ORIGINAL

Preliminary Geologic Evaluation Of a Proposed Nuclear Power Plant Site Hawks Point, Pacific County, Washington

by

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PURPOSE AND SCOPE OF INVESTIGATION

The Washington State Department of Water Resources and the Office of Nuclear Energy are jointly making preliminary studies of a number of sites proposed for nuclear power plants. To assist with the studies the writer was asked to prepare a preliminary report on geologic conditions and potential geologic hazards that may be encountered in locating a nuclear plant at Hawks Point, on Willapa Bay.

This report is based on my general knowledge of the geology of the area and a review of published and open-file reports which are available. A special trip for an on-site reconnaissance was not made since I have visited the area several times in recent years and it was felt that insufficient additional information would be obtained to justify the special trip. The outcrop pattern of surficial geology was taken from an open-file map of the South Bend 15' quadrangle by Holly C. Wagner. Geology of areas not covered by the Wagner report were interpreted from the geologic map of the state of Washington.

Geologic sections across the project area (Fig. 2) were constructed without adequate data to verify the thickness of the various materials or to accurately define the contacts between geologic units. Where data were lacking, contacts and thicknesses were inferred.

Logs of test borings by the Department of Highways for that section of SSH No. 13A between the North River and North Cove were examined and did provide a good soil profile and geologic data to a depth of 30 to 40 feet below land surface. Foundation borings for the North River bridge provide a good section down to the bedrock-overburden interface which ranges between 70 and 115 feet below land surface.

LOCATION AND TOPOGRAPHY

Hawks Point, the site under consideration, is a southerly projection of the mainland into Willapa Bay and occupies a position midway between the mouths of the North and Cedar Rivers in Sections 3, 4 and 5, Township 14 North, Range 10 West, W.M., Pacific County, Washington. The area is served by State Highway No. 105 which connects the towns of Raymond and Tokeland and has access from Willapa Bay by shallow draft water craft, principally barges.

The area consists of an irregular, hilly upland surface of moderate relief ranging in elevation from sea level to slightly in excess of 400 feet as you progress north. It is a part of the Willapa Hills uplift and occupies a position on the west slope of that structure.

Willapa Bay enjoys a maritime climate with cool dry summers and warm wet winters. Weather is strongly influenced by storms approaching from the Pacific Ocean to the west. The area receives in excess of 80 inches of rainfall annually, occurring mainly during the winter and spring months.

GEOLOGY, GENERAL

Although very little detailed geologic mapping has been done in the Willapa Bay area, it is possible to reconstruct geologic conditions in a generalized way in sufficient detail to permit a preliminary evaluation of geologic problems that may be encountered when locating a nuclear power plant at Hawks Point.

The proposed project is underlain primarily by fluvial, glaciofluvial and marine deposits of the Satsop formation herein referred to as "terrace deposits". The terrace deposits are confined to an uplifted coastal plain lying west of the Willapa Hills and north to Grays Harbor. The terrace deposits occur at elevations greater than 400 feet above sea level and extend to an unknown depth, perhaps as much as 200 feet below sea level where they lie unconformably on volcanic (predominantly basalt) rocks of the Crescent formation. The terrace deposits are overlain by up to 30 to 40 feet of recent marine mud, beach sands and peat deposits.

There are no known deep wells on Hawks Point peninsula so the total thickness of the unconsolidated materials is not known. However, wells at Bay Center, approximately 40 miles south of

Hawks Point, were drilled to depths of 600 feet below sea level and did not encounter the underlying volcanic rock.

Fine-grained mud and silt overlies the Pleistocene marine sediments in Willapa Bay. The total thickness of the river-laid sediments is not known, but probably is not in excess of 20 to 30 feet other than in drowned channels of the North and Willapa Rivers which were subsequently filled with the bay sediments.

The Willapa Bay sediments are of concern since their ability to support the large dikes necessary to provide the fresh water reservoir proposed for temperature control of the nuclear reactor is questionable.

