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GEOHYDROLOGY AND WATER SUPPLY, SHEMYA ISLAND, ALASKA

By

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(Map)

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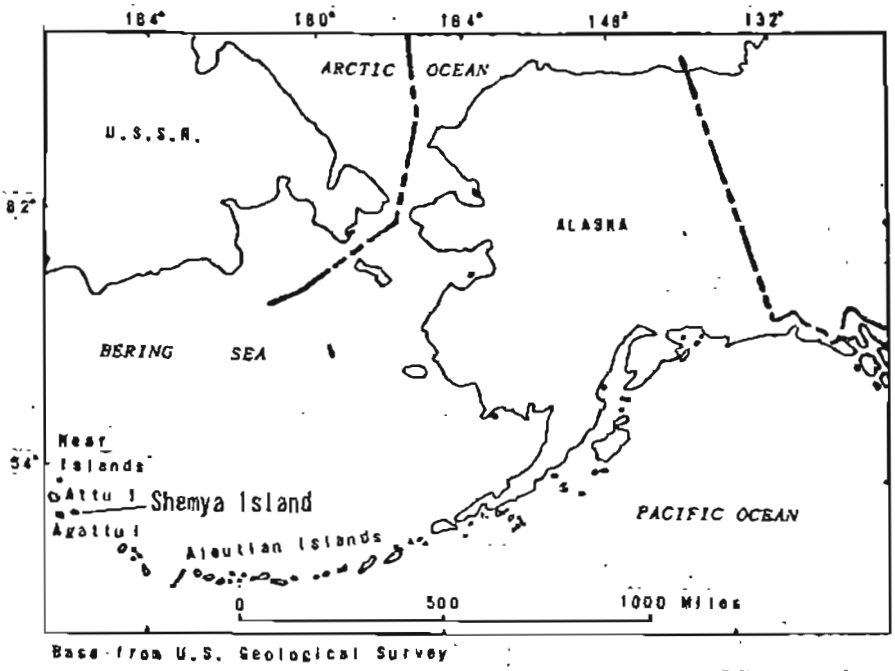

Index map of Aleutian Islands, Alaska, showing location of Near Islands and Shemya Island.

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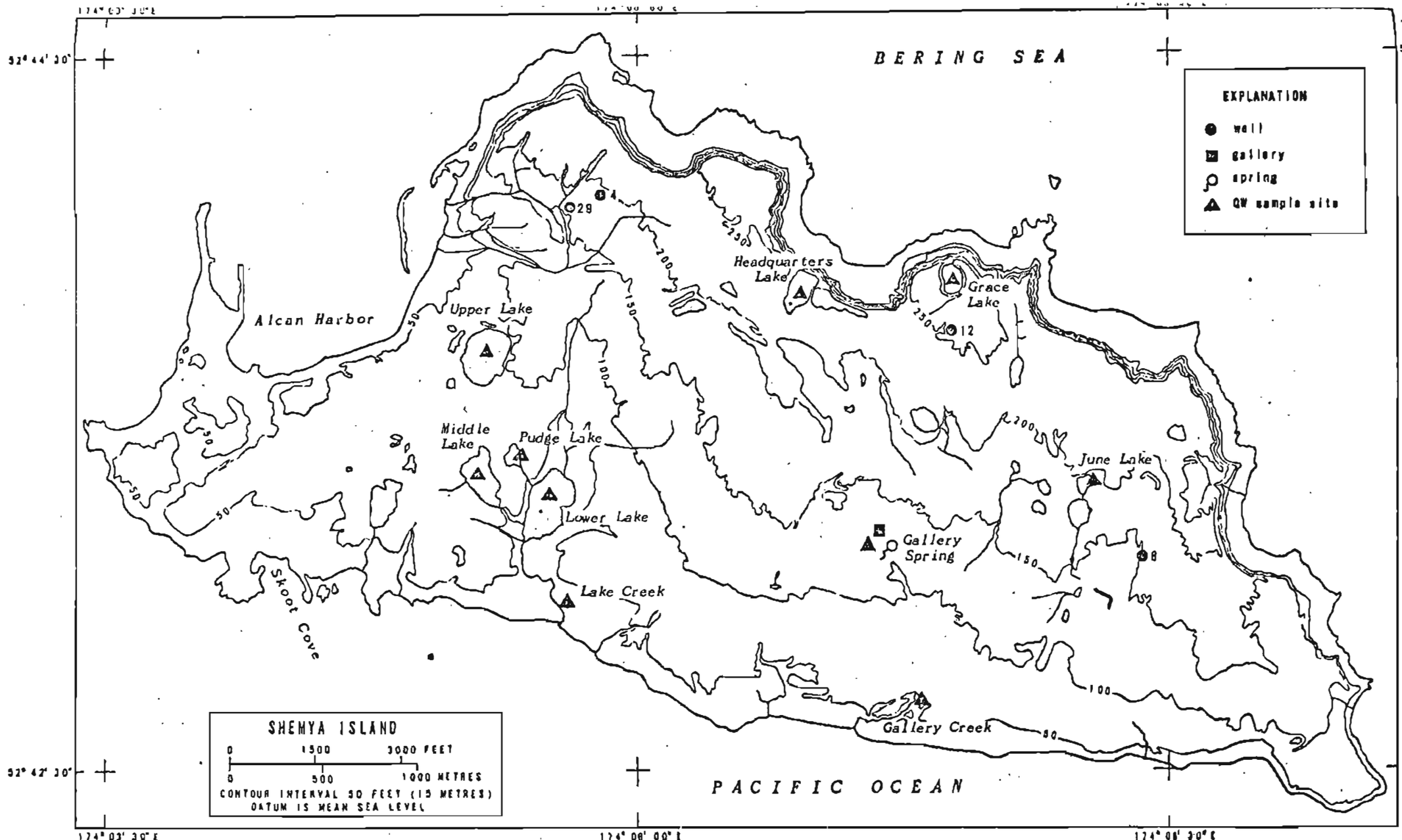
REVIEW OF WATER-SUPPLY DEVELOPMENT

