 12 ft.		

Material	Thickness (feet)	Depth (feet)
Well 2 (470140N12241501). J. A. Iyall. Drilled by Soil Sampling Service, 1971.		
Topsoil, silty	3	3
Gravel	17	20
Sand and gravel	20	40
Sand, some gravel, wet	20	60
Sand, silty, wet	10	70
Sand, wet	18	88
Gravel, hard, dry	32	120
Sand, coarse, moist	19	139
Gravel, sandy, moist	44	183
Gravel and sand	17	200
Gravel (2-inch pebbles) and coarse sand	5	205
Sand, silty, and gravel	2	207

Material	Thickness (feet)	Depth (feet)
Well 3 (470132N12241281). Carolina Sandoval. Drilled by Carrs Drilling Co., 1971.		
Boulders, cobbles, and clay, hard	10	10
Gravel and sand, loose, medium	22	32
Gravel, large and small, with boulders	8	40
Sand and clay	18	58
Clay, brown, and gravel	10	68
Sand and clay	6	74
Gravel, and brown sand, with some water at 78 ft	4	78
Sand, brown, and clay	10	88
Gravel and clay (hardpan)	37	125

(continued)

Material	Thickness (feet)	Depth (feet)
Well 3--Continued		
Gravel, loose, small	5	130
Cobbles, gravel, and clay (hardpan)	10	140
Gravel, large, and clay (hardpan)	20	160
Gravel, clay, and brown sand	22	182
Gravel and clay (hardpan)	21	203
Gravel and sand with water (bailer tested at 213 ft, 14 gpm, 2 ft dd)	13	216
Gravel and reddish brown clay	3	219
Gravel and reddish brown sand (bailer tested at 221 ft, 13 gpm, 7 ft dd)	2	221
Gravel, sand, and blue clay	5	226
Sand, gravel, and reddish clay	5	231
Clay, brown, with dry sand	14	245
Sand, blue clay, and some gravel	2	247
Clay and sand, mixed colors	13	260
Sand and some gravel, with some water	1	261
Sand and large gravel, with water, but not good flow	7	268
Sand and large gravel, more water	6	274
Gravel, small, and sand with water (bailer tested at 275 ft, 19 gpm, 4 ft dd)	3	277
Sand and some gravel, with some water	5	282
Clay, silty, dry, gray	6	288
Sand, with gravel layers and some water	9	297
Sand and clay	2	299
Clay, mixed colors, with chunks of wood	15	314
Sand, gravel, and blue clay	4	318
Sand, fine, with gravel and silt	9	327
Sand and fine gravel, with water	2	329
Sand, fine, with gravel and clay	2	331
Clay, peaty, brown	9	340
Gravel, large, and sand, with water (bailer tested at 341, 20 gpm, 12 ft dd	1	341
Sand (water)	4	345
Gravel and sand, with water, very good	5	350
Gravel and blue clay (dry)	2	352

Screened 341-351 ft.

Material	Thickness (feet)	Depth (feet)
Well 4 (470134N1224049l). M. Krise. Drilled by Soil Sampling Service, 1971.		
Sand, silty, brown, and gravel	51	51
Sand, silty, brown	18	69
Gravel, sandy, brown	3	72
Sand and gravel, moist	17	89
Sand, silty, and gravel	136	225
Sand, brown, and gravel; static water level at 226 ft	20	245
Sand, silty, and gravel	2	247
Screened 239-244 ft.		

Material	Thickness (feet)	Depth (feet)
Well 5 (470002N1223926l). J. Simmons. Drilled by Soil Sampling Service, 1971.		
Soil, silty, dark brown, and gravel	4	4
Sand, silty, brown, and gravel	36	40
Sand, clean, and gravel	17	57
Sand, silty, brown, and gravel	8	65
Gravel	4	69
Boulder	1	70
Sand and gravel, with some water	40	110
Gravel and silt	20	130
Silt, light brown	10	140
Gravel, silty, brown	16	156
Sand, silty, brown, with gravel	3	159
Gravel, silty, brown, with sand	30	189
Gravel and sand, clean, with water	31	220
Gravel, sandy	11	231
Screened 224-229 ft.		

Material	Thick-ness (feet)	Depth (feet)
Well 6 (465959N1223930l). C. Smith. Drilled by Soil Sampling Service, 1971.		
Loam, sandy, silty	2	2
Sand, light brown, and gravel	58	60
Sand, light brown, and gravel; silty	28	88
Sand, medium to coarse, and gravel	2	90
Sand, medium to coarse, and gravel; silty	17	107
Silt, fine, sandy, and brown gravel	10	117
Sand, silty, fine, gray, and gravel	1	118
Sand, silty, brown, and gravel	12	130
Silt, brown and gray	6	136
Sand, silty, brown, and gravel	64	200
Sand, silty, fine, brown, and gravel	21	221
Sand, medium to coarse, gray, and gravel with water, static water level at 208 ft	17	238
Sand, silty, gray, and gravel with water, static water level at 193 ft	1	239

Material	Thick-ness (feet)	Depth (feet)
Well 7 (465949N1223927l). J. McCloud. Drilled by Soil Sampling Service, 1971.		
Loam, sandy, brown	4	4
Sand, silty, brown, and gravel	10	14
Sand, silty, brown	6	20
Sand, silty, brown, and gravel	126	146
Sand, silty, gray, and gravel	13	159
Sand, silty, brown, and gravel	21	180
Sand and gravel, clean, with water	3	183
Sand, silty, gray-brown, and gravel	7	190
Sand, clean, and gravel	22	212
Screened 203-208 ft.		

Material	Thickness (feet)	Depth (feet)
Well 8 (465952N1223930l). G. McCloud. Drilled by Soil Sampling Service, 1971.		
Silt, and sandy gravel	21	21
Gravel, sandy, some silt	50	71
Gravel, sand, some silt; cemented	10	81
Gravel, silty, wet	20	101
Sand and silt, some 2-inch gravel	20	121
Sand and gravel, cemented	20	141
Gravel and sand	19	160
Boulders	10	170
Sand, silty, brown, and gravel	14	184
Sand, silty, brown, and gravel	6	190
Sand, coarse, silty, brown, and gravel	13	203
Sand, brown, and gravel, with water, static water level at 181 ft	19	222

Material	Thickness (feet)	Depth (feet)
Well 9 (465949N1223954l). F. Mounts. Drilled by Soil Sampling Service, 1971.		
Loam, silty, brown	4	4
Sand, silty, brown, and gravel	14	18
Sand, gray, and gravel	2	20
Sand, silty, gray, and gravel	5	25
Sand, brown, and gravel; clean	32	57
Sand, silty, gray, and gravel	14	71
Sand, fine to medium, silty, gray	6	77
Sand, coarse, gray	3	80
Sand, fine to medium, silty, gray	19	99
Sand, silty, gray, and gravel	7	106
Sand, gray, and gravel	4	110
Sand, silty, gray, and gravel	6	116
Sand, gray, and gravel	7	123
Screened 118-123 ft.		

C. Drinking-water standards of the U.S. Public Health Service (1962) and chemical quality of ground waters from two wells are listed below:

Milligrams per liter											
Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrogen (N)	Total dissolved solids	Coliform (colonies per 100 ml)
U.S. Public Health Service											
*N	N	N	N	N	N	250	250	1.5	10	500	0
Well 6 - C. Smith											
49	8.8	6.0	7.0	2.7	69	3.4	4.1	0.1	0.51	122	0
Well 9 - F. Mounts											
58	10	7.5	12	1.1	102	2.5	3.0	0.3	0.01	108	0

*N, no established limit.