GEOLOGIC UNITS

Crescent Formation The Crescent formation is a predominantly fine-grained pillow and blocky-jointed basalt at least 5,000 feet thick and is exposed in most of the stream valleys and on the western slope of the Willapa Hills and is believed to underlie Willapa Bay and the project area.

Terrace Deposits Within the area of the proposed project, the terrace deposits consist mostly of massive to cross-bedded, semi-consolidated fine sand and pebbly gravel containing an iron-stained cementing material.

The terrace deposits contain a few cobbles and some gravel. The gravels are generally silty and from cross-bedding and channeling suggest stream deposition.

Silt and clay beds up to 30 feet thick are present throughout most of the area. The silt and clay beds are thin bedded to massive and in places contain pebbles and organic material. The stiffer, more massive clays in places express vertical jointing.

In most of the upland area of the project, the upper 30 to 40 feet of material consists principally of fine-grained sand, silts and clays with numerous peat deposits. Deeper, the percent of larger grain size materials seems to increase; however, since there are no known deep bore holes, the exact character of the materials is not known and can only be inferred. The terrace deposits within the project area are essentially flat lying.

ENGINEERING PROPERTIES OF ROCK MATERIALS

The volcanic rocks which are believed to underlie the project area at about minus 200 feet mean sea level are quite dense and resistant to erosion and would serve as a good foundation and should possess adequate loading capacity for major engineering structures.

It is believed that the marine sedimentary formations (Lincoln Creek and McIntosh formations) are missing beneath Hawks Point and the marine sand and gravel materials (terrace deposits) probably lie directly on the volcanic rock. Although the engineering properties of the Pleistocene sediments are not known, it is felt that they would possess properties similar to much of the Vashon glacial drift materials of the Puget Sound area which do support many major structures. Clay interbeds should be considered marginal and subject to sliding.

The river-laid muds and silts of Willapa Harbor are the poorest quality foundation materials within the project area and it is questionable whether they would support the dikes required to provide the fresh water reservoir proposed for temperature control of the reactor. It is quite possible that the fine-grained deposits would have to be removed to a considerable depth before placing the dike material.

It is strongly recommended that a seismic profile be constructed from Hawks Point eastward to Kellogg and from the power plant site southeasterly to Bruceport Park. This plus test drilling on Hawks Point would clearly define the thickness and seismic properties of the tidal flat deposits of Willapa Bay and the Pleistocene sand and gravel materials of Hawks Point. The test drilling on Hawks Point would also provide drill samples of the material penetrated and permit pump testing of all water-bearing formations.

SEISMISCITY

Hawks Point on Willapa Bay like the entire west coast of the state of Washington is in an active seismic area and is subject to periodic earthquakes of varying intensity. Dr. Norman Rasmussen, seismologist at the University of Washington, compiled an intensity-distribution record for earthquakes in the state of Washington that occurred between 1840 and 1965. His compilation shows that there has been a marked increase in the frequency of seismic activity in the Puget Sound area since about 1940. Some of the strongest earthquakes recorded in the state of Washington occurred during that period.

Dr. Rasmussen's intensity-distribution map shows Hawks Point to be in intensity zone No. 1, a zone where earthquakes of