Shemya Island, the easternmost island of the Near Island Group at the western extremity of the Aleutian Island chain, was occupied as a military base in 1942. Initially the military's water supply was obtained from intakes adjacent to small streams near the southern coast. Construction of an east-west runway (fig. 1) in 1943 obliterated some of these streams and changed the course of others. Approximately 16 lakes were then used successively as the principal water-supply sources. To supplement the lake supply, 30 wells were drilled in 1943 and 1944. By late 1944, only 18 of these wells were producing water. Pumping of the wells lowered water levels and some of the wells were deepened. In 1945 several were pumping saline water and the yields of others had significantly decreased. A gallery system was then built below a spring (fig. 1) which flowed at a rate of approximately 100 gal/min (gallons per minute). This gallery is still being used as the principal source of water. The yield is about 200,000 gal/d (gallons per day). Two of the wells, numbers 4 and 29, have been rehabilitated and, at present, are used as standby sources for emergencies. Together they yield 150,000 gal/d. These wells and the gallery, used in conjunction with storage tanks which have a total capacity of 800,000 gal (gallons), satisfy the current water requirement of the military installation on Shemya Island. The water is used almost exclusively for potable supply; chlorination is the only treatment applied.

Earth movement during a severe earthquake (magnitude 7.6 on the Richter scale) on February 2, 1975, broke several waterlines on the island. Because of this, an evaluation of the water supply and future potential for water-supply development was undertaken.

GEOLOGY

Shemya Island is composed of volcanic, pyroclastic, and minor amounts of intrusive rocks. The oldest rocks are interbedded sedimentary and volcanic rocks of Tertiary age which make up the western two-thirds of the island (fig. 2). Interbedded pyroclastic rocks, which have been intruded by small igneous bodies and are overlain locally by volcanic rocks, comprise the bulk of the eastern third of the island. Pleistocene glacial deposits, consisting of ground moraine and outwash sand,



Base from Coast and Geodetic Survey, U.S. Department of Commerce, 1948)

Figure 1.-- Hydrologic data collection sites on Shemya Island.

Figure 2.--Bedrock geology of Shemya Island. (Modified from Gates, Powers and Wilcox, 1971.)