Generalized Seismic Intensity Map of State of Washington

by Norman Rasmussen

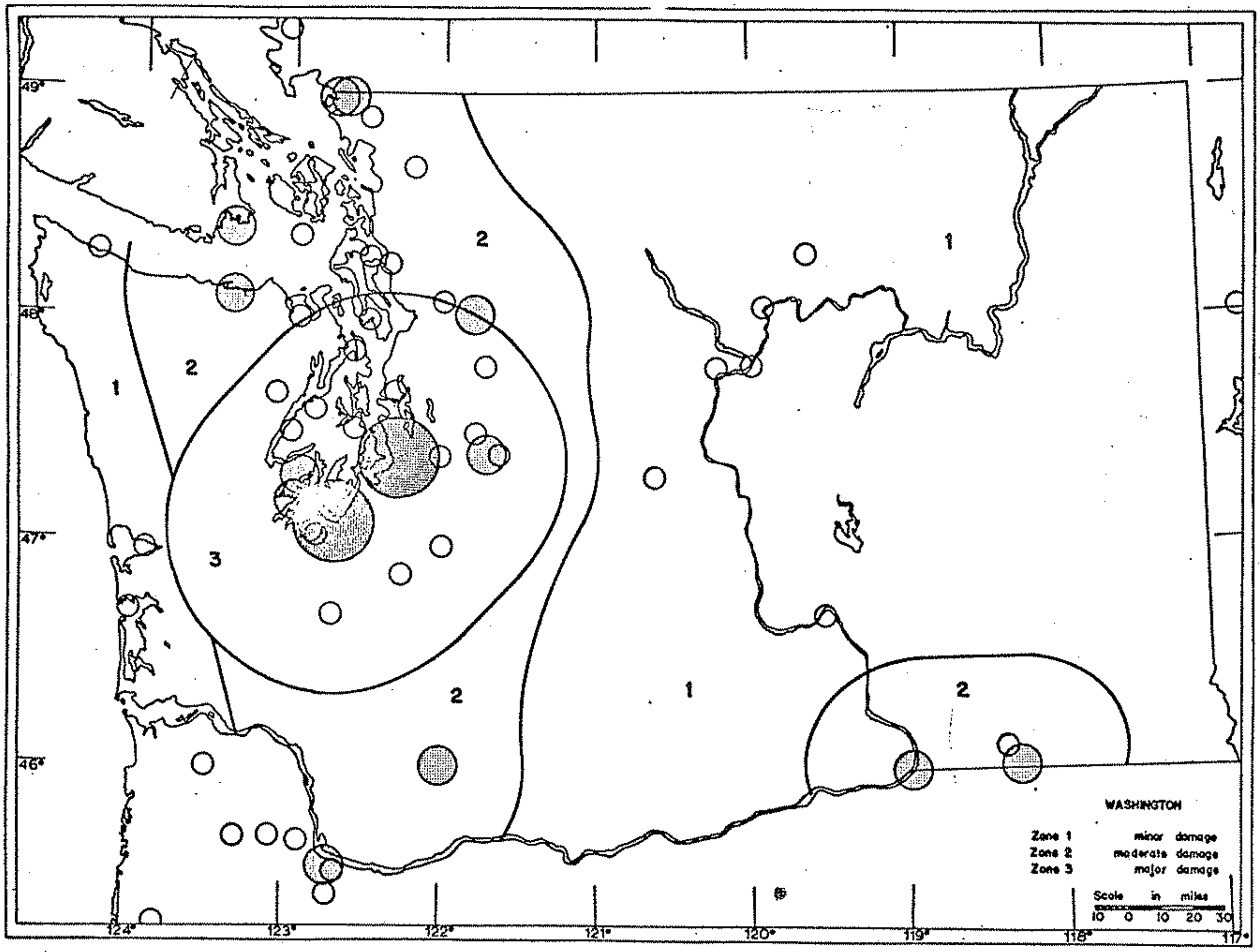


Figure 4

intensity VI on the modified Mercalli scale can be expected. Quakes of intensity VI are capable of causing only minor damage. However, Dr. Rasmussen's map shows the area a few miles east of Hawks Point to be in intensity zone III where major damage may occur. To provide an adequate safety factor, a nuclear power plant at Hawks Point should be designed to withstand an earthquake of intensity VIII on the modified Mercalli scale.

TSUNAMIS & TIDAL WAVES

Willapa Harbor is exposed to the Pacific Ocean, therefore, any nuclear power plant on Hawks Point should be designed to withstand tsunamis, the huge walls of water that sometimes follow submarine earthquakes and volcanic activity. Tidal waves may also be of concern, however, there has not been a history of major tidal wave activity in this area during recent times.

WATER RESOURCES

<u>Surface Water, Fresh</u> There are no known sources of fresh water either surface or ground water immediately available to Hawks Point in sufficient quantity to satisfy temperature control requirements on a once-through basis. The major streams in the area, the North and Willapa Rivers, do not possess sufficient flows on a year-round basis to satisfy the needs of the facility and other demands placed on the two sources. It is possible to obtain sufficient water from the North River for an initial filling and make-up water if a reservoir of sufficient capacity to dissipate the heat is developed on the tidal flats adjacent to Hawks Point. The design and capacity would be

NORTH RIVER BASIN

North River near Raymond, Wash.

Location.—Lat. 46°48′30″, long. 123°51′00″, in sec. 6, T. 15 N., R. 8 W., on left bank 1¼ miles upstream from Salmon Creek and 10 miles northwest of Raymond.

Drainage area.—219 sq. mi.

Records available.—August 1927 to September 1960.

Gage.—Water-stage recorder. Datum of gage is 7.39 ft. above mean sea level (Western Washington Electric Light & Power Co. benchmark).

Average discharge.—33 years (1927-60), 954 cfs (690,700 acre-ft. per year).

Extremes.—1927-60: Maximum discharge, 35,000 cfs Dec. 10, 1933 (gage height, 15.8 ft., from floodmarks), from rating curve extended above 7,500 cfs; minimum, 21 cfs Aug. 24, 1951 (gage height, 1.01 ft.).

Remarks.—Some diversion for farm and domestic use. No regulation.

Revisions.—Revised figures of discharge, in cubic feet per second, for the water years 1952 and 1953, superseding figures published in State WSB No. 6, are given herewith:

MONTH	Mean	Per square mile	Runoff		Momentary maximum		Minimum day
			Inches	Acre-feet	Discharge	Date	
December 1951	1,980	....	....	....	....	....	687
Calendar year 1951	1,103	5.49	74.48	798,400	....	....	....
January 1952	1,567	....	....	....	....	....	628
February	1,708	....	....	....	....	....	567
March	890	....	....	....	....	....	522
April	608	....	....	....	....	....	300
May	351	....	....	....	....	....	178
June	161	....	....	....	....	....	116
July	78.7	....	....	....	....	....	56
August	63.9	....	....	....	....	....	44
September	46.4	....	....	....	....	....	37
Water year 1951-52	817	4.06	55.31	592,900	5,640	Feb. 5, 1952	37
October 1952	42.4	....	....	....	....	....	32
November	120	....	....	....	....	....	....
December	1,292	....	....	....	....	....	83
Calendar year 1952	575	2.86	38.95	417,500	....	....	....
January 1953	4,649	....	....	....	....	....	....
February	2,289	....	....	....	....	....	
March	940	....	....	....	....	....	674
April	622	....	....	....	....	....	435
May	592	....	....	....	....	....	440
June	314	....	....	....	....	....	319
July	129	....	....	....	....	....	236
August	90.0	....	....	....	....	....	78
September	79.8	....	....	....	....	....	56
Water year 1952-53	926	4.61	62.53	670,300	9,040	Jan. 24, 1953	32

Mean Discharge, in Cubic Feet Per Second

YEAR	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Annual
1954	346	1,434	2,958	2,926	3,247	1,064	1,021	254	279	192	150	378	1,175
1955	494	1,682	1,436	1,479	1,419	1,522	1,827	416	191	175	131	94.1	901
1956	1,112	2,734	3,151	2,756	1,367	2,882	848	210	329	115	75.8	107	1,310
1957	1,154	1,187*	2,305	811	1,771	1,899	911	318	170	99.4	79.5	52.4*	893
1958	206	616	2,047	2,187	2,121	894	1,129*	342*	184*	71.1*	45.1*	101	822
1959	474	2,714	1,746	2,586	1,212	1,098	1,449	876	374	150	69.3	505	1,102
1960	874	2,208	1,956	1,395	2,286	1,221	1,280	858	330	106	82.3*	69.1	1,055