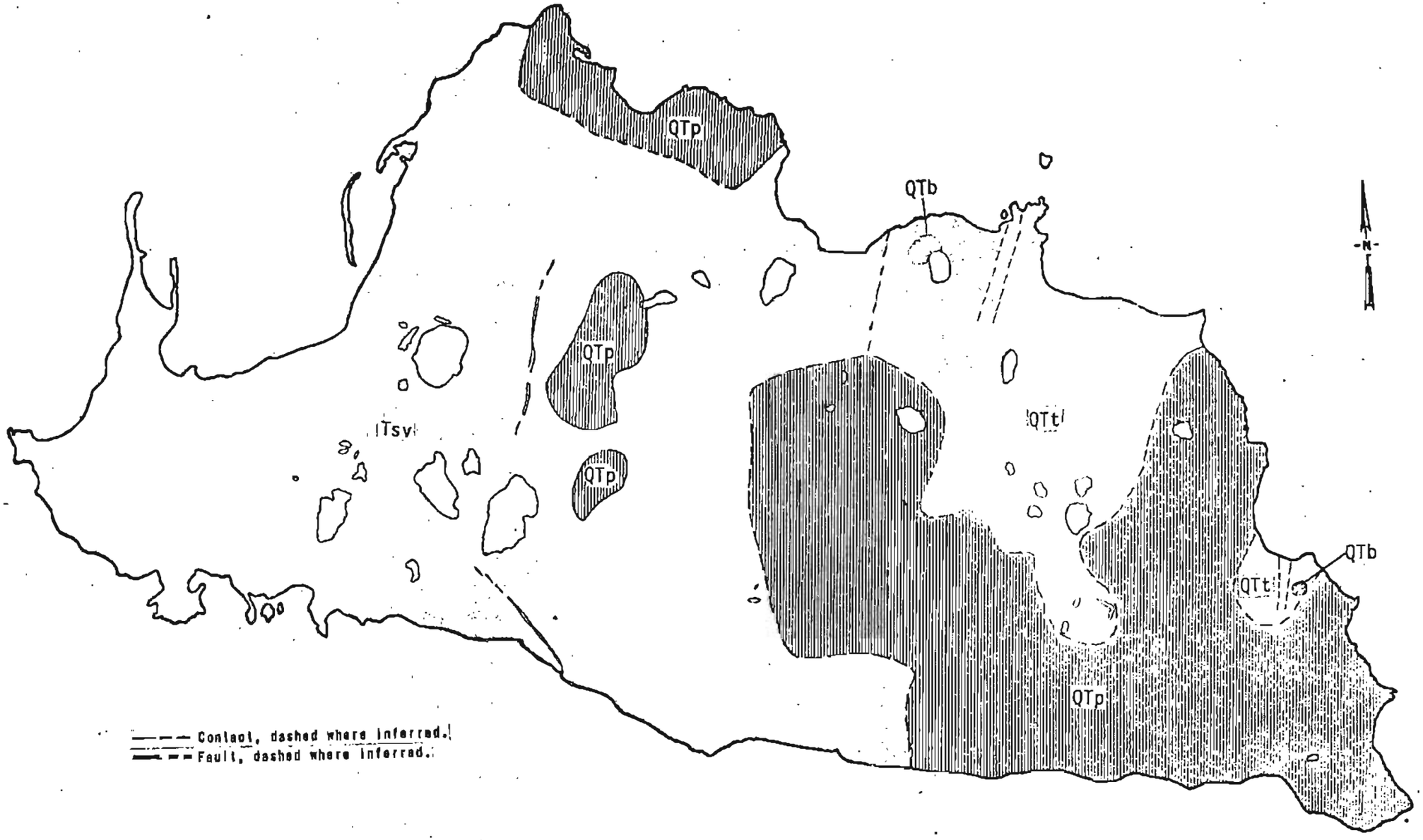
EXPLANATION

Basalt porphyry. Black fine-grained basaltic rocks with columnar jointing. Ground-water potential unexplored.

Hornblende porphyry. Very hard hornblende andesite or dacite. Weathered zone about 6 in. to 5 ft deep; unweathered rock breaks into large blocks and polygonal columns. Relatively low yields (<5-15 gal/min) have been obtained from wells completed in these rocks.