Figure 3

NORTH RIVER BASIN

North River near Raymond, Wash.—Continued

Minimum Discharge, in Cubic Feet Per Second

YEAR	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Annual
1954...	144	555	932	994	1,110	495	400	176	174	104	76	213	76
1955...	187	300	778	823	561	771	729	271	129	93	65	58	58
1956...	84	820	1,230	1,000	648	948	315	133	133	70	55	42	42
1957...	81	470*	430	450*	591	986	500	187	118	70	50*	41*	41*
1958...	55*	131	533	743	1,090	620*	500*	220*	85*	41*	32	40	32
1959...	61	289	940	1,210	902	736	355	360	240	86	61	81	61
1960...	271	323	708	511	641	555	622	533	178	65	54*	54	54

Summary

YEAR	WATER YEAR ENDING SEPTEMBER 30							CALENDAR YEAR		
	Momentary maximum		Minimum day	Mean	Per square mile	Runoff		Mean	Runoff	
	Discharge	Date				Inches	Acre-feet		Inches	Acre-feet
1953	....	....	....	....	....	....	....	1,201	74.45	869,600
1954	9,240	Jan. 6, 1954	76	1,175	5.37	72.82	850,600	1,079	66.86	780,800
1955	6,710	Nov. 19, 1954	58	901	4.11	55.83	652,100	1,185	73.47	858,200
1956	7,940	Dec. 13, 1955	42	1,310	5.98	81.43	951,100	1,115	69.33	809,600
1957	8,840	Dec. 9, 1956	41	893	4.08	55.35	646,300	743	46.08	538,300
1958	5,560	Dec. 27, 1957	32	822	3.75	50.91	594,800	991	61.41	717,500
1959	8,480	Nov. 13, 1958	61	1,102	5.03	68.28	797,700	1,115	69.08	806,900
1960	11,500	Nov. 22, 1959	54	1,055	4.82	65.54	765,600	....	....	....

* Estimated.

Figure 3

greatly influenced by the ability of the tidal flats sediment to support the required dikes. Water quantities and storage capacity figures would have to be developed by the engineers responsible for designing the facility. Figure 3 contains a summary of stream flows of the North River at a gage 10 miles west of Raymond.

Ground Water, Fresh There are no records of drilled wells on the Hawks Point peninsula or adjacent areas which would indicate the water-bearing potential or thickness of the Pleistocene sand and gravel materials which are exposed over most of Hawks Point and which may extend to as much as 200 feet below sea level in that area. However, based upon wells that have been drilled in similar material at some distance from Hawks Point, it would appear that the Pleistocene materials could serve as an aquifer capable of producing moderate amounts of ground water if said deposits do extend to as much as 200 feet below sea level. It would not be unreasonable to expect yields of 100 to 200 gallons per minute from properly designed wells penetrating a relatively thick series of these materials. The test well previously recommended for the area would define water-bearing potential of these materials and furnish some of the data required for a quantitative evaluation. Yields in this range would be adequate to furnish domestic and plant requirements other than temperature control for the nuclear facility.

Marine Water Salt water in sufficient quantities for cooling purposes could no doubt be pumped from Willapa Bay. However, Willapa Bay is quite shallow and somewhat confined, suggesting that normal exchange of water due to tidal fluctuation and inflow from tributary streams would probably be limited to the point that ecological problems would result. In summary, it would appear that it would be necessary to develop a "water reuse" program if many of the environmental problems associated with the heat dissipation are to be prevented.