Tuff and tuff breccia. Stratified sequence of andesitic and basaltic tuffs and agglomerates 10 to 100 ft thick. Hardness variable. Groundwater potential unexplored.

Interbedded sediments and volcanics. Stratified sequence of thin-bedded argillite, tuff and graywacke conglomerate. Deeply weathered and soft beneath tundra; hard near coast and where baked by volcanic heat. Highly fractured to depths of about 10 ft. Wells with highest yields completed in these rocks.



(Map modified from Gates and others, 1971).

1 Mile

1:25,000

gravel, and boulders, are present in the east-central part of the island (fig. 3). The average thickness of these deposits is 5 feet, but locally may be 12 or more feet thick. The youngest geologic materials are the sand, gravel, and boulder deposits on modern and old raised beaches, peat deposits which range in thickness from a few inches to as much as 15 feet, and eolian sand in still-active dunes on the southern coastal portion of the island. Peat deposits are the predominant surficial deposit on the island. The geologic history and rock types occurring on Shemya Island are described in detail by Gates and others (1971).

THE OCCURRENCE OF WATER

The source of all fresh water on Shemya Island is precipitation, which averages 27 inches per year. Some of this precipitation moves directly overland to lakes and streams. Streams are less than 2 miles in length and the southward-sloping topography of the island causes all significant surface-water flow to be discharged along the southern coastline. Much of the precipitation percolates through the surficial peat, gravel, and sand deposits to the underlying bedrock. Only the upper 10 to 15 feet of the bedrock is severely weathered and fractured; thus deep ground water is available only where larger fractures extend to considerable depth. Large yields from wells in bedrock are uncommon. Because of the southward-sloping topography and the low permeability of unfractured bedrock, most of the shallow ground water moves southward through the surficial deposits and the upper 10 to 15 feet of fractured bedrock to be discharged as seeps and springs along stream courses or at the shoreline. A limited amount of deeper ground water reaches the zones from which it is withdrawn through irregularly and unpredictably spaced fractures in the bedrock. Based upon the yields of wells drilled on the island it appears that the fractures are more numerous in the northwestern part of the island than elsewhere.

SURFACE WATER

Precipitation and continuous streamflow data at three gaging stations were collected for a 2-year period (figs. 1 and 4). Analyses of those data show that, except for some winter months when precipitation occurs as snow, streamflow on Shemya Island responds directly and rapidly to precipitation. Ground-water inflow (that is, seepage along stream channels) sustains stream discharge during nonprecipitation periods. Water is also stored temporarily in lakes.

GROUND WATER

Ground water is present in most of the surficial deposits on Shemya Island. These deposits are either quite thin, averaging 5 feet, or are very poor aquifers (peat). Well yields are limited to about 25 gal/min. Shallow ground water has been developed by use of a gallery, an installation which utilizes horizontal "collectors" which have a much larger water intake area than does a conventional well. The gallery at Shemya provides at least 200,000 gal/d.

Figure 3.--Surficial deposits of Shemya Island. (Modified from U.S. Geological Survey, 1960.)