SUMMARY AND CONCLUSION

From this preliminary evaluation of the Hawks Point proposed nuclear power plant site the following summary is drawn:

The Hawks Point site is quite remote but occupies a position on Willapa Bay where adjacent areas are used extensively for boating, fishing and other recreational purposes. Willapa Bay is an important spawning and rearing area for a number of salt water fishery species and any appreciable water temperature change could upset the ecological balance of the area. There are no apparent geologic problems that would prevent development of a nuclear power plant on Hawks Point. However, the mud and silt deposits in Willapa Bay may require special attention or removal before dikes are built to provide water storage for temperature control of the reactor. Sufficient water for cooling purposes and for facility needs could probably be obtained from the North River and drilled wells respectively but would require a sophisticated reuse program for temperature control.

Conclusions

1. The preliminary evaluation of the Hawks Point nuclear power plant site disclosed no apparent geologic problems that

could not be accommodated in the engineering design of the plant.

2. Clay interbeds and peat deposits in the top 30 to 40 feet of overburden are of questionable stability and subject to slide.

3. Muds and silts of Willapa Bay may have to be removed to create foundations for dikes to enclose the reservoir.

4. Water requirements for cooling purposes probably are available but would require a sophisticated reuse program.

5. Power plant facility should be designed to accommodate an earthquake of intensity VIII on the modified Mercalli scale and to withstand tsunamis and tidal waves from the Pacific Ocean.

6. A number of environmental problems peculiar to projects such as the one under consideration are mentioned below but will require evaluation by people competent in the specific areas; they are:

a. Potential ecological imbalance.

b. Thermal pollution.

c. Project impact on present and potential recreation and residential developments.

d. Psychological effect on people who now live or plan to move to the area.

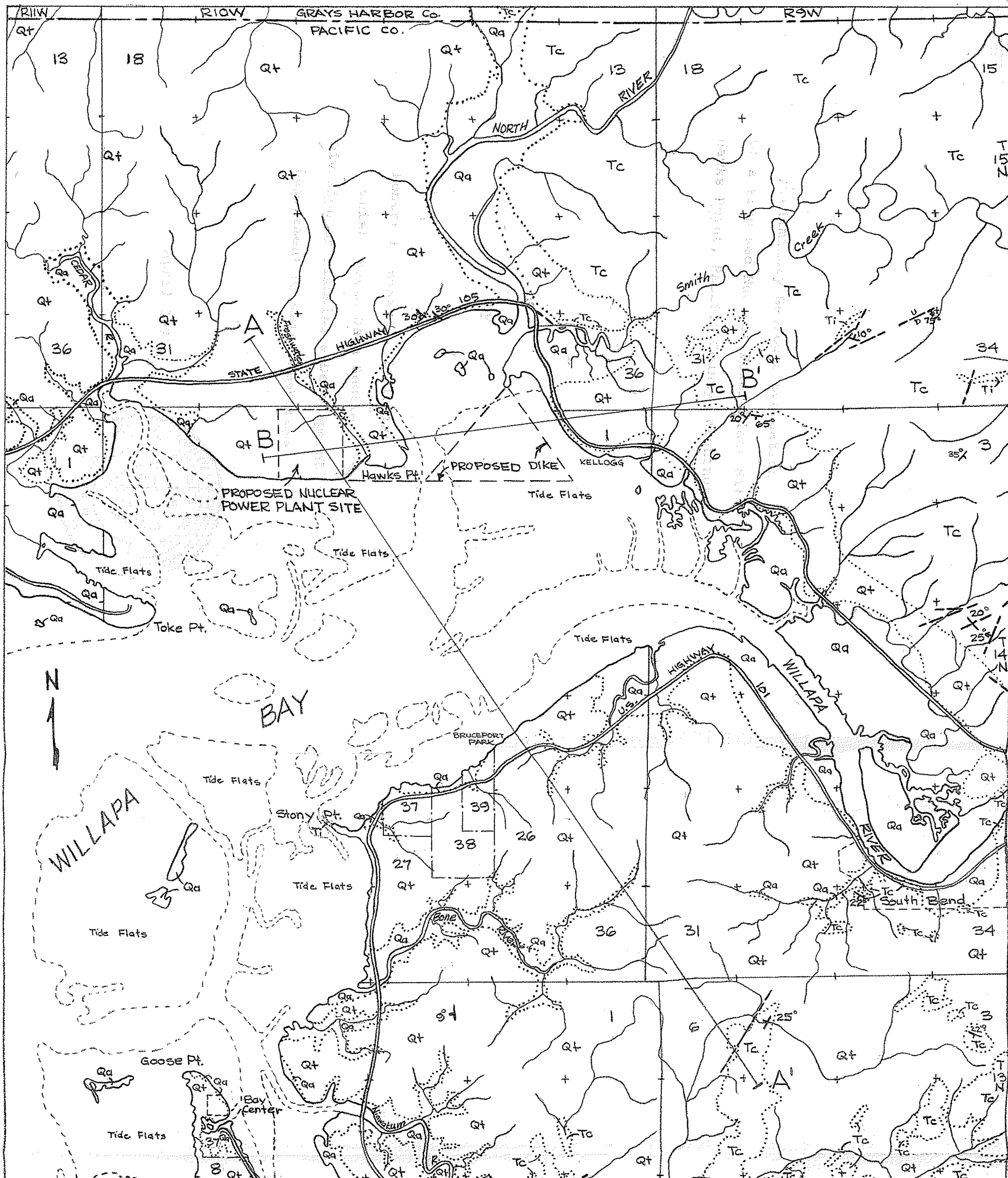
e. Impact on land values.