EXPLANATION

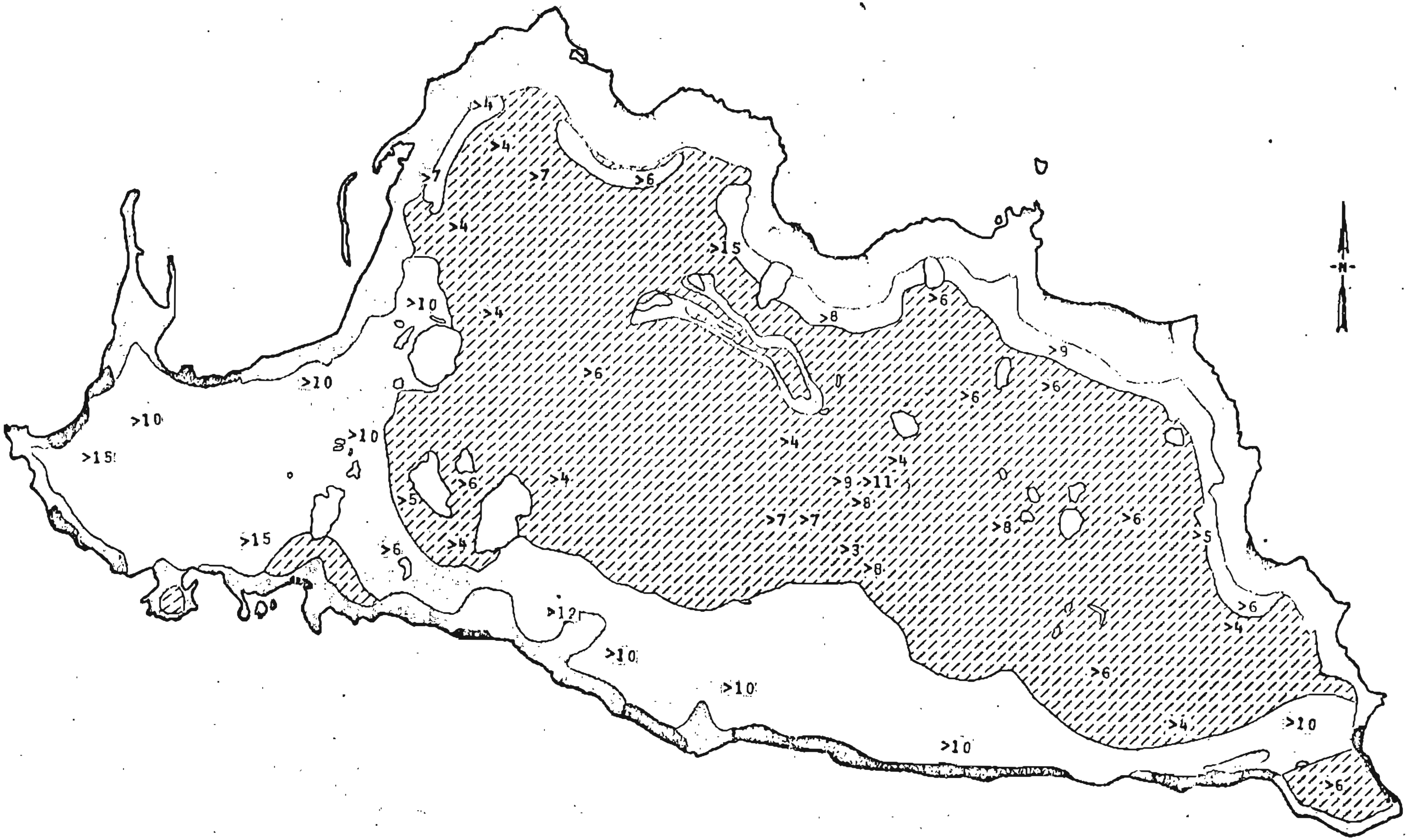
Bedrock. See figure 2 for type of bedrock at specific locations.

Beach deposits. Sand and gravel in discontinuous, narrow, active beaches, and in old raised beaches 15 ft above mean sea level along north shore. Thickness of these deposits generally 6 ft or less. Size and shape of active beaches may be changed annually by severe winter storms.

Eolian deposits. Well-sorted sand in active dunes in southern and western parts of the island. Maximum known thickness about 50 ft; underlies and interfingers with peat deposits. Along northern sea cliff consists of ridge of silty sand, similar to loess; in places overlain by peat.

Peat. Partly decayed grass, moss, and root debris with varied admixture of clay, silt or sand. At least 3 ft thick where shown on map; overlies and interfingers with other surficial materials..

>3 Thickness of surficial deposits in feet.



1 ½ 0 1 Mile

1:28,000

(Map modified from U.S. Geological Survey, 1980).

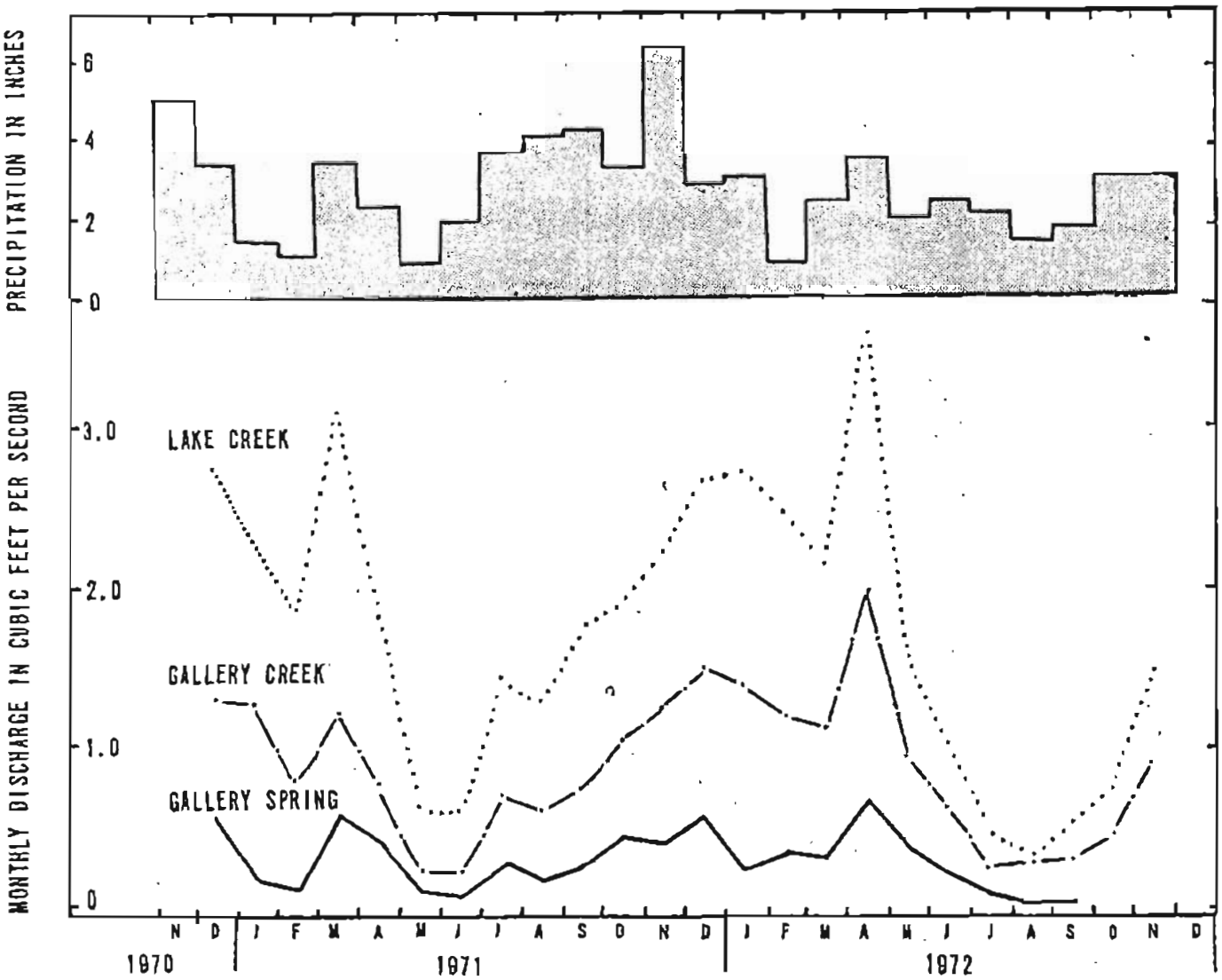


Figure 4. -- Precipitation data from a gage near the south shore and discharge measurements from gaging stations, Shemya Island.

The volcanic, intrusive, and pyroclastic rocks on Shemya have a wide range of hydrologic properties. Porosity and permeability depend on secondary fracturing or jointing, and, in the case of pyroclastics, are related to fragment size, sorting, and degree of cementation. The wells drilled on Shemya Island range in depth from 40 to 205 feet and all were completed in bedrock. Several wells were completed below sea level. Water from these wells increased in salinity after long periods of pumping. Available aquifer-test information suggests that nearly all the wells produce water from fractures (secondary openings in the rock) rather than from an areally extensive and homogeneous bedrock aquifer. The small amount of water-level data available suggests an irregular ground-water "surface" having a gradual slope to the south, similar to the island's topographic surface. This suggests that the permeability of the bedrock complex is low.