RECOMMENDATION

To provide answers for the points still in question about the geologic suitability of the proposed Hawks Point nuclear power plant site and to determine availability of ground water to satisfy plant fresh water requirements, it is recommended that:

1. Seismic profiles be developed south and east from the power plant site at Hawks Point across Willapa Bay to Bruceport Park and east from Hawks Point across Willapa Bay to Kellogg.

2. A test drilling program be carried out at the plant site to clearly define geologic facies between the land surface and the underlying volcanic rock and provide quantitative information on the ground water potential of the sands and gravels of the terrace deposits.



- LEGEND -

QUATERNARY	RECENT	Qa	BAY FILL AND ALLUVIUM UNCONSOLIDATED CLAY, SILT, SAND, AND GRAVEL.
	PLEISTOCENE AND RECENT	Qt	TERRACE DEPOSITS. UPLIFTED BEACH SAND AND GRAVEL, AND ANCIENT BAY FILL. OCCURS AT ALTITUDES AS HIGH AS 500 FT.
TERTIARY	MIDDLE & UPPER (?) EOCENE	Tc	CRESCENT FORMATION PREDOMINANTLY FINE-GRAINED PILLOW AND BLOCKY-JOINTED BASLT AT LEAST 5,000 FT. THICK.
	EOCENE & MIOCENE (?)	Ti	INTRUSIVE ROCKS FINE-TO COARSE-GRAINED DIKES AND SILLS OF BASLTIC AND GABBROIC COMPOSITION, MAINLY OF LATE EOCENE AGE. SOME INTRUSIVES WITHIN THE OUTCROP AREA OF THE CRESCENT FORMATION POSSIBLY OF MIDDLE EOCENE AGE.

DIP & STRIKE 25° — FAULT ZONE U/D — FAULT WITH DIP 10°

NOTE:
MOST GEOLOGY FROM OPEN-FILE REPORT, PRELIMINARY GEOLOGIC MAP OF SOUTH BEND QUADRANGLE BY HOLLY C. WAGNER, 1967.

FIG. 1

PRELIMINARY GEOLOGIC MAP
HAWKS POINT - NORTH WILLAPA BAY

SCALE - 1:62500 (MILES 1 ½ 0 1 2)

JAN. 1970 — ROBERT H. RUSSELL - GEOLOGIST; JOHN C. MILHOLLIN - CARTOGRAPHER