CHEMICAL QUALITY OF WATER

The small number of water-quality analyses available indicate the water in streams on Shemya Island is a sodium calcium bicarbonate type (table 1) and also has a relatively high chloride content. The water is moderately hard (101-160 mg/l [milligrams per litre] $CaCO_3$), and the dissolved-solids concentrations range from 223 to 286 mg/l. Lakes on the island contain water of sodium chloride type, perhaps the result of salt spray during storms. Lake water is relatively softer than water in streams. The color of the lake water (values as great as 100 platinum-cobalt units) suggests a high organic content. Well water is a calcium sodium bicarbonate type, is moderately hard, and has a sodium chloride concentration similar to the island's surface waters. The chemical quality of water obtained from the gallery well generally approximates that of surface water on the island. None of the constituents in samples from streams, lakes, or ground water, except the August 27, 1970, analysis for Lower Lake, exceed the recommended limits for drinking water (Environmental Protection Agency, 1973).

DEVELOPMENT OF ADDITIONAL WATER SUPPLIES

Lakes on the island hold an estimated 30 million gallons of water in storage (U.S. Geological Survey, 1960). The water in many of the larger lakes in the western part of the island is reported to be contaminated (presumably by sewage leaking from ruptured sewer mains in that part of the island--W. H. Morris, U.S. Air Force, oral commun., 1975). Lake water could be utilized for fire protection if new intakes and lines are extended from the lake to either points of use or the current lines carrying fire protection water. However, the lines, intakes, and pumps installed in the early 1940's have deteriorated to the point that they can no longer be used. The drilling of additional wells might provide a significant addition to the military installation's water supply, but past experience with wells suggests that obtaining a yield of more than a few tens of gallons per minute would be a rare occurrence. Even surface geophysical techniques are generally of limited use in determining favorable ground-water development sites in volcanic rocks (Davis and DeWeist, 1966, p. 341).

Because of the likelihood of contamination in lakes and the unpredictable but generally low yields of wells on Shemya Island, additional water supplies could be most easily developed through the use of the gallery-type water-supply facility now in use. Either a new and separate facility could be installed on the east fork of Gallery Creek immediately upstream from the present water-supply gallery (on a western branch of Gallery Creek) or a gallery system might be installed on the east branch of Gallery Creek with an overflow pipe extending to the present gallery supply point. Test augering in the area of the present gallery and adjacent to the east fork of Gallery Creek in July of 1975 indicated that the bedrock surface is covered by 7 to 11 feet of peat. Although the current supply from the gallery is adequate for present demands, the watershed of the east fork on Gallery Creek should be protected from any contamination in the event that future needs arise. The two wells currently in use as standby wells were test pumped following the earthquake and pumps were replaced. The wells should provide a 30-day standby supply even if the pumps were operated almost continuously in any future emergency. Either the extension of the present gallery system to the east or construction of a new gallery facility should provide an additional 200,000 gal/d of water to add to the combined ground-water and surface-water supply obtained via the gallery system.

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Station number	Station name and location	Date	Lead (Pb) micrograms/l	Mercury (Hg) micrograms/l	Discharge ft^3/s	Depth (ft)
	- LAKES -					
15-297750	June Lake	8-27-70	7	1.3	NA	-
15-297755	Grace Lake	8-27-70	6	0.6	NA	-
15-297757	Headquarters Lake	8-27-70	4	1.4	NA	-
15-297762	Middle Lake	8-27-70	4	1.0	NA	-
		1-28-72	-	-	NA	5.0
15-297763	Upper Lake	8-27-70	5	.8	NA	-
		1-28-72	-	-	NA	1.0
15-297764	Pudge Lake	8-27-70	5	1.4	NA	-
		1-28-72	-	-	NA	7.4
15-297766	Lower Lake	8-27-70	3	.8	NA	-
		1-28-72	-	-	NA	-
	- STREAMS -					
15-297767	Lake Creek	4-25-72	-	-	2.7	-
		7-07-72	-	-	0.94	-
15-297771	Gallery Spring	4-25-72	-	-	.66	-
		7-07-72	-	-	.19	-
15-297773	Gallery Creek	4-25-72	-	-	1.51	-
		7-07-72	-	-	.35	-
	- WELLS -					
Well 4	-	9-1961	-	-	-	118
Well 29	-	9-1961	-	-	-	118
Gallery	-	8-28-70	-	-	-	-
		1-26-72	-	-	-	-

Table 1. -- Selected water-quality ana

(Explanation of symbols: Iron (Fe) and Mangan
t = total, d = dissolved, u = undifferentiate
Method of collection or field treatment of sa

Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
mg/l	micrograms per litre						mg/l
1.3	220t	60t	11	4.3	26	1.7	41
0	750t	100t	2.8	4.5	36	2.5	5.0
0	220t	50t	3.0	4.1	32	2.0	6.0
4.5	200t	750t	20	11	43	2.3	120
8.4	680d	20d	18	9.0	43	2.0	69
1.3	100t	140t	12	6.0	32	2.4	43
1.0	350d	-	10	5.8	35	2.2	38
0.3	600t	40t	1.4	3.6	28	1.5	2.0
.7	330t	30t	3.8	4.0	33	1.7	3.0
9.8	80t	480t	26	11	48	4.3	114
7.0	320t	20t	13	7.2	44	2.6	44
7.5	280d	160d	24	9.8	42	2.4	114
9.4	300d	190d	32	13	52	3.1	166
18	240d	360d	24	14	41	2.3	134
20	660d	410d	23	14	39	3.3	135
13	630d	290d	30	11	39	3.3	140
20	340d	440d	43	13	40	3.3	183
15	100u	280u	39	20	46	4.8	227
14	30u	100u	91	33	63	8.5	352
16	260t	380t	22	14	40	3.6	135
18	170d	370d	22	14	39	3.6	132

es, Shemya Island.

ganese (Mn) values
ated
samples unknown)

r-te	Ortho-phos-phorous (P)	Sul-fate (SO_4)	Chlo-ride (Cl)	Fluo-ride (F)	Ni-trate as (N)	Dis-solved solids Calcu-lated	Hardness as $CaCO_3$ (Ca,Mg)	Specif-ic con-duct-ance μ mhos at 25°C	pH units	Tem-per-ature (°C)	Color	Remarks
g/l	(milligrams per litre)											
	0.0	9.8	40	0.1	0.50	116	45	228	7.0	-	40	
.0	.16	9.8	61	.3	1.54	127	26	253	5.5	-	30	
.0	.07	9.8	54	.1	.57	109	21	220	6.7	-	30	
	.03	11	56	.2	1.1	213	95	399	7.5	-	20	
	.02	13	76	.1	.05	204	83	383	7.0	1.0	5	Ammonia as N=0.04; org. N=0.08; total P=0.20
	.0	6.8	61	.1	1.06	147	54	282	7.2	-	10	
	.04	8.8	64	.0	.07	146	49	300	6.7	1.0	20	Ammonia as N=0.10; org. N=0.20; total P=0.18
.0	.03	9.2	52	.1	.27	98	18	201	5.6	-	50	
.0	.03	8.4	63	.1	.05	116	26	236	5.3	1.0	60	Ammonia as N=0; org. N=0.11; total P=0.15
	.30	14	50	.3	5.45	243	108	464	6.7	-	100	
	.02	15	78	.1	.07	189	61	363	7.0	-	30	Ammonia as N=0.04; org. N=0.07; total P=0.14
	-	20	60	.2	.05	223	101	409	7.7	4.0	35	
	-	21	64	.2	.38	279	133	505	7.3	10.5	15	
	-	13	59	.1	.0	238	118	419	7.2	4.5	0	
	-	11	58	.1	.02	236	116	421	7.8	4.5	5	
	-	13	59	.2	.20	239	120	429	7.7	4.5	25	
	-	12	61	.1	.77	286	160	503	7.9	6.0	10	
	-	27	53	.0	.02	317	180	564	7.8	6.0	0	Formerly pumped at 100 gal/min
	-	97	88	.0	.02	568	362	971	7.9	5.0	0	Formerly pumped at 500 gal/min
	-	12	58	.2	.34	235	111	421	8.2	-	10	
	-	11	60	.1	.02	233	108	425	7.2	5.0	